Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India

Capacity Building for Industrial Pollution Management Project

Inception Report (Final version)

Ministry of Environment and Forests
September 10th, 2012

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Technochem Group, Indus Technologies (Netherlands) BV

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Abbreviations

CBIPMP	Capacity Building for Industrial Pollution Management Project
CETP	Common Effluent Treatment Plant
CII	Confederation of Indian Industry
CPCB	Central Pollution Control Board
HW	Hazardous Waste
IR	Inception Report
MoEF	Ministry of Environment and Forests
NPRPS	National Programme for Rehabilitation of Polluted Sites
PCC	Pollution Control Committee
PM	Project Management
PT	Project Team
SPCB	State Pollution Control Board
TEP	Technical Expert Panel
TL	Team leader
TOR	Terms of Reference
TTCWMA	Trans Thane Creek Waste Management Association

1 Introduction

1.1 Background

The project ‘Development of methodologies for national programme for rehabilitation of polluted sites’ is part of the ‘Capacity Building for Industrial Pollution Management Project (CBIPMP)’. The objective of the overall project is (i) to build tangible human and technical capacity in selected state agencies for undertaking environmentally sound remediation of the contaminated sites and (ii) to support the development of a policy, institutional and methodological framework for the establishment of a National Programme for Rehabilitation of Polluted Sites (NPRPS).

As stated in the Terms of Reference (ToR) the objective of the project ‘Development of methodologies for national programme for rehabilitation of polluted sites’ is to develop methodologies to implement remediation projects by government agencies under the NPRPS.

In India there is currently no generally accepted process for selecting and implementing preferred remediation options. Such a process is to be developed to ensure a harmonized approach to soil and groundwater contamination across India and obtained benefits from it. There are currently in India no technical guidelines or standards that agencies at the State or Municipal levels can refer to when faced with soil or groundwater contamination, or when faced with further steps to be taken in an ongoing process of taking on soil or groundwater contamination. Such guidelines and standards are to be developed as part of our study. This should be done based on other international experience, as well as in individual countries where processes, guidelines and standards like the ones that India seeks here, are already in use.

After prequalification our consortium submitted a proposal and was finally selected as contractor for this project. The consortium consists of the companies Grontmij Nederland BV (the Netherlands), Shah Technical Consultants (India), Technochem group (India) and Indus Technologies BV (the Netherlands).

Our approach for the project is described in full detail in the Work Plan that is part of the Contract for Consultants’ Services, with number MOEF/CBIPMP/3, regarding Methodology and Work plan for performing the Assignment - Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India”, March 26th, 2012.

The scope of the Inception Report is to describe the project status at the end of the Inception phase. With this Inception report we report our activities during the Inception phase.

On request of the client, the Grontmij presentation during the Technical Expert Panel (TEP) meeting for the World Bank aided ‘Capacity Building for Industrial Pollution Management Project (CBIPMP)’, June 28th, 2012 is included in Appendix 6, These slides present both an overview of the project team activities between the inception phase and the same TEP meeting as well as the draft results of Task 1, 2, 3, and 4 at the time of that TEP meeting. In appendix 7 we present the project team’s conclusions on the comments the TEP offered on the draft Inception Report.

1.2 Objectives of the Inception phase

The objectives of the Inception phase are:

- to give additional explanation of our proposal and discuss our ideas of the project with the Ministry of Environment and Forests (MoEF);
- to have detailed internal discussions with full project team;
- meeting and discussion with other major stakeholders such as the Central- and some of the State Pollution Control Boards;

- visit some project locations relevant for the project;
- jointly working on a project strategy for the upcoming period (first quarter of the project);
- team building between project team and MoEF, CPCB, etc.;
- to make a detailed planning for activities in coming months;
- to conform project approach based on our discussions with MoEF.

1.3 Our Approach

Figure 1.1 gives a schematic overview of our proposed approach to this assignment, as described in the Work Plan of our Contract, based on the tasks outlined in the ToR:

- Task 1 Review the nature and type of hazardous waste polluted sites in India;
- Task 2: Review of national and international approaches to remediation;
- Task 3: Identify Options and recommend standards for remediation of polluted sites;
- Task 4: Develop Guidance Document on Methodology for Design, Implementation and Monitoring of Remediation Plans;
- Task 5: Identify capacity building requirements;
- Task 6: Consultation and finalisation.

We have adopted these tasks (in grey) and have divided them into subtasks. The overview in figure 1.1 demonstrates the different tasks 1 to 4 and for each task the subsequent steps and activities. While developing this overview we identified a coherence between distinguishable tasks and the other two assignments within the project. Points of interaction are included in figure 1.1 (see also appendix 5).

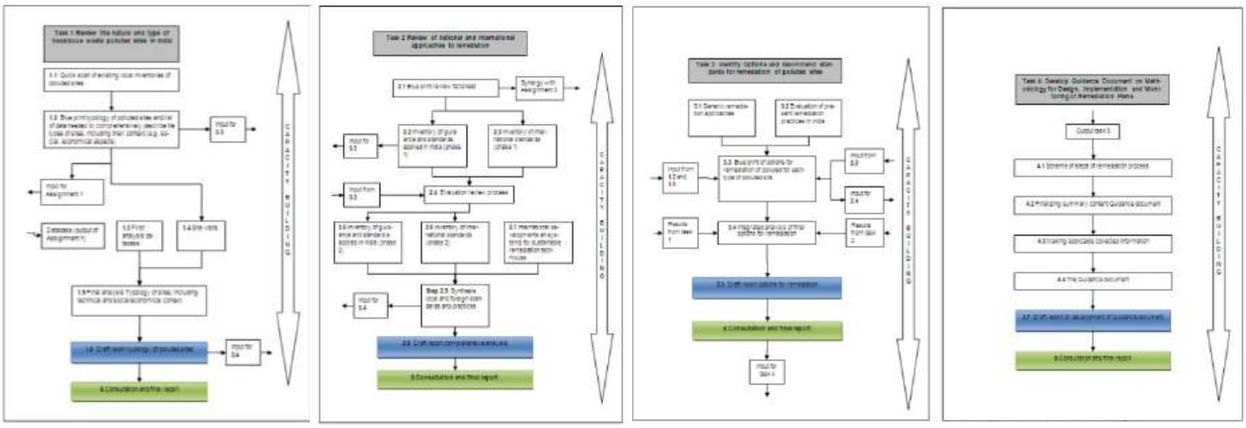


Figure 1.1 Schematic overview of stepwise project approach

This inception report will give suggestions for issues on which a decision should be made for further implementation of the project.

1.4 Structure of the report

Next chapters will further detail our findings during the Inception phase.
Chapter two presents the activities performed in the inception period. Chapter three includes an overview of the foreseen project activities with special attention to the first 3 months after the inception period. The report includes six appendices.

2 Activities and findings during inception (April 2012)

2.1 Activities inception mission

The mission report of the inception mission is included as Appendix 1. The mission took place between April 8th and April 15th, 2012. Goal of the mission was to specify the activities as mentioned in section 1.2, all in close consultation with involved organisations in the project.

The project team had meetings with the following organisations:

- MoEF, CPCB and DPCC, at MoEF office;
- CPCB, at CPCB office;
- Delhi Pollution Control Committee, at DPCC office;
- Government of Maharashtra, by a visit to Mr. Sachin Ahir, Minister of Environment of the State of Maharashtra;
- Further contact with Maharashtra PCB.

In addition, the project team completed visits to the following sites;

- two CETP-sites in Delhi (Wazirpur Industrial Estate CETP and Badli Industrial Area CETP);
- sanitary landfill Mumbai (TTCWMA);

In preparation of the project two other visits to India took place, for contract negotiations, and for the signing of the contract. During these visits we already gathered some information that was useful to make a good start with the project.

For a detailed overview and findings of the meetings please refer to Appendix 1. The main findings and conclusions from these meetings, relevant for the project, are described in this chapter.

2.2 Data and relevant research

From CPCB we received following data and reports. This is the list of formal data which we will use for the project. It includes an overview of 25 hazardous waste contaminated dump sites and 12 priority dump sites. The total list of hazardous waste contaminated sites in these documents includes 73 sites.

1	Chapter - 1	summary of 12 priorities of contaminated dump sites
2	Annexure	For each of the States a description of the hazardous waste dump sites
3	Annexure - I	List of hazardous waste contaminated dump sites in the country (preliminary information)
4	Annexure - II	Methodology; sequence of steps site investigation, assessment, characterization, proposing remediation options
5	no title	Table/list with contaminated sites; almost same information as nr. 3

The prioritized sites described in these documents are:

S.No	State	Name of the Site	Nature of Contaminant	Preliminary details
1	Gujarat	Vadodara	Chromium	Apprx. 77000 tonnes of chromium residue is dumped in industrial plot. Groundwater is contaminated.
2	Kerala	Eloor, Cochin	Heavy metal and POPs	24.5 hectares of soil and water bodies contaminated with Pesticides and heavy metals in 4 locations.
3	Madhya Pradesh	Ratlam	Gypsum, iron salts and Naphthalene	Severe contamination of ground water with PAH and Iron salts imparting red colour .
4	Orissa	Ganjam	Mercury	About 56,000 MT of sludge containing mercury dumped along and near the banks of the river Rishikalya.
5	Orissa	Talcher	Chromium	60000 tonnes of chromium leach residue is dumped in closed industry premises. Contamination of soil, and surface water bodies during rains.
6	Orissa	Sundergarh	Chromium	Chromium leach residue dumps at 4 locations
7	Rajasthan	Bichhadi	Inorganic salts, organics	Contamination of soil and groundwater.
8	Tamil Nadu	Ranipet	Chromium	Hexavalent Cr leaching from 7.41 acre dumpsite, with 2.2 lakh MT of leach residue. Soil and groundwater and surface water contamination.
9	Uttar Pradesh	Rakhimandi, Kanpur	Chromium	Approx. 10000 tonnes of residue dump in approx. 5-6 acres. Owners not known. Population effected, groundwater contaminated
10	Uttar Pradesh	Rania, Kanpur Dehat	Chromium	Area 2 sq. km. Private land is contaminated with open dump of Apprx. 45000 tonnes of waste.
11	Uttar Pradesh	Lucknow	HCH (hexa chloro cyclo hexane)	Apprx. 36432 tonnes of pesticides waste dumped in closed industry premises
12	West Bengal	Nibra Village, Howrah	Chromium	About 4440 tonnes of residue dumped, human settlement exists above the dump, contamination of groundwater

These sites are indicated on the map below.

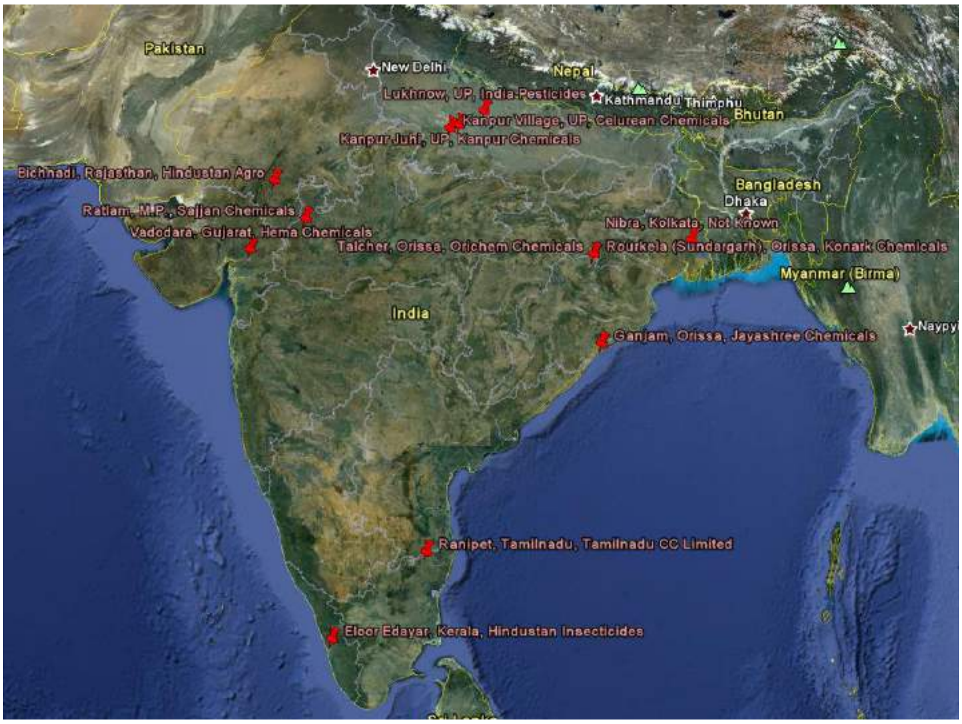


Figure 2.1 Location of 12 prioritized hazardous waste contaminated sites

2.3 Task 1-4

In the Work Plan of our Contract some issues are described leaving different options open. In this section we describe our findings on each of these issues, and a final proposal is suggested based on our experience with the subject, discussions during the inception period and the specific situation in India.

2.3.1 Task 1 Review nature and type of hazardous waste sites

The result of Task 1 will provide a thorough insight in the nature and types of polluted sites in India, leading to a typology suited for the identification and selection of remediation strategies in Task 3.
To develop a solid typology we need detailed information on the contaminated sites that have already been inventoried. CPCB had indicated they will provide soft copies of reports on polluted sites to be involved in this inventory.

The project team will visit some of the sites where soil contamination is present. Point of interest is that these sites should be representative for important types of contaminated sites. The project team will always contact the SPCB in advance of such visits.

2.3.2 Task 2 Review of national and international approaches

We will inventory information on the soil contamination approach, and related environmental and social-economical aspects, in the following countries: India, The Netherlands, China, United Kingdom, France, USA, Australia, Romania or Poland and the European Union. The experiences on soil remediation approach in these countries will be analysed for the applicability in India.

The following information will be part of this inventory:

- Presence of soil contamination: numbers of sites, costs, geology, climate;
- Recognized effects of contaminated soils: threats to health, ecology, drinking water, etc;
- Policy goals, strategic as well as operational;
- Policy instruments: legislation, financing, technical development, communication, etc.;
- Remediation Techniques, including their cost;
- Examples of remediation of sites similar to known Indian sites;

- Economical and social factors;
- Feasibility of implementation.

2.3.3 Task 3 Options and standards for remediation

Task 3 will provide an approach for remediation of polluted sites and a menu of prioritized options for remediation, applicable to the typology developed in task 1, i.e. each category of polluted sites. For the evaluation of the already remediated sites in India we need detailed information on these sites. CPCB has indicated they will provide soft copies of reports on research and remediation of several sites.

2.3.4 Task 4 Guidance document

For the presentation of the guidance document we have basically identified three different options. These are illustrated in figure 2.2.They range from a more descriptive report to a flowchart type of report or lists and tables. Based on the brief discussion on this topic during the Inception meeting, we suggest to combine these elements to provide suitable guidelines. During the workshop (see chapter 3) we will present these options and discuss with participating stakeholders what suits them best. On the basis of the results of that discussion, we propose to determine more precisely the expected shape and detail of the final guidance document.

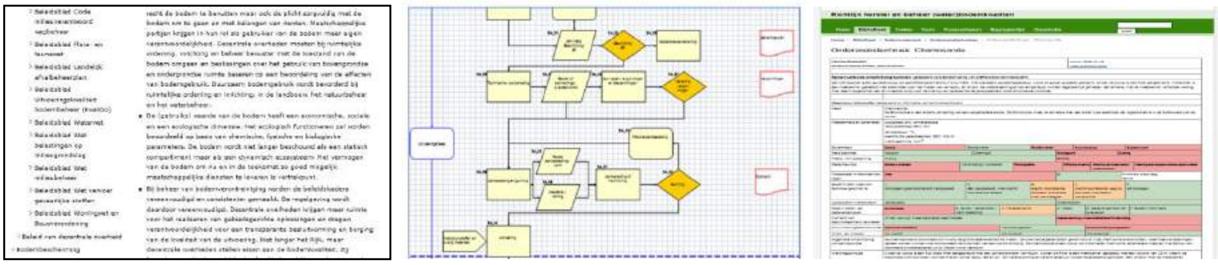


Figure 2.2 Options for presentation forms of the Guidance document

2.4 Organizations

Whereas we recognize that many organizations can be affected by soil contamination and remediation, the main concerned organizations in this project are the MoEF, the Central Pollution Control Board (CPCB) and all State Pollution Control Boards (SPCB) and Pollution Control Committees (PCC's) in India.

2.4.1 MoEF

The Ministry of Environment & Forests (MoEF) is the nodal agency in the administrative structure of the Central Government for the planning, promotion, co-ordination and overseeing the implementation of India's environmental and forestry policies and programmes.

Our understanding of the broad objectives of the Ministry are:

- Conservation and survey of flora, fauna, forests and wildlife;
- Prevention and control of pollution;
- Afforestation and regeneration of degraded areas;
- Protection of the environment;
- Ensuring the welfare of animals.

These objectives are well supported by a set of legislative and regulatory measures, aimed at the preservation, conservation and protection of the environment.

The MoEF consist of two main divisions: Environment and Forestry. This project is within the Environment division. With the main office in Delhi the Ministry has regional offices in Bangalore, Bhubaneswar, Bhopal, Shillong and Chandigarh. The organization of the Environment division within the MoEF is shown in figure 2.3.

Earlier activity on soil remediation was initiated from the office of the Minister of State, MoEF. There is no separate office or department designated in MoEF for soil. The CBIPMP is run by the MoEF. Project director of the project is Mr. Aniruddhe Mukerjee, Deputy Director is Dr. R.B. Lal. Mr. Rambabu is the Senior Environment Engineer in the project and Mr. R.K. Gupta is the Procurement Officer on behalf of the MoEF.

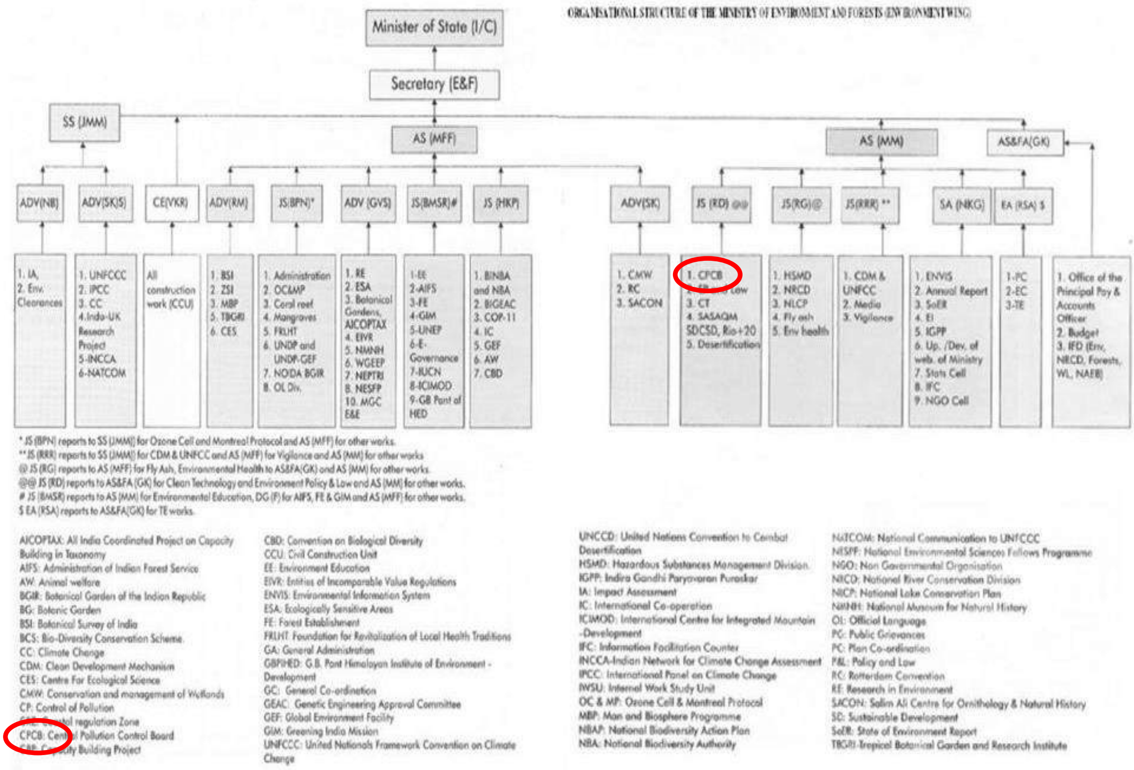


Figure 2.3 Organisation of MoEF, Environmental division, with the position of the CPCB marked

2.4.2 CPCB

The Central Pollution Control Board (CPCB) is a statutory body under the aegis of the Ministry of Environment & Forests, Government of India. It was constituted in September 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981.

The CPCB serves as a field formation and also provides technical services to the Ministry of Environment and Forests of the provisions of the Environment (Protection) Act, 1986. Principal Functions of the CPCB, as spelt out in the Water (Prevention and Control of Pollution) Act, 1974, and the Air (Prevention and Control of Pollution) Act, 1981, (i) under Chapter IV, Section 16 subsection (1) to promote cleanliness of streams and wells in different areas of the States by prevention, control and abatement of water pollution, and (ii) under Chapter III, Section 16 sub-section (1) to improve the quality of air and to prevent, control or abate air pollution in the country.

The main office of the CPCB is located in Delhi but it also has zonal offices (Bengaluru, Bhopal, Kolkata, Lucknow, Shillong, Vadodara) and a project office (Agra). The organization of the CPCB is shown in figure 2.4.

Our understanding of the functions of the Central Board at the National Level (amongst others):

- Advise the Central Government on any matter concerning prevention and control of water and air pollution and improvement of the quality of air;
- Plan and cause to be executed a nationwide programme for the prevention, control or abatement of water and air pollution;
- Co-ordinate the activities of the State Boards and resolve disputes among them;

- Provide technical assistance and guidance to the State Boards, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement;

The CPCB also has multiple functions as State Committees for the Union Territories.

The CPCB, along with its counterparts the State Pollution Control Boards (SPCBs), is responsible for implementation of legislations relating to prevention and control of environmental pollution.

Activities for this project are mainly in the Hazardous Waste Management Division (HWMD). The director of this division is Mr. B. Vinod Babu.

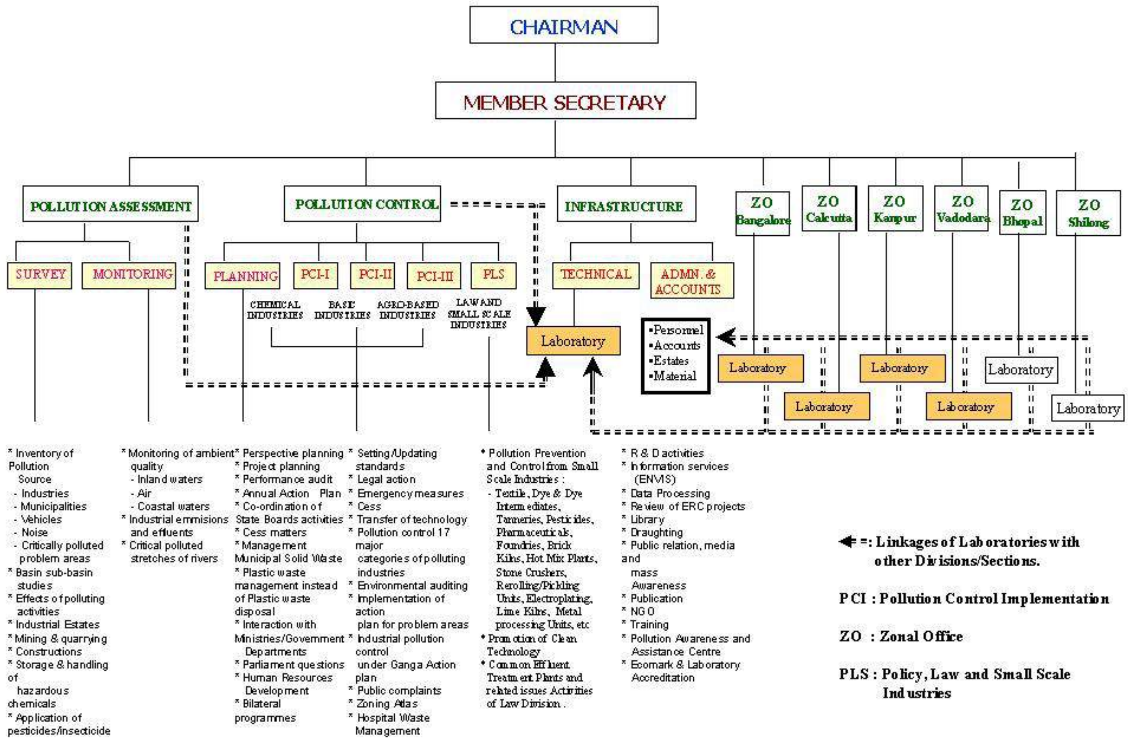


Figure 2.4 Organisation of the CPCB

2.4.3 SPCB

The SPCBs were established following the State Legislatures' adoption of the Water Act of 1974 and then the Air Act of 1981. At the State level, the SPCBs are attached either to the Environment Department, or to the Forest and Wildlife Department. As we understand in general, SPCB's perform the following functions:

- advise the state governments on pollution related issues;
- plan a comprehensive state-level pollution control/prevention/abatement program;
- implement and enforce national standards, making them more stringent if warranted by local conditions;
- grant consents to establish and to operate under the Air and Water Acts and authorize hazardous waste disposal per rules under the EPA; and
- collect water cess for the use of water.

In the SPCBs, staffing numbers range widely between 10 and 800 (4 to around 300 technical) depending on the geographic area, number of industries and financial status of the board.

SPCBs are primary enforcement authority in the states. The SPCBs have delegated some enforcement responsibilities to their regional and sub-regional offices. SPCBs have to coordinate among themselves and other state-level government agencies that have some environment-related responsibilities, including departments of transport (with respect to mobile source pollution), or urban development (municipal waste), and industries (siting of industrial facilities), etc. SPCBs receive administrative directions and some funding from their state governments.

Figure 2.5 State Map including Capital cities

2.4.4 Other organizations

Main involved organizations are described in previous sections. At a later stage, we think it might be useful to include other organizations as well. Either in training and/or in consultation. However, this has to be discussed with MoEF and we suggest MoEF will take a final decision on if and if yes, what other organizations to involve. Other organizations that could be involved later in the project are:

- Research labs and education institutions;
- Other institutes on technology and geosciences;
- Contractors and private companies on research and remediation;
- Local authorities (spatial planning, housing, environment, etc).

2.5 Social Impacts

The impact assessments on social issues are an integral part of the study and solicit views of the stakeholders including the community for designing the project. The consultation process helps in making the project responsive to social development concerns, including options that enhance benefits for poor and vulnerable people while mitigating risk and adverse impacts.

The nature of social impacts may be direct, indirect and cumulative, based on the characteristics of impacts. However, social impact assessment may primarily include the following:

Following activities are primarily required to establish the level of significance for each identified impact on the community:
- Socio-economic details of the nearby areas including type of settlements,
- Apart from the main stakeholders, consultation with the community is necessary to identify the type and magnitude of pollution and its impact on the health due to poor sanitation and ground water contamination;
- Determination of the severity of the effect; for example, an impact is of low, medium, or high significance. Emphasis should be given on the slum population in the nearby areas as they are more exposed to hazardous wastes;
- A plan for the site specific mitigation measures is to be formulated in consultation with the stakeholders for sustainable remediation techniques and to reduce hazardous impact on the community of the nearby areas.

Anticipated Social Impacts due to Remediation of Hazardous Waste Dump sites:
- During remediation process, impacts of air and noise pollution on the local communities depend on the duration of the project activities;
- Spillage of wastes during transportation may cause negative impact on the community;
- Impact on livelihood around dump site will have to be considered during remediation period;
- There is a positive impact on employment opportunity as when the remediation activity is large. The site development for disposal of waste will also generate additional employment opportunity.

Moreover, following activities are required for sustainability of the project:
- Cover community awareness, participation, and education with respect to implementation and management of facilities, and educate communities about the issues related to improvement of the health and environment;
- Inform the project beneficiaries including stakeholders at different level about implications to the community in terms of benefits and responsibilities;
- Stimulate civic concern about environmental quality and responsibility.

2.6 Technical Expert Panel

The project will be reviewed by a Technical Expert Panel (TEP). The TEP is constituted for technical inputs during the implementation of the project.

Our reports will be sent to all the members of the review committee by MoEF. Recommendations of the review committee will be incorporated by the project team. In case of disagreement, the decision of Secretary MoEF will be binding on both the parties.

2.7 Project communications

For the Ministry the main contacts will be Dr. Lal (contractual issues) and Mr. Rambabu (content).

The main contact persons on behalf of the project team are:
- Mr. de Groof: Team Leader (TL) of the project team, overall responsibility, technical content (from the Netherlands);
- Mr. Bhatia: for logistical issues and direct personal contact (from Delhi);
- Mr. Rane: as our local technical specialist (from Mumbai);
- Mr. Jambagi will also be available for coordination matters.

For all issues in which decision making is expected, the Team leader should be contacted by phone, skype or e-mail.

The Ministry has prepared a general letter, supporting the project team (PT) in contacting the SPCB’s and PCC’s for data collection and, where applicable, site visits. The MoEF has sent this letter on behalf of the project teams of all three assignments, to all organisations mentioned in appendix 4 on April 13th, 2012.

During the Inception meeting, we have discussed the way the PT contacts the stakeholders, and in general the PT can contact the stakeholders directly if we have the contacts. We agreed that if we do so, we would inform the MoEF beforehand. If we do not have the contacts or would like to have assistance from the Ministry, we will contact the Ministry and discuss the options available.

All other communications will go through the MoEF. This includes contacting, data sharing etc. with the teams on the assignment 1 and 3. We expect data from our project (assignment 2) will be shared with the teams on the other assignments only after consulting our Team Leader.

2.8 Project office

As described in our proposal, our main project office will be in Mumbai. Our project office will be within the office of one of our consortium partners, Technochem Agencies (Bombay) Pbt. LTd., location 31-A, Giriraj Industrial Estate, Mahakali Caves Road, Andheri (East), Mumbai -400 093. The office can be contacted through Mr. de Groof or Mr. S. Kulkarni for official matters.

During longer project missions in Delhi we will make use of one of the project offices of STC, location B4 /114, Safdarjang Enclave, New Delhi – 110029, Ph : 011 - 26171457. This office can be contacted through Mr. Bhatia (e-mail: rsbhatia99@gmail.com, phone: +91 9811007440).

3 Proposed Work Plan

3.1 Project plan

The project is proposed to consist of the following six project Tasks:

- Task 1 Review the nature and type of hazardous waste polluted sites in India
- Task 2: Review of national and international approaches to remediation
- Task 3: Identify Options and recommend standards for remediation of polluted sites
- Task 4: Develop Guidance Document on Methodology for Design, Implementation and Monitoring of Remediation Plans
- Task 5: Identify capacity building requirements
- Task 6: Consultation and finalization

In addition, the overall project management and Capacity Building process runs over all project tasks. The project management includes the project progress reporting and meetings with the Client.

In section 3.2 the main activities, milestones and outputs for each of the six project tasks are summarised in table form.

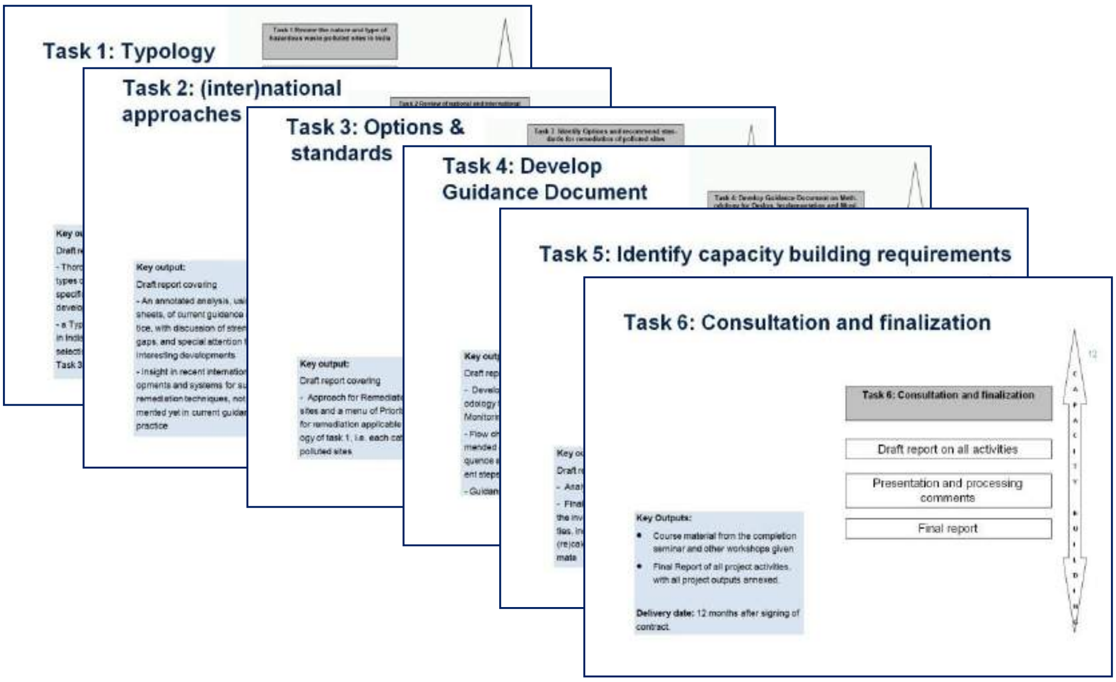


Figure 3.1 Overview of project tasks

3.2 Stepwise Activities and Output

The following tables demonstrate the activities, duration of the activities and milestones and outputs for each individual Task. These are unchanged compared to the Work Plan in our Contract.

Table 3.1. Task 1: Review the nature and type of hazardous waste polluted sites in India

Nº	Activities	Duration	Milestones & Outputs
1	**1.1** Quick scan existing local inventories of polluted sites	**4 Months** **(Month 2-5)**	**Key output:** Draft report covering - Thorough insight in the nature and types of all polluted sites in India and specifications for the database to be developed in Assignment 1 - a Typology of probably polluted sites in India, suited for the identification and selection of remediation strategies in Task 3.
2	**1.2** Blue print typology of polluted sites and list of data needed to comprehensively describe the types of sites, including their context (e.g. social, economic aspects)		
3	**1.3** First analysis database		
4	**1.4** Site visits		
5	**1.5** Final analysis Typology, including technical and social/economical context		
6	**1.6** Draft report typology of polluted sites		

Table 3.2. Task 2: Review of national and international approaches to remediation

Nº	Activities	Duration	Milestones & Outputs
1	**2.1** Blue print review factsheet	**4 Months** **(Month 2-5)**	**Key output:** Draft report covering - An annotated analysis, using factsheets, of current guidance and practice, with discussion of strengths and gaps, and special attention to especially interesting developments - Insight in recent international developments and systems for sustainable remediation techniques, not implemented yet in current guidance and practice
2	**2.2** Inventory guidance and standards applied in India (phase 1)		
3	**2.3** Inventory international standards (phase 1)		
4	**2.4** Evaluation review process		
5	**2.5** Inventory guidance and standards applied in India (phase 2)		
6	**2.6** Inventory international standards (phase 2)		
7	**2.7** Inventory international developments and systems sustainable remediation techniques (phase 2)		
8	**2.8** Synthesis of Indian and foreign standards and practices		
9	**2.9** Draft report comprehensive analysis		

Table 3.3. Task 3: Identify Options and recommend standards for remediation of polluted sites

Nº	Activities	Duration	Milestones & Outputs
1	**3.1** Generic remediation approaches	**4 Months** **(Month 4-7)**	**Key output:** Draft report covering - Approach for Remediation of Polluted sites and a menu of Prioritized options for remediation applicable to the typology of task 1, i.e. each category of polluted sites
2	**3.2** Evaluation of present remediation practices in India		
3	**3.3** Blue print of options for remediation for each type of polluted site		
4	**3.4** Integrated analysis final options of remediation		
5	**3.5** Draft report options for remediation		

Table 3.4. Task 4: Develop Guidance Document on Methodology for Design, Implementation and Monitoring of Remediation Plans

Nº	Activities	Duration	Milestones & Outputs
1	**4.1** Scheme of steps of remediation process	**3 Months** **(Month 7-9)**	**Key output:** Draft report covering - Development of guidance on Methodology for Design, Implementation and Monitoring of Remediation Plans. - Flow chart summarizing the recommended approach including the sequence and relationships of the different steps in the remediation process. - Guidance documents
2	**4.2** Finalizing summary content Guidance document		
3	**4.3** Making applicable collected information		
4	**4.4** Guidance documents		

Table 3.5. Task 5: Identify capacity building requirements

Nº	Activities	Duration	Milestones & Outputs
1	**5.1** Relevant organisations	**3 Months** **(Month 9 - 11)**	**Key output:** Draft report covering - Analysis of capacity requirements - Final estimate of the investment of all the investigation and remediation activities, including the model for (re)calculating and fine tuning the estimate
2	**5.2** Analysis of investments for steps in remediation process		
3	**5.3** Analysis per category of hazardous waste sites		
4	**5.4** Inventory of activities		
5	**5.4** Inventory of activities and model calculations		

Table 3.6. Task 6: Consultation and finalisation

Nº	Activities	Duration	Milestones & Outputs
1	**6.1** Prepare draft Final Report of all activities	**12 Months** **(Month 10-12)**	**Key Outputs:** • Course material from the completion seminar and other workshops given • Final Report of all project activities, with all project outputs annexed. **Delivery date:** 12 months after signing of contract.
2	**6.2** Presentation of the report at the Clients office		
3	**6.3** Discussion of draft Final Report with the Client and Review Committee		
4	**6.4** Processing of comments and remarks in the report		
5	**6.5** Submit Final Report to Client		
6	Capacity building *) Inform and train employees of MoEF, CPCB en SPCB's who in the future will be involved with the contaminated sites about continuation approach.		

**) During the implementation of the tasks 1 through 5 various meetings and workshops have already taken place. During each of these events time will be reserved for things like providing background information.*

3.3 Activities April-June 2012

During the Inception mission we discussed our proposal with MoEF and other selected stakeholders. On various subjects we found these stakeholders to have different interpretations of the subject scope.
One of the main outcomes of the project is the guidance document as deliverable of Task 4, based on the results of Task 1-3. We strive to develop these guidelines according to the wishes and needs of the end-users of this document. Only if these wishes can be met, the applicability and user acceptance of the project results will be optimal. For that reason we suggest a different and more dedicated approach to the first part of the project, as described in our proposal.

In our proposal we proposed to work on the different tasks (one after the other) and deliver the draft guidance report 9 months after the start of the project. That way we could end up with a product which may not be sufficiently take into account the actual needs of the Client and the end-users and their practical preferences. Therefore we would like to propose an intermediate step where in a workshop the following could be planned:

- review in detail the progress of the study so far;
- demonstrate the outcomes of tasks 1,2,3 and 4 on a pilot basis – for a small number of representative sites;
- demonstrate the tool box and the soil contamination approach to remediation, which are quite well demonstrated in The Netherlands but probably are new to SPCB's;
- initial capacity building by the way of hands- on application of representative methodologies by end users;
- further understanding of the preferences of MoEF and end users on the actual report formats.

If MoEF recommends, the project team can, in addition to the workshop, have an interaction with others such as Review Committee members, World Bank representatives and other consortia.

We strongly believe that such a workshop will provide a very good opportunity for effective application of the tools, methodologies and technologies covered under this project and contribute to the success of CBIPMP as a whole.

In practical terms for the period until June we will work on the tasks and activities as originally planned for the period until September. However, we will not work out all aspects in full detail but cover all elements based on the priority sites as described in section 2.2. In short, we will report a first draft typology, first draft inventory of standards and guides and first draft inventory of remediation techniques as well as a first draft guidance document. The results will be presented in the workshop at the end of June.
Based on the findings and outcomes of the workshop we will be able to finalize our draft products accordingly and meeting the applicability and user acceptance to a maximum. Activities to be carried out up to and including the workshop are described in Table 3.7.

The invitees to the workshop will be decided by MoEF. In our view the workshop should be focussed on the senior specialists of the MoEF, CPCB, SPCB's and PCC's and other institutions involved in implementation of CBIPMP and follow up. The participants should have good knowledge of English language, basic knowledge of soil pollution and Indian soil policy, actual presence and needs of reclamation of hazardous sites across India.

The program of the workshop is being proposed in a separate communication to MoEF but also included in Appendix 3.

For the workshop we propose MoEF will send out invitations, including a request to bring an example of hazardous waste pollution from their own jurisdiction, a few weeks in advance. The project team can prepare a draft text for this invitation and some materials for participants to use as preparation for the workshop.

After the workshop, findings from the workshop will be worked out and included in the guidance document. With the knowledge and experience of the workshop, tasks 1.1 through 4.1 will be worked out in more detail and completed at full scale.

At the same time activities for task 1 and 2 will continue in such a way that the deliverables for these tasks will be delivered as scheduled (task 1: July 2012, task 2: September 2012).

Table 3.7 Activities for period April-June 2012

Task-No	Activities	Explanation
	Quick scan content tasks 1-4	
1.1	Data collection	pdf's reports contaminated sites from CPCB
	Table with basics of site characteri-zation	table to make the first analyses of typology
2.1	Blue print review factsheet of nation-al and international approaches	
1.3	Analyses of about 12- 15 sites using table "Site description"	description of 12-15 sites including major remediation scope per site
	Inception report	finishing report;
1.2	Typology	based on analyses of 15 sites
2.2	Standards and guidances India	
2.3	Standards and guidances internatio-nal	
2.2	Hazardous waste policy in India	brief overview HW regulations. Pur-pose: Differences and connections of HW-management and Soil Remedia-tion
3.2	Remediation practices in India	
3.1	Generic remediation options	
4.1	Scheme of remediation process	
3.4	Synthesis	
	Preparation Workshop	
	Preparation Workshop, incl testing	meeting with MoEF
	Workshop	
	Evaluation workshop	evaluation meeting with MoEF
	Draft report workshop	

3.4 Project organization

The project team will remain the same as described in our proposal.
We have included Mr. Bhatia in the Project Team as Support Key Staff for local logistical issues and non-technical discussions in Delhi.

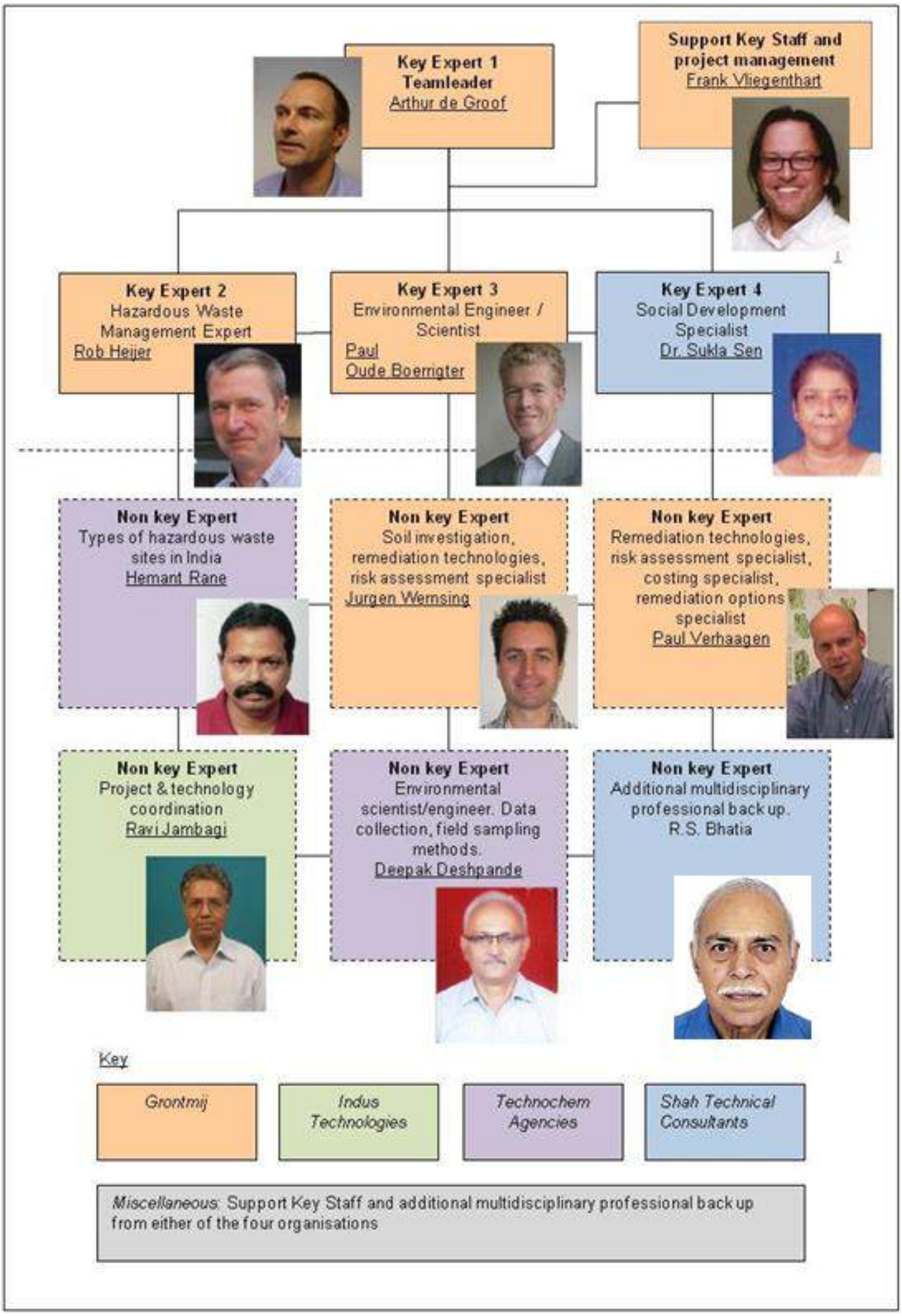


Figure 3.2 Overview Project Team

3.5 Interaction with assignment 1 and 3

As we highlighted in the Inception meeting on April 10th we endorse the need of close interaction with the consultants working on both other assignments.

For assignment 1 insight in the implementation of our activities is essential to reach an inventory of sites containing the data, which in turn are relevant for the development of the methodologies in this assignment. At the same time we need updated information from assignment 1 of the inventory and mapping of probably contaminated sites, giving us additional information on the nature of these sites, which in turn is needed to develop methodologies that fit these sites.

We also endorse the need of close interaction with the consultants working on assignment 3. Insight in the implementation of assignment 3 is essential to properly assess the capacity and other resources needed for the implementation of an effective NPRPS. Updated information on the assessments of assignment 3 ensures the development of realistic and methodologies that will prove to be feasible on a day to day basis.

We request MoEF to formalize the cooperation between the different projects. We believe most of information exchange can be via emails. If actual meetings are required, the same should be planned well in advance so that suitable representation from our side could be arranged. We have included our schedule for project missions in section 3.7. Most likely this schedule will be revised after every mission, therefore we will discuss with MoEF after every mission when the next mission should be planned.

In the figure below we included “interaction steps” as we foresee with the teams on the assignments 1 and 3. As described above we request MoEF to coordinate these interaction steps, for which we will give input.

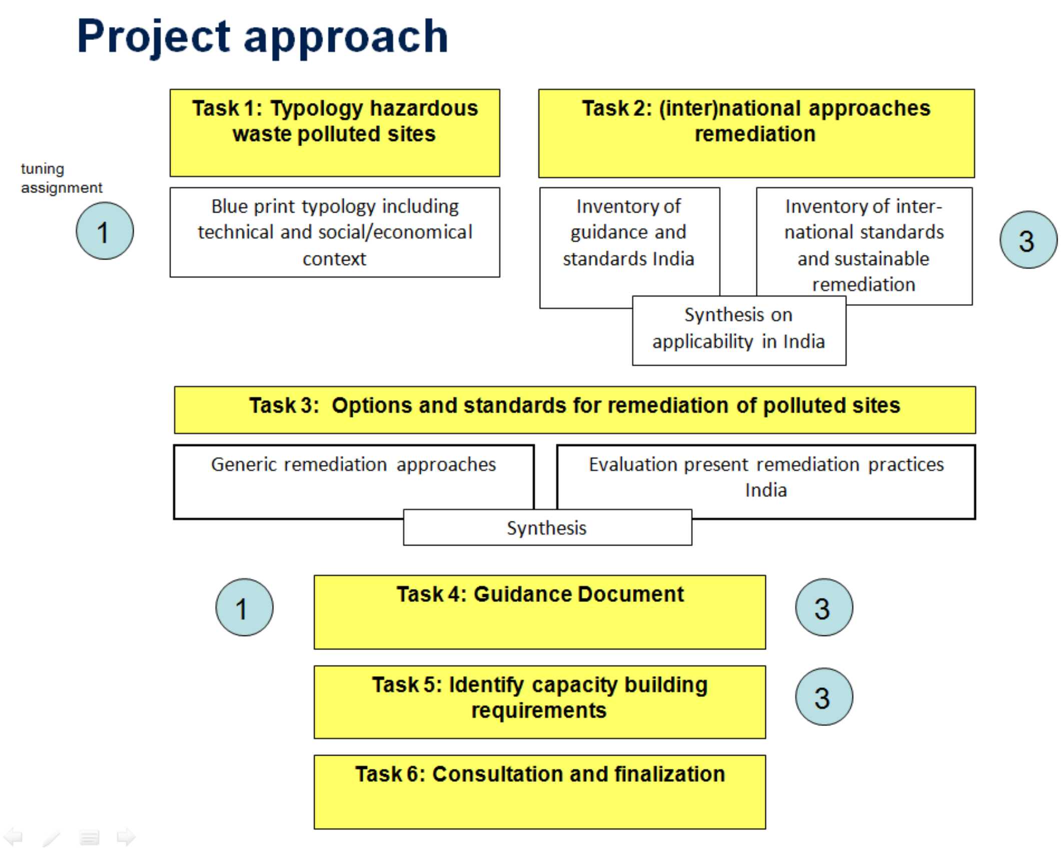


Figure 3.3 Project approach: the encircled numbers indicate interface with PT 1 or 3

3.6 Foreseen information needed

In our proposal we have defined the following information (belonging to certain tasks and steps) we need from MoEF, CPCB and the teams on assignments 1 and 3:

- General: MoEF Introduction letter of the project team, announcing requests by project teams to SPCB's and PCC's (see section 2.7);
- Step 1.1: CPCB report with inventory of sites (information has already been handed over, detailed reports on research and remediation of various sites have been announced to be sent to the project team);
- Step 1.2: Overview of industrial categories (from CPCB);
- Step 1.2: Data and information from interviews (MoEF, CPCB, SPCB) (this information will be gathered during project missions);
- Step 1.3: Database structure (from team on assignment 1);
- Step 1.4: Information handed over during visits (from private and public organisations);
- Step 2.4: Existing guidance and standards currently applied in India (CPCB information has already been handed over to the project team);
- Step 2.4: Clients preference regarding the countries to be reviewed (this has already been discussed during the Inception meeting on 10 April);
- Step 2.6 /3.2: Reports on recently completed remediation actions (CPCB has indicated they will hand over soft copies of reports);
- Step 2.8: Number and priority of specific types of sites (from the team on assignment 1);
- Step 5.4: Information on role of public organisations from interviews (information on the proposed roles of public and private organizations, according to policy proposals should come from the team on assignment 3).

3.7 Project missions

On the basis of the present knowledge, available time frame and activities to be carried out we expect the following mission schedule.

2.	Workshop task 1-2-3 + site visits + interviews and Capacity Building	24 June - 3 July 2012
3.	Draft report task 1-2-3 + interviews and Capacity Building	September 2012
4.	Draft Guidances 4 + interviews and Capacity Building	December 2012
5.	Final Guidances and Capacity Building	February 2013
6.	Final workshop and final report	March 2013

Appendices

Appendix 1 Mission report Inception mission

The first mission of this project after signing the contract took place between April 8th and April 15th, 2012. Goal of the mission was to specify the activities as mentioned in section 1.2, all in close consultation with involved organisations in the project.

The project team had meetings with the following organisations:

- Inception meeting with MoEF and CPCB at MoEF office;
- meeting with CPCB;
- meeting with Delhi Pollution Control Committee;
- visit to Mr. Sachin Ahir, Minister of Environment of the State of Maharashtra.

In addition the project team conducted visits to the following sites:

- two CETP-sites (Wazirpur Industrial Estate CETP and Badli Industrial Area CETP);
- sanitary landfill Mumbai (TTCWMA).

A discussion with Maharashtra PCB was planned and arranged but could not take place due to traffic problems in Mumbai. This meeting will be held later.

Sunday, 8 April
Internal meetings with STC, Technochem and Dutch team.

Monday, 9 April, Mumbai
Project team meeting at Technochem office: final preparation of the Inception Meeting with MoEF and of the planning of the rest of the mission, finalize presentations and information.

Tuesday, 10 April, Delhi
Morning: Inception meeting with MoEF, CPCB and DPCC at MoEF office.
MoEF (Mr. Mukerjee, Mr. Rambabu, Mr. Lal, Mr. Gupta), CPCB (Mr. Babu), Delhi PCC (Mr. Kabila) and project team;

Mr. Mukerjee opened the meeting and briefly introduced the participants from the Indian side. After that Mr. Jambagi and Mr. De Groof introduced the project objectives and project team. In his presentation Mr. De Groof gave insight in the steps the project team proposes. Several issues were discussed. After that Mr. Heijer gave a presentation on the general approach of soil contamination management, based on experiences in The Netherlands. For this project, relevant experiences of various countries should be inventoried that are well applicable in the Indian situation.

Afternoon: meeting at the CPCB office, including Mr. Babu, Mr. Rambabu and the project team. Mr. Babu presented the project team with information on the 73 officially registered hazardous waste dump sites in India. He indicated that soft copies of detailed reports of research, assessment and remediation plans would be sent to the project team in short term. The situations of some of the sites were explained by Mr. Babu, as well as the communication about this inventory between the SPCB's and CPCB.
Travel to Delhi.

Wednesday, 11 April, Delhi
Morning: meeting project team to evaluate Tuesday's meeting results.

Afternoon: meeting with DPCC (Mr. Sandip Mishra, Member Secretary, DPCC, Mr. B. Kumar, Additional Director, DPCC, Mr. Chawla (Senior Environmental Engineer, DPCC) and the project

team, including visit to two CETP-sites (Mr. Sood, Mr. Bhowal). At the DPCC office Mr. Mishra welcomed the project team and promised support to visit sites. The organization of hazardous waste management in India and in The Netherlands was discussed.
During the site visits it became clear that in Delhi a large problem exists in lack of space for final disposal or treatment of sludge as product of the waste water treatment. This lack of space strongly hinders adequate functioning of these facilities.

Thursday, 12 April, Mumbai
Morning: travel to Mumbai
Afternoon: project team meeting at Technochem office: evaluation of meetings and visits; planning further steps of the project.

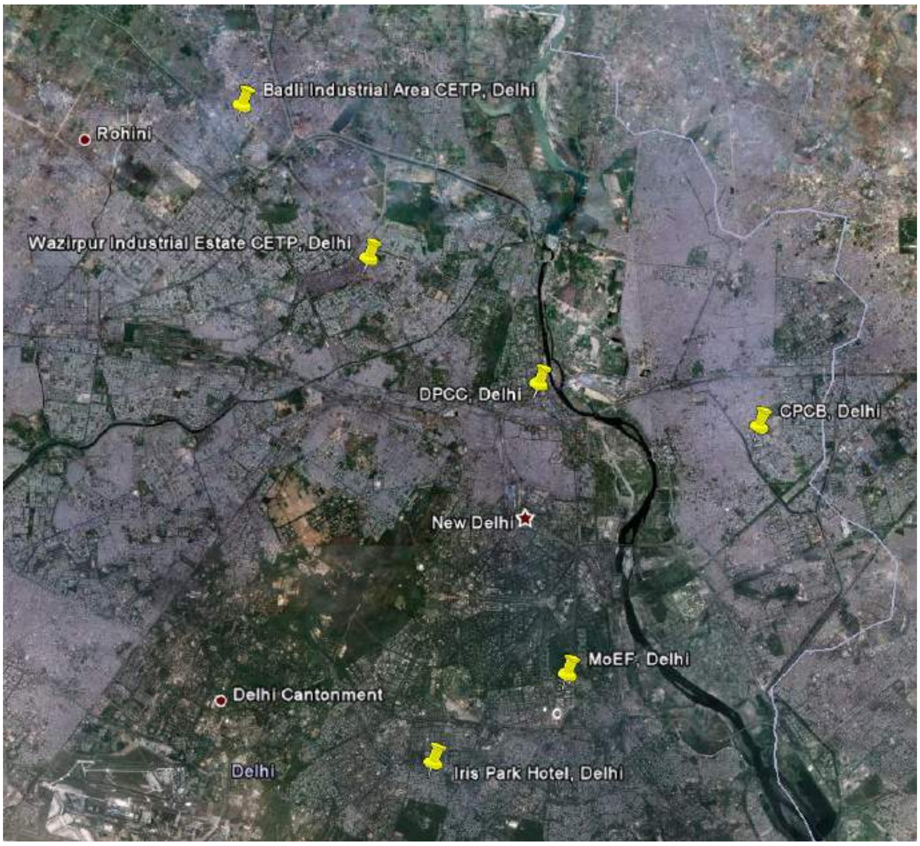
Friday, 13 April, Mumbai
Morning: site visit to TTC, including Mr. Sreevalsan, Mr. Nimskar and the project team. A presentation of the construction of a secure landfill, built in 2009, was given by TTC. After that the project team observed the activities at the landfill and at the laboratory facilities at the TTC office.

Afternoon: courtesy visit to the Hon. Mr. Ahir, by the project team. Mr. Ahir is the minister of State for Housing, Slum Improvement, Repairs and Reconstruction, Urban Land Ceiling, Industries, Mining, Social Justice, De-Addiction, Activities and Environment for the State of Maharashtra. Mr. Ahir is very interested in the approach of soil contamination. He invited the project team to make use of the possibility to visit sites that are interesting regarding this project.

Late afternoon: project team meeting at Shah Technical Consultant’s office: evaluation and final planning for next months.

Wednesday, 18 April, Mumbai
A meeting was scheduled between MPCB and mr. Jambagi but could nog be held due to traffic problems in Mumbai.

Appendix 2 Potential project locations presently foreseen



Map of Delhi-India

Appendix 3 Proposed programme Workshop Mission 2

Draft schedule Workshop, June 2012

Monday 25 June	MoEF/Review Committee/Worldbank and project team • Final preparation of workshop • `Testing` of workshop • TL & PM available for contact with MoEF and Assignments 1 and 3
Tuesday 26 June	MoEF, CPCB, SPCB, and PCC delegates (possibly member secretaries and technical experts), and project team • Presentations by project team (basic knowledge on soil remediation; typology developed so far); • Inventory of perceptions; discussion of Guidance & standards.
Wednesday 27 June	MoEF, CPCB, technical experts SPCB's and PCC's, and project team • Feedback on Tuesdays proceedings; • Discussion on cases: remediation options.
Thursday 28 June	MoEF, CPCB, technical experts SPCB's and PCC's, and project team • Feedback on proposed options for Guidance Documents; MoEF and project team: • Team's evaluation & planning of further steps; • TL & PM available for contact with MoEF and Assignments 1 and 3
Friday 29 June	Additional site visit in Uttar Pradesh or Maharashtra

Appendix 4 Overview of addresses of SPCB's and PCC's

The Member Secretary
Madhya Pradesh Pollution Control Board
Paryavaran Parisar,
E-5, Arera Clony,
Bhopal - 463016
Madhya Pradesh

The Member Secretary
Maharashtra Pollution Control Board
Kalpataru Points, 3 rd & 4 th floor,
Opp. Cine Planet,
Sion Circle, Sion (E)
Mumbai-400 022

The Member Secretary
Orissa State Pollution Control Board
A-118, Nilakantha Nagar,
Unit-VIII, Bhubaneswar 751012.
Orissa

The Member Secretary
Punjab Pollution Control Board,
Vatavaran Bhawan,
Nabha Road,
Patiala-147 001 Punjab

The Member Secretary
Rajasthan Pollution Control Board,
A-4, Institutional Area,
Jalana Dungri,
Jaipur-302 004, Rajasthan

The Member Secretary
Uttar Pradesh Pollution Control Board
IIIrd floor PICUP Bhavan,
Vibhuti Khand,
Gomti Nagar, Lucknow - 226020, UP

The Member Secretary
Jammu & Kashmir State Pollution Control Board
Sheikhul-Alam Campus,
Behind Govt. Silk Factory,
Rajbagh , Srinagar

The Member Secretary
Goa State Pollution Control Board
Dempo Tower,
Ist Floor Patto Plaza
Goa – 403110

The Member Secretary
Gujarat State Pollution Control Board
Sector 10-A,
Gandhi Nagar – 382043
Gujarat

The Member Secretary
Haryana State Pollution Control Board
S.C.O.No.11 A-12,
Sector 7-C Madhya Marg,
Chandigarh - 160019

The Member Secretary
Jharkhand State Pollution Control Board
T.A. Building,
HEC P.O. Dhurwa Ranchi - 834004
Jharkhand

The Member Secretary
H.P. State Environment Protection & Pollution Con
Paryavaran Bhawan,
Phase III
New Shimla -171 009
Himachal Pradesh

The Member Secretary
Karnataka State Pollution Control Board
Parisara Bhawan, No.44, 4th & 5th floor
Church Street
Banglore-560 001, Karnataka

The Member Secretary
Andhra Pradesh Pollution Control Board
Paryarana Bhawan,
A-3, Industrial Area , Sanathnagar,
Hyderbabad-500 018,
Andhra Pradesh

The Member Secretary
Assam Pollution Control Board
Bamunimaidam,
Guwahati - 781021
Assam

The Member Secretary
West Bengal Pollution Control Board
Paribesh Bhavan, 10-A, Block LA,
Sector III, Salt Lake City,
Kolkata-700 091.

The Member Secretary
Bihar State Pollution Control Board
IInd Floor, Beltron Bhavan,
Jawaharlal Nehru Marg, Shastri Nagar,
Patna 800023, Bihar.

The Member Secretary
Kerala State Pollution Control Board
Plamoodu Junction, Pattom Palace
Trivandrum-695004, Kerala

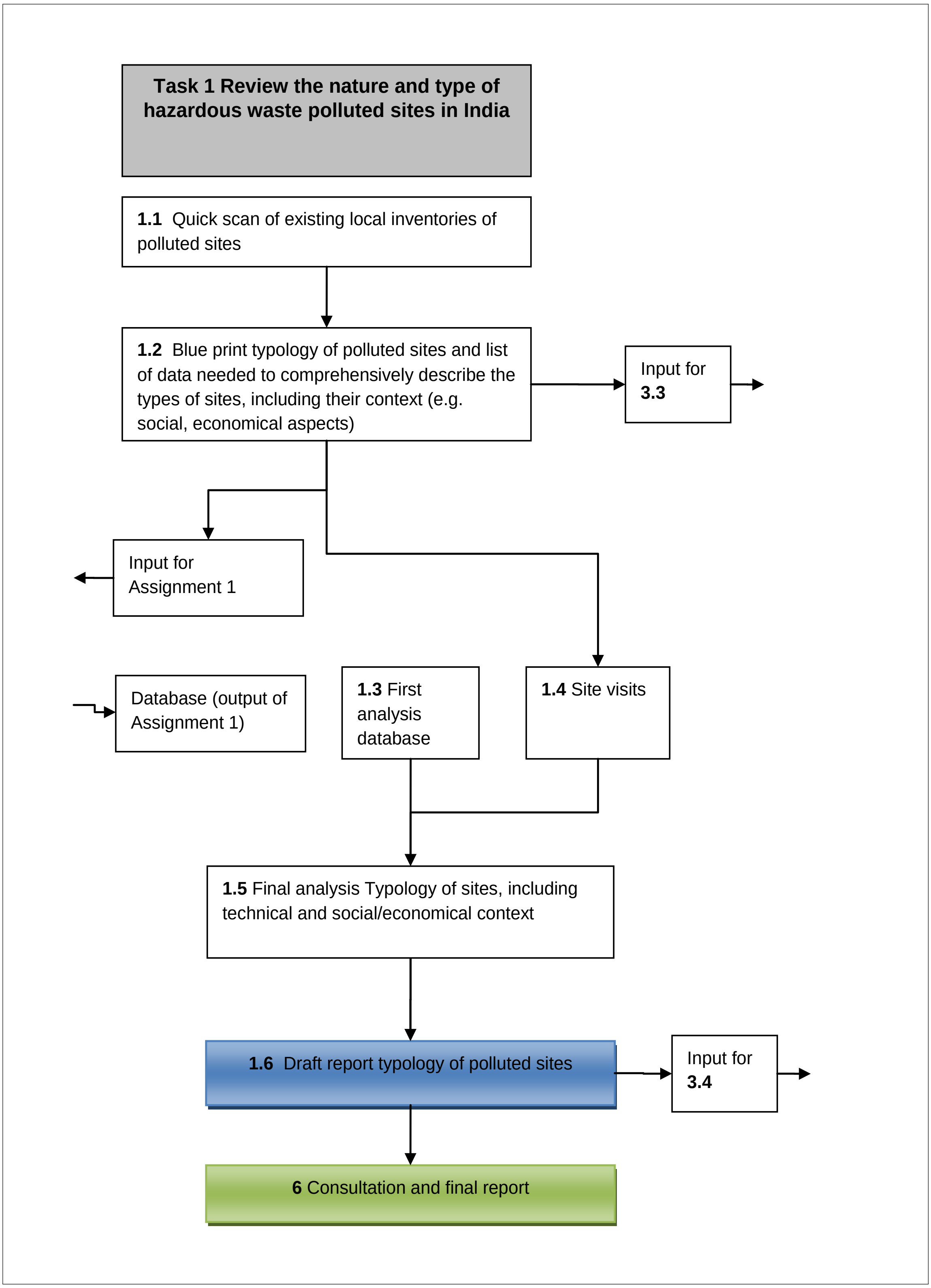
The Member Secretary
Chattisgarh State Environment Conservation Board
Nanak Nivas, Civil Lines
Raipur - 492001
Chattisgarh

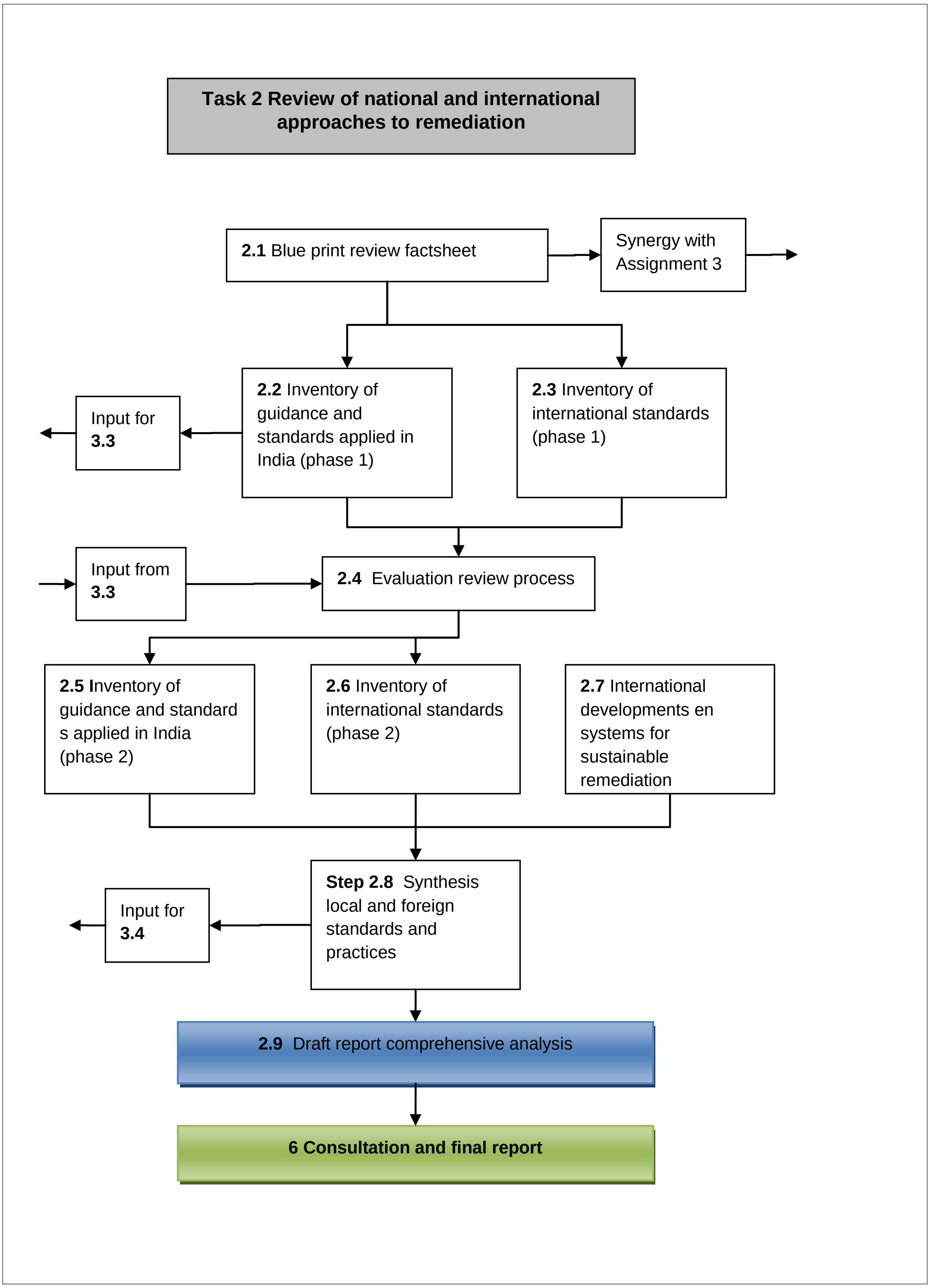
The Member Secretary
Chandigarh Pollution Control Committee
Chandigarh Administration,
Additional Town Hall Building, IInd Floor,
Sector 17-C, Chandigarh 160 017.

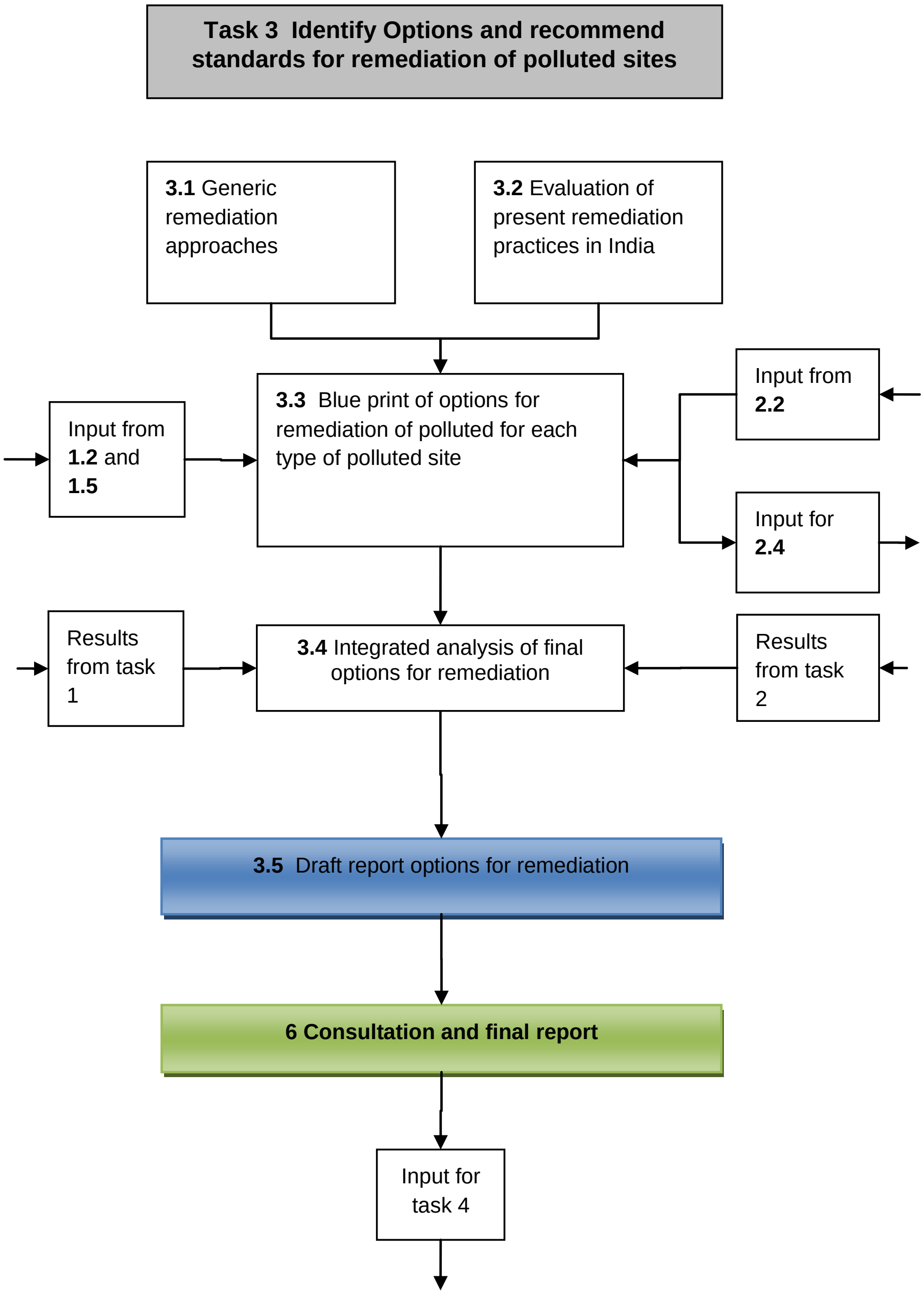
The Member Secretary
Delhi Pollution Control Committee
4th Floor, I.S.B.T. Building,
Kashmere Gate,
Delhi-110006

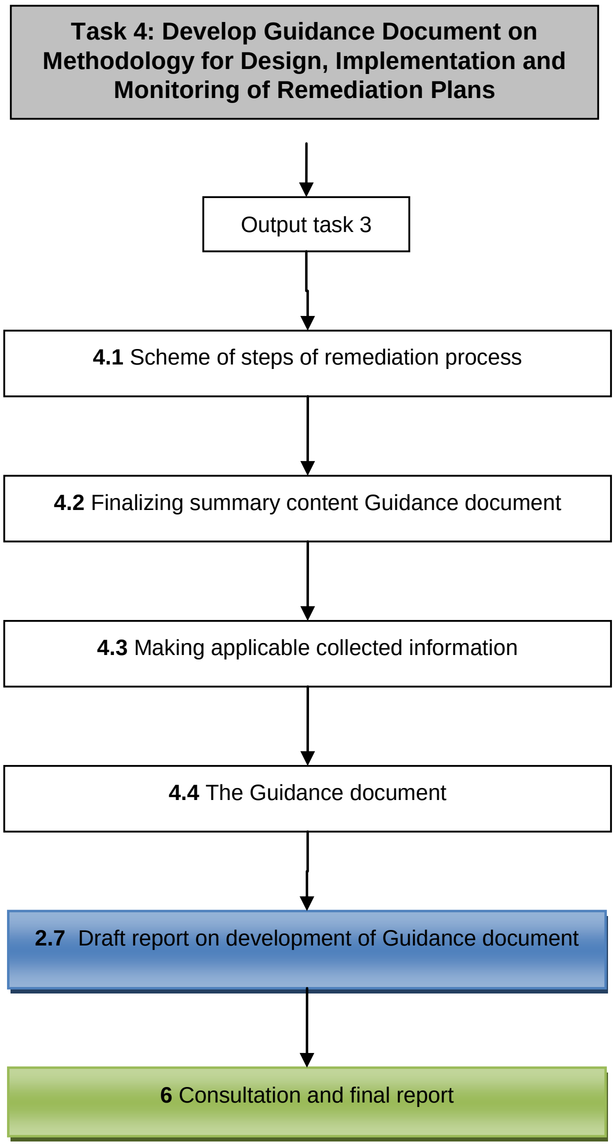
The Member Secretary
Pondichery Pollution Control Committee
Department of Science, Technology & Env.
Housing Board Complex, IIIrd Floor
Pondicherry-600 005

Appendix 5 Detailed figure "Schematic overview of stepwise project approach"




Task 2 Review of national and international approaches to remediation
2.1 Blue print review factsheet
Synergy with Assignment 3
Input for 3.3
2.2 Inventory of guidance and standards applied in India (phase 1)
2.3 Inventory of international standards (phase 1)
Input from 3.3
2.4 Evaluation review process
2.5 Inventory of guidance and standard s applied in India (phase 2)
2.6 Inventory of international standards (phase 2)
2.7 International developments en systems for sustainable remediation
Input for 3.4
Step 2.8 Synthesis local and foreign standards and practices
2.9 Draft report comprehensive analysis
6 Consultation and final report


Task 3 Identify Options and recommend standards for remediation of polluted sites
3.1 Generic remediation approaches
3.2 Evaluation of present remediation practices in India
3.3 Blue print of options for remediation of polluted for each type of polluted site
Input from 1.2 and 1.5
Input from 2.2
Input for 2.4
3.4 Integrated analysis of final options for remediation
Results from task 1
Results from task 2
3.5 Draft report options for remediation
6 Consultation and final report
Input for task 4


Task 4: Develop Guidance Document on Methodology for Design, Implementation and Monitoring of Remediation Plans
Output task 3
4.1 Scheme of steps of remediation process
4.2 Finalizing summary content Guidance document
4.3 Making applicable collected information
4.4 The Guidance document
2.7 Draft report on development of Guidance document
6 Consultation and final report

Appendix 6 – Presentation results Inception phase and first results Tasks 1, 2 3 and 4 during 5th TEP meeting, June 28th, 2012

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GOVERNMENT OF INDIA

Inception - available data

3

- List of 12 priority contaminated dump sites
- List of 25 hazardous waste dump sites
- Overview of methodology, sequence of steps:
  - Site investigation
  - Assessment
  - Characterization
  - Proposing remediation options

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Inception Report Assignment 2

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Inception – conclusions task 1

4

Task 1 – Nature and type of sites in India

- From existing data we can only derive a limited number of site types
- Needed to complete this task:
  - International experience
  - Data from inventory (assignment 1) to indigenise typology
  - Site visits to fine-tune and further indigenise typology

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Task 1 – site visits

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- Sites
  - Noor Muhammad Kunta, APPCB
  - Wazirpur Industrial Estate CETP and Badli Industrial Area CETP
  - Hazardous waste landfill Mumbai (TTCWMA)
  - Ranipet, TNPCB
  - Hooghly, WBPCB
  - Nibra Village, WBPCB
- Site selection based on following criteria:
  - Priority as well as non-priority
  - Different types
  - Good initial data
  - Geographically spread
  - Different PCBs

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Task 1 – Typology

6

Target

- Classification of all polluted sites with a similar remediation approach

Method: grouping characteristics

- Principal characteristics
- Secondary characteristics
- Non distinctive characteristics

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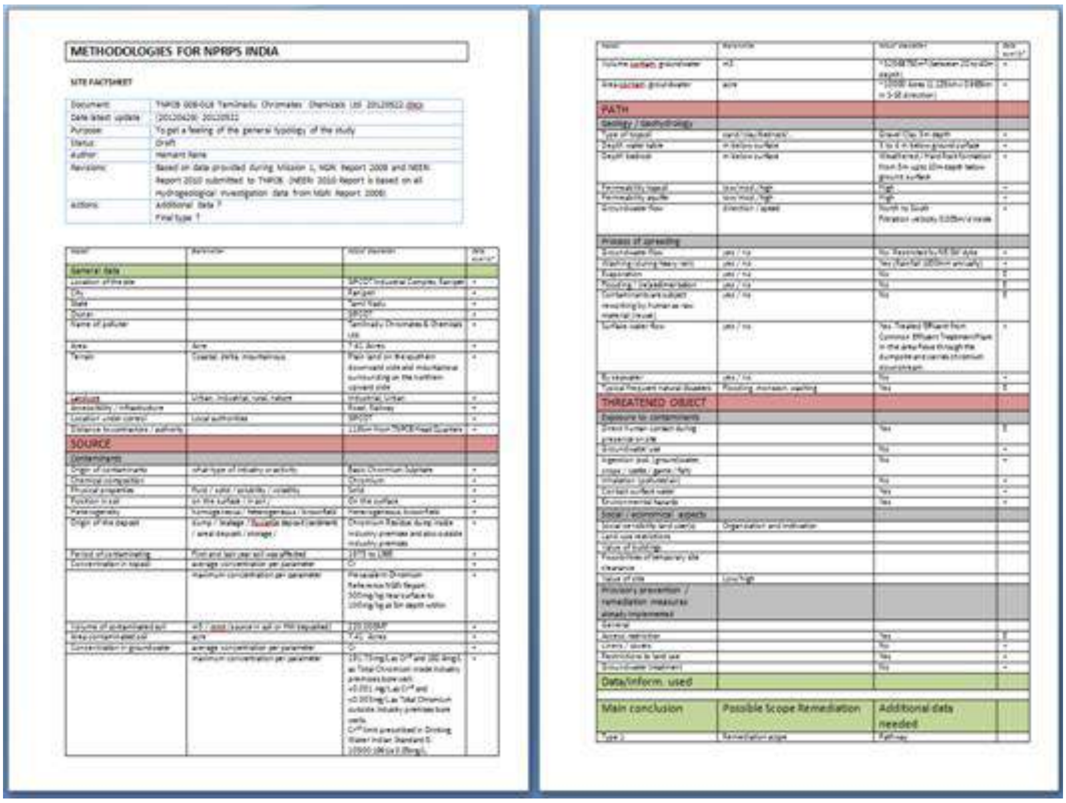
Task 1 – Typology

7

Types on basis of available data

- All sites Industrial Hazardous waste dump sites
- **Type 1**: Groundwater pollution (urban / industrial / rural setting)
- **Type 2**: Urban settlement
- **Type 3**: Complex. Multiple pollutions, pathways and receptors
- **Type 4**: Surface spreading (spreading by rain / flooding / reworking by men)
- **No Type:** no or insufficient data to determine type

Type of industrial waste *)	Typical chemical composition *)
Tannery	Chromium and inorganic salts
Agro chemicals including Pesticides insecticides and Herbicides	Organic compounds, pesticides, insecticides, herbicides and inorganic salts
Ore processing	Heavy metals / rare earth metals
Dyes	Organic compounds and inorganic salts
Fertilisers	Inorganic salts


METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET

General data

SOURCE

PATH

THREATENED OBJECT

Data/inform. used

Main conclusion | Possible Scope Remediation | Additional data needed

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Task 1 – Typology

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General characteristics
Landuse
- Industrial site
- Urban site
- Industrial site in rural environment

Geography:
- Plain land
- Mountainous

Source
- Industrial waste dumpsite
- Volume
  - < 10 MMton
  - >10 MMton
  - >100 MMton
- Type of contaminants:
  - Anorganic *)
  - Organic *)
  - Mix *)

Note: Missing data: spatial aspects

Pathway
- Groundwater
- Flooding / river
- Washing (rain)
- Picking / human spreading

Receptor
Risk type
- Consumption groundwater
- Contact surface water
- Environmental hazard
- Direct human contact on dumpsite

Social aspects
- Industrial use – hardly any human assess / human assess
- Urban use (housing)
- Food production
- Ecology
- Economy

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Task 1 – Typology

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Type 1 – Groundwater pollution

General aspects
Landuse
- Industrial site
- Urban site
- Industrial site in rural environment

Geography
- Plain land
- Mountainous

Source
- Industrial waste dumpsite
- Volume
  - < 10 MMton
  - >10 MMton
  - >100 MMton
- Type of contaminants
  - Anorganic *)
  - Organic *)
  - Mix *)

Pathway
- Groundwater
- Flooding / river
- Washing (rain)
- Picking / human spreading

Receptor
Risk type
- Consumption groundwater
- Contact surface water
- Environmental hazard
- Direct human contact on dumpsite

Social aspects
- Industrial use – hardly any human assess / human assess
- Urban use (housing)
- Food production
- Ecology
- Economy

Subtypes:
- urban setting
- industrial setting
- rural setting

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Task 1 – Typology

Type 2 – Urban settlement

General aspects

Landuse
- Industrial site
- Urban site
- Industrial site in rural environment

Geography
- Plain land
- Mountainous

Source
- Industrial waste dumpsite
- Volume
  - < 10 MMton
  - >10 MMton
  - >100 MMton
- Type of contaminants
  - Anorganic *)
  - Organic *)
  - Mix *)

Missing data: spatial aspects

Pathway
- Groundwater
- Flooding / river
- Washing (rain)
- Picking / human spreading

Receptor

Risk type
- Consumption groundwater
- Contact surface water
- Environmental hazard
- Direct human contact on dumpsite

Social aspects
- Industrial use – hardly any human assess / human assess
- Urban use (housing)
- Food production
- Ecology
- Economy

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Task 1 – Typology

Type 3 – Complex (multiple pollutions - pathways – receptors)

General aspects

Landuse
- Industrial site
- Urban site
- Industrial site in rural environment

Geography
- Plain land
- Mountainous

Source
- Industrial waste dumpsite
- Volume
  - < 10 MMton
  - >10 MMton
  - >100 MMton
- Type of contaminants
  - Anorganic *)
  - Organic *)
  - Mix *)

Missing data: spatial aspects

Pathway
- Groundwater
- Flooding / river
- Washing (rain)
- Picking / human spreading

Receptor

Risk type
- Consumption groundwater
- Contact surface water
- Environmental hazard
- Direct human contact on dumpsite

Social aspects
- Industrial use – hardly any human assess / human assess
- Urban use (housing)
- Food production
- Ecology
- Economy

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Task 1 – Typology

Type 4 – surface spreading

General aspects
Landuse
- Industrial site
- Urban site
- Industrial site in rural environment

Geography:
- Plain land
- Mountainous

Source
- [illegible]
- Volume
  - < 10 MMton
  - >10 MMton
  - >100 MMton
- Type of contaminants
  - Anorganic *)
  - Organic *)
  - Mix *)

Missing data: spatial aspects

Pathway
- Groundwater
- [illegible]
or
- [illegible]
or
- [illegible]

Receptor
Risk type
- Consumption groundwater
- [illegible]
or
- [illegible]
or
- [illegible] on dumpsite

Social aspects
- Industrial use – hardly any human assess / human assess
- Urban use (housing)
- Food production
- Ecology

Subtypes based on type of spreading:
- rain
- flooding (river water and sediment polluted)
- reworking by men

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Task 1 – Typology

	TYPE 1	TYPE 2	TYPE 3	TYPE 4	NO TYPE
CPCB 12 PRIORITY SITES	1				
	2	2	2	2	
			3		
	4				
	5			5	
	6				
	7		7		
	8			8	
	9				
	10	10	10		
		11	11		11
		12			
OTHER SITES (CPCB Annex.-I)			2		
			4		7
					8
			13		
		14			14
		15			15
					20
					23
		25			

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Inception – conclusions Task 2

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Task 2 – National and international standards

- Countries from which to collect information
- Specification of information to collect

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Inception Report Assignment 2

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Task 2 – International Practices

16

Countries and relevant documents (examples)

- India – CPCB documents
- The Netherlands – Guideline on soil remediation
- China
- United Kingdom – Contaminated Land Report no. 11
- France – Std. (NF X 31-620): Services in field of cont. land
- USA – Cleanup Enforcement, basic information
- Australia – Guidelines for assessment of on site containment of contaminated soil
- Romania or Poland
- European Union

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Inception Report Assignment 2

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Inception – conclusions Task 3

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Task 3 – Remediation options

- Needed
  - reports on remediated sites from CPCB
- Inventory of options applied in India will be based on these reports

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Task 3 – Preliminary Remediation options groundwater pollution

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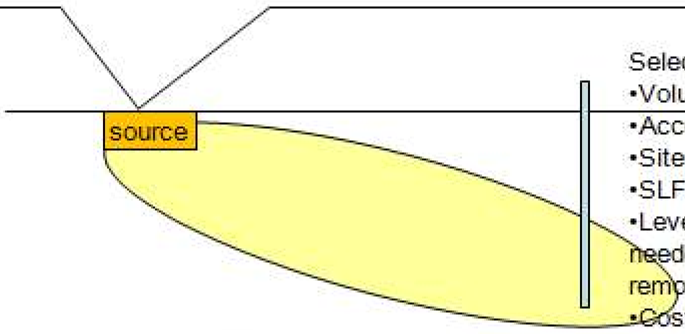
Option 1: removal by digging. Disposal of HW in SLF
Option 2: removal by in situ chemical oxidation
Option 3: isolation with a capping layer
Option 4: isolation by buildings or pavements
Option 5: a site specific combination of 1, 2, 3 or 4



Selection criteria
- Volume source
- Accessibility source
- Site use
- SLF capacity
- Level of removal needed for pathway removal
- Costs

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Task 3 – Preliminary Remediation options groundwater pollution

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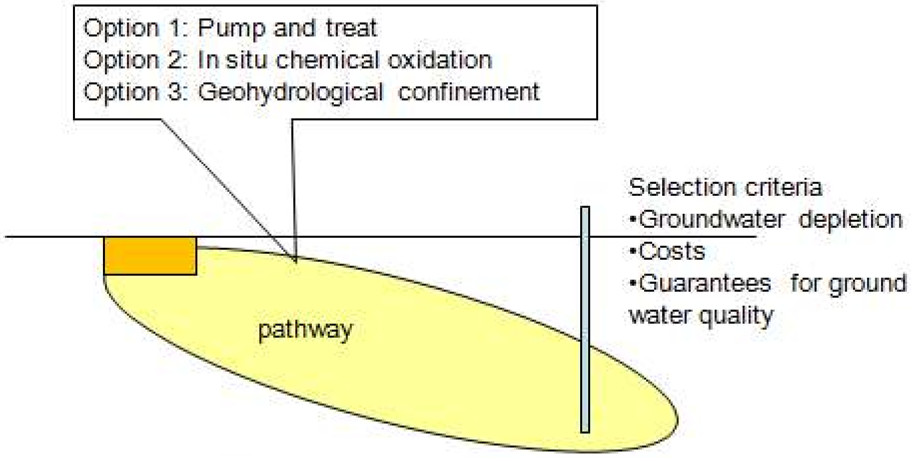

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Task 3 – Preliminary Remediation options groundwater pollution

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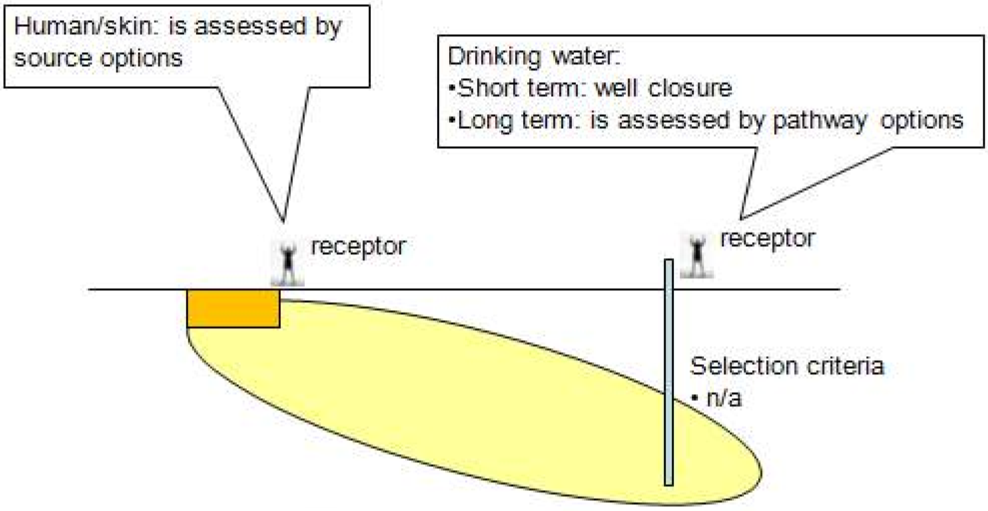

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Conclusions on social impact aspect

Focus on:

- Establishing the level of significance of each individual identified community impact
- Anticipating on social impact of remediation actions
- Developing practical tools for handling social aspects (e.g. a communication protocol)

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Task 4 – Guidance

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Inception – conclusions Task 4

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Task 4 – Guidance Document

- We intend to propose three different options for format
- Needed
  - Feedback on preferred format

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Inception – conclusions Task 4

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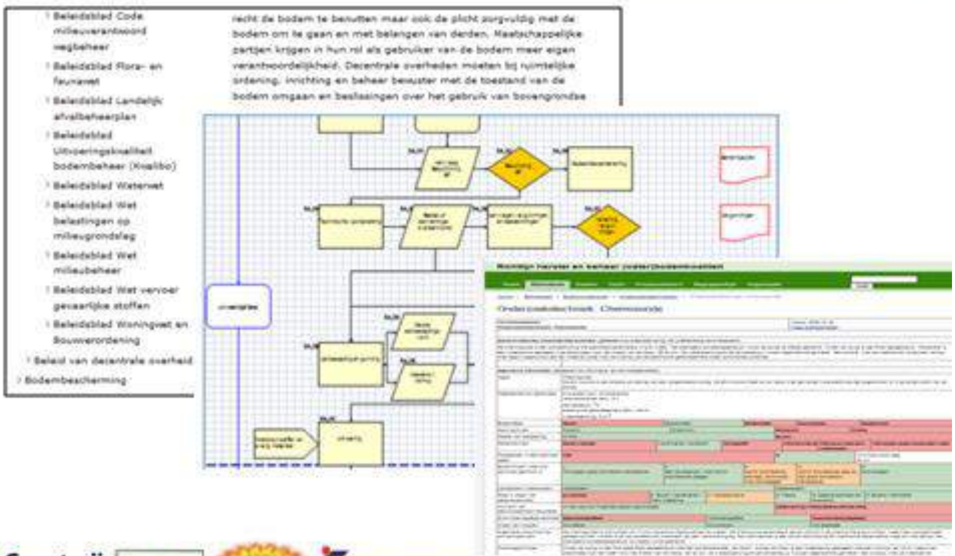

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Task 4 – Guidance Framework document

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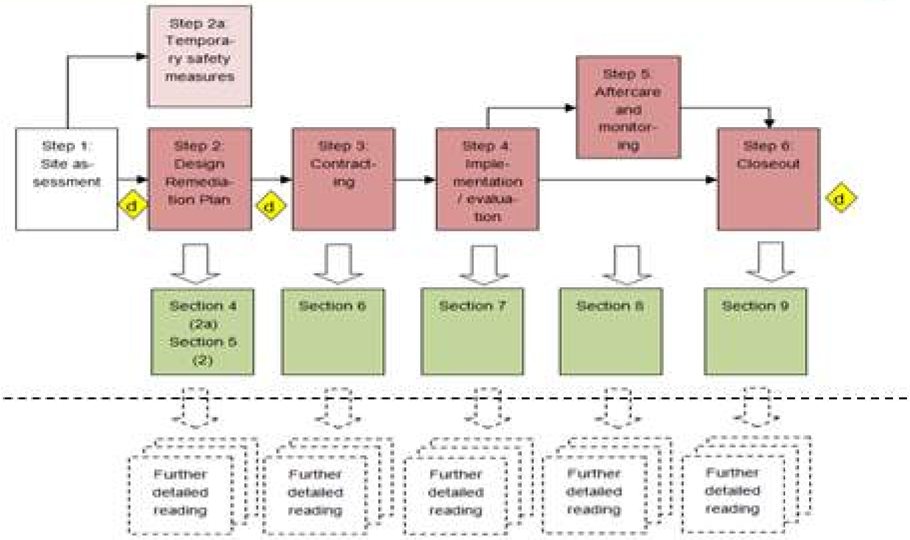

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Task 4 – Guidance: Overview per step

5.7 Critical element 6 - Selection remediation option

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Backgrounds
Selection and decision of the most favourable option of remediation. In the engineering phase several remediation options can be developed. Each option has its own characteristics as each option is based on different combinations of techniques, has a different remediation level, has a different implementation time and costs. A careful weighting is based on different criteria such as technical, financial, environmental, organisational and social factors. When taking these factors into account the selection of the most favourable remediation option will result in the best remediation option applicable.

Decisions made base on the results of the step
- The remediation option to be detail engineered in a remediation plan.
- Coherence between site remediation and redevelopment. Remediation will frequently be followed by site redevelopment. As technical aspects of the remediation are closely connected to the redevelopment, it is effective to closely connect to develop the plans of both together.

Tools and strategies
- → Guidance: selection remediation option. This Guidance document describes a methodology to compare remediation options and select the best option fit for a specific site. The guidance also offers a methodology to balanced the specific elements of a remediation.
- → Guidance: Stakeholder involvement
- → Guidance: social aspects

Do's and don'ts
- Authorities at a state and local level are likely to be involved in the weighing of remediation options.
- Take local conditions into account when evaluating the effectiveness of remediation options and practical applicability remediation techniques and or availability of resources.

Literature / data sources
- Link1
- Link2
- Link3

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Task 4 – Guidance: Further detailed reading

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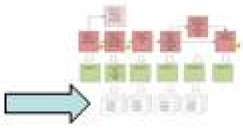
- Design and selection remediation options
  - Remediation Goals and Techniques
  - Standardized options per type of site
  - Risk based (SPR) versus Standard based design approach
  - Remediation plan content
  - Financial aspects
  - Selection remediation options
- Contracting
- Implementation remediation options
  - Monitoring
  - Evaluation
- Aftercare and post remediation
- Safety procedures
- Documentation and record keeping
- Stakeholder involvement
- Social aspects



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Technique factsheet: Capping layers

Aspects	Natural material	Natural material with sealing layer	Pavement	Building
Basics				
Physical characteristics	Coverage with natural materials	Coverage with materials like sand and clay Sealing layer to prevent leaching / evaporation of contaminants	Pavement including stabilization layer	Building
Picture / schematic illustration	Picture 1	Picture 2	Picture 3	Picture 4
Technical variations on basic design	Layer may consist of sand, clay or other local available (not contaminated) material	Sealing layer may consist of HDPE, PPE, clay etc.	Different kinds of pavement are applicable. Break up characteristics determine rate of protection (e.g. gravel vs. asphalt). Slope of pavement determines the effectiveness of prevention of leaching.	Depending on the building. A closed physical construction layer should prevent physical contact with the contaminant. In case of volatile contaminants additiona might be neces sary to prevent risks of vapour accumulation i the building.
Remediation				
Principle of remediation (how does it work)	Physical barrier to prevent contact	Physical barrier to prevent contact and stop leaching	Physical barrier to prevent contact (and reduce leaching)	Physical barrie to prevent con tact (and reduc leaching)
Fit for what kind of contaminations				
• Volatile	-	+	0	0
• Inert	+	+	+	+
• Mobile (leaching)	-	+	0	+
Fit to assess S-P-R				
• Source	-	+	0	+
• Pathway	-	-	-	-
• Receptor	+	+	+	+
Recommended or much applied additional measures: - General	- site management - site inspection - damage repair - user instructions -redevelopment instructions			

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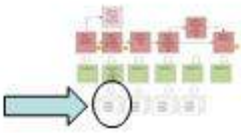

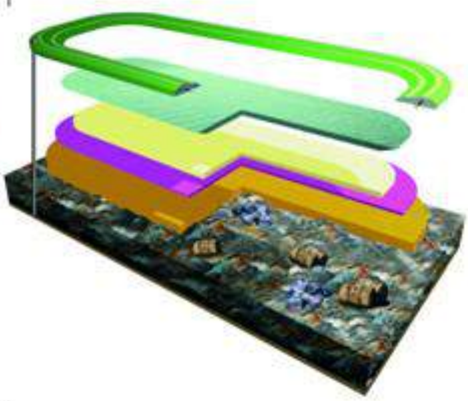

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Synergy with assignments 1 and 3

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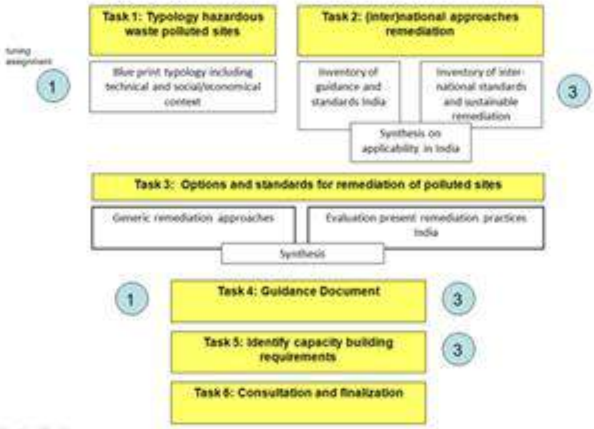

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Information needed

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- Step 1.2: Overview of industrial categories (from CPCB)
- Step 1.3: Data (from assignment 1)
- Step 2.6 / 3.2: Reports on recently completed remediation actions
- Step 2.8: Number and priority of specific types of sites (from assignment 1)
- Step 5.4: Information on role of public organizations (from interviews and assignment 3)

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Planning - Project Missions

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3 - Draft report task 1-2-3 + interviews and Capacity Building	Sep-12
4 - Draft Guidances 4 + interviews and Capacity Building	Dec-12
5 - Final Guidances and Capacity Building	Feb-13
6 - Final workshop and final report	Mar-13

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Questions?

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Discussion

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Appendix 7 Conclusions on TEP comments on draft Inception Report

Introduction
After the 5th TEP-meeting on June 28th, 2012, our consortium received comments by the TEP on the draft Inception Report "Development of Methodologies for National Program for Rehabilitation of Polluted Sites" (version of May 8th, 2012). In this Appendix the consortium's reaction on each of these comments is presented, including a short description of the way we will incorporate the comment in the future project steps. On request of the TEP this reaction has been added to the Inception Report in this appendix.

Comments TEP and conclusions Consortium

- <u>Comment</u>: Country specific topology of the contaminated sites shall be prepared (Correction: typology in place of topology).
  <u>Conclusion:</u> In Task 2 of our Assignment we will give insight in the typology in other countries, to be used as examples for the approach of contaminated sites in India. We will make a typology applicable for the scope of the project, keeping in mind the international approaches, as well as suitability for the Indian sites and conditions. The typology, which will take into account the nature of the contaminants, will make it convenient to go to the following steps, i.e. selection of remediation options, and rehabilitation of sites.

- <u>Comment</u>: Consultant shall go ahead with their component based on the available information of contaminated sites. Whenever a complete inventory of contaminated sites is available, the same shall be used to frame the methodology of contaminated site assessment and remediation options.
  <u>Conclusion</u>: We will continue developing our typology based on available data provided by CPCB and Blacksmith Institute reports. We will not wait for Assignment 1 for delivery of the inventory, since we agree with the TEP that sufficient information is available to develop the typology and prepare the guidance document. However, we wish to highlight that an early insight in the results of Assignment 1 will help Assignment 2 to proceed in a way that is most applicable to Indian sites. When the inventory of assignment 1 is finished we will add possible missing details to the typology or introduce new types as needed. In the meantime we will continue developing the guidance document, methodology and remediation strategies.

- <u>Comment</u>: Canadian (Alberta Guideline, 2010) and UNIDO (Persistent organic pollutants (PoPs), contaminated site investigation and management toolkit) are good examples for ranking of the contaminated sites and may be followed.
  <u>Conclusion</u>: The ranking of contaminated sites, meaning the prioritization based on environmental criteria, is to be done under Assignment 1. Our Assignment 2 will also use mentioned documents for contaminated site management (amongst other literature) as far as it is applicable to the scope of the project.

- <u>Comment</u>: Alpha-numeric ranking of contaminated sites be implemented for better understanding.
  <u>Conclusion</u>: As concluded on the previous point of comment, the ranking of contaminated sites is done under Assignment 1. However, if required, we can provide cross reference in our guidance document to the proposed ranking under assignment 1, provided the complete and final ranking is available in time.

- <u>Comment</u>: Topology and ranking are two different ways to identify a contaminated site (Correction: typology in place of topology).
  <u>Conclusion</u>: We agree with the conclusion that typology and ranking are two different ways to identify a contaminated site. Please see remarks above related to typology and ranking.

- Comment: The ranking of contaminated sites shall be risk based.
  Conclusion: Ranking is part of Assignment 1. See remarks above related to ranking.

- Comment: Based on ranking system, one site is assigned a rank. However, under the topology system, one site can come under different types (1-5).
  Conclusion: This is correct, within one type there can be more subtypes. In our report on Task 1 we will report this in detail.

- Comment: The remediation option should be specific for a particular contaminant;
  Conclusion: For Assignment 2 the typology is used to develop various approaches for remediation options. For specific types a limited number of remediation options are relevant. The typology is largely defined by the contaminants, but includes other factors as well. In Task 3 we will report on the potential remediation options for each of the types defined in the typology.

- Comment: When methodology of a contaminate site is considered, due diligence shall be accorded to the modeling aspects of the site, which is an essential tool to assess the extent of contamination;
  Conclusion: As a part of our study we will keep modeling requirements in mind while proposing assessment and remediation options.

- Comment: The levels of contamination and desired levels of remediation should be well defined in the guidelines;
  Conclusion: Levels of contamination to be achieved after remediation will be given by our Assignment 2. This will be done for the most important substances. Assignment 1 will derive 'screening levels/levels of concern' for contamination.

- Comment: While preparing methodology, post project monitoring of the remediated site should be taken into consideration with a long term action plan;
  Conclusion: This will be part of the Guidance document (Task 4).

Review of the nature and type of hazardous waste polluted sites in India
Key output Final Report Task 1

Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India

Ministry of Environment and Forests
GOVERNMENT OF INDIA

Ministry of Environment and Forests, Government of India, Delhi
The World Bank, Washington, D.C.

Authorisation

Title	:	Review of the nature and type of hazardous waste polluted sites in India - Key output Final Report Task 1
Subtitle	:	Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India
Project number	:	317550
Reference number	:	CBIPMP_Methodologies_Task1_v5_final
Revision	:	Final
Date		May 1st, 2013

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Executive summary

General
This report presents the key output of the activities carried out under Task 1 (Review the nature and type of hazardous waste polluted sites in India) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

Objective and report content
The objective of Task 1 is to review the available inventory on hazardous waste contaminated sites and understand the nature of contaminated sites in India. This insight was used to develop a typology of probably contaminated sites in India, suited for the identification and selection of remediation strategies in Task 3. We define 'typology' as 'The taxonomic classification of characteristics found in contaminated sites, based on a set of common characteristics of sites'.
This report offers a typology covering all contaminated sites as described in the database developed in Assignment 1 ('Inventory and Mapping of Probably Contaminated Sites in India'). The inventory of available data was used to get thorough insight in the nature and types of contaminated sites in India as well as to validate the typology and the database.
The developed typology is robust, offering the possibility for sites not yet inventoried to fit in.

Data sources
The available version of the inventory on hazardous contaminated sites was consulted and analysed. As the database to be developed in Assignment 1 was not yet available when we started working on this task, we have used initially:

- available data sources from CPCB (including data provided to them by SPCB's and PCC's), and the Blacksmith Institute;
- several literature references;
- the results of site visits conducted by members of the project team;
- and the results of our review of international approaches for remediation of contaminated sites, as conducted in Task 2 of this project.

Results

- Site visits conducted by members of the project team (described in chapter 5) resulted in information directly from the field, to strengthen the development, selection and prioritization of realistic remediation options, taking into account practical limitations;

- The Typology (described in Section 6.4) distinguishes the following main types of contaminated sites:
  - Source related:
    - Type S1: Land bound solid phase contamination
    - Type S2: Water bound sediments solid phase contamination
    - Type L: Land bound liquid phase contamination
  - Pathway related:
    - Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids)
    - Type P2: Groundwater contaminations
- depending on the specific situation, a site may fit into more than one of these types;
- subtypes are defined (see table 6.1 in Section 6.4);
- data needed to designate a site to a specific type are listed (Section 6.5);
- classification of identified sites within the typology (Section 6.6).

Conclusions

Care has been taken to make sure that the scope of the typology includes at least the sites included in the data sources mentioned above. The developed typology, described in Section 6.4, is generic and robust, so that it is expected that any contaminated or potentially contaminated site identified in India, including sites that are not yet present in existing site inventories, can be classified within its scope. The typology is based on activities and geometry of the contamination to be used when developing a site assessment strategy. Combined with site specific information on chemical substances and soil characteristics, this typology will be used to get insight in realistic remediation options (to be developed for each type of site in Task 3) to support the user of the Guidance document (to be developed in Task 4) in the process of remediation option appraisal.

Remarks

- Available data for several sites is too poor to make a detailed analysis of the spreading of contamination, risks and remediation options or to allocate those sites to a specific site type;
- Data from the Inventory (Assignment 1) can be used to validate the developed typology. We have offered the standard site factsheet and typology to give the Assignment 1 project team the opportunity to make the database fit for linkage with the typology and Guidance document. We plan to validate the developed Typology against the database of Assignment 1 as soon as that database, including the data from their site visits, will become available. A tentative validation against a draft version of this database of 13th December 2012 made clear that all sites in this version of the database, except the sites where contamination is limited to surface water, could be assigned to a type within the typology. In some cases multiple types are assigned to a site. The structure of the typology allows this multiple assignment. We will include the results in of the validation against the final version of the database in the final report of this project, to be developed in Task 6. In case the validation results in the need to apply changes to the results of Task 3 (Review of remediation options) and Task 4 (Guidance document); these will be dealt with in detail in the same final report.

Table of contents

Note: Annexure 4a, containing the standard site factsheets on the sites mentioned in annexure 4, is presented in a separate annexure report to this report.

1 Introduction

1.1 General

This report presents the key output of the activities carried out under Task 1 (Review the nature and type of hazardous waste contaminated sites in India) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

The report presents the results of steps 1.1 to 1.5. Earlier drafts of this report were presented to and discussed with the Technical Expert Panel (TEP) on June 28th and August 13th, 2012. An earlier draft of this report was presented to and discussed with the World Bank and MoEF on 30th November 2012. An earlier draft of this report was presented to the project teams of the Assignments 1 and 3 on 10th December 2012. The comments by the TEP, the World Bank, MoEF, and the project teams of the Assignments 1 and 3 referring to this Task have been implemented in this final version of the report.

It is important to note that the development of the NPRPS is at a very early stage at this time, and that therefore this Assignment, along with the parallel Assignments 1 (Inventory and mapping of sites) and 3 (Development of NPRPS), will provide the very basis for its further development. As this process will continue, during these Assignments and perhaps even more so after their completion, new findings may change the perspective on the results of all three Assignments. Hence, we see the development of the NPRPS as a process of growth, in which the results of earlier projects like this one may have to be reviewed periodically in later stages.

1.2 Objectives Task 1

The objective of Task 1 is to review the available inventory on hazardous waste contaminated sites and understand the nature of contaminated sites in India. The Key output is this report, presenting both a thorough insight in the nature and types of all contaminated sites in India as well as specifications for the database to be developed in Assignment 1 (‘Inventory and Mapping of Probably Contaminated Sites in India’) and a typology of probably contaminated sites in India, suited for the identification and selection of remediation strategies in Task 3.

For these objectives in this task the available inventory on hazardous contaminated sites is inventoried and analysed. This step is the very basis for the development of remediation options, which will be addressed to the different types of sites in the field. With that, the development of a typology of contaminated sites is an important step towards effective priority setting of remediation options.

1.3 Basic assumptions

The activities of Task 1 are based on the following basic assumptions.

Definitions

The definitions for Contaminated and Probably contaminated site are given by the Client. The original draft version, provided by the Client on 30th July 2012, was revised. We have used the revised definitions, sent by the Client to the Assignment 1 project team in January 2013, and refer to Annexure 1 for this definition.

Data sources

Only site related data provided or approved by the Client are used. A list of used data is shown in Annexure 2. Types of contaminated sites for which we have received no information provided or approved by the Client have not been incorporated in the typology.

It is generally acknowledged that the best basis for the development of a Typology is the database to be developed in Assignment 1. As this database could not be available at the outset of the project we have developed the typology described in this report on the basis of whatever data, meeting the criteria described above, was available. On 17th September 2012 the Blacksmith Institute kindly granted our project team access to their database ‘Toxic Sites Identification Program, Global Database’, the most comprehensive known database on contaminated sites in India to date. Before that we had already developed draft versions of this report, based on the rather limited data available until that time. We then proceeded to incorporate the results of our study of the Blacksmith database into this report. On 13th December 2012 we received a draft version of the inventory of sites from Assignment 1. After discussion for alignment with the Assignment 1 project team we then proceeded to incorporate that version of the inventory into this report.

1.4 Activities in Task 1 and reading guide

We have carried out the steps in Task 1 as described in the Contract for Consultants’ Services (26/03/2012) and the report follows these steps:

- Step 1: Quick scan of existing local inventories of contaminated sites
- Step 1.2 - Blue print of the typology of contaminated sites and list of data needed to comprehensively describe the types of sites
- Step 1.3 - First analysis of database developed in Assignment 1
- Step 1.4 - Site visits
- Step 1.5 - Final analysis of the Typology

Note: Step 1.6 - Draft report typology of contaminated sites, constitutes the present report.

2 Step 1.1 - Quick scan of existing local inventories of contaminated sites

2.1 Data sources

When starting the project the database of Assignment 1 was not available yet. Therefore, a first impression of the types of contaminated sites was made using existing site inventories. It is planned to validate the developed Typology against the database of Assignment 1 as soon as that database, including the data from their site visits, will become available. Please refer to Section 6.6 for more information on the validation of the typology. The following inventories were made available by the client for this purpose:

- List of 12 priority contaminated dump sites (CPCB, no specific reference, Annexure 6);
- List of 25 hazardous waste dump sites (CPCB, no specific reference, Annexure 7);
- Reports available for some of these sites.

During the TEP meeting on June 28th, 2012, the following reports were mentioned as useful for this Task and were studied subsequently:

- 'Polluted Sites - India' (Blacksmith institute, 2007);
- 'A compilation of polluted places India; Initial site assessment reports' (Blacksmith institute, 2007);
- Persistent Organic Pollutants: Contaminated Site Investigation and Management Toolkit (UNIDO, 2009);
- Alberta Canada User Guide for Waste Managers Part 1 to 4 (1995).

An overview of site related data provided or approved by the Client is presented in Annexure 2.

2.2 Standard site factsheet

As a first step in developing the typology a standard set of elements was made to analyse the site data. This standard set, based on the best practices and consultant's experience, is used for a systematic analysis of these dossiers and to list data that could be significant for a comprehensive description of all site types. Depending on the dossiers not all elements will be distinctive for the typology. E.g. in case a non-soluble contaminant is dumped, the information on the geology will not be distinctive for the typology or for the remediation strategies.

The purpose of the assessment was not to make a complete description of all these sites (this task is carried out in assignment 1), but to enable the development of a comprehensive typology. Based on this assessment a typology was developed. Conducting a quick scan on the inventories mentioned above resulted in an overview of the most important site characteristics, such as size, chemical content, probable spreading of pollutants, risks, geographical and potential social aspects. To present these characteristics effectively a standard site factsheet was developed.

This standard site factsheet was developed also bearing in mind the following steps in the project:

- Interaction with assignment 1. E.g., using the database developed in Assignment 1 it should be possible to generate a list of all sites of a specific type;
- Select sites for site visits. The site factsheets give more detailed information to make a more confident selection of the sites to be visited;
- Identify standard options and recommended standards for remediation of contaminated sites in Task 3. In that task a menu of remediation options is developed based on the Typology;
- Give a focus for the Task 2 review of the national and international approaches.

In the Task 2 report of Assignment 2 it is concluded that the 'source-pathway-receptor' concept is the cornerstone of contaminated land remediation policy and practices in many countries like the UK, the US and The Netherlands. Therefore, the standard site factsheet (figure 2.1) contains general data of the site and site related data based on this concept. Also, the Typology, as described in Section 6.4 in this report, and the Guidance document (site assessment and option appraisal, to be developed in Task 4) will be based on the 'source-pathway-receptor' concept, so as to align the methodology with international practice. Please refer to the following textbox for more detailed backgrounds to the source-pathway-receptor concept.

Source – Pathway – Receptor concept

The 'Source – Pathway – Receptor' (SPR) data meet a fundamental and internationally widely accepted approach. The three elements of this concept are:

- *Source: The cause or source of the contamination is identified. For example, the source might be a leaking oil tank or a layer of pure oil in the topsoil, leaching into an emerging contaminated plume in the groundwater.*
- *Pathway: The pathway is the route the source takes to reach the receptor. Pathways include, for example, air, water, soil, animals, vegetables and eco-systems.*
- *Receptor: If contamination is to cause harm, it must reach a receptor. A receptor is a person, animal, plant, eco-system, property or a controlled water. Each receptor must be identified and their sensitivity to the contaminant must be established.*

The concept is used in risk assessment to identify the source of any contamination, what the source may affect (receptor) and how the source may reach the receptor (pathway). Conclusions are drawn on the potential risks caused by the source of contamination. Conceptual models are commonly used to implement a structured and ef-

ficient investigation. Where the concept is used to develop remediation options, the remediation techniques can be designed in such way a that the effects meet an optimum, e.g. by balancing the intensity of a technique over the three elements of a specific site. For example, removing most, but not all, of a source will significantly reduce leaching from the source. This will not remove, but will stop the growth of the plume of contaminated groundwater (pathway), thereby necessitating some long term remediation action.

Adverse effects, and thereby the need for soil remediation, only occur when the following three elements are present:

- *Source = potential hazard, e.g. a toxic chemical or other agent;*
- *Pathway = connection between source and receptor;*
- *Receptor = target for protection (human life, ecosystem, resources (water and land)).*

The exact situation regarding these SPR-elements not only determines the need to remediate, but also the focus and with that the potential types of remediation options.

The impact for the Typology is that it is not technology driven but methodology driven. This methodology will be an important element of the Guidance to be developed in Task 4 and lead the user through the process of analyzing and investigating a contaminated site, assessing risks and designing a remediation approach which will address these risks. In this process techniques are just (but very important) tools to reduce the risks and are not seen as targets by themselves.

We can illustrate the concept of a methodology driven Typology by the following example case.

- *Site description: hazardous waste dumpsite;*
- *Risks: direct human contact;*

Remediation options only focused on the risks at hand: [1] removal of the waste by excavating and Secured Landfill (SLF) storage, [2] removal of the waste by using in situ techniques or [3] capping the waste using a clean soil top layer. These remediation options offer three different generic methods for remediation without going into the details of the specific techniques to be applied. Each option offers a solution which meets a different set of criteria and objectives (e.g. time available to reach the remediation goal, future land use target concentration).

Once the selection of the most applicable remediation option is carried out the most favourable remediation option can be detailed out into a remediation strategy. At this point a specific technique can be selected out of a wide variety of techniques. For example, an in-situ technique specifically applicable to the local conditions, possibly after some pilot testing. Using this top down approach from method to technique it is most likely that the selection process will result in the most favourable remediation strategy in a most transparent and effective way.

Figure 2.1 Standard site factsheet

Aspect	*Explanation*	*Actual description*	*Data quality* *
General data			
Name			
City			
State			
Owner			
Area	Acre		

Aspect	*Explanation*	*Actual description*	*Data quality* *
Terrain	Coastal, delta, mountainous,		
Land use	Urban, industrial, rural, nature		
Accessibility / infrastructure			
Distance to contractors / authority			
Spreading zone: urban-industrial-rural-nature-…			
SOURCE			
Contaminants			
Physical properties	fluid / solid / solubility / volatility		
Position in soil	on the surface / in soil /		
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /		
Period of contaminating	First and last year soil was affected		
Origin of contaminants	what type of industry or activity		
Typical type of tailings	sludge, tailing		
Typical chemical composition			
Concentration in topsoil	average concentration per parameter		
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)		
Area contaminated soil	Acre		
Concentration in groundwater	average concentration per parameter		
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	Acre		
PATH			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			
Groundwater flow	yes / no		
Washing	yes / no		
Evaporation	yes / no		
Flooding	yes / no		
Contaminants are subject reworking by human as raw material (reuse)	yes / no		
Surface water flow	yes / no		
By seawater	yes / no		
Typical frequent natural disasters	Flooding, monsoon, washing		
THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on contaminated site			
Groundwater use			
Ingestion of crops			

Aspect	*Explanation*	*Actual description*	*Data quality **
Contact surface water			
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Awareness	Low/high		
Land use			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention measures already implemented			
Access restriction			
Liners / covers			
Restrictions to land use			
Groundwater treatment			
Data / information used			

** poor/high, fact /expert guess*
Note. We have offered the Standard Site Factsheet and typology to give the Assignment 1 project team the opportunity to make the database fit for linkage with the typology and Guidance

This standard site factsheet was used to give the project team members a first impression of contaminated sites and to analyze the dataset.
Data on sites with great similarity to other sites are incorporated in a single standard site factsheet and sites with poor data are skipped altogether. For a comprehensive analysis of all sites, the database of Assignment 1 can be used. These standard site factsheets were also used to select sites for site visits and finally to develop the typology. It should be noted that the standard site fact-sheet has not been developed to be a final product as such. It is only shown in this report to give insight in our working process. Additional site characteristics can be added to the standard site factsheet as presented above to anticipate to Assignment 1 or 3 activities or for the implementation of the remediation program itself. Those additional site characteristics are not needed for Assignment 2 and the analysis of the typology.

Examples of characteristics that could be added to the site factsheet are:
- Physical address of site;
- Coordinates (Lat/Lon);
- Owner address or status as orphan site;
- Contact person and his/her contact details;
- Responsible local authority, including contact details,
- Access restrictions (administrative, physical/artificial (e.g. fenced) or natural);
- PPE required/recommended for site visit;
- Inside/adjacent to/outside protected area (including type);
- Dumping on-going/finished;
- Type of industry.

2.3 Evaluation of step 1.1

Annexure 4 presents an overview of the sites analyzed using the standard site factsheet. A summary of characteristics of these sites gives some insight in sites identified in India. However, these sites cannot be regarded as showing a representative cross-section of contaminated sites in India. For this the Assignment 1 database, which will show a more representative image of all sites in India, is needed. That database will therefore be used to validate the generic typology described in this report. Please refer to Section 6.6 for more information on the validation of the typology. Until we can carry out that validation we need to limit ourselves in this section to a first impression of the sites listed in the sources we have been able to consult so far.

On the sites listed in these sources, a variety of contaminations is found, such as chromium in various forms, lead, cadmium, pesticides, fluorides, arsenic, mercury, and sulphur dioxide. The sources also include sites with multiple contaminants, and, often the same, sites with contamination from multiple sources. In the latter case often several contaminated spots have been identified in a larger area, e.g. on industrial estates, or a contaminated groundwater plume has been ascertained downstream of a multitude of (former) small industrial activities. In the lists, sites situated in various settings (urban, industrial, rural) are represented. Ownership or polluter are not known in all cases, indicating there will certainly be orphan sites among the sites listed. Several cases resulted in a contaminated groundwater plume.

The Blacksmith institute initial site assessment report is available for 34 sites, but the analytical details are not available for all of those sites. Most of the analytical results indicate contaminants below permissible level, if related to US-EPA, World Health Organization (WHO) or Bureau of Indian Standards (BIS) limits, except known sites like Bicchadi. Sampling was not done at several sites, among which the TCCL site.
From the report one additional type of site was derived (type S2, see chapter 6), but – as the report gives limited site specific data – this type could only be described on a very basic level.

2.4 Conclusions drawn from step 1.1

- Available data for some specific sites are adequate to make a quick scan analysis of site characteristics, spreading of contamination, risks and remediation options, so as to get a first impression of contaminated sites to be assessed with the NPRPS;
- The inventory and analysis gives a first and valuable impression of the sites which should fit in the typology to be developed;
- Data from the Inventory (Assignment 1) is used as a validation to the generic typology to be developed in step 1.5. In this process the standard site factsheet (figure 2.1) is to be evaluated by the Assignment 1 project team.

The overview in Annexure 2 was used by the project team as a basis for planning the next step, Step 1.2.

3 Step 1.2 - Blue print of the typology of contaminated sites and list of data needed to comprehensively describe the types of sites

Based on the contaminated site overview created in Step 1.1 and presented in Annexure 2 a blue print typology of contaminated sites in India was developed. This 'bottom up' blue print typology was based on an analysis of site specific data.

Discussion with representatives of MoEF, CPCB, TEP and several SPCB's led to the conclusion that this approach would not result in a generic typology, which would be robust enough as to include sites not yet mentioned in the database. Subsequently, this 'bottom up' typology was thoroughly revised in step 1.5, resulting in a top down approach. The result is a robust generic Typology, covering all possible types of sites, including sites that may only be found in other countries. This top down approach should therefore be fit for all contaminated sites in India, either inventoried in step 1.1 or beyond.

This latter approach is accepted as a useful tool for the guidance.

As the revised typology is more generic and applicable to all probable sites not yet included in available inventories the blue print typology as was presented in earlier drafts of this report is not shown in this report.

We refer to chapter 6 of this report for the results of these steps.

4 Step 1.3 – First analysis of database developed in Assignment 1

When we started writing this report a database from Assignment 1 was not yet available.

Around the time of the June TEP meeting the project teams of Assignment 1 and 2 met and discussed mutual relationships between the Assignment 1 database and the Assignment 2 typology.

We agreed to cooperate wherever possible with the aim to maximize the coherence between the results of Assignment 1 and 2:

- The typology developed in Assignment 2 must be applicable to the database developed in Assignment 1. Using the right queries, all sites of a specific type should be reported from the Assignment 1 database. To make this possible the standard site factsheet (figure 2.1) will be evaluated by the Assignment 1 team. This procedure will ensure that the database developed in Assignment 1 will be *'fit for purpose'*, securing its use on a day to day basis, and thereby making it a valuable and sustainable asset that can serve an effective performance of the NPRPS for years to come;
- The database developed in Assignment 1 will give the Assignment 2 team insight in the complete scope of sites and will thus be the dataset the final typology should cover;
- Conforming to one of the TEP comments on the Inception Report, we have gone ahead with this component, based on the available information of contaminated sites. Whenever a complete inventory of contaminated sites is available, the same shall be used to frame the methodology of contaminated site assessment and remediation options. As agreed, the team of Assignment 1 has made a first draft version of the database available to our team. It is planned to validate the developed Typology against the database of Assignment 1 as soon as that database, including the data from their site visits, will become available. Please refer to Section 6.6 for more information.

5 Step 1.4 – Site visits

During the initial phase of the project the project team carried out visits of select sites, representing the main types of sites, across the entire scope of the typology as developed up to this point.
The aim of these visits was to get to the basis of understanding the nature of contaminated sites in India. New information coming out of this step is used in step 1.5 to fine tune the blue print typology towards its final form, to develop a reliable basis for risk assessment and to evaluate the practical applicability of remediation techniques taking site specific geographical circumstances into account.

During the site visits interviews with local authorities were conducted and where possible with other parties involved. The aim of these interviews was to gather input directly from the field for important operational aspects in the selection of remediation options, communication strategies and socio-economic aspects. This input will considerably strengthen the development, selection and prioritization of realistic remediation options, taking into account practical limitations.

Table 5.1 and figure 5.1 present an overview of sites which were visited by members of the project team.
These sites were selected based on the following criteria:

- Priority as well as non-priority;
- Different types;
- Good initial data;
- Geographically spread;
- Different PCB's.

Table 5.1 Overview of visited sites

Site	State or UT	Date of visit
Noor Muhammad Kunta	Andhra Pradesh	11.01.2012
Wazirpur Industrial Estate CETP and Badli Industrial Area CETP	Delhi C.R.	11.04.2012
Hazardous waste landfill Mumbai (TTCWMA)	Maharashtra	13.04.2012
Ranipet	Tamil Nadu	26.06.2012
Hooghly	West Bengal	02.07.2012
Nibra Village	West Bengal	02.07.2012
Dhapa, Kolkata	West Bengal	03.07.2012

Results of step 1.4

Of each site visit a report was made. These reports are presented in Annexure 3.

The site visits, the interviews, and site specific data provided by MoEF and SPCB's resulted in valuable background information for step 1.5 (see chapter 6) and for Tasks 4 and 6. e.g.:

- The site visit results are used to verify the Typology (see chapter 6);
- Information directly from the field, to relate the remediation options to be developed to situations actually encountered in India. Discussions with representatives of the local PCB gave detailed background information on the practical applicability of remediation options, e.g. regarding the possibility of removal under constructions or roads, specific conditions to be considered when generating remediation options, such as the importance of social aspects and site ownership. E.g. Pilot remediation plans and provisional remediation assessments are often focused on the applicability of a single technique without an adequate option appraisal assessing the best remediation strategy fit for purpose. Remediation of urban areas is a delicate process when rehousing is inevitable. In some cases economical aspects that exceed the scope of a contaminated site may play a role in the decision making for the remedial approach;
- First hand information on Sanitary Landfill as a destination for excavated contaminated soil, e.g. capacity, potential for the development of new sites, level of experience in India in design, building and exploitation of sanitary landfills At present the sanitary landfill capacity for contaminated soil is restricted. On the other hand expertise on design, construction and exploitation of such sites is present (e.g. the TTCWMA landfill site);
- First hand information on the capacity of PCB's, local experience and insight in remediation practices and organisations playing a role in the remediation, such as laboratory facilities. E.g. on the Ranipet site a pilot soil remediation and monitoring has already been carried out;
- Some sites are characterized by a series of similar subsites of the same type, distributed over a restricted area (e.g. Nibra village and Hooghly).
- The results of step 1.4 give a good basis for more detailed and focussed interviews to be held in Task 4.

Figure 5.1 Overview of visited sites

Legend

Nr.	Office or site visited		State / UT
001	office	MoEF	Delhi
002	office	CPCB	Delhi
003	office	DPCC	Delhi
004	site	Wazirpur Industrial Pollution Control CETP	Delhi
005	site	Badli Industrial Estate CETP Society	Delhi
006	office	WBPCB HQ, Kolkata	West Bengal
007	site	Nibra Village, Hooghly	West Bengal
008	site	Minu Weigh Bridge, Hooghly	West Bengal
009	site	Shivang Texrium, Hooghly	West Bengal
010	site	Dhapa MSW Dump site, Kolkata	West Bengal
011	site	TTCWMA, Navi Mumbai	Maharashtra
012	office	STC HQ, Mumbai	Maharashtra
013	office	Technochem Agency HQ, Mumbai	Maharashtra
014	office	TNPCB HQ,Chennai	Tamil Nadu
015	site	TNCCL, Ranipet	Tamil Nadu

6 Step 1.5 – Final analysis of the Typology

6.1 Introduction

In step 1.5 a comprehensive evaluation of steps 1.1 to 1.4 was carried out, including the results of studying the Blacksmith database, which was made accessible for the project around that time. In this chapter, we present the result, the typology of contaminated sites.

Note: the Assignment 1 database was not available for the Assignment 2 project team at the time of writing of this report. The TEP confirmed this expectation during the August TEP-meeting. On the other hand it is not expected that the typology will need to be extended with additional types, as the typology is generic and robust. Nevertheless, the typology presented in this chapter will be validated once the Assignment 1 inventory, including the results of the site visits, becomes available. More on this in Section 6.6.

6.2 Theoretical backgrounds – why a typology?

Contaminated sites are delineated areas in which toxic and hazardous substances exist at levels and in conditions which pose existing or imminent threats to human health or the environment. These sites often pose multi-faceted health and environmental problems. They can impact all components of the environment, particularly surface waters, soils, and groundwater and can result in people being knowingly or unknowingly exposed to toxic substances. Contaminated sites may include production areas, landfills, dumps, waste storage and treatment sites, mine tailings sites, spill sites, chemical waste handler and storage sites. These sites may be located in residential, commercial, industrial, rural, urban, or wilderness areas. All those elements are of importance in the designing and implementation process of those remediated sites. By developing a typology of contaminated sites these elements can be made manageable.

In this assignment we use the following definition of Typology: “The taxonomic classification of characteristics found in contaminated sites, based on a set of common characteristics of sites”. The typology can be used for multiple purposes from which some go beyond the scope of assignment 2:

- all contaminated sites can be described based on actual data;
- all contaminated sites can be classified based on policy based criteria to be developed in Assignment 3;
- all contaminated sites can be ranked and programmed in terms of priority setting based on policy based criteria to be developed in Assignment 3;
- categories of effective and economically similar remediation options, to be assessed in Task 3, can be assigned.

Basics of typology

The typology described in this report has been developed primarily to support the user of the Guidance document, to be developed in Task 4 in this assignment, in assessing soil remediation. The typology therefore should give a clear overview of all types of contaminated sites, including those where the contamination is soil, groundwater or surface water related, supporting the different steps in the process of soil remediation. If the typology is not distinctive, it will not provide the users with enough support. If the typology is too broad it will overstock the user in giving him too many details. An example of overstocking the typology is to distinguish all possible contaminants, leading to a huge bulk of types. In such a situation, only if one type of contaminant is overabundant the designation of a contamination specific type will effectively support the user.

Examples of foreign types of contaminated sites are gas distribution stations, private small scale subsurface oil storage tanks or immobile top layer contaminations in urban areas (brownfields). These specific and very detailed types are defined based on a combination of technical and non technical characteristics. The complexity of some of these types of sites is low, remediation can be dealt with in a uniform way, governmental laws are applied to enforce the remediation of the huge quantity of sites or type related subsidies are made available to speed up the remediation program.

The typology we present in this report is based on the results of Steps 1.1 through 1.4, and on the inventory of national and international approaches, carried out in task 2 in this assignment, and is made applicable for the use in Indian conditions and the scope of the NPRPS. As a result of this approach, the typology is applicable to almost any probable contaminated site. The user is guided through the typology, using the Indian hazardous waste (HW)-rules (Management, Handling and Transboundary Movement Rules, 2008). Elements of this Act which are used in the typology are Schedule I, listing processes generating hazardous wastes, and Schedule II, presenting a list of waste constituents with concentration limits.

Concluding from the inventory of international approaches as documented in the Task 2 report of Assignment 2 the typology is based on activities potentially leading to soil contamination in a specific geometry (e.g. spatial spreading), the first step in building a Conceptual Site Model. This means the typology is *not* primary based on a complete list of e.g. types of industries as is sometimes used in developing typologies or specific contaminants. Such an approach would lead to a very long list not giving a systematic approach for the development of site assessment strategies or remediation options. Task 2 reports that a typology for example based on a type of industry is used for programming or financing reasons and not for technical similarity.
The typology is based on activities and geometry of the contamination to be used when developing a site assessment strategy. Combined with site specific information on chemical substances and soil characteristics this typology is useful to get insight in realistic remediation options to facilitate the process of remediation option appraisal.

6.3 Scope of the typology

Care has been taken to make sure that the scope of the typology includes at least the sites included on the lists mentioned below. The developed typology, described in Section 6.4, is generic and robust, so that any contaminated or potentially contaminated site identified in India can be classified within its scope. Please refer to Section 6.6 for the classification of identified sites within the typology.

The scope of the typology is based on the following sites:

- Sites present in the available lists of sites:
    - CPCB Annexure I List of hazardous waste dump sites (provided by CPCB 20120410);
    - CPCB List of hazardous waste dump sites (provided by CPCB 20120410);
    - A Compilation of contaminated places India initial site assessment reports supported by the Asian Development Bank (ADB) Under the Poverty & Environment Program, June 2007, Blacksmith Institute;
    - Blacksmith Institute database (http://www.dbisa.org/isa/in/).

  For these types an overview of remediation options (Task 3) and remediation techniques will be presented (Task 4). Please refer to Section 6.6 for more information on the validation of the typology against the Assignment 1 database;
- Sites meeting the characteristics of waste constituents (HW-rules, Schedule II) or processes generating hazardous waste (HW-rules, Schedule I) as far as they are not covered by the types in which sites are present from the sources mentioned above. Note. Indian Hazardous Waste regulation describes Secured Landfill sites. As these sites are regarded as secure, any possible contamination emerging from these sites is covered by technical measures and procedures attached to these sites. If such measures are not sufficient and soil remediation becomes necessary the landfill sites should be regarded as a S1-c type as indicated in table 6.1;
- Site common in inventories of policies in other countries (provide by the Task 2 results).

As the Guidance document will offer a generic Remediation Option Appraisal (ROA) tool to assess the best remediation option for specific sites, all types as described by this typology can be assessed using the Guidance.
This typology covers all possible contaminated sites from ‘mega contaminated sites’, containing over 100.000 megatons of contaminated soil, right down to very small scale sites, containing minor quantities of contaminated soil. Although for one type a series of remediation options can be given, these differences in the amount of contaminated soil can result in the selection of different remediation options. The guidance will lead the user through such elements in the process of remediation option appraisal.

6.4 Typology

Table 6.1 presents an overview of the typology, by showing all activities leading to contaminated soil and types of spreading. These activities are regardless of the party causing the contamination. E.g. liquid phase contaminations are not necessary focused only to industrial activities. On the other hand it is expected that most of this type of contaminations can be found in industrial areas. The following main types of contaminated sites are distinguished using this approach:

Source related:

- Type S1: Land bound solid phase contamination;
- Type S2: Water bound sediments solid phase contamination;
- Type L: Land bound liquid phase contamination. The source of this type of contaminations is connected to human activities or infrastructure.

Pathway related:

- Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids);
- Type P2: Groundwater contamination.

Note 1: Although elements in the typology are based on the 'source-pathway-receptor' approach, it is not primary 'receptor' (risk) based. The typology is not based on risks (risks to human health, ecological risks, spreading or vaporizing). This is because site assessment and soil remediation options appraisal, for which this typology is developed, is not limited to the assessment of unacceptable risks, but needs to give insight in a contaminated site as a whole.

Note 2: depending on a specific situation:

- *a combination of these types may be found on one site. Example: a land bound storage of Chromium containing hazardous waste (type S1), leaching Chromium to groundwater and leading to a contaminated groundwater plume (type P2). This combination of types on one single site could result in multiple site assessment strategies and multiple remedial options, each assessing the different types of contaminants (both the site assessment and remediation approach can be combined for practical reasons);*
- *multiple sites can form a cluster of contaminated sites of a specific type or combination of types. A combination of sites of a specific type in a single cluster or a combination of types on a single site can be recognized. These situations could be indicated as a "cluster-site" with a wide variety of scales. In general, the applicability of remediation techniques will not depend on this setting, but correct balancing of remediation techniques per type of site in a cluster will lead stakeholders to the best applicable remediation option. This principle of balancing, including site scale factors, is assessed in the Guidance document and is independent of the type of sites.*

Note 3: Coordination with the Assignment 1 project team has resulted in the incorporation of the typology in the Assignment 1 database.

Note 4: Both in type L as in type P1 liquid phase contaminants are involved. Type P1 is distinguished from type L by the specific type of contaminant, Non-Aqueous Phase Liquids (NAPL's), which have a characteristic spreading pattern on or in the groundwa-

ter aquifer. This characteristic leads to different site assessment strategies, spreading mechanisms, risk profiles and remediation approaches for type P1 sites, as compared to type L sites. A type L site may, due to further spreading of the contaminant plume, develop over time into a type P1 site.

The main types listed above are based on normative characteristics, which play a role in determining the basics for remedial options. Side characteristics may do so as well, but their influence will in certain cases be restricted to the finer points (mostly technical details) in the selection of remedial options or to the planning or implementation of remedial actions. Thus subtypes come into perspective when remediation option appraisal is going into the second step of option appraisal, the detailed engineering phase. In this detailed engineering phase aspects have to be included related to contaminant specific specifications of remediation techniques, assessment of specific social aspects of the remedial actions or site use specific technical requirements.

Case example. The first step of a site specific remediation option appraisal, based on normative characteristics only, has shown that the remediation should be implemented within a period of less than two months and should result in a removal of all contaminants. In this case only then the site will meet the specific needs for planned reconstruction works. At this point it is already clear that only excavating techniques will be applicable, rendering the assessment of in situ techniques obsolete. This saves gathering and analysing detailed information on the performance of these techniques (e.g. contaminant related performance of in situ techniques) as this will not meet any purpose.

Subtypes can be distinguished based on the following secondary criteria:

- **Type S1 and L** related subtypes are defined, based on the activity causing the contamination. HW-Schedule I (listing processes generating hazardous wastes) may help to focus on possible activities.
  In table 6.1 these subtypes are coded ‘a’ through ‘f’ (type S) and ‘a’ through ‘d´ (type L).
  These subtypes are distinguished to support the site assessment.

- **Type P1** related subtypes are defined, based on the bulk density of a NAPL (non aqueous phase liquids, dense and light).
  In table 6.1 these subtypes are coded ‘a’ and ‘b’ (type P1).
  These subtypes are distinguished to support the site assessment.

- **Land use**: urban, industrial, nature, agricultural.
  These subtypes are designated to support the risk assessment (as receptors are land use related) and giving a direction in the selection process of remediation options.

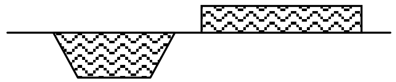
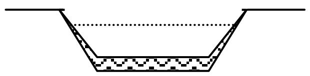
- **Heavy metal contaminated sites**. As sites contaminated with heavy metals are overabundant in the CPCB- and Blacksmith reports, these sites will be assigned to a specific subtype.

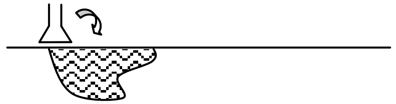
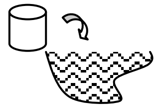
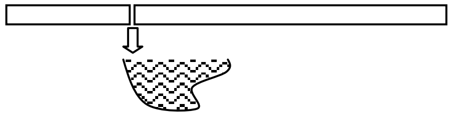
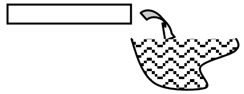
This subtype is distinguished to support the user in the remediation option appraisal giving best practices in soil remediation options.

The typology is aimed to support the remediation options appraisal. Some examples to illustrate this point. A site assessment plan for a S1-f type contaminated site (deposition by flooding or washing) will focus on the boundaries of the flooded areas of a river system, easily recognizable on maps or areal pictures. Once the pattern of flooding is known an extensive sampling plan can be carried out to validate the flooding pattern and to validate the hypothesis on the spreading of the contamination with field data. By contrast, a site assessment plan for a S1-c type of contaminated site (storage of contaminated material) will focus on a relatively small area where human activities such as incineration have taken place.

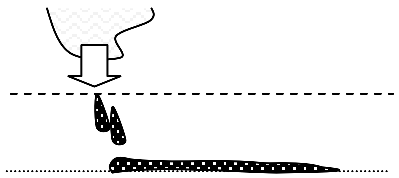
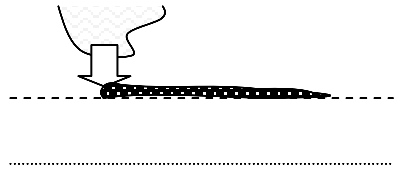
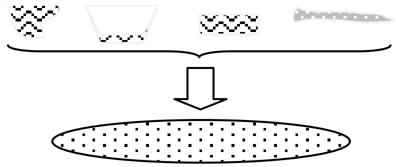
The total volume of the removal of contaminated material, which accounts for the major part of remediation costs, will be smaller for a S1-e type of contaminated site (atmospheric deposition) than for a S1-a type (soil mixed with contaminated material). Therefore, it is more likely that the best applicable remediation option on a S1-e type site will be a complete removal of all contaminants, where for a S1-a type site a capping option is more likely to come into perspective.

Table 6.1 Typology

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
S-1	Solid phase contamination (land bound site)		
S1-a *	Mixing the soil with contaminated material or materials containing contamination, not including agricultural activities.	Well defined body below surface level defined by boundaries of soil where soil is mixed with contaminants.	
S1-b **	Embankment, filling of pits or depressions, filling of surface waters with contaminated material or materials containing contamination.	Well defined body of non-mixed contaminants . E.g. storage of tailings.	
S1-c **	(Bulk) storage of contaminated material or materials containing contamination. (Industrial) activities in which contaminated solids are used. 'Leftovers' of incineration and burning of material.	Irregular shaped layer of contaminated material, recognizable as such. The shape of the contaminated site is related to the activity leading to the contamination	
S1-d *	Adding material containing contamination through agricultural activities (e.g. pesticides, fertilizers or additives to animal feed).	Agricultural site bound contaminations found up to a depth to which the soil is treated by ploughs and other agricultural tools.	
S1-e *	Atmospheric deposition (roads, railway, industries) of emissions or windblown dust.	Thin layered contaminations found over large areas with the highest concentrations close to the source following the prefailing wind direction.	
S1-f *	Deposition by flooding or washing.	Contaminations found in areas flooded by water systems or in downstream areas of flooding areas. The shape of the contaminated site is determined by the flooding of flow of a watersystem.	
S-2	Solid phase contamination (water bound site)		
S-2 **	Contaminated open water sediments.	Solid phase contaminants sedimented from surface water. The shape of the contaminates site corresponds to the shape of the water system itself. Contaminants may be bound to clay or organic compounds of sediments.	

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
L-1	Liquid phase contamination*) (land bound site)		
L1-a *	(Business) activities involving fluids e.g. solvents, lubricants, paint, etc.	Liquid contamination in soil situated near a potential source of the contamination.	
L1-b *	Storage of liquids that contain contaminations in tanks or barrels (either storage on surface or subsurface).	Liquid contamination in soil situated at any place at a liquids storage site.	
L1-c *	Transfer and transport of fluids through linear infrastructure. Weak points are couplings, pressure regulators, valves, breakpoints and the passage through foundations / buildings.	Liquid contamination in soil situated at any place along a transport piping system or drains.	
L1-d **	Spills or leaks of liquids. (either on surface or in rivers/lakes) *Note. Possibly leading to type S2 or P2.*	Liquid contamination in soil situated at the end of a transport piping or drain system.	

*) caused by multiple sources or situation where source cannot be attributed.

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
P-1	NAPL contaminants in soil		
P1-a	Dense Non-Aqueous Phase Liquid (DNAPL a)) in permeable soil. (bulk density > water)	Spreading of liquids due to gravity flow resulting in a characteristic spreading pattern. The DNAPL's laying of the bottom of an aquifer can result in a 'secondary source' of spreading of type P-2	
P1-b	Light Non-Aqueous Phase Liquid (LNAPL [b])) in permeable soil. (bulk density < water)	Spreading of liquids in a characteristic spreading pattern of floating layers. The LNAPL's laying at the top of a water table can result in a 'secondary source' of spreading of type P-2	
P-2	Leached or dissolved contaminants in groundwater		
P-2	Groundwater contamination	Due to spreading of leachate or mobile dissolved contaminants in a permeable soil	

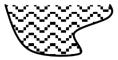
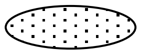
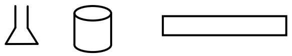
Notes

**	*Sites present in the available lists of sites (CPCB, Blacksmith-list, Blacksmith database)*
*	*Sites meeting the characteristics of waste constituents (HW-rules, Schedule II) or processes generating hazardous waste (HW-rules, Schedule I) or additional sites from inventories of policies in other countries (task 2)*

a) *A dense non-aqueous phase liquid or DNAPL is a liquid that is both denser than water and is immiscible in or does not dissolve in water. The term DNAPL is used primarily by environmental engineers and hydro geologists to describe contaminants in groundwater, surface water and sediments. DNAPLs tend to sink below the water table when spilled in significant quantities and only stop when they reach impermeable bedrock. Their penetration* *into an aquifer makes them difficult to locate and remediate. Examples of materials that are DNAPLs when spilled include chlorinated solvents or creosote.*

b) *Light Non-Aqueous Phase Liquid (LNAPL) is a groundwater contaminant that is not soluble and has a lower bulk density than water, which is the opposite of DNAPL. Once LNAPL infiltrates through the soil, it will stop at the water table. The effort to locate and remove LNAPL is relatively cheaper and easier than DNAPL because LNAPL will float on top of the water in the underground water table. Examples of LNAPLs are gasoline and other hydrocarbons.*

Table 6.2 Key to icons in table 6.1

Icon	Key
	Solid waste or solid waste mixed with soil (all solid phase). Varying in shape, thickness and extent, depending on local conditions.
	Groundwater table Base of aquifer / top of impermeable layer.
	Liquid waste. Pure or mixed with soil.
	Leaching / spreading of contaminants to soil / groundwater. Depending on permeability of the soil.
	Contaminated groundwater plume. Depending on permeability of the soil.
	DNALP or LNAPL.
	Spill / leakage.
	Not soil related human activity / construction e.g. industrial process, storage, bulk transfer.

6.5 Data needed to designate sites to a specific type

The remediation options to be developed in Task 3, as well as the Guidance Document to be developed in Task 4, will be geared to types of sites in the typology. Any user of the Guidance Document will therefore, as one of the first actions in relation to a newly identified contaminated site, need to designate that site to one or more of the types in the typology. Table 6.3 shows the data needed to be able to do that.

The Guidance document, to be developed in Task 4, will offer type specific site assessment strategies to deal with additional data needed to take further steps in the option appraisal process. Aspects like detailed site investigation, sampling strategies, conceptual site models and site modelling will be described.

Table 6.3 Data needed to designate sites to a specific type

Type of data	Possible data sources	Comments
Activity potentially leading to soil contamination Time span of the activity	Historical survey of the site. Permits and technical drawings of the industrial processes on the site. Archive of the party / parties active on the site Interviews. Site visit.	The site permit details the Products/Class of Products Manufactured and the type and scale of industry. HW-Schedule I (listing processes generating hazardous wastes) can be used as checklist. Please see the separate attachment of Type Industry that can be identified from the Permit.
Contaminants used on the site	Historical survey of the site Permits and technical drawings of the industrial processes on the site Archive of the party / parties active on the site Interviews Site visit	Use HW-Schedule I (listing processes generating hazardous wastes) as a checklist and HW-Schedule II, giving a list of waste constituents. This list of waste constituents is elaborate and applicable to nearly all the industrial processes.
Terrain conditions prior to the activity	Historical survey of the site using areal pictures Site visit Geomorphologic data Maps available at the collector's office of the region.	e.g. presence of pits, ditches, depressions
Geology and hydrology of the site	Central Soil and Material Research Station (CSMRS) of Ministry of Water Resources, Govt. of India (database on soils in India)	e.g. soil layering, permeability, organic and clay compounds in soil, aquifers and groundwater characteristics
Physical properties of contaminants	As above	e.g. phase (solid, aqueous), solubility, density, co-contaminants, spreading characteristics in soil and groundwater
Presence of adequate protective measures to prevent soil contamination	Permits and technical drawings of the industrial premises. Archive of the party / parties active on the site. Interviews. Site visit.	

Type of data	Possible data sources	Comments
Land use	Location of the site. State Industrial Development Corporations. SPCBs. PCCs.	e.g. urban, industrial, nature, agricultural; source and pathway may have different types of land use

**) As per Sr.No.70.12.(12) RE:Location of Industrial Sites and Secured Landfill:- of the Supreme Court Order dated 14th October 2003, only industries in those States where the Hazardous Waste generation is less than 20,000MT per year, are allowed to temporarily store Hazardous Waste on the premises before they get a permission for Transboundary Movement. In all other States where the Hazardous Waste generation is more than 20,000MT per year, Industry can store Hazardous Waste on the premises not more than 90 days but is required to transfer the waste to Common Hazardous Waste Treatment Storage Facility (CHWTSDF) in that State.*
Not all permits specify on-site Hazardous Waste Storage with adequate protection.
In earlier time, say 10 years before Industries have illegally stored Hazardous Wastes on the premises without due protection.

6.6 Validation of the typology

Preliminary validation

The typology has been applied to the sites included in the available lists of sites, i.e. the CPCB-list, the Blacksmith Institute list and the Blacksmith Institute database. Table 6.4 presents the results of this application. Distinctive elements to designate contaminated sites to a specific type or specific types are the processes leading to the contamination, such as emplacement of contaminated materials, mixing of contaminants with soil, embankment of low situated sites with contaminant material or the leakages or spill of liquid material transport pipes.

Table 6.4 clearly shows that all main site types have been identified in India except for type P1, which could not be recognized due to lack of very specific data. From table 6.4 it is also concluded that all sites listed in the three sources used can be classified using the typology.

The purpose of table 6.4 is to provide an overview of all types and subtypes in the developed typology. We have supported this by including the names of some sites as examples to every type. The reason not all sites from the CPCB list, Blacksmith Institute list, and Blacksmith Institute database are mentioned in this table is that the purpose of the table is not to give a ranking of all assessed sites.

For a number of sites the CPCB list, the Blacksmith Institute list and the Blacksmith Institute database show limited data. Many sites are still under review or under investigation or have not been investigated in detail. Therefore, details on the analysis of these data as reported in table 6.4 may be under dispute. This would definitely have been the case should subtypes have been used in table 6.4. On the other hand, this application of the typology to these sites has clearly shown the working methodology used is robust and the results will be useful for the NPRPS.

Validation against database from Inventory project

It is planned to validate the developed Typology against the database of Assignment 1 as soon as that database, including the data from their site visits, will become available. We have done a tentative validation against a draft version of this database, made available to us by the project team of assignment 1 on 13th December 2012. This tentative validation made clear that all sites in this version of the database, except the sites where contamination is limited to surface water, could be assigned to a type within the typology. In some cases multiple types are assigned to a site. The structure of the typology allows this multiple assignment. We will include the results in of the validation against the final version of the database in the final report of this project, to be developed in Task 6. In case the validation results in the need to apply changes to the results of Task 3 (Review of remediation options) and Task 4 (Guidance document); these will be dealt with in detail in the same final report.

Table 6.4 Overview of (combination of) types of sites applicable to the CPCB-list, the Blacksmith Institute list, and the Blacksmith Institute database

Type					**Subtype**					**Example sites assigned to a type of site**
S1	**S2**	**L**	**P1**	**P2**	**Land use (present)**				**Nature of contaminants**	**(including reference to list where site is included)**
					Urban	**Industry**	**Nature**	**Agricul-ture / rural**		
X		(x)		X	X	X	(x)	X	Most common are heavy metals	Hooghly 2, Nibra, West Bengal (1) Chemical company*, Kanpur, Uttar Pradesh (1) TCCL, Ranipet, Tamil Nadu, (1,3) Picnic Garden, Kolkata, West Bengal (2,3) (x) Alloy & Power company*, Kandra&Ratanpur Village, Jharkhand (2,3)
	X				X	X	X	X	Various	Humbran Ludhiana, Punjab (1) Chemical company*, Orissa (1,3) Muthia Village, Naroda Industrial Area, Ahmedabad, Gujarat (2,3)
	X			X				X	Not determined (too few sites)	Ranipet, Tamil Nadu (1)
X					X	X		X	Various	Chemical company*, Kanpur, Uttar Pradesh, (1) South Indian Viscose, Sirumugal, Tamil Nadu (2) Pesticides company*, Chinhat, Lucknow, Uttar Pradesh (2,3)
X						X	X		Heavy metals	Kodaikanal, Tamil Nadu (2)
	X	X					X	X	Most common are effluent fluxes	Nandesari Industrial Area, Vadodara, Gujarat (2,3) Sanganer, Rajasthan (2,3)
X	X	X					X	X	Most common are heavy metals in effluent fluxes	Damanganga, Vapi Industrial Area, Gujarat (2,3) Tanneries, Tangra, Kolkata, West Bengal (2,3)
	X	X		X			X		Not determined (too few sites)	Palar River Basin, Tamil Nadu (2,3)
		X					X		Most common are effluent fluxes	Tiruppur, Coimbature, Tamil Nadu (2,3)

(x) subtype 'e' only

** as per request by the TEP company names have been deleted from the site names*

Source of site data:

(1) CPCB Annexure I List of hazardous waste dump sites (procured by CPCB 20120410) or CPCB List of hazardous waste dump sites (procured by CPCB 20120410).

(2) A Compilation of contaminated places India initial site assessment reports supported by the Asian Development Bank (ADB) Under the Poverty & Environment Program, June 200, Blacksmith Institute.

(3) Blacksmith Institute database (http://www.dbisa.org/isa/in/).

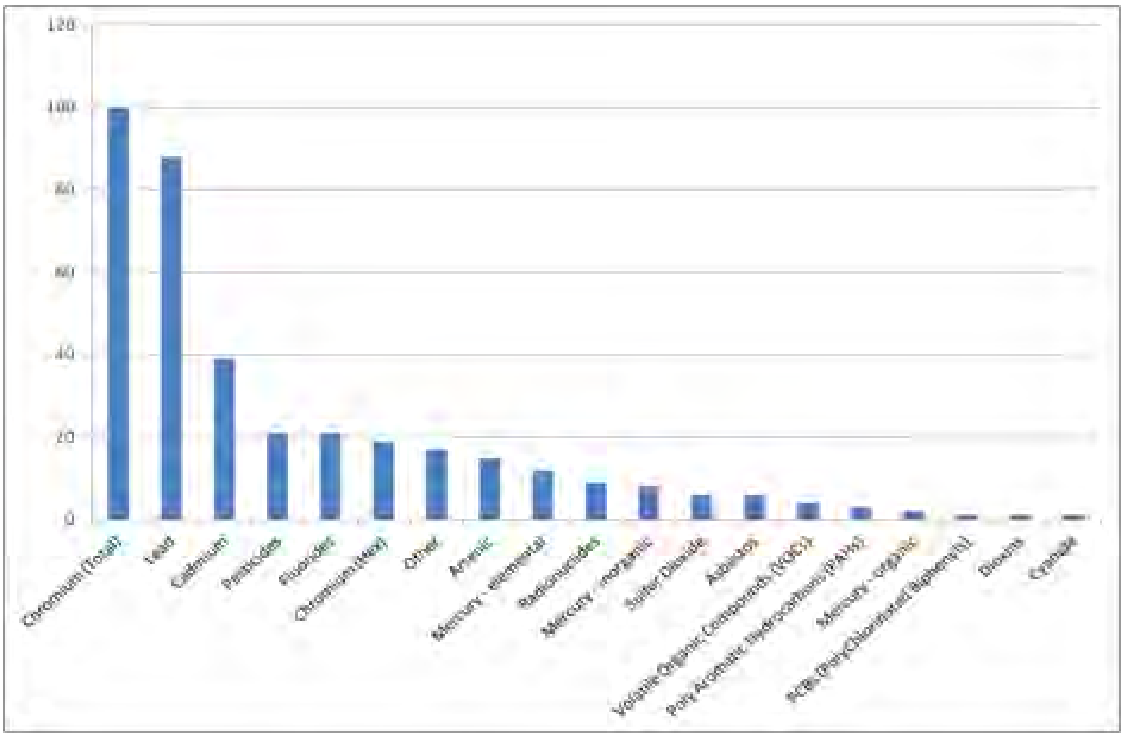
6.7 Analysis of the developed typology

The typology presented in this report has been based on data from sources mentioned in chapter 2, and the Blacksmith Institute database.
To mitigate the effects of the possibility of not covering all sites in India, the typology has also been based on the Task 2 report and on our expertise on contaminated sites outside India, as per the discussion on this point with the Technical Expert Panel. Using this approach the typology is fit for sites not yet incorporated in the sources used.

Note: not all sites from the CPCB list, Blacksmith Institute list and Blacksmith Institute database could be assigned to a type due to poor data.

Figure 6.1 demonstrates the number of sites with a specific key pollutant. This figure is based on the Blacksmith Institute database. This database encloses a large number of sites (400+) and has an overlap with the sites from the CPCB-list and the Blacksmith Institute report (2007). Therefore, figure 6.1 presents a solid focus for the Guidance document. In case a specific (group) of contamination(s) is common in India the Guidance document will present specific additional backgrounds, e.g. the evaluation of remediation techniques for assessing hexavalent chromium.

Figure 6.1 Number of sites with specific key pollutants



From this graph it can be concluded that heavy metals (in soil, groundwater or surface water) are the most common type of contaminant identified in India. Combined with detailed information from the sites it can be concluded that most sites are not contaminated with just a single key pollutant, but rather with a mix including other pollutants.

6.8 Using the typology within the NPRPS framework

The typology described in this report will form the basis for Task 3, where potential remediation options will be developed for each type of site, incorporating best practices from other countries. During this step, contaminant specific aspects of techniques will come into view. An analysis of these remediation options will offer insight in the best applicable techniques. This will support the user of the Guidance document, to be developed in Task 4, in the remediation options appraisal process. It will be the Guidance document that will take the user through the generic process of remediation option appraisal. Detailed site characteristics such as those listed below will be dealt with:

- physical aspects, relevant for the technical aspects of remediation:
  - chemical content and origin of the waste sites. Example: from the site data available at this time it is evident that many sites are contaminated with hexavalent chromium sludge. This type of site should fit into the typology and the Task 3 Review will include additional backgrounds, specifically aimed at hexavalent chromium techniques;
  - size, geographical setting (natural hazards, infrastructure, distance to assets), geohyhydrological and geological setting. For example, the geographical setting often forms a dominant factor in the pathway of contaminants and thereby in the types of risks and applicable remediation options;
  - practical aspects of available techniques. For example, the excavation of contaminated sites and storage in a sanitary landfill (SLF) is only possible if the storage capacity is sufficient and the SLF-technology is well implemented.
- potential and existing risks relevant for the focus of the site remediation measures (prevent human contact, prevent spreading due to land use, prevent spreading of contaminants in groundwater);
- practical aspects of remediation, relevant for the impact of the technical measures of remediation and a potential change in land use, both of the site itself and of the surrounding area:
  - social context and urban setting influences the level of acceptable nuisance during the implementation of remediation options;
  - the legal and financial position of the owner and his choice to redevelop a contaminated site to a higher standard of land use is likely to influence the level of remediation;
  - urban redevelopment plans, including their planning, are likely to influence the time available for remediation and thus might exclude certain remediation techniques;
  - legal and economic aspects (ownership, political attention, liability).

7 Annexures

7.1 Annexure 1 Definition of a contaminated site

This annexure presents the revised version of the definition of a contaminated site, as presented by MoEF to the Assignment 1 project team in January 2013.

1(a). Definition of a contaminated site

"Contaminated Sites are delineated areas in which the constituents and characteristics of the toxic and hazardous substances, caused by humans, exist at levels and in conditions which pose existing or imminent threats to human health and/or the environment".

Notes:

I. Site is defined by the area consisting of the aggregation of sources, the areas between sources, and areas that may have been contaminated due to migration from sources; although contaminated groundwater plumes normally not will be considered as a part of the site boundary. Site boundaries are independent of property boundaries.

II Confirmed presence of toxic and hazardous substances having constituents and characteristics of the contaminants as per the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008 (see Appendix D).

III. Natural contaminants are not treated as contaminants or substances, which basically are anthropogenic.

IV. Land would not be considered contaminated merely due to presence of hazardous substances in, on or under the land. The level of contaminants should be above risk level. Land may be contaminated even if it was contaminated partly or entirely by the migration of contaminants into, onto or under the land from other land.

V. The risk may be considered based on human health and/or the environment; and may be accessed on the basis of existing or planned future land use as well as use of ground water and surface water.

VI. The risk approach should also take into account any possible combination of contaminants [interaction between contaminants and or with environmental constituents] or certain levels of contaminants, wherever applicable

1(b). Definition of a probably contaminated site

"Sites with alleged (apparent, purported) but not scientifically proven presence of constituents of contaminants or substances caused by humans at concentrations and characteristics which can either pose a significant risk to human health or the environment with regard to present or future land use plan [pattern] or exceeding specific concentrations or standards prescribed for human health and or the environment "

Notes:

I. The constituents and characteristics of contaminants shall be as per Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.

II. Natural contaminants are not treated as contaminants or substances, which basically are anthropogenic.

III. The risk may be considered based on human health and/or the environment; and may be accessed on the basis of present or planed future land use as well as use of ground water and surface water.

IV. The risk approach should also take into account any possible combination of contaminants [interaction between contaminants and or with environmental constituents] or certain levels of contaminants, wherever applicable

7.2 Annexure 2 Site related data provided or approved by the Client

nr	title document	content document	organization
1	No title, Chapter - 1	summary of 12 priorities of contaminated dump sites	CPCB
2	No title, Annexure	For each of the States a description of the hazardous waste dump sites	CPCB
3	No title, Annexure - I	List of hazardous waste contaminated dump sites in the country (preliminary information)	CPCB
5	No title	Table/list with contaminated sites; almost same information as nr. 3	CPCB
6	Dump Sites Orissa - GTZ report	dump site report	CPCB
7	Dump_Site_Assessment_AP	dump site report	CPCB
8	Dump_Site_Assessment_Madhya_Pradesh	dump site report	CPCB
9	Dump_Site_Assessment_Madhya_Pradesh2	dump site report	CPCB
10	Dump_Site_Assessment_Report_Kerala	dump site report	CPCB
11	Dump_Site_Report_GTZ_Kerala	dump site report	CPCB
12	Dump_Site_Report_Kerala	dump site report	CPCB
13	Dump_Site_Report_Orissa	dump site report	CPCB
14	Dump_Site_Report_Punjab.CV01	dump site report	CPCB
15	Dump_Site_Report_Punjab	dump site report	CPCB
16	Dump_Site_Report_Uttar_Pradesh	dump site report	CPCB
17	Dump_Site_Report_WB	dump site report	CPCB
18	NEERI_Report_Ranipet_Site_TN	dump site report	CPCB
19	NGRI_Report_Ranipet_Site_TN	dump site report	CPCB
20	POLLUTED PLACES - INDIA		Blacksmith Institute
21	Initial Site Assessment Report POLLUTED PLACES - India		Blacksmith Institute
22	AP_Investigation & Remediation	Investigation and Remediation Plan	SENES
23	Gujarat_Investigation & Remediation	Investigation and Remediation Plan	SENES
24	Kerala_Investigation & Remediation	Investigation and Remediation Plan	SENES
25	MP_Investigation & Remediation	Investigation and Remediation Plan	SENES
26	Orissa_Investigation & Remediation	Investigation and Remediation Plan	SENES
27	UP_Investigation & Remediation	Investigation and Remediation Plan	SENES
28	West Bengal_Rem Plan	Investigation and Remediation Plan	SENES
33	Need Assessment for Implementation of Hazardous Waste Management & Preparation of NPRPS		SENES
34	Blacksmith database (internet access)	400+ site factsheets	Blacksmith Institute

7.3 Annexure 3 Site visit reports

Site Appreciation Report - Visit to APPCB and Noor Mohammed Kunta - *11 January 2012*

A first hand feel for the available data:

In response to our request during the pre-bid meeting on 10th January 2012, the Project Director [CBIPMP] has kindly arranged for Ms. Ramani at the Andhra Pradesh Pollution Control Board [APPCB] to receive two representatives of the consortium on 11th January 2012. Our discussion with Ms. Ramani and some of her colleagues enabled us to get a first hand feel for site conditions and to make a first assessment of the structure, nature, format, and quantum of the available data and of the software used. A visit to Noor Mohammed Kunta in Hyderabad gave us an overall impression of this pilot site.

Action taken on orphan sites:

We learned from Ms. Ramani and Mr. Bhaskar that both Andhra Pradesh and Maharashtra have declared NIL orphan contaminated sites. AP was the first state to adopt Secure Landfilling. APPCB acquired an existing contaminated site at Dundigul in Ranga Reddy District, treated the same and is now using this site, named TSDF, to receive and treat contaminated material from various orphan and owned contaminated sites. Environment Protection Training and Research Institute (EPTRI) identified all the orphan contaminated sites in AP. Based on this report, APPCB spent Rs 19 million in collecting, transporting and treating the contaminated soils from individual sites to the TSDF. In total, 24,000 tons of contaminated material was transported from 147 orphan sites (in 44 locations) to the TSDF. Arrangements with a few cement factories for co-incineration of the contaminated waste at reasonable cost has encouraged the industries to responsibly handle their contaminated wastes.

Plans for the future:

- an Environmental Compliance Assistance Center [ECAC] is expected to be operational by June 2012;
- AP does not currently operate a site ranking system of its own;
- on the basis of a national policy, AP will decide whether additional State policy is needed to account for specific regional circumstances.

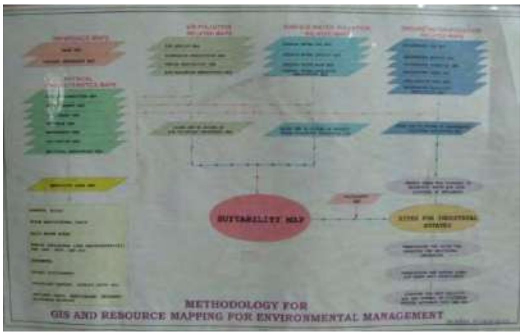
Current Remediation Works:

As mentioned in the Project Appraisal Document [PAD], Andhra Pradesh currently has undertaken remediation works for two sites: Noor Mohammed Kunta and Kadapa. A visit to Noor Mohammed Kunta and the adjacent waste water treatment facility gave us an impression of the site and the surroundings. The pond, in suburban Hyderabad, is between a mix of small industries/ businesses and residential dwellings, and a railroad, upstream, and the Agricultural University Campus, and a trunk road, downstream. The pond and its sludge have been contaminated mainly by dyes from the textile industries for Katedan Industrial Zone. The regulator has closed down these industries/ businesses, and the pond's sludge is currently being characterized, in which APPCB samplers take part. On the basis of the results, remedial action is envisaged, and the regulator will ensure compliance by remaining industries/ businesses.

Noor Mohammed Kunta, seen from the waste water treatment facility

GIS - A substantial initiative by APPCB:

APPCB seems to have taken a substantial initiative in developing a GIS facility. A discussion with Ms. Sudha and Mr. Padmanabhan gave us a first understanding of their system. The GIS and layering was originally, in 2002-2005, based on guidelines provided by the CPCB to each SPCB, and is due for an update. APPCB GIS cell used 1:50,000 scale topographic sheets of the Survey of India, scanned them and digitized the raster images using ERADS. They use ARC GIS version 9 – although they are looking to upgrade the same to ARC GIS Version 10, since this allows image processing and geo rectification. The system is visible in the field, as APPCB uses this GIS in deciding whether or not it should grant permission for the setting up of industries in certain zones.



Methodology for GIS and resources mapping for environmental management at AP SPCB

Meeting report visits CETP Delhi Inception phase, 11 April 2012

Date meeting:	April 11th 2012
Purpose meeting:	site visits possible contaminated sites
Location Meeting:	two sites for treatment waste water, Wazirpur Industrial Pollution Control CETP Society and Badli Industrial Estate CETP Society, Delhi
Present:	Mrs. Nupur, (in-charge & Chemist- Wazirpur CETP), O. P. Bhowal, Executive Secretary CETP, Ravi Sood, General Secretary, Badli CETP, Mr. Chawla (senior environmental engineer DPCB), Mr. Surindar Singh (environmental engineer DPCC), project team members: Mr. H. Rane, Dr. S. Sen, Mr. F. Vliegenthart, Mr. R. Heijer, Mr. P. Oude Boerrigter

Introduction
The project team for the Methodologies project had the opportunity to visit Delhi Pollution Control Committee. Member Secretary Mr. Sandeep Mishra invited the project team for a short discussion on soil contamination and waste management. Mr. Mishra and members of his team emphasized the problems with waste management due to lack of space for final disposal sites. There were some discussions on the Dutch approach and experiences.

This visit was the starting point for two site visits of CETP-sites, the project team could visit accompanied by DPCC-employees.

Information CETP employees
- The project team visited two sites where waste water of industrial sites is treated. One site was built in about 2000, the other site is 6 years old.
- The CETP construction is funded, 25% by MoEF, 20% by DIDC (Delhi Industrial Development Corporation), 5% by DPCC and 50% by member group of industrial companies. Fees are collected by DIDC for the amount of water that each industry is consuming irrespective of discharge of effluent.
- CETP receives waste water from many industries, mainly metal constructing industries.
- Transport of waste water is by subsurface sewers, sometimes 2-3 meters below surface.
- Sludge generated at the waste water treatment plant is dewatered by filters.
- Effluent of the facility is discharged to the river / surface water.
- The last step at the site is storage of sludge in tanks. There are no liners in the sludge tanks, the roofs will not always be water tight.
- DPCC task is to check the quality of the discharged water of CETP sites. There is no check on the quality of the sludge because that is too expensive.
- There is no possibility to transport the sludge to a final deposition site for hazardous waste. At CETP-sites the storage tanks are filled with dry sludge. This sludge contains chemical elements like heavy metals and POP.
- The acidity of the waste water when entering the CETP-facility, is 3,5 PH and DOC (termed as COD- Chemical Oxygen Demand) is 45 mg/L. To reduce acidity lime is added. To reduce DOC to 20-25 m/L, the wastewater is aerated.
- Soil or groundwater quality is not tested near these sites. Groundwater depth is 8 feet below surface.

Information of Mr. Rane:
- CETP-facilities have an environmental permit;
- When not complying regulations, a fine can be given and sometimes a bank guarantee is required
- Permits can be withdrawn as ultimate penalty.

Internal conclusion project team:

- These two facilities are facing problems functioning; sludge cannot be transported to a final disposal dump site for hazardous waste.
- The storage tanks are filled with old sludge. No 'fresh' sludge was seen. We presume that all waste water is only treated to raise pH-level before discharging to rivers / surface waters.
- At these sites many tons of hazardous waste is stored, without good soil protection measures.
- The sewage systems that are transporting discharged water from industrial companies to CETP facilities can possibly leak, causing groundwater contamination outside the borders of industries or CETP sites.

	Site 1	**Site 2**
Name / location	Wazirpur	Badli
Number of industries, waste water is collected from	4.000	450, of which 15 are polluting
Year start of facility	About 2000	2006
Amount of waste water collected	24,000 m^3/day maximum capacity; only 4 % is presently used capacity	12,000 m^3/day maximum capacity; only 1,200-1,500 m^3/day is collected
pH of collected waste water	3,5	6,2 (formerly 5, but industries were closed)
Number of sludge tanks	8, capacity of one tank was 25x15x3 m3.	2, capacity of one tank was 25x15x3 m3. Other tank is fill and draw type.
Sludge generation	1000 to 2000kg/day	100kg/day

Meeting report TTC Waste Management Association, 13 April 2012

TTC Waste Management Association

Mr. P.M. Sreevalsan, Site Manager
Dr. N.R. Nimskar
Several colleagues TTCWMA

Projectteam:

Mr. A. de Groof	Grontmij, Netherlands
Mr. R. Jambagi	Indus Technologies
Mr. R. Heijer	Grontmij, Netherlands
Mr. P. Oude Boerrigter	Grontmij, Netherlands
Mr. F. Vliegenthart	Grontmij, Netherlands
Mr. H. Rane	Technochem, Mumbai
Mrs. Dr. S. Sen	STC, Mumbai

Review Points:

A. Owners;
B. Disposal site;
C. Type of waste;
D. Efficiency waste management and other environmental aspects

Observations, Comments and Suggestions on the above Review Points:

S. No.	Observation	Comments / Suggestion
A.	Owners	→ Industries are the owner of the TTCWMA, which is a company funded by an association of 1,650 companies (almost all companies in the region); → In board of directors representatives of BASF, SIEMENS are present amongst others; → TTCWMA reports environmental results to Maharashtra-PCB (MPCB); → Financial support for construction of site was (Capital Investment) : MoEF 25%, MIDC 20%, MPCB 5% (total 50% of Capital Cost) and member industries contributed the rest 50%. → Within the borders of TTCWMA-site a secure landfill site of hazardous waste is present; → In others States these facilities are there as well, but nowhere there is an industry association constructed and operated site that runs this like here. All other facilities are privately owned.
B.	Disposal site	→ The landfill was build in 2009 by Indian contractors; → It can contain 300,000 Metric Tons of waste over 10 years period; → The soil protection measures are: sealing of the waste by under laying and upper laying HDPE and mineral layers; → The site has a surface of 7,000 m2;

S. No.	Observation	Comments / Suggestion
		→ Groundwater level is 45 m below surface → Upper layers of soil have thickness of couple of meters → Under laying Bedrock consists of basalt → Groundwater is not used for drinking or process water. Only a small amount is pumped up for using as irrigation water for the gardens of the site.
C.	Type of waste	→ After 3 years the capacity is used. Last year one company provided 100,000 Metric tons of waste, due to a soil remediation. → The waste is transported from industries to site by truck; → During monsoon period the waste is not stored in the landfill site but will be kept at the production sites of the industries. TTCWMA has some space for storing waste before final disposal can take place. Sludge material will not be accepted and will be sent back to the companies if not meeting the pre-estimated specifications;
D.	Efficiency waste management and other environmental aspects	→ Regulations on waste say that waste with higher caloric value than 2,500 cal/kg must be incinerated. → A cement industry can use certain waste as fuel. This can be an efficient way to save primary fuel, but due to regulations on segregation of waste, this is not an option. Of course this is not the primary scope of this Methodologies project but there is some overlay in practical situations. → Another situation that is related to our project is the waste management of about 5,000 small units of industry. This is not regarded as hazardous waste due to the small amount. The waste is treated as municipal waste and relatively high costs are made.

Background and Draft Report of the visit of Dutch/ Indian consortium to Tamil Nadu PCB and site visit to Ranipet

Monday-Tuesday, 25th and 26th June 2012

Present

Mr. R. Kumar,	Joint Chief Engineer,TNPCB, Chennai
Mr. Sumargopan	TNPCB, Chennai
Mr. Er. P. Kamraj,	District Environmental Engineer, Vellore, TNPCB & Others
Mr. A. de Groof	Grontmij, Netherlands
Mr. R. Jambagi	Indus Technologies (only 25th)
Mr. R. Heijer	Grontmij, Netherlands
Mr. P. Oude Boerrigter	Grontmij, Netherlands
Mr. H. Rane	Technochem, Mumbai
Mr. D. Deshpande	Technochem, Mumbai
Mr. R. Sridhar	STC, Chennai
Mr. D. Pari	STC, Chennai

Background for the visit and objectives

The Ministry of Environment and Forests is carrying out the World Bank financed CBIPMP. Towards the end of March 2012, MoEF has, within the framework of this project, commissioned three studies, aimed at developing a basis for a National Programme for the Remediation of Polluted Sites (NPRPS) in India. While Study 1 should deliver an inventory of contaminated sites across India, Study 3 should deliver key elements for the NPRPS itself. A consortium of Grontmij, STC and Technochem, together with Indus Technologies from The Netherlands, is carrying out Study 2, aimed at developing methodologies for rehabilitation of the contaminated/probably sites. From the moment a contaminated site has been identified, a series of decisions on required action will need to be taken. The outcome of these decisions largely depend on the type of site. The consortium is planning to develop a set of tools, most important of which will be a Guidance Document that should guide CPCB and SPCB's through every one of these decisions. These documents, it is expected, will be used by CPCB, SPCB and other implementing agencies in India for rehabilitation of sites at present and in future.

A key part of the work of Dutch-Indian consortium is discussion of selected, representative SPCBs and visit to representative sites. This exercise is aimed at getting an understanding of ground level conditions in India, assess the nature and extent of technical and non-technical expertise available with SPCBs and understand the current practices relating to remediation of contaminated sites.

The discussions with respective SPCBs and information gathered during site visits will be used by the consortium to:

a. Identify and recommend further capability building requirements of visited SPCBs and sites, their technological and non technological needs, training requirements and other inputs needed to strengthen the implementation agencies' capabilities to undertake rehabilitation work of contaminated sites

b. Assess the criticality of rehabilitation work needed at the visited and similar sites and report the same to MOEF/WB as a part of final reports

c. Improve the tools, standards, methods and other aids being developed by the consortium to make them more user friendly for the implementing such as SPCB

The visit to TNPCB and Ranipet site was requested by the Dutch/Indian consortium after a careful study of available information at MOEF and other sources as the consortium felt that TNPCB represents a progressive and dynamic implementing agency for rehabilitation of contaminated sites and Ranipet is a representative site for application of international standards, rehabilitation methods and technologies and additional capacity building for rehabilitation and reclamation of contaminated sites. Consultation with MOEF officials confirmed our choice.

The request was made via MOEF to MS TNPCB (Dr. Balaji) and ACE (Mr.Kumar) who kindly consented to the request. Since Dr.Balaji was travelling at the time of the visit, Mr.Kumar received the delegation and facilitated the visit.

Programme of the visit, discussions and site visit

In the afternoon of Monday 25th June the project team met Mr. R. Kumar, Mr. Sumargopan and colleagues at Head Office TNPCB in Chennai. The project team learned about the organization and tasks of TNPCB through a very detailed and comprehensive presentation by Mr. R. Kumar. This provided good insight into the priorities in environmental issues for TNPCB as well as their capacity regarding hazardous waste management. The approach of soil remediation is at present being attended to by a team of three employees.

After this the project team gave a presentation on the approach of soil remediation and the best practices in selected countries. The project team and the attending TNPCB staff then discussed some options that could be of applied for the Ranipet site. It was clarified by the consortium that while designing solutions for specific sites is not within the project team's present assignment, the consortium was happy to share information and advice on technologies and practices available in the Netherlands and other European countries on approach to remediation of sites such as Ranipet.

The project team's representatives were taken on a guided tour over the Tamil Nadu Chromates & Chemicals Ltd. Ranipet site's premises by Mr. R. Kumar and his staff. During this tour, on Tuesday 26th, the representatives were briefed on the site's history of Chromium ore processing from 1976 to 2001, with a focus on the pollution's causes due to accumulation of 1,60,000 MT of hexavalent Chromium bearing Process Residue (Sludge), the present situation, and the existing plans for taking on the contamination by removing sludge and transferring the same to a nearby contained site.

Both the site's installations, now defunct, and the area outside the buildings, were included in the tour, as was an installation for a pilot remediation study on the premises, and several points where contaminated leachate is surfacing, both right outside the premises and a kilometre or so downstream. Additional questions on the site's history were be asked to Mr. V. Nirmal Gandhi, the Deputy General Manager- E.H.S. at neighbouring Thirumalai Chemical Ltd. (TCL), who has personally witnessed developments over the past two decades. The group then concluded the visit by discussions over lunch.

The representatives gained insight in the intended results of the study the consortium is carrying out and the methods to achieve those results. The project team's representatives gained insight in the TNPCB's mandate and scope of work, relevant for the study, which is important considering they are the intended end users of the tools being developed in the study. On top of that, the consortium gained considerable insight in one of the types of contaminated sites that are subject of the study, as well as in the solutions that are being considered at present.

Assessment, conclusion and future steps

The Dutch consortium is very grateful to TNPCB and Mr.Kumar for the open and very informative discussions at TNPCB and during the site visit.

It is the assessment of the consortium that TNPCB's objectives and approaches are forward looking and targets quite ambitious. TNPCB has some excellent and unique practices such as real time reporting and monitoring of some sites. They have an extensive network of district level organisations. Their current technological knowledge is significant and substantial.

However it is recognised by the consortium that rehabilitation of contaminates sites in TN, as in rest of India , is an enormous challenge and while agencies such as TNPCB are doing their best to attend to this need, their current technological and organisational capacity needs to be vastly enhanced and strengthened. They will need additional tools and training in their projects and hands on training and experience in their application.

They also need appropriate funding to undertake rehabilitation work, monitor the rehabilitated sites and take preventive measures to prevent further contamination and propagation of hazards.

These conclusions will be incorporated by the consortium in their reports and guidance documents and other deliverables to MOEF and WB.

The consortium will continue to interact with TNPCB in the next steps in its work such as exposure of the guidance documents to representative implementing agencies, training and capacity building.

The consortium would like to express its gratitude to MS TNPCB and Mr.Kumar for their assistance and cooperation and looks forward more such interaction.

The information in this site visit report shows the state of affairs at the time of the visit. A request for more recent information has been made to WBPCB. This information will be incorporated in this report as soon as it is received.

METHODOLOGIES FOR NPRPS INDIA

Summary of site visits Kolkata West Bengal and meetings with WBPCB

Setting:

The Ministry of Environment and Forests is carrying out the World Bank financed CBIPMP. Towards the end of March 2012, MoEF has, within the framework of this project, commissioned three studies, aimed at developing a basis for a National Programme for the Remediation of Polluted Sites (NPRPS) in India. While Study 1 should deliver an inventory of polluted sites across India, Study 3 should deliver key elements for the NPRPS itself. A consortium of Grontmij, STC and Technochem, together with Indus Technologies from The Netherlands, is carrying out Study 2, aimed at developing methodologies for approaching contaminated sites. From the moment a contaminated site has been identified, a series of decisions on required action will need to be taken. The outcome of these decisions largely depends on the type of site. The consortium is planning to deliver a set of tools, most important of which will be a Guidance Document that should guide CPCB and SPCB's through every one of these decisions.

The consortium has started the project by developing drafts of the intended tools, based on the relatively limited data that are presently available. After consultation with the Client the consortium intends to finalise the tools, bases on the more comprehensive data that Study 1 will yield. The visit to WBPCB was aimed at getting an idea of the challenges a SPCB is facing in dealing with polluted sites. Ranipet and Hoogli are sites listed in central databases. The visit to these sites was aimed at getting an idea of this type of listed site, to enable the consortium to develop tools more accurately aimed at this type of site.

Program:

Wednesday, 27 June 2012 – Interview with mrs. Kundu, environmental engineer of WBPCB, at MoEF office Delhi
Monday, 2th July 2012 – Site visit to Nibra and Hooghli, accompanied by Mrs. Kundu
Tuesday, 3rd July 2012 – Site Visit to Dhapa, accompanied by Mr. Bhaumik of WBPCB and meeting with Prof. B. Dutta, Chairman of WBPCB and other WBPCB officials working on the project.

Members of project team, visiting Kolkata:

Mrs. Dr. S. Sen	STC, Kolkata
Mr. R. Heijer	Grontmij, The Netherlands
Mr. P. Oude Boerrigter	Grontmij, The Netherlands
Mr. H. Rane	Technochem, Mumbai
Mr. D. Deshpande	Technochem, Mumbai

Results:

The project team gained insight in the specific situation of the three contaminated sites. With WBPCB the project team discussed on possibilities for remediation. Based on further analysis the project team will work on the Guidance document in next months.

The results of the meeting of July 3rd and the site visits have been reported in separate documents.

Apart from these documents the following points were discussed with Mrs. Kundu:

- Legal Aspects
  There is presently no mechanism to prevent construction at possibly contaminated sites like closed industrial sites. In case any application is received by the Board seeking clearance for construction of residential buildings on a known contaminated land, the WBPCB advises the builder/ promoter to get the site assessed prior to construction.
- The project site at Hooghly is covered over both public and private properties making a comprehensive remediation assessment difficult when the role of the private property owners is not defined and their cooperation cannot be ensured.
- Capacity WBCPB
  - The infrastructure is highly inadequate with only four staff members working on all Waste Management issues (hazardous, bio-medical, municipal, plastic and e-waste management all

aspects including technical, legal, policy and awareness generation).
- As no comprehensive guidance is present, all activities are carried out on the basis of personal insights.

- Scope of Methodology goals according to WBPCB
  - Both for WBPCB and consultants / contractors
  - Assessment of remediation goals (level of risk reduction required) – future land use at the contaminated site, distance from receptors, potential of new pathways being created, etc.
  Functional remediation options would meet local needs as long as it is backed up by a remediation policy.
  - What party is commissioned to choose the remediation option to be implemented? [assignment 3]
  - Integrated remediation approach for multiple equivalent sites with same contaminant .
  - The Guidance document should provide a method for 'getting sites off the list' i.e. – de-notification of contaminated sites and a tool / selection criteria for choosing site-specific remediation approach (remediation technology + communication strategy + social impact management)
  - Not to focus on only Cr remediation techniques but remediation techniques for a broader range of contaminants and taking into considerationslocal conditions (climate may have a role in the performance of various technologies especially those based on microbes).
  - the proposed focus of the Methodology meets the ideas of WBPCB
- Social
  - For land owners/ users, the value of properties is most often dominant over health issues *(due to non availability of land with same locational advantages)*. Thus it might be difficult to justify remediation needs where heath effects are not pronounced (immediate and severe). As remediation is dealing with health issues, in discussions with land users different issues are getting mixed up and gives a bias on the focus of remediation options. Rag pickers are deprived from their income due to a clean capping layer, there will be no support for such a remediation option
  - Only if a complete solution is given (livelihood) a remediation option is likely to be executed.
  Sustainability issues – regular maintenance and environmental monitoring of remediated land.
- Three following steps are important when approaching soil contamination: 1) environmental priority; 2) social aspects: in what way assessment and remediation are applicable? 3) choosing methodology
- Mrs. Kundu would be pleased to share WBPCB's experiences under the CBIPMP regarding tendering and bidding process for appointment of consultants for site assessment and drawing up remediation plans. This is of interest for the project team as part of the Guidance document, so we agreed to discuss this subject in future during another mission of the project team.

The information in this site visit report shows the state of affairs at the time of the visit. A request for more recent information has been made to WBPCB. This information will be incorporated in the project information as soon as it is received.

METHODOLOGIES FOR NPRPS INDIA

Site Visit Nibra Village, District Howrah, Kolkata, West Bengal, 2 July 2012

Inputs: West Bengal Pollution Control Board
Mrs. Sarmistha Kundu, Environmental Engineer

Site investigation report, 2005 by National Productivity Council (NPC),

Purpose of site visit:
For the project team working on Methodologies for the NPRPS under CBIPMP site visits are necessary to be able to develop a Guidance document for the remediation approach that fits with different types of contaminated sites, listed in India.

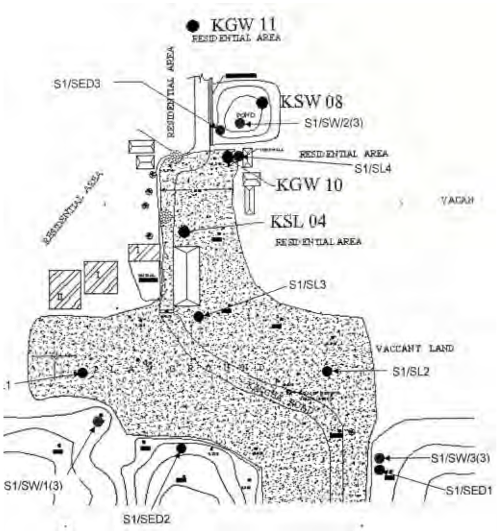
Review Points:

E. Location;
F. Type of Waste;
G. Size of site;
H. Present Status of site;
I. Owners;
J. Social Issues and other environmental aspects;
K. Earlier investigation of site

A. Location:
The Nibra village site is located in Howrah District a few kilometres after the Vidyasagar Setu (Vidyasagar Bridge) after crossing over the Hooghly River towards west of Kolkata.
The site is located outside municipal boundaries and is near a small village with hutments, approachable by a narrow road which ends into a playground. The small village is set further after the playground.

B. Type of waste:
WBPCB has identified the site as a Hazardous Solid Waste dumpsite as a large volume of Chromium Ore Processing Residue (COPR) was dumped by unknown agencies to fill-up the site area from the year 1998 to year 2000 (as reported by NPC).
The generators of the waste are unknown.

C. Size of site:
The site comprises of a field and a road leading to the village of total area approximately 0.73 Hectares as reported by NPC.



D. Present Status of site:

The site is a well levelled compacted ground, surfaced with some gravel. There are new buildings constructed on the site and in the village.

There are ponds nearby and people take bath in these ponds.

There is no visual evidence of hazardous waste at the site as the waste is fully covered under the soil and gravel material.

E. Owners:

Land owner is not known. Local village (Gram) Panchayat is the custodian of the public areas including the village approach road . The land use is not regulated and is decided by the land owners.

F. Social Issues and other environmental aspects:

Conversation with the villagers indicated that most are unaware of the presence of Hazardous waste in the soil where they have built their houses.

The village gets its drinking water from a bore well, dug deep, probably, through the waste dump within the village.

There are no known issues with the health of the villagers.

G. Earlier investigation of the site:

Site investigation was carried out in the year 2005 by the National Productivity Council (NPC), New Delhi and the investigation report was submitted to WBPCB in the year 2006.

Some features of the report are as below:

Surface Water- Hooghly River flows on the eastern side of the Howrah District.

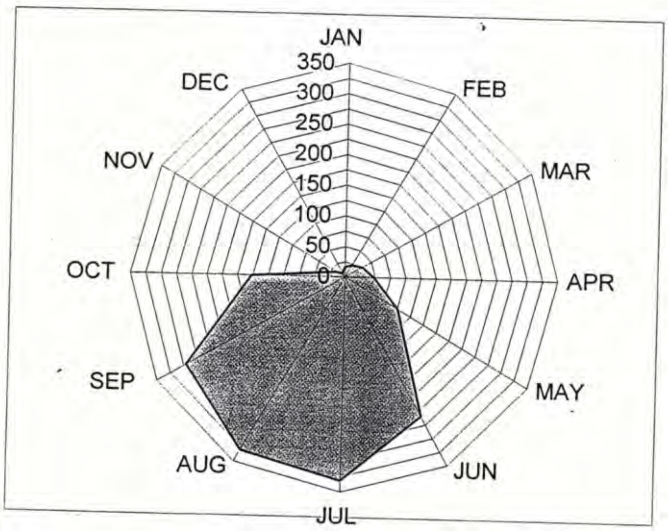
Groundwater- Groundwater table in the district is generally high between 2m below surface post monsoon to 4m premonsoon.

Geology- The lithological exploration has been done by Central Ground Water Board near the site which is as follows:-

Depth of formation starting at ground level (m)	Lithology
4.57	Clay, yellowish gray
17,68	Clay, gray hard
27.73	Clay, gray
43.89	Sand, fine, yellowish gray
22.25	Sand, grayish white fine/ medium to coarse
24.79	Sand, medium to coarse grayish white
13.92	Clay, gray
25.61	Sand, fine grayish white
12.8	Sand, grayish white medium
10.97	Clay, gray
9.15	Sand, Fine grayish white
3.64	Clay, gray
33.54	Sand, coarse, grayish white
14.63	Clay, dark gray
30.48	Sand, fine, grayish white
9.75	Clay, gray, silty

(Source: Report on selection of Tubewell site for FCI at Dankuni, Hoogli District, Central Ground Water Board, Eastern Region, July 1988)

Monthly Rainfall in mm in Kolkata region as recorded by Kolkata Meteorological Centre is as below:



Characteristics of waste as reported by NPC is as below:

pH	Cd	Cu	Pb	Ni	Cr (T)	Cr (vi)	Zn
Total Concentration (in mg/kg on Dry Weight Basis)							
--	BDL	10.6 – 12.2	11.4 – 12.2	955.3 – 976.2	27120 – 55509.7	988 – 1956.3	174.8 – 213.8
Parameters in TCLP, mg/l							
--	0.14 – 0.19	0.51 – 0.67	1.47 – 1.87	3.72 - 36.49	46 – 775.8	698.49	10.56 – 12.34
Parameters in 1:10 water eluate, mg/l							
10.7 - 12.5	BDL	BDL – 0.004	BDL	0.011 - 0.021	46 - 260	2 – 255.41	0.039 - 0.044

Total contaminants in soil are as below:

Sample Codes	Parameters in mg/kg on dry weight basis						
	Cd	Pb	Zn	Cu	Cr(T)	Ni	Cr(vi)
KSL-04	BDL	10.8	64.1	25.5	32	24.7	6.6
S1/SL1/1(4)	BDL - 0.7	33.6 - 36	74 – 96.6	55.7 - 78	42.2 - 46	37 – 39.3	BDL – 1.5
S1/SL1/2(4)	BDL	27 - 31	82 – 86.2	42.8 - 61	37.8 - 55	32.3 - 52	BDL – 1.3
S1/SL1/3(4)	BDL	13 – 34.5	51 – 58.3	27.2 - 40	31 – 36.2	20 - 27	BDL – 5.5
S1/SL1/4(4)	BDL	7.8 – 24.3	27 – 60.6	15 – 35.4	24 – 31.14	12 – 25.3	BDL – 0.54
S1/SL2/1(4)	BDL - 0.8	27.8 - 30	76 - 79	44.1 - 79	33 - 38	36	BDL – 1.25
S1/SL2/2(4)	BDL	37 - 57.7	80	57 – 66.14	39.15 - 55	32 - 43	BDL - 0.48
S1/SL2/3(4)	BDL	11 – 16.8	42.2 - 47	13.6 - 34	12 – 21.3	15.8 - 20	BDL – 0.64
S1/SL2/4(4)	BDL	6 – 36.51	30	17 – 49.94	10 – 40.13	10 – 34.85	BDL – 0.28
S1/SL3/1(4)	BDL	25 – 28.5	67.1 - 76	27.6 - 60	41.2 - 68	24.54 - 48	7 - 8.9
S1/SL3/2(4)	BDL	30.4 – 41	59 – 83.55	42.53 - 66	44.6 - 64	37.21 - 53	BDL – 9.5
S1/SL3/3(4)	BDL	8 – 22.15	37 – 62.34	30 – 31.5	23 – 36.84	21 – 27.74	BDL – 16.3
S1/SL3/4(4)	BDL	7 – 34.3	13 – 105.6	14 – 55.3	18 – 47.42	13 – 43.9	BDL – 2.55
S1/SL4/1(4)	BDL	28.13 - 41	81 – 88.6	36.88 - 110	34.1 - 54	29.05 - 55	BDL – 0.83
S1/SL4/2(4)	BDL	31.45 - 37	68 – 102.7	42.11- 49	40.25-52	32.69 - 35	BDL – 1.03
S1/SL4/3(4)	BDL	9 – 34.81	37 – 120.3	24 – 52.5	16 – 53.61	19 – 48.2	BDL – 0.33
S1/SL4/4(4)	BDL	5 – 37.86	22 – 100.6	19 – 54.05	12 – 39.2	6 – 36.1	BDL – 0.92

Leachable contaminants in soil are:

Sample Code	Parameters in TCLP, mg/l						
	Pb	Zn	Cu	Cr(T)	Ni	Cd	Cr(vi)
KSL-04	0.8	7.9	2.36	13.66	1.4	0.06	--
S1/SL1/1(4)	0.2	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL1/2(4)	BDL – 0.53	BDL – 12.5	BDL	BDL	BDL	BDL	BDL
S1/SL1/3(4)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL1/4(4)	BDL – 0.3	BDL – 12.8	BDL	BDL	BDL	BDL	BDL
S1/SL2/1(4)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL2/2(4)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL2/3(4)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL2/4(4)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL3/1(4)	0.3	BDL	BDL	0.3	BDL	BDL	BDL
S1/SL3/2(4)	0.1 – 0.13	BDL – 10.24	BDL	0.1 – 4.86	BDL	BDL	0.502
S1/SL3/3(4)	BDL	BDL	BDL	0.06	BDL	BDL	BDL
S1/SL3/4(4)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL4/1(4)	BDL – 0.4	0.04 – 11.12	BDL - 0.01	BDL	BDL	BDL	BDL
S1/SL4/2(4)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL4/3(4)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL4/4(4)	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Water soluble contaminants are:

Sample Code	Parameters in 1:10 water eluate, mg/l							
	PH	Pb	Zn	Cu	Cr(T)	Ni	Cd	Cr (VI)
KSL-04	8.1	BDL	0.05	BDL	0.28	0.01	BDL	0.12
S1/SL1/1(4)	7.21 - 8.4	BDL – 0.01	0.01 – 0.28	BDL -	BDL	BDL -0.04	BDL	BDL
S1/SL1/2(4)	7.31 - 8.4	BDL	0.02 – 0.36	BDL	BDL	BDL	BDL	BDL
S1/SL1/3(4)	7.7 - 8.9	BDL	BDL – 0.45	BDL	BDL – 1.43	BDL	BDL	BDL–1.27
S1/SL1/4(4)	7.5 - 8.3	BDL – 0.06	BDL – 0.28	BDL	BDL	BDL – 2.6	BDL	BDL
S1/SL2/1(4)	7.9 -9.0	BDL	0.01 – 1.26	BDL	BDL	BDL	BDL	BDL
S1/SL2/2(4)	8.04 -9.4	BDL	0.01 – 0.93	BDL	BDL	BDL	BDL	BDL
S1/SL2/3(4)	7.81 - 9.9	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SL2/4(4)	7.8 - 9.1	BDL – 0.07	BDL – 0.75	BDL	BDL	BDL	BDL	BDL
S1/SL3/1(4)	7.7 - 9.3	BDL – 0.083	0.02 – 1.14	BDL	0.68 - 4.82	BDL	BDL	0.60–4.68
S1/SL3/2(4)	7.67 - 9.4	BDL – 0.049	BDL - 0.99	BDL	0.02 – 4.31	BDL	BDL	BDL–4.12
S1/SL3/3(4)	7.83 - 9.4	BDL	BDL – 0.75	BDL	BDL – 2.95	BDL – 2.68	BDL	BDL–2.85
S1/SL3/4(4)	7.83 - 9.9	BDL – 0.01	BDL – 2.53	BDL	BDL	BDL	BDL	BDL
S1/SL4/1(4)	7.4 - 9.0	BDL – 0.039	0.21 – 2.0	BDL - 0.10	BDL - 0.11	BDL - 0.10	BDL	BDL-0.10
S1/SL4/2(4)	7.86 - 9.6	BDL - 0.01	0.02 – 1.12	BDL - 0.04	BDL - 0.08	BDL - 0.02	BDL	BDL
S1/SL4/3(4)	7.86 - 9.5	BDL - 0.205	BDL – 1.15	BDL - 0.01	BDL	BDL	BDL	BDL
S1/SL4/4(4)	7.78 - 9.4	BDL - 0.045	BDL – 1.52	BDL	BDL	BDL – 3.4	BDL	BDL

The reported results on groundwater and surface water are:

Sample codes	pH	Cl-	SO_4	As	Cd	Cu	Pb	Cr (T)	Cr(6)	Ni	Zn	Fe
Surface Water												
KSW08	7.43	92.31	8.51	BDL	BDL	BDL	0.03	BDL	BDL	BDL	BDL	0.48
SW/1(3)	7.84	NA	NA	BDL – 0.003	BDL	BDL – 0.01	BDL	BDL	BDL	BDL – 0.02	BDL – 0.02	BDL – 1.88
SW/1(3)	8.14	NA	NA	BDL – 0.001	BDL	BDL – 0.01	BDL	BDL	BDL	BDL	BDL – 0.01	BDL – 0.17
SW/1(3)	7.85	NA	NA	BDL – 0.002	BDL	BDL – 0.01	BDL	BDL	BDL	BDL	BDL – 0.01	BDL – 0.10
Ground Water												
KGW10	7.38	287.8	12.44	BDL	BDL	BDL	0.006	BDL	BDL	BDL	BDL	0.86
KGW11	7.28	416.9	16.67	BDL	BDL	BDL	0.004	BDL	BDL	BDL	0.10	1.07

(*) All the parameters are in mg/l except pH; NA = Not analyzed

Sediment analysis of surface water was carried out and the results reported for water soluble sediments are:

Sample codes	pH	Cl-	SO_4	As	Cd	Cu	Pb	Cr (T)	Cr(6)	Ni	Zn	Fe
Surface Water												
KSW08	7.43	92.31	8.51	BDL	BDL	BDL	0.03	BDL	BDL	BDL	BDL	0.48
SW/1(3)	7.84	NA	NA	BDL – 0.003	BDL	BDL – 0.01	BDL	BDL	BDL	BDL – 0.02	BDL – 0.02	BDL – 1.88
SW/1(3)	8.14	NA	NA	BDL – 0.001	BDL	BDL – 0.01	BDL	BDL	BDL	BDL	BDL – 0.01	BDL – 0.17
SW/1(3)	7.85	NA	NA	BDL – 0.002	BDL	BDL – 0.01	BDL	BDL	BDL	BDL	BDL – 0.01	BDL – 0.10
Ground Water												
KGW10	7.38	287.8	12.44	BDL	BDL	BDL	0.006	BDL	BDL	BDL	BDL	0.86
KGW11	7.28	416.9	16.67	BDL	BDL	BDL	0.004	BDL	BDL	BDL	0.10	1.07

(*) All the parameters are in mg/l except pH; NA = Not analyzed

Results of leachable sediments are:

Sample Code	Parameters in TCLP, mg/l						
	Cr(VI)	Cr(T)	Cu	Ni	Pb	Zn	Cd
S1/SED(1)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SED(2)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S1/SED(3)	BDL	BDL	BDL	BDL	BDL	4.99	BDL
S1/SED(1)	BDL	80.36	26.02	17.94	23.69	69.85	BDL
S1/SED(2)	BDL	50.85	149.54	14.02	19.59	54.12	BDL
S1/SED(3)	BDL	1145.22	50.42	30.05	38.23	144.37	1.22

The impact of waste disposal on surface water and ground water is pictured schematically below:

Conclusions:

The project team gained useful information for this type of contaminated sites near to residential areas where waste material is used for land levelling and road construction purposes. Some tentative options for the management of such sites were discussed during the site visit with Mrs. Kundu. Technical as well as social aspects were part of this discussion.

The information in this site visit report shows the state of affairs at the time of the visit. A request for more recent information has been made to WBPCB. This information will be incorporated in the project information as soon as it is received.

Site Visit Hooghly area, District Hooghly, West Bengal, 2 July 2012

Inputs: West Bengal Pollution Control Board
Mrs. Sarmishta Kundu, Environmental Engineer
Site investigation report, 2006 by National Productivity Council (NPC),

Purpose of site visit:
For the project team working on Methodologies for the NPRPS under CBIPMP site visits are necessary to be able to develop a Guidance document for the contaminated site assessment and remediation approach that fits with different type of contaminated sites.

Review Points:

L. Location;
M. Type of Waste;
N. Size and present status of site;
O. Owners;
P. Social Issues and other environmental aspects;
Q. Present assessment.

H. Location:
Alongside the road leading from Kolkata to Delhi in Hooghly district the area has varied users: residential area as well as industrial area (agricultural use also). There are some very large industrial sites. Few of the sites are closed.
In 2006 a report of National Productivity Council reported 7 contaminated sites in the area along an approximately 15 km stretch of the road (presently State Highway 13) from Kolkata to Delhi. At these 7 sites residues of chromium ore processing were found. The State Highway is situated about 1-2 meters above the adjacent area. Next to the road there are water bodies (ponds), maybe artificially made when material was excavated for construction of the road (highway).
We visited two sites with numbers 3 and 4 according to the NPC report. Site 3: Delhi Road, near Shivang Trexium Pvt. Ltd (now renamed Fortune Furnitech) & Shree Balaji Veneers Pvt. Ltd, Netaji More, Dist. Hooghly. Site 4: Delhi Road (100 m from Netaji More), Near Minu Weighbridge and Dhaba, Dist. Hooghly.

I. Type of waste:
The contamination has taken place due to use of waste material of Chromium Ore Processing Residue (COPR) as construction material (most probably between 1995 and 2005) to raise the ground level for infrastructure and buildings and to get a good connection between the residential and industrial premises and the high lying State Highway. The waste material was produced by many chrome chemical manufacturing industries in Hooghly district that already stopped production years ago. In Hooghly district only one chromium ore processing industry is still present and this unit disposes hazardous wastes to the authorized HWTSDF in the state.

J. Size and present status of site:
Site number 3: the approach roads leading to two industries have been made up of chrome waste with a possibility of other waste types having been used in the lower layers. Detailed underground investigations are expected to throw light on the exact scenario. The roads are now capped with asphalt. One hand pump and an open well is located just adjacent to the dumpsite. There are several ditches filled up with water adjacent to it. We visited the area of one of these industrial sites, engaged in furniture making.. Behind the gate of the industrial premises the soil

is partly covered with granular material of different size and origin. At some spots the surface had a yellow colour. Near the surface the walls of some of the buildings had yellow-green spots. According to the NPC report the area is about 0.2 ha (industrial land not included) and the depth of the waste material and contaminated soil is 3 meters with an assumed quantity of 6,000 m^3 (see figure 4.7 of NPC-report, 2006). Then measured Total Chromium concentration of the waste material was about 16,000 mg/kg dry weight of which maximum of 3,300 mg/kg with Chromium VI. In the surrounding soil contamination with Chromium was found. In surface water and groundwater, contamination was within limits of Drinking Water Standards.

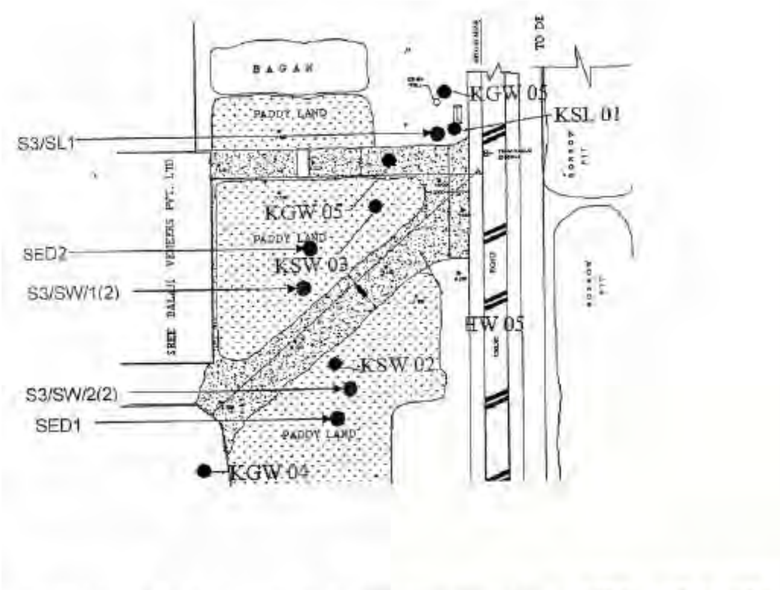
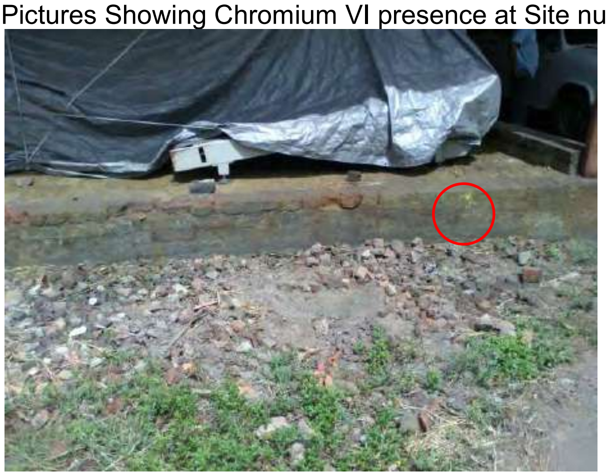


Figure-4.5: Site map & location of soil (KSL), ground water (KGW), surface water (KSW) and sediment (SED) sampling points

Pictures Showing Chromium VI presence at Site number 3 & surrounding at Site number 3



Site number 4 is an access road leading to some houses and the Minu Computer Weighbridge. Comparing the situation with the map of the 2006 report it is clear that these houses have been built on the spot at a later date. Near the surface the white walls of the residential buildings are green-yellow coloured, so it is estimated the waste material is still laying below the houses. Alongside the access road, at the slope to the pond other construction material (broken pottery) is situated there.
According to the NPC report the area is 0.17 ha and the depth of the waste material is 0.5-3 meters with an assumed quantity of 2,000 m^3 (see figure 4.7 of NPC-report, 2006). Then measured Total Chromium concentration of the waste material was about 26,000 mg/kg dry weight of which maximum of 2,600 mg/kg with Chromium VI. In the surrounding soil contamination with chromium was found. In surface water and groundwater contamination were found below limits of Drinking Water Standards.

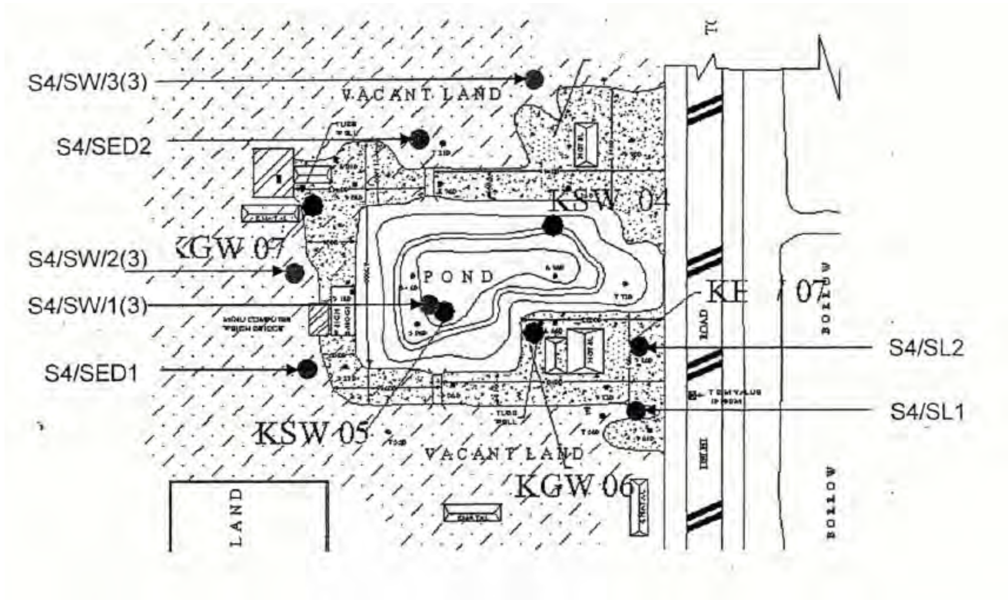


Figure-4.7: Site map & location of soil (KSL), ground water (KGW), surface water (KSW) and sediment (SED) sampling points

Pictures Showing Pond at Site number 4 and Chromium VI waste now covered with soil

K. Owners:

Site number 3 is a small access road leading to an industrial site, nowadays making wooden articles. The access road is built on PWD land but the industrial land is privately owned. Mrs. Kundu explained that she expects the owner still does not know his site is probably contaminated but in future after the detailed investigations are completed, WBPCB will need to inform him to ensure necessary clean-up.

The area in front of the contaminated site number 4 is owned by PWD but the residential houses and the weighbridge are private properties.

L. Social Issues and other environmental aspects:

On site number 4 houses have been built. It is not known at this moment if people have knowledge of the soil contamination of their premises. Workers engaged in the industries and weighbridge are constantly exposed to the chromium waste through skin contact, inhalation and possible ingestion. Vehicles using the weighbridge are spreading the contamination as the loose waste road-fill is being carried over by the wheels and also causes resuspension of the waste dust leading to air pollution. During the rains, the waste gets carried to other areas including nearby agricultural land and surface water bodies along with surface run-off.

There appears to be a clear preference for such industrial wastes for road construction and land-filling in the said area. A large number of potentially contaminated spots have already been identified and recent instances of such landfilling have also been detected by the WBPCB. The

general ignorance of people, including the administration, is an important social aspect of the project. Such widespread use of industrial waste will eventually raise social costs and influence choice of remediation technology in case serious health impacts are predicted through detailed assessments.
Use of industrial waste to build access roads over public land and obstruction of drainage canals is also a matter of public concern. It is fairly clear that the number of industries in the area is increasing fast and there is an obvious tendency in the region for conversion of farm land to industrial land. Industrial infrastructure development, drainage and sewerage issues, access/service road development etc. are allied social and environmental needs.
With the above context, it is necessary to assess the social cost and cost of suitable remedial measures of the sites. The social cost may significantly increase if remediation measures require relocation of habitation and industries.
Planning for infrastructure and specific roles and responsibilities of the institutions (line govt. departments) should be addressed to reduce social cost.
Documentation of the health hazards is necessary to prioritize the need for remediation.
Govt. policy is required to regulate land use pattern.

M. Present assessment:
Site assessment is currently being carried out by ERM using several techniques e.g. Vertical Electrical Sounding (survey coverage thickness), techniques as XRF (pre screening in field before selecting lab samples) and classical sampling and lab testing. The lab testing is carried out in a third party laboratory, approved by the government (to meet requirements of legal procedures). The WBPCB lab is well equipped but not adequately staffed to handle the large number of samples and test the extremely broad range of specific contaminants. Samples are being analysed on 50 parameters as the heterogeneous waste may contain several sources and thus several contaminants. The consultant has till now identified 27 potential Chromium contaminated sites (hot-spots) spread over 18 sq. km. along the road through XRF screening. Detailed investigations will help in establishing the level and extent (spread) of contamination.

A site assessment should meet an integrated approach among which the complete source-pathway-receptor. A broad range of data is needed. Much data is already available, e.g. geohydrological data can be gained from the Central Groundwater Board.
WBPCB archives will not cover all permits for HW producing industries as the PCB is founded in 1976 and initially was focused on other environmental issues (Water Act- 1976, Air Act- 1981). Hazardous Waste Rules were notified only in 1989.

Conclusions:
The project team gained useful information for this type of contaminated sites near to industrial and residential areas where waste material is used for construction purposes. Some tentative options for the management of such sites were discussed during the site visit with Mrs. Kundu. Technical as well as social aspects were part of this discussion.

The information in this site visit report shows the state of affairs at the time of the visit. A request for more recent information has been made to WBPCB. This information will be incorporated in the project information as soon as it is received.

METHODOLOGIES FOR NPRPS INDIA

Site Visit Dhapa, Kolkata, West Bengal, 3 July 2012

Inputs: Mr. Debajyoti Bhaumik, Project Engineer (MSW), CBIPMP
West Bengal Pollution Control Board
Mr. Mehul Petkar, Assistant Consultant
Kadam Environmental Consultants, Vadodara Partner to CAT alliance Ltd.

On the instance of World Bank during the TEP Workshop in Delhi on 28 June 2012, the Dhapa Municipal Waste Dump site in Kolkata was visited by the project team on 3 July 2012. The site is under the World Bank CBIPM Project and is under remediation on pilot basis. It is anticipated that the project will result in significant environmental benefits i.e. improvement in water and air quality, improved hygienic conditions, health benefits such as reduction in water borne, vector borne diseases and economic benefits i.e. employment generation during rehabilitation and remediation.
For the project team working on Methodologies for the NPRPS under CBIPMP site visits are necessary to be able to develop a Guidance document for the remediation approach that fits with the different types of contaminated sites, listed in India.

The Dhapa site is Kolkata Municipal Corporation's (KMC) Municipal Solid Waste Old landfill site located about 10 km south-east of Kolkata city.
Total area of landfill site is 12.500 Hectares. The disposal site is shaped long and thin from west to east with a size approximately of 150 m by 2,000 m. The depth of the waste dump is approximately 29m.

In compliance with the East Kolkata Wetland Management Plan the site is identified for closure and rehabilitation. The post rehabilitation land use has been defined by the East Kolkata Wetland Act which prohibits any commercial developments.
The site contains unsegregated waste, including organic waste, debris and some recyclable refuse. Surface and ground water is contaminated by the leachate from the dump site reaching the nearby water bodies.

The remediation plan envisages capping of the disposal site and capture of land fill gas. The site remediation/rehabilitation plan is designed to mitigate health hazards from toxic pollution, which poses risks to community and ecology (especially humans and animals that come into direct contact with the waste); reduce water and soil contamination in the land surrounding the site, which is used for small farming.
Remediation also would improve the aesthetic appearance of the natural area, help eliminating the nuisance of flies and other insects that breed intensively on the site, and very likely lower the incidence of environment-related disease.

The proposed plan to close and reclaim the waste dump site is also expected to result in potential cost-savings with decreased levels of pollution in soil, potential cost savings with decreased health budget from lower incidence of environment-related disease.
Improvement/better management of the site would make it easier to set up transportation facilities and roadside amenities, which would generate income.

A social assessment has identified dangers posed to public safety from toxic waste at the contaminated sites, including health hazards due to open dumps and unmanaged/inadequate solid waste collection, dumping, and treatment services. 700 rag-pickers derive their livelihoods collecting waste at the Dhapa MSW sites and will lose their income upon closure of the sites.
There is pollution of the ambient environment due to burning of solid waste (air pollution) and

contamination of water sources. There is also degradation of natural and cultural resources and lack of attention to their preservation. There is child labour, particularly at the dumpsites.

The site is presently being monitored for waste composition, metal contaminants, hydrogeology, groundwater contamination etc. by an agency assigned by WBPCB for the CBIPM Project. Therefore this agency is making bore holes to depths of about 50 meters. Groundwater samples will be investigated on various parameters in a laboratory. Also samples of soil and surface water will be investigated.
In the soil from 0 to 47 meters below surface the soil mainly consists of clay. From 47 to 60 meters sandy layers are present.
There is also a Fertiliser Manufacturing Factory as well as the Municipal Crematorium near the Dumpsite.

Conclusion site visit:
Although the Dhapa site is a specific waste management site that is not on the CPCB-list of hazardous waste contaminated dump sites, the project team gained useful information on this type of contaminated sites where municipal waste potentially contains hazardous waste as well. Some tentative options for the management of such sites were discussed with Mr. Bhaumik during the site visit.

7.4 Annexure 4 Overview of the sites analyzed using the standard site factsheet

The following sites have been analyzed using the standard site factsheets.

- GPCB 000-002 Unknown Industries, Valad, Gujarat
- GPCB 001-001 Hema-II, Vadodara, Gujarat
- KSPCB 002-003 Insecticide Company, Eloor, Kerala
- MPPCB 000-004 Vitamin Company, Ratlam, Madhya Pradesh
- MPPCB 003-004 Chemical Company, Ratlam, Madhya Pradesh
- OSPCB 004-006 Chemical Company, Ganjam, Orissa
- OSPCB 005-009 Chemical Company, Talchar, Orissa
- OSPCB 006-010 Chemical Company, Sundargarh, Orissa
- OSPCB 013-012 Fertilizer Company, Mayurbanj, Orissa
- PSPCB 014-013 Humbran Road, Ludhiana, Punjab
- RSPCB 007-016 Chemical Company and other, Bichhadi, Rajastan
- TNPCB 008-018 Chemical Company, Ranipet, Tamil Nadu
- TNPCB 015-017 Chemical Company, Kodaikanal, Tamil Nadu
- UPSPCB 09-019 Pesticide Company, Lucknow, Uttar Pradesh
- UPSPCB 010-021 Chemical Waste site, Kanpur, Uttar Pradesh
- UPSPCB 011-0023 Chemical Waste site, Kanpur, Uttar Pradesh
- WBPCB 012-024 Nibra Village, West Bengal

Annexure 4a, presented in a separate annexure report to this report, contains the site fact-sheets on these sites.

7.5 Annexure 5 References

Literature

- Persistent Organic Pollutants: Contaminated Site Investigation and Management Toolkit (UNIDO, 2009);
- Alberta Canada User Guide for Waste Managers Part 1 to 4 (1995).
- Management, Handling and Transboundary Movement Rules, 2008.

Lists of contaminated sites

- CPCB (reference not specified) - List of 12 priority contaminated dump sites (Annexure 6);
- CPCB (reference not specified) - List of 25 hazardous waste dump sites (Annexure 7);
- Blacksmith Institute, 2007a - Polluted Sites - India;
- Blacksmith Institute, 2007b - A compilation of polluted places India; Initial site assessment reports', supported by the Asian Development Bank (ADB) Under the Poverty & Environment Program;
- Blacksmith Institute, dynamic source through internet, referenced September 2012 - Toxic Sites Identification Program, Global Database (http://www.dbisa.org/isa/in/). Accessed through login with the kind permission of the Blacksmith Institute.

7.6 Annexure 6 CPCB List of 12 priority contaminated dump sites

A reference to the CPCB List of 12 priority contaminated dump sites could not be located.

CHAPTER - 1

1.0 Background

There are several contaminated dump sites in various parts of India where hazardous wastes was dumped by various industrial units, which resulted in contamination of soil and groundwater thereby posing severe health and environmental risks. These contaminated dump sites needs to be remediated on priority and restored in an environmentally sound manner through appropriate remediation technologies, to safeguard human health and environmental safety. This note contains an implementation methodology along with the institutional and legal frame work for remediation of hazardous waste contaminated dump sites through engagement of technologically and financially competent entities having techno-economical viable solutions.

An initial inventory of such illegal hazardous waste dump sites in the country has been prepared by the Supreme Court Monitoring Committee (constituted by the Hon'ble Supreme Court of India in the matter of Writ Petition (Civil) No. 657 of 1995), is perhaps a first compilation of such sites in India. Central Pollution Control Board (CPCB) has further updated the list of such sites as per information received from SPCBs/PCCs, the list of such sites having preliminary information is Table-1 below. The details of the above illegal hazardous waste sites are given in Annexure-1.

Table-1: Hazardous Waste Contaminated Dump Sites

State	Current Number of Sites
Andhra Pradesh	-
Assam	-
Delhi	21
Gujarat	2
Karnataka	-
Kerala	4
Madhya Pradesh	4
Maharashtra	-
Orissa	21
Punjab	5
Rajasthan	1
Tamil Nadu	2
Uttar Pradesh	5
West Bengal	8
Total	73

The list of contaminated sites identified by SPCBs having preliminary information/data on the type of waste dumped and nature of contamination is given at Annexure-I. Based on the quantum of waste dumped, extent of groundwater/soil contamination, nature of pollutants, ecological and health impacts, the following 12 contaminated sites (Table – 2) may be designated as priority contaminated dump sites in the country, which require immediate attention.

The priority of sites is arrived based on the following criteria:

a. Constituents of contamination (inorganic salts < toxic metals < POPs)
b. Ground water contamination (exceeding drinking water norms)
c. Affected population, flora / fauna
d. Health & Ecological impacts

Priority Hazardous Waste Contaminated Dump Sites

S.No	State	Name of the Site	Nature of Contaminant	Preliminary details
1	Gujarat	Vadodara	Chromium	Apprx. 77000 tonnes of chromium residue is dumped in industrial plot. Groundwater is contaminated.
2	Kerala	Eloor, Cochin	Heavy metal and POPs	24.5 hectares of soil and water bodies contaminated with Pesticides and heavy metals in 4 locations.
3	Madhya Pradesh	Ratlam	Gypsum, iron salts and Naphthalene	Severe contamination of ground water with PAH and Iron salts imparting red colour
4	Orissa	Ganjam	Mercury	About 56,000 MT of sludge containing mercury dumped along and near the banks of the river Rishikalya.
5	Orissa	Talcher	Chromium	60000 tonnes of chromium leach residue is dumped in closed industry premises. Contamination of soil, and surface water bodies during rains.
6	Orissa	Sundergarh	Chromium	Chromium leach residue dumps at 4 locations.
7	Rajasthan	Bichhadi	Inorganic salts, organics	Contamination of soil and groundwater.
8	Tamil Nadu	Ranipet	Chromium	Hexavalent Cr leaching from 7.41 acre dumpsite, with 2.2 lakh MT of leach residue. Soil and groundwater and surface water contamination.
9	Uttar Pradesh	Rakhimandi, Kanpur	Chromium	Approx. 10000 tonnes of residue dump in approx. 5-6 acres. Owners not known. Population effected, groundwater contaminated
10	Uttar Pradesh	Rania, Kanpur Dehat	Chromium	Area 2 sq. km. Private land is contaminated with open dump of Apprx. 45000 tonnes of waste
11	Uttar Pradesh	Lucknow	HCH (hexa chloro cyclo hexane)	Apprx. 36432 tonnes of pesticides waste dumped in closed industry premises
12	West Bengal	Nibra Village, Howrah	Chromium	About 4440 tonnes of residue dumped, human settlement exists above the dump, contamination of groundwater

7.7 Annexure 7 CPCB - List of 25 hazardous waste dump sites

A reference to the CPCB List of 25 hazardous waste dump sites could not be located.

Inderjit

ANNEXURE

Andhra Pradesh

APPCB (Andhra Pradesh Pollution Control Board) entrusted a project to EPTRI (Environment Protection Training and Research Institute), Hyderabad for identification of illegal hazardous waste dump sites in Andhra Pradesh in the year 1999. From the identified sites, about 24,000 tonnes of the illegally dumped hazardous solid waste was lifted and disposed in TSDF (Treatment, Storage, Disposal Facility) established by HWMP (Hyderabad Waste Management Project) at Dundigal, R.R. District in 2001.

APPCB has further identified 16 nos. of isolated illegal dumps from 2001 to 2009. About 4095 tons of the hazardous waste dumped in the above 16 sites was transported to TSDF and the identified offenders were made to pay the disposal charges to TSDF. The analysis reports of random soil samples collected from these sites, indicated that the soil at these sites is not contaminated.

5 fresh dump sites have been further identified having traces of hazardous wastes. The central laboratory, APPCB is carrying out the quantification and characterisation of these dump sites for taking further action.

Assam

PCBA (Pollution Control Board, Assam) has reported 92 nos. of hazardous waste dumpsites within 9 industrial units. However, all these dumpsites are apparently pits/lagoons/secured landfill/bio-remediation sites and are located within the premises of industries, which are operational. These sites are existing in the following industries

- Hindustan Paper Corporation Ltd, Nagaon Paper Mill, Morigaon,
- Hindustan Paper Corporation Ltd., Cachar Paper Mill, Panchgram, Hailakandi
- Numaligarh Refinery Ltd., Golaghat
- Indian Oil Corporation Ltd., Noonmati, Guwahati
- Indian Oil Corporation Ltd., Digboi Refinery, Digboi, Tinsukia
- Brahmaputra Valley Fertilizer Corporation Ltd., (BVFCL) Namrup
- Indian Oil Corporation Ltd. Bongaigaon Refinery, Dhaligaon,
- Oil India Ltd., Duliajan
- Oil & Natural Gas Corporation Ltd., Nazira

Delhi

DPCC (Delhi Pollution Control Committee) had engaged Ramky Infra Consulting Pvt. Ltd., for study and preparation of report for 'Inventory of Hazardous Waste Generation by Industrial Units in Delhi', who has reported 23 illegal hazardous waste dump sites in Delhi in their report submitted to DPCC.

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CPCB constituted Expert Committee visited three illegal hazardous waste dump sites on 24-11-2009, and observed the presence of industrial waste, which is also mixed with municipal solid waste. The Expert Committee recommended carrying out analysis of the industrial wastes laying at all the 23 sites and depending upon the waste characteristics after the analysis report, the mode of disposal and remediation plan shall be worked out and executed by DPCC. Immediate fencing of the sites was also suggested to stop further illegal dumping of the waste.

Gujarat

GPCB (Gujarat Pollution Control Board) as a part of action plan for the years 2000-01 and 2001-02 has reportedly contained about 6 MMT of waste at 5 locations. Lifting and shifting of 0.025 MMT of waste consisting iron waste, gypsum waste, carbon waste, old chromium waste, tarry waste, ETP sludge and chalk had been carried out from total 77 locations. Fresh inventory was undertaken as per Honorable Supreme Court order and 22 dump sites were identified. About 34,000 tonnes of waste was lifted and shifted to TSDF from around 15 sites at approximate cost of ` 1.43 crores. This was accomplished on the basis of identification of probable culprits, co-operation of TSDF authorities, industrial associations and enforcement of the principle of "Polluter Pays".

Illegal hazardous waste from 4 of the remaining 6 sites, have been lifted and shifted to TSDF. The remaining two sites i.e. one site at Valad, Dist. Gandhinagar has been taken up by the World Bank for detailed assessment and remediation in consultation with MoEF (Ministry of Environment & Forests). The consultants appointed by the MoEF under WB (World Bank) scheme have started their study.

GPCB has prepared final report of the rehabilitation plan pertaining to the site of Hema chemicals (Unit-II), Vadodara (one of the remaining seven sites that requires remediation), which is contaminated with chromium (VI).

Karnataka

The KSPCB (Karnataka State Pollution Control Board) identified two sites for rehabilitation i.e. dump site located at Bommasandra Industrial Area, Bangalore and Koratagere Taluk, Dist. Tumkur. The GTZ (German Technical Cooperation), with whom the Board has technical co-operation, carried out the study of Bommasandra area and prepared a report. As per the report, 85% of the waste is non-hazardous and remaining 15% is hazardous (only 1% is toxic). KSPCB is of the view that Bommasandra dump site is not considered as a serious threat to the environment and requires no immediate remediation. The waste from the Tumkur site was removed from the site and disposed in TSDF established at Dabaspet for landfilling. KSPCB has spent Rs. sixteen lakhs forty thousand of its own funds for the remediation of the waste dump.

Kerala

Kerala State Pollution Control Board has identified four dump/contaminated sites. The Kuzikandom thodu and Ammenthuruth sites in Kerala are contaminated with heavy metals and POP (Persistent Organic Pollutants). The other two sites i.e. Edayattuchal and Chakkarchal having total size of 30000 sq. m and 15500 sq. m respectively and are contaminated with having heavy metals and mixed waste respectively.

Industries such as Fertilizers and Chemicals Travancore Ltd., - Udyogamandalam division, Hindustan Insecticides Ltd., Indian Rare Earths Ltd and Merchem have dumped their solid wastes in low lying areas within their premises. The Leachate/spill-over from these wastes has reached the Kozhikandom thodu. The sediments collected from Kuzhikandom thodu contain hazardous constituents of wastes from the above units. The leachate and spill over from wastes of these units have also reached the nearby paddy fields like Ammanthuruthu and Karipadam, making those unsuitable for cultivation, which are now in abandoned condition. Binani Zinc Ltd has dumped their solid wastes along with jarosite in their premises in early days and the leachate has reached the nearby paddy fields like Edayattuchal and Chakkarchal.

Madhya Pradesh

The 6 dump sites identified by the MPPCB (Madhya Pradesh Pollution Control Board) pertaining to 4 closed industries namely Sajjan Chemicals, Ratlam (responsible for 3 dump sites), Bordia Chemicals, Ratlam, Jayant Vitamins Ltd., Ratlam, Beta Naphtol, Maksi).

Results of random monitoring of Ratlam region revealed surface & sub-surface (30 cm) soil within the premises of these industries were found to be contaminated with organics such as Naphthalene, Binaphthyle Sulfone, 1,2 Nephthylemethylene etc. Evidence of contaminants in the adjoining land parcels was found during preliminary examination.

Results of the analysis of Maksi region, Shajapur revealed surface & sub-surface (30 cm) soil within the premises of the industry to be contaminated with organics such as naphthalene, sulphur, amines & phenols etc. No evidence of contamination was found in the adjoining land parcels during preliminary examination.

Maharashtra

MPCB (Maharashtra Pollution Control Board) explored the possibility of using remote sensing techniques for the identification of illegal hazardous waste dump sites. The work was outsourced to NRSA (National Remote Sensing Agency), Hyderabad.

MIDC (Maharashtra Industrial Development Corporation) has set up a SLF (secured landfill) at Tarapur to encap approx. 1.5 lakhs MT of hazardous waste lying at the site. This consists mostly of ETP (Effluent Treatment Plant) sludge, ash etc. accumulated over a period of 10 years. The hazardous waste (i.e. 1.5 lakh MT) dumped in MIDC area and out side of the MIDC area in Tarapur has been completely capped in the SLF.

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Besides Tarapur, in other industrial areas, all identified smaller dumps were removed by lifting about 2085 MT of hazardous waste to common hazardous waste TSDF at Taloja. MIDC is reportedly providing alternate water supply to the villagers in the vicinity of MIDC areas.

Orissa

The SPCB, Orissa (State Pollution Control Board, Orissa) has identified 21 nos. of illegal hazardous waste dump sites in 6 locations within the state. The sites are located in the industries namely, Jayashree Chemicals, Ganjam (3 sites, Mercury contaminated), Orichem Ltd., Talcher (1 site, chromium contaminated), HINDALCO, Hirakud (3 sites, cyanide contamiantion), NALCO, Angul (3 sites), East Coast Fertiliser & Chemicals, Kalma (2 sites, fluoride and vanadium contamination), Kerbs & Cie Ltd., Kalma (5 sites), Lotus Chrome Chemicals, Rourkela, Sundargarh (1 site), Lotus orange chemicals, Rourkela, Sundargarh (1 site), Siddhartha Chemicals & Konark Chemicals (2 sites).

Punjab

The PPCB (Punjab Pollution Control Board) initially identified 32 illegal dump sites in the state of Punjab. After preliminary survey 20 sites have been ruled out as illegal hazardous waste dump sites by PPCB. PPCB has appointed Tetra Tech India Ltd., New Delhi for investigation of the remaining 12 sites.

In the report prepared by Tetra Tech, at seven sites (namely - On the bank of Patiala ki Rao Choe, Mohali; Along the banks of river Siswan, Kurali; MC disposal site, Kotkapura; Seed farm road, Abohar, Old Fazilka road, Abohar; Village Warlana, Kapurthala road; and Village Chugitti, Bye pass road, Jalandhar), no contamination of either soil or groundwater has been observed.

Out of the remaining 5 sites, two sites at Ludhiana i.e. Humbran and Tajpur road, and one site at Jalandhar i.e. Basti Sheikj dump site are contaminated with organic pollutants, which may be due to municipal waste/hazardous waste.

Rajasthan

The State Board has identified only one hazardous waste dump site in the State at Bichhadi, Udaipur. Hindustan Agro Chemicals Ltd., Bhicchadi, Udaipur was in operation up to 1996 and discharged/dumped its hazardous waste generated by it and its subsidiary units namely Silver Chemicals, Jyoti Chemicals, Phosphate India and Rajasthan Multi Fertilizers in and around the premises of the industry. These units were manufacturing H-Acid, Sulphuric Acid, Oleum, Chloro sulphonic Acid, Phosphatic Fertilizers and other chemical.

Tamil Nadu

TNPCB (Tamil Nadu Pollution Control Board) has identified two sites located within the premises of – (i) Tamilnadu Chromates & Chemicals Ltd., Ranipet (TCCL), which is contaminated due to disposal of chrome bearing waste (2.2 lakh tones) during its operation from 1975 to 1995, and; (ii) Hindustan Unilever Ltd., (HUL) Kodaikanal, which is contaminated due to deposition of air borne Mercury from thermometer manufacturing activity at site for 18 years, 1983 till closure in 2001.

- At HUL site decontamination of the machinery was started on 13th February 2006 and was completed on 7th May 2006. Materials of quantity 274.695 MT were decontaminated and dispatched to recyclers and approx. (4088 m^3) 7400 MT of soil at the factory sites still remains to be remediated. Development of the remediation plan of the same under progress.
- At Tamilnadu Chromates and Chemicals Ltd., Ranipet, site assessment was carried by NGRI, Hyderabad and NEERI, Nagpur on behalf of TNPCB based on drilling, soil sampling & analysis. TNPCB has entrusted several reputed institutes such as NGRI (National Geophysical Research Institute), Hyderabad; NEERI, Nagpur; Sri Ramachandra University, Chennai and IIT (Indian Institute of Technology), Chennai to conduct thorough investigations related to geoenvironmental, remediation/rehabilitation work, health and bio-remediation assessments at the chromium contaminated site in and around TCCL, Ranipet. Reports in various stages have been submitted by the respective institutes in this regard to TNPCB. According to Geological Survey of India, the chromium contamination has spread up to a distance of 2 km on the southern side from the site.
- Rehabilitation plan for TCCL, Ranipet is not yet finalized, however, report prepared by TIDCO (Tamilnadu Industries Development Corporation) for decontamination of soil and containment facility. TIDCO, one of the joint venture of the unit in earlier period has furnished proposal for containment of chromate sludge at cost of ` 24.8 crores. The same was sent to MOEF, GOI for financial assistance under their R& D programme.
- Further TNPCB had prepared a project proposal for ` 80.36 crores, including spot monitoring of the site (TCCL). The said project proposal has been submitted to Principal Secretary to Government, Finance Department ,secretariat vide letter dt 16.8.2010 requesting the World bank loan under Capacity building Industrial pollution management Programme assisted by the World bank through the MoEF, New Delhi

Uttar Pradesh

The UPPCB (Uttar Pradesh Pollution Control Board) had identified 11 illegal dump sites within the state. The UPPCB appointed institute IITR (Indian Institute of Toxicology Research), Lucknow has submitted a detailed survey of all the illegal dump sites in UP.

Out of the 11 sites, one site at Bhowapur, Kaushambi, Ghaziabad was containing mostly municipal waste, which has been removed. At five other sites, no waste was

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found lying within the premises of the respective industries (Brij Chemicals, Dinesh Chemicals, R.K. Industry, K.M. Chemicals, K.B. Industries, all from Mathura) and all units were permanently closed.

At two illegal dump sites i.e. Nauraiya Khera, Kanpur and Juhi Baburiya, Rakhi Mandi, Kanpur 15, 000 tonnes and 10,000 tonnes of BCS (Basic Chrome Sulphate) waste containing chromium was illegally dumped.

At site situated in Panki Industrial area Kanpur Nagar, apprx. 35,000 tonnes of wastes was dumped containing heavy metals. Wastes are of complex nature and consist of waste from dyes, foundries, leather manufacturing units, cotton textiles, carpet industries and municipal waste.

At Village Khanpur, Rania, Kanpur Dehat, apprx. 45,000 tonnes of visible waste & BCS waste containing chromium was dumped over land, which is still lying at the village.

At dump site in Deva road, Lucknow, the responsible factory, Indian Pesticides Ltd. (IPL) has informed that the pesticides dumped in an old brick kiln is filled with muck up to the height of about 3 meters and topped up with the boiler ash & soil. Almost all the waste has been lifted from the abandoned brick klin site at Deva Road and transferred to above TSDF.

West Bengal

WBPCB (West Bengal Pollution Control Board) has identified 8 nos. of illegal hazardous waste dump sites, which are located in the districts of Howrah and Hooghly. The sites are located in and around Nibra village, Dist. Howrah and along the Delhi road (NH2), Dist. Hooghly and containing mostly of wastes from bichromate manufacturing units contaminated with chromium and heavy metals. Assessment of these sites was done by NPC (National Productivity Council), New Delhi in the year 2005 by physical inspection, sampling and analysis. A second assessment was done by SENES Consultants India Pvt. Ltd. in 2008. Among the 8 sites, the World Bank and MoEF teams have selected 7 sites in Hooghly district, as a single cluster, for remediation.

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Review of the nature and type of hazardous waste polluted sites in India

Key output Final Report Task 1: Annexure 4a - Site factsheets

Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India

Ministry of Environment and Forests, Government of India, Delhi
The World Bank, Washington, D.C.

Authorisation

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1 Introduction

1.1 General

This report presents Annexure 4a to the Key output Final Report Task 1. In this Task the Review of the nature and type of hazardous waste polluted sites in India is given as a part of the ‘Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India’.

The objective of Task 1 is to review the available inventory on hazardous waste polluted sites and understand the nature of polluted sites in India. The Key output is the report, presenting both a thorough insight in the nature and types of all polluted sites in India and a typology of probably polluted sites in India.
For these objectives in this task the available inventory on hazardous polluted sites is inventoried and analysed. The results are presented in the Key output Final Report of Task 1.

This Annexure to that report includes the site factsheets, for background reading only. The purpose of the factsheets is an intermediate step in the understanding of the sites in India and not to give an accurate description of all individual sites in India as such. For this purpose the reader is referred to the Assignment 1 database which will be developed for that reason specifically.

1.2 Data sources

The site factsheets were drawn up on sites selected from the following site inventories:

- List of 12 priority contaminated dump sites (CPCB, no specific reference);
- List of 25 hazardous waste dump sites (CPCB , no specific reference);
- Reports available on some of the sites.

Note. Not all sites from these lists were used to make a site factsheet, because the scope of the factsheets is not to give a description of all individual contaminated sites in India as such, but to support the analysis of the different types of such sites in India.

The site factsheets are presented in the next section of this Annexure report.

2 Site Factsheets

Overview of Site Factsheets in this section:

- GPCB 000-002 Unknown Industries, Valad, Gujarat
- GPCB 001-001 Hema-II, Vadodara. Gujarat
- KSPCB 002-003 Hindustan Insecticides Limited, Eloor, Kerala
- MPPCB 000-004 Jayant Vitamins, Ratlam, Madhya Pradesh
- MPPCB 003-004 Sajjan Chemicals, Ratlam, Madhya Pradesh
- OSPCB 004-006 Jayashree Chemicals, Ganjam
- OSPCB 005-009 Orichem Limited, Talchar, Orissa
- OSPCB 006-010 Konark Chrome Chemicals, Sundargarh, Orissa
- OSPCB 013-012 East Coast Fertilizers, Mayurbanj, Orissa
- PSPCB 014-013 Humbran Road, Ludhiana, Punjab
- RSPCB 007-016 Hindustan Agro Chemicals Limited and Others, Bichhadi, Rajastan
- TNPCB 008-018 Tamil Nadu Chromates & Chemicals Ltd., Ranipet, Tamil Nadu
- TNPCB 015-017 Hindustan Unilever, Kodaikanal, Tamil Nadu
- UPSPCB 09-019 India Pesticides, Lucknow, Uttar Pradesh
- UPSPCB 010-021 Juni Baburaiya, Kanpur, Uttar Pradesh
- UPSPCB 011-0023 Cerulean Chemicals, Kanpur, Uttar Pradesh
- WBPCB 012-024 Nibra Village, West Bengal

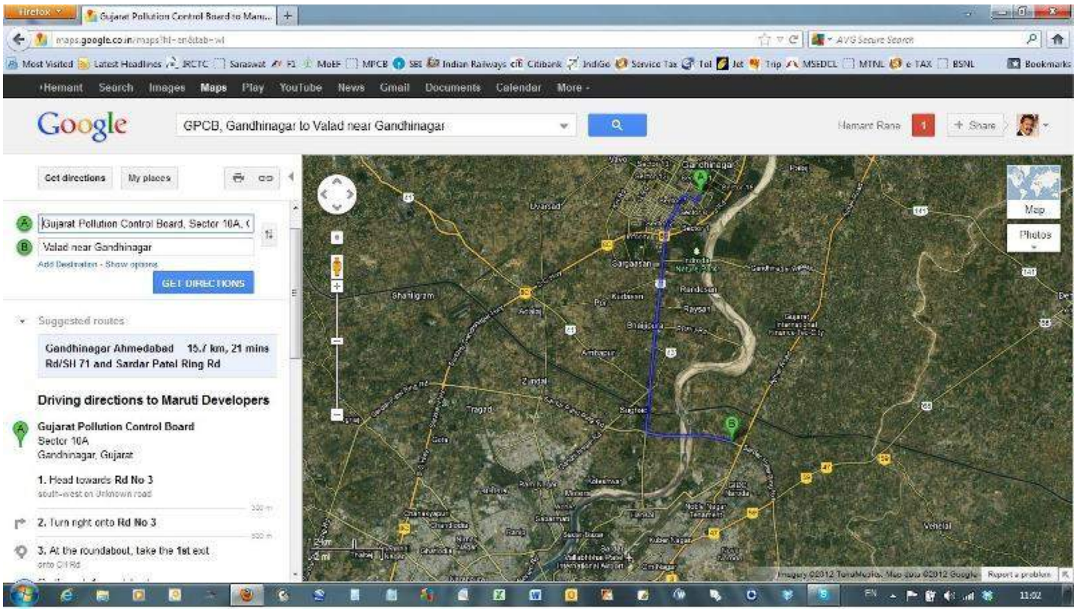
METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Valad, Gujarat

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Valad	+
City		District Gandhinagar	+
State		Gujarat	+
Owner			
Name of polluter		Not Known	+
Area	Acre	0.004942	+
Terrain	Coastal, delta, mountainous,	Plain land	+
Landuse	Urban, industrial, rural, nature	Urban and Industrial	+
Accessibility / infrastructure		By Road, Nearby Ahmedabad Airport	+
Location under control	Local authorities	Gujarat Pollution Control Board	+
Distance to contractors / au-thority		~17km	+
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Dye & Dyechem industry	+
Chemical composition		Mixed organic and inorganic chemicals	+
Physical properties	fluid / solid / solubility / volatility		
Position in soil	on the surface / in soil /		
Heterogeneity	homogeneous / heterogeneous / brown-field		
Origin of the deposit	dump / leakage / fluviatile deposit (sedi-ment) / areal deposit / storage /	Waste	+
Period of contaminating	First and last year soil was affected		
Concentration in topsoil	average concentration per parameter		
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposit-ed)	500MT	+
Area contaminated soil	acre	0.04942	+
Concentration in groundwater	average concentration per parameter		
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			
Groundwater flow	yes / no		
Washing (during heavy rain)	yes / no		
Evaporation	yes / no		
Flooding / (re)sedimentation	yes / no		

Aspect	*Explanation*	*Actual description*	*Data quality**
Contaminants are subject re-working by human as raw mate-rial (reuse)	yes / no		
Surface water flow	yes / no		
By seewater	yes / no		
Typical frequent natural disas-ters	Flooding, monsoon, washing		
RECEPTOR / THREATENED OB-JECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use			
Ingestion (soil, (ground)water, crops / cattle / game / fish)			
Inhalation (polluted air)			
Contact surface water			
Environmental hazards			
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / reme-diation measures already implemented			
General			
Access restriction			
Liners / covers			
Restrictions to land use			
Groundwater treatment			

- poor
0 uncertain
+ fact / reported
E expert guess


GPCB, Gandhinagar to Valad near Gandhinagar
Get directions
My places
Gujarat Pollution Control Board, Sector 10A, (
Valad near Gandhinagar
GET DIRECTIONS
Suggested routes
Gandhinagar Ahmedabad Rd/SH 71 and Sardar Patel Ring Rd 15.7 km, 21 mins
Driving directions to Maruti Developers
Gujarat Pollution Control Board
Sector 10A
Gandhinagar, Gujarat
1. Head towards Rd No 3
2. Turn right onto Rd No 3
3. At the roundabout, take the 1st exit
Gandhinagar
Map
Photos

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Vadodara (Hema), Gujarat

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Vadodara	+
City			
State		Gujarat	+
Owner			
Name of polluter		Hema Chemicals Unit - II	+
Area	Acre		
Terrain	Coastal, delta, mountainous,		
Landuse	Urban, industrial, rural, nature		
Accessibility / infrastructure			
Location under control	Local authorities	Vadodara Municipal Corporation	+
Distance to contractors / authority			
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Basic chromium sulphate production	+
Chemical composition		Cr	+
Physical properties	fluid / solid / solubility / volatility		
Position in soil	on the surface / in soil /		
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Residue is dumped in industrial plot	+
Period of contaminating	First and last year soil was affected		
Concentration in topsoil	average concentration per parameter		
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	77.000 ton	+
Area contaminated soil	acre		
Concentration in groundwater	average concentration per parameter	Groundwater is contaminated. Concenrations not in dossier	+
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			
Groundwater flow	yes / no		
Washing (during heavy rain)	yes / no		
Evaporation	yes / no		
Flooding / (re)sedimentation	yes / no		

Aspect	Explanation	Actual description	Data quality*
Contaminants are subject re-working by human as raw material (reuse)	yes / no		
Surface water flow	yes / no		
By seewater	yes / no		
Typical frequent natural disasters	Flooding, monsoon, washing		
RECEPTOR / THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use			
Ingestion (soil, (ground)water, crops / cattle / game / fish)			
Inhalation (polluted air)			
Contact surface water			
Environmental hazards			
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / remediation measures already implemented			
General		DPCB has prepared a report of the rehabilitation plan 1)	+
Access restriction			
Liners / covers			
Restrictions to land use			
Groundwater treatment			
Data/inform. used			
1) “annexure” page 12 (provided by CPCB during mission 1)			

- poor
0 uncertain
+ fact / reported
E expert guess

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Eloor Edayar, Kerala

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Eloor Edayar (4 sites) Site 1: Kuzhikandom Thodu Site 2: Ammenthuruthu Karipadam Site 3: Edayattuchal Site 4: Chakkachal	+
City		Cochin	+
State		Kerala	+
Owner		Site 1 : State Government of Kerala Site 2 & 3 : Private Site 4 : Industrial Private Owner	+ + +
Name of polluter		Site 1 & 2: Hindustan Insecticides Limited; Fertilizers and Chemicals Travancore Ltd., Udyogamandalam Division; Indian Rare Earths Limited and Merchem. Site 3 & 4: Binani Zinc Ltd.	+ +
Area	Acre	Site 1: Kuzhikandom Thodu 2000 Acre Site 2: Ammenthuruthu Karipadam 62 Acre Site 3: Edayattuchal 300 Acre Site 4: Chakkarachal 155 Acre	+ + + +
Terrain	Coastal, delta, mountainous,	Plain Land, water bodies	+
Landuse	Urban, industrial, rural, nature	Industrial, Rural	+
Accessibility / infrastructure		Road, Railway	+
Location under control	Local authorities	Site 1 : State Government of Kerala Site 2 & 3 : Private owner Site 4 : Industrial Private Owner Authority: Kerala State Pollution Control Board	+ + + +
Distance to contractors / authority		10km from KSPCB Ernakulum Regional Office	E
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Site 1 & 2: Agro Chemicals (DDT, Endosulphon, Diclofol, Thiazoles, Sulphonamides); Fertilizer; Rare Earth Metals; Heavy Metals Site 3 & 4: Zinc Ingots	+ +
Chemical composition		Site 1 & 2: POPs, Heavy Metals Site 3 & 4: Jarosite, Zinc waste	+ +
Physical properties	fluid / solid / solubility / volatility	Solids	+
Position in soil	on the surface / in soil /	On the surface (contained within industry premises) and also in	+

Aspect	Explanation	Actual description	Data quality*
		soil	
Heterogeneity	homogeneous / heterogeneous / brown-field	Heterogeneous	+
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Waste	+
Period of contaminating	First and last year soil was affected	1947 to 1997	+
Concentration in topsoil	average concentration per parameter	Analysed in Leachate at site 1: DDT: Below Detectable Limit (BDL) to 3660 mg/kg; BHC: BDL to 20 mg/kg; Endosulphan: BDL to 525 mg/kg; Organic Halidas: BDL to 250 mg/kg; Lead: BDL to 253 mg/kg; Cadmium: BDL to 4.7 mg/kg; Chromium: BDL to 491 mg/kg; Copper: BDL to 177 mg/kg; Nickel: BDL to 57 mg/kg; Mercury: BDL to 2.8 mg/kg; Zinc BDL to 832 mg/kg	+
		Analysed in Leachate at site 2: DDT: BDL to 21.6 mg/kg; BHC: BDL to 0.06 mg/kg; Endcsulphan: BDL to 2.13 mg/kg; Zinc: 110 to 1449 mg/kg; Iron: 18900 to 50260 mg/kg; Lead: 25 to 598 mg/kg; Cadmium: BDL to 19 mg/kg; Copper: 28 to 186 mg/kg; Nickel: 40 to 54 mg/kg; Mercury: BDL to 0.79 mg/kg; Chromium(IV): 9 to 202 mg/kg; Arsenic: 3 to 7 mg/kg	+
		Analysed in Leachate at site 3 & 4: Zinc: 72 to 188060 mg/kg; Iron: 6600 to 139640 mg/kg; Lead: 90 to 424 mg/kg; Cadmium: 3 to 568 mg/kg; Copper: 20 to 804 mg/kg; Chromium(IV): 2 to 19.2 mg/kg	+
		As reported in GTZ Report: HCH: Isomeric HCH (hexachlorocyclohexanes) were not detected but HCH are visible in surface water, sediment, and some soil samples but were not detected in well water or groundwater. DDT: p,p'-DDD is visible in all the soil samples and in the	+

Aspect	Explanation	Actual description	Data quality*
		groundwater sample. Endosulfan: alpha Endosulfan is visible in surface water, sediment and one soil sample, but beta-Endosulfan and Endosulfan sulphate are not detected in any of the samples. The Endosulfan metabolite Endosulfan lactone is visible in one of the two soil samples, in the sediment sample and in the groundwater sample. Dicofol: An unknown metabolite of Dicifol is visible in all the 3 soil samples analysed and in the groundwater sample. Other organochlorine compounds like Heptachlor, Heptachlor epoxide or Methoxychlor were not detected at all. MTBT, regarded as a characteristic metabolite for the benzothiazol compounds produced by Merchem, was not visible.	
		Heavy Metal Analysis Reported by GTZ wet weight: In Sediment, mg/kg: Lead 194, Cadmium 9.75, Nickel 21.03, Chromium 67.6, Zinc 294, Iron 22250, Copper 71, Arsenic 7.1, Mercury 0.75. In Soil, mg/kg: Lead 77.5, Cadmium 5.9, Nickel 13.7, Chromium 25.2, Zinc 516, Iron 4740, Copper 31.6, Arsenic 1.7, Mercury 0.5.	+

Aspect	Explanation	Actual description	Data quality*
		In well water, mg/kg: Lead 0.001, Cadmium <0.001, Nickel 0.035, Chromium 0.011, Zinc 0.199, Iron 5.025, Copper 0.02, Arsenic 1.3, Mercury <0.001. In Surface water, mg/kg: Lead 0.003, Cadmium <0.001, Nickel 0.036, Chromium 0.01, Zinc 0.028, Iron 20, Copper 0.01 Arsenic 1, Mercury <0.001. In ground water, mg/kg: Lead 0.083, Cadmium 0.0015, Nickel -, Chromium 0.1, Zinc 0.085, Iron -, Copper 0.023, Arsenic -, Mercury -. Dry weight: In Sediment, mg/kg: Lead 847, Cadmium 46, Nickel 89, Chromium 293, Zinc 1209, Iron 89040, Copper 299, Arsenic 27.4, Mercury 3.3. In Soil, mg/kg: Lead 136.4, Cadmium 10.2, Nickel 24.6, Chromium 90.6, Zinc 524, Iron 8645, Copper 58.6, Arsenic 3.2,	

Aspect	Explanation	Actual description	Data quality*
		Mercury 0.95.	
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposit-ed)	$377550 m^3$	+
Area contaminated soil	acre	Site 1: 49.42 Acres Site 2: 50.95 Acres Site 3: 7.41 Acres Site 4: 3.83 Acres	+ + + +
Concentration in groundwater	average concentration per parameter	Not available	
	maximum concentration per parameter	Not available	
Volume contam. groundwater	m3	Not available	
Area contam. groundwater	acre	2450 Acres inclusive of land and ground water.	+
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface	1.5m below surface	+
Depth bedrock	m below surface	Not available	
Permeability topsoil	low/mod./high	Not available	
Permeability aquifer	low/mod./high	Not available	
Groundwater flow	direction / speed	Not available	
Process of spreading			
Groundwater flow	yes / no	Yes	+
Washing (during heavy rain)	yes / no	Yes	+
Evaporation	yes / no	No	+
Flooding / (re)sedimentation	yes / no	Yes	+
Contaminants are subject re-working by human as raw mate-rial (reuse)	yes / no	No	+
Surface water flow	yes / no	Yes	+
By seawater	yes / no	No	+
Typical frequent natural disas-ters	Flooding, monsoon, washing	Yes	+
RECEPTOR / THREATENED OB-JECT			
Exposure to contaminants			
Direct human contact during presence on site		Yes	+
Groundwater use		Yes	+
Ingestion (soil, (ground)water, crops / cattle / game / fish)		Yes	+
Inhalation (polluted air)		No	+
Contact surface water		Yes	+
Environmental hazards		Yes	+
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions		Agriculture Abandoned	+
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / reme-			

Aspect	*Explanation*	*Actual description*	*Data quality**
diation measures already implemented			
General			
Access restriction		No	+
Liners / covers		No	+
Restrictions to land use		Within Industry Premises	+
Groundwater treatment		No	+
Data/inform. used			
010 Dump Site Assessment Report Kerala received from CPCB on 03 05 2012, 011 Dump Site Report GTZ Kerala received from CPCB on 03 05 2012 and 012 Dump Site Report Kerala received from CPCB on 03 05 2012			

- poor
0 uncertain
+ fact / reported
E expert guess

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Ratlam (Jayant), Madhya Pradesh

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Ratlam	+
City		Ratlam	+
State		Madhya Pradesh	+
Owner		Ratlam Industrial Department	+
Name of polluter		Jayant Vitamins	+
Area	Acre		
Terrain	Coastal, delta, mountainous,	Plain land	+
Landuse	Urban, industrial, rural, nature	Industrial	+
Accessibility / infrastructure		Road, Railway	E
Location under control	Local authorities	Ratlam Industrial Department Industry Closed since year 2000 and under custody of Bank of India	+ + MPPCB Report
Distance to contractors / authority		110km from Ujjain Regional Office, MPPCB	E
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Vitamin C, Sorbitol	+
Chemical composition		ETP Sludge, Nickel Oxide Sodium Sulphate, Activated Carbon	+ E
Physical properties	fluid / solid / solubility / volatility	Solids	E
Position in soil	on the surface / in soil /	On the surface	E
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Waste	+
Period of contaminating	First and last year soil was affected	Preliminary examination	+
Concentration in topsoil	average concentration per parameter		
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	30MT of waste, 30cm depth of soil	+
Area contaminated soil	acre		+
Concentration in groundwater	average concentration per parameter		
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			

Aspect	Explanation	Actual description	Data quality*
Groundwater flow	yes / no		
Washing (during heavy rain)	yes / no	Yes	E
Evaporation	yes / no		
Flooding / (re)sedimentation	yes / no		
Contaminants are subject re-working by human as raw mate-rial (reuse)	yes / no		
Surface water flow	yes / no		
By seawater	yes / no		
Typical frequent natural disas-ters	Flooding, monsoon, washing		
RECEPTOR / THREATENED OB-JECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use			E
Ingestion (soil, (ground)water, crops / cattle / game / fish)			
Inhalation (polluted air)			
Contact surface water			
Environmental hazards			E
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / reme-diation measures already implemented			
General			
Access restriction		Within industry premises	+
Liners / covers			
Restrictions to land use		Closed industry	+
Groundwater treatment			

- poor
0 uncertain
+ fact / reported
E expert guess

Additional Details as per MPPCB Report:

• The industry was engaged in manufacturing Vitamin-C and sorbitol.
• The industry was generating ETP sludge to the tune of 109.5MT/A & 22MT/A Nickel sludge.
• The industry is closed since 2000 and expected to have accumulated waste in its premises.
Presently under custodian of Bank of India as per the instruction of Hon. Bombay High Court, hence entry is restricted.
• But there is possibility that industry might have disposed off some waste in the premises of the industry which had to be verified by monitoring of soil, sub-soil and UG waste.


Sajjan Mill Talab
Google earth

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Ratlam (Sajjan), Madhya Pradesh

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Site-1: Plot No. 54-E, Dosigaon Industrial Area, Ratlam Site 2: Plot No. 61-B, Dosigaon Industrial Area, Ratlam Site 3: Khandeshara Mines, Namali village, 16 KM away from Dosigaon Industrial Area, Ratlam	+
City		Ratlam	+
State		Madhya Pradesh	+
Owner		Site 1, Site 2 & Site 3 : Madhya Pradesh Audyogik Kendra Vikas Ltd. (MPAKVN)	+
Name of polluter		closed since20.06.1999	+ +
Area		Site 1: 92x 7x 2.5 M x 12 no. Concrete Pits Site 2: 100X100 M Godown Site 3 : 500 sqm Mine	+ + E
Terrain	Coastal, delta, mountainous,	Plain land	E
Landuse	Urban, industrial, rural, nature	Industrial, rural	+
Accessibility / infrastructure		Road, Rail	+
Location under control	Local authorities	Pradesh Audyogik Kendra Vikas Ltd. (MPAKVN)	+
Distance to contractors / authority		110km from Ujjain Regional Office, MPPCB	E
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	H-Acid & G-Acid	+
Chemical composition		Site 1: Iron Sludge &Gypsum Sludge Site 2: Iron Sludge &Gypsum Sludge, Incineration Ash Site 3: Iron Sludge &Gypsum Sludge	+ + +
Physical properties	fluid / solid / solubility / volatility	Site 1: Solids Site 2: Solids Site 3: Solids	+
Position in soil	on the surface / in soil /	On the surface (contained within industry premises) and also in soil	+
Heterogeneity	homogeneous / heterogeneous / brownfield	Heterogeneous	+
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Waste Site 1: Storage Site 2: Storage	+

Aspect	Explanation	Actual description	Data quality*
		Site 3: Dump	
Period of contaminating	First and last year soil was affected	From year 1988 Till year 1999	E +
Concentration in topsoil	average concentration per parameter	Napthalene, Binapthyl Sulphone, 1,2 Napthyl Methylene	+
	maximum concentration per parameter	Napthalene, Binapthyl Sulphone, 1,2 Napthyl Methylene	+
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	Site 1: 20906MT Site 2: 1156MT Site 3: 1410MT	+
Area contaminated soil	acre	Site 1: 2 acre Site 2: 2.5 acre Site 3: 0.1 acre	+ + E
Concentration in groundwater	average concentration per parameter	Coloured, Napthalene, Binapthyl Sulphone, 1,2 Napthyl Methylene: Chlorides: 957 mg/l Sulphates: 180 mg/l Phosphates: 1.5 mg/l Nitrates : 127 mg/l Iron :	+
	maximum concentration per parameter	Not available	-
Volume contam. groundwater	m3	- Not available	-
Area contam. groundwater	Sq KM	30 SqKM	+
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…	Not available	-
Depth water table	feet below surface	Site1: Not available Site2: Not available site3:300 feet below ground level at	
Depth bedrock	m below surface	Not available	
Permeability topsoil	low/mod./high	Not available	
Permeability aquifer	low/mod./high	Not available	
Groundwater flow	direction / speed	Not available	
Process of spreading			
Groundwater flow	yes / no	Yes	+
Washing (during heavy rain)	yes / no	Yes	+
Evaporation	yes / no	No	+
Flooding / (re)sedimentation	yes / no	Yes	+
Contaminants are subject reworking by human as raw material (reuse)	yes / no	No	+
Surface water flow	yes / no	Yes	+
By seawater	yes / no	No	+
Typical frequent natural disasters	Flooding, monsoon, washing	Yes	+
RECEPTOR / THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on site		Yes	+

Aspect	*Explanation*	*Actual description*	*Data quality**
Groundwater use		Yes	+
Ingestion (soil, (ground)water, crops / cattle / game / fish)		Yes	+
Inhalation (polluted air)		No	+
Contact surface water		Yes	+
Environmental hazards		Yes	+
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation	Health impact as skin diseases	+
Land use restrictions		Productivity of agricultural field reduced	+
Value of buildings		Low	+
Possibilities of temporary site clearance		Site 1 & Site 2: To Dismantle and dispose to TSDF, Pithapur 200 km away Site 3: To keep as is and moni-tor	+
Value of site	Low/high	Low	+
Provisory prevention / reme-diation measures already implemented			
General			
Access restriction		Yes	+
Liners / covers		No	+
Restrictions to land use		No	+
Groundwater treatment		No	+
Data/inform. used			
08 Dump_Site_Assessment_Madhya_Pradesh received from CPCB on 03 05 2012,011, 09 and Dump_Site_Assessment_Madhya_Pradesh2 received from CPCB on 03 05 2012			

- poor
0 uncertain
+ fact / reported
E expert guess

Additional Details as per MPPCB Report:
M/s. Sajjan Chemical & Investment (P) Ltd., Ratlam was engaged in themanufacture of H-acid, G-acid and is closed since20.06.1999.
• The industry was generating: 1000MT/A of Gypsum sludge, 410MT/A Iron Sludge4000MT/A of Sodium Sulphate & 1500MT/A of incinerated ash as hazardouswastes.
• Some of the wastes were being disposed off in khasara No 469/1 Kandarwasa mine.
The incinerated ash was stored at plot No 61B, Industrial area.
• Presently all structures have been dismantled and equipments, machinery and allscrap materials have been removed from the site.
• Waste debris are still lying in underground storage tanks & sheds within &near byto factory premises.
• Legal action under EPA has been filed in CJM, Ratlam.


Sajjan Mill Talab
Google earth

METHODOLOGIES FOR NPRPS INDIA

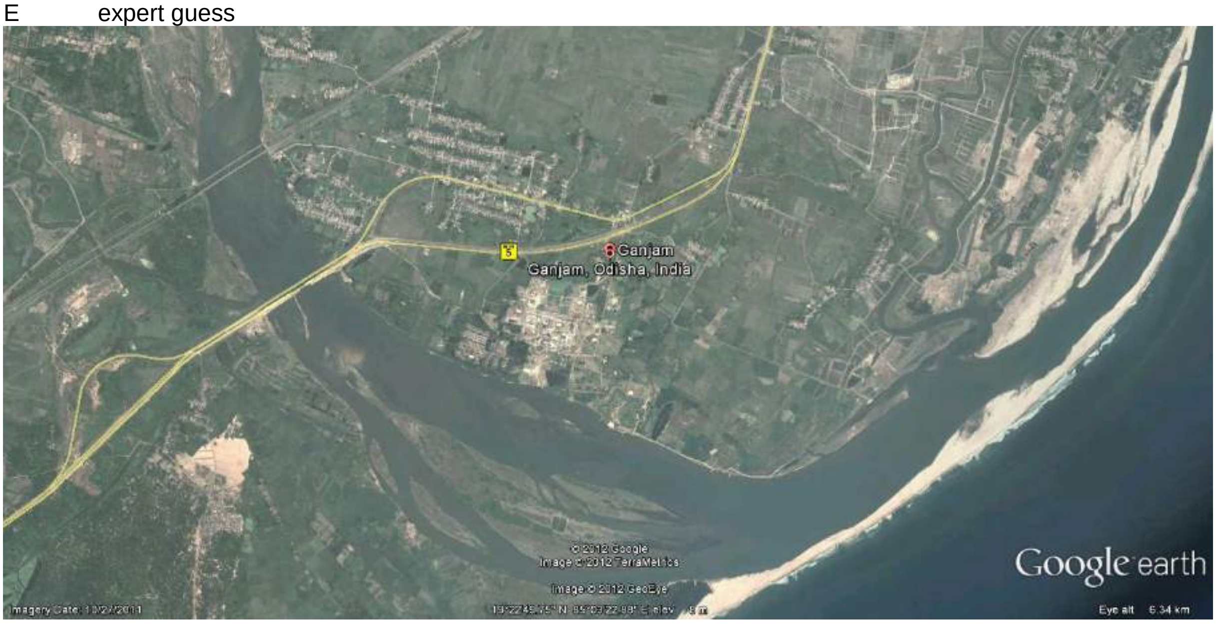
SITE FACTSHEET Ganjam (Jayashree), Orissa

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Ganjam	+
City		Ganjam	+
State		Orissa	+
Owner		Notified Area Council	+
Name of polluter		Jayashree Chemicals	+
Area	Acre	3 locations	+
Terrain	Coastal, delta, mountainous,	Partly Waterlogged, flat morphology	+
Landuse	Urban, industrial, rural, nature	Industrial, Rural	+
Accessibility / infrastructure		Road	+
Location under control	Local authorities	Gram Panchayat, Rural Area	+
Distance to contractors / authority		30km from Bahrampur Regional Office of OSPCB	E
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Chlor-Alkali	+
Chemical composition		Brine Sludge, Mercury Sulphide?	+
Physical properties	fluid / solid / solubility / volatility	Solid	+
Position in soil	on the surface / in soil /	On the surface and in soil	+
Heterogeneity	homogeneous / heterogeneous / brownfield	Heterogeneous	+
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Stored Waste	+
Period of contaminating	First and last year soil was affected	1967 to 2004	+
Concentration in topsoil	average concentration per parameter	Brine sludge and Hypo Sludge Location 1: pH ~ 13; Hg ~64mg/kg Location 2: pH ~9; Hg ~1280mg/kg; Ba compound except $BaSO_4$ ~2930mg/kg Location 3: pH ~9.9; Hg ~19mg/kg	+ + + +
	maximum concentration per parameter	Location 1: Hg 81.9mg/kg Location 2: Hg 2000mg/kg; Ba compound except $BaSO_4$ ~7830mg/kg Location 3: Hg 33.6mg/kg	+ + +
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	Location 1: 5000MT Location 2: 33000MT - 30000m^3 Location 3: 18000MT - 15000 m^3	+ + +
Area contaminated soil	acre	Location 1: 35 Acre Location 2: 120 Acre Location 3: 80 Acre	+ + +
Concentration in groundwater	average concentration per parameter	Hg Below Detectable Limit 0.001mg/L	+
	maximum concentration per parameter		
Volume contam. groundwater	m3	Not available	
Area contam. groundwater	acre	Not available	

Aspect	*Explanation*	*Actual description*	*Data quality**
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…	Sand	+
Depth water table	m below surface	~3m in pre monsoon and 0.3m in post monsoon	+
Depth bedrock	m below surface	Not available	
Permeability topsoil	low/mod./high	Not available	
Permeability aquifer	low/mod./high	Not available	
Groundwater flow	direction / speed	NW to SE; speed not available	+
Process of spreading			
Groundwater flow	yes / no	Yes	+
Washing (during heavy rain)	yes / no	Yes	+
Evaporation	yes / no	No	+
Flooding / (re)sedimentation	yes / no	Yes	+
Contaminants are subject re-working by human as raw mate-rial (reuse)	yes / no	No	+
Surface water flow	yes / no	Yes, N to S	+
By seawater	yes / no	No; Sea 2km away	+
Typical frequent natural disas-ters	Flooding, monsoon, washing	Flooding	+
RECEPTOR / THREATENED OB-JECT			
Exposure to contaminants			
Direct human contact during presence on site		Yes	+
Groundwater use		No	+
Ingestion (soil, (ground)water, crops / cattle / game / fish)		No	+
Inhalation (polluted air)		Not available	
Contact surface water		Yes	+
Environmental hazards		Yes	+
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / reme-diation measures already implemented			
General			
Access restriction		No	+
Liners / covers		Yes	+
Restrictions to land use		Yes	+
Groundwater treatment		No	+
Data/inform. Used			
006 Dump Sites Orissa - GTZ report received from CPCB on 03 05 2012 013 Dump Site Report Orissa (NPC REPORT) received from CPCB on 03 05 2012			
Note			

Aspect	*Explanation*	*Actual description*	*Data quality**
Out of 3 locations; Location 2 requires more attention from the point of view of Environmental Hazard.			

- poor
0 uncertain
+ fact / reported
E expert guess



METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Talchar (Orichem), Orissa

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Talchar	+
City		Talcher	+
State		Orissa	+
Owner		Panchayat	+
Name of polluter		Orichem Limited (closed industry)	+
Area	Acre	1 site in industry premises	+
Terrain	Coastal, delta, mountainous,	Plain land	+
Landuse	Urban, industrial, rural, nature	Industrial, rural	+
Accessibility / infrastructure		Road, Railway	+
Location under control	Local authorities	Rural Area Panchayat	+
Distance to contractors / authority		113km from Cuttack Regional Office of OSPCB	E
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Chromium ore processing; ETP	+
Chemical composition		Sodium Chromate, Total Chromium from ETP sludge	+
Physical properties	fluid / solid / solubility / volatility	Solid	+
Position in soil	on the surface / in soil /	On the surface	+
Heterogeneity	homogeneous / heterogeneous / brownfield	Heterogeneous	+
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Waste	+
Period of contaminating	First and last year soil was affected	1983 to 1998	+
Concentration in topsoil	average concentration per parameter	Hexavalent Chromium 580mg/kg; Total Chromium 17500mg/kg	+
	maximum concentration per parameter	Hexavalent Chromium 3340mg/kg; Total Chromium 12300mg/kg	+ +
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	80000MT (NPC Report) 70000MT (GTZ estimate for additional unaccounted waste)	+ +
Area contaminated soil	acre	320 Acre within industry premises	+
Concentration in groundwater	average concentration per parameter	Hexavalent Chromium 1mg/L; Total Chromium 3mg/L	+
	maximum concentration per parameter	Hexavalent Chromium 1mg/L; Total Chromium 3mg/L	+
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…	Laterite	+
Depth water table	m below surface	4.4 m below surface in pre-monsoon and 2.6m in post monsoon	+

Aspect	*Explanation*	*Actual description*	*Data quality**
Depth bedrock	m below surface	Not available	+
Permeability topsoil	low/mod./high	Low	E
Permeability aquifer	low/mod./high	High	+
Groundwater flow	direction / speed	West to East	+
Process of spreading			
Groundwater flow	yes / no	Yes	+
Washing (during heavy rain)	yes / no	Yes	+
Evaporation	yes / no	No but wind dispersion possible	+
Flooding / (re)sedimentation	yes / no	No	+
Contaminants are subject re-working by human as raw material (reuse)	yes / no	No	+
Surface water flow	yes / no	Yes	+
By seawater	yes / no	No	+
Typical frequent natural disasters	Flooding, monsoon, washing	Yes	+
RECEPTOR / THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on site		Yes	+
Groundwater use		Yes	+
Ingestion (soil, (ground)water, crops / cattle / game / fish)		Yes	+
Inhalation (polluted air)		Yes	+
Contact surface water		Yes	+
Environmental hazards		Yes	+
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / remediation measures already implemented			
General			
Access restriction		Yes	+
Liners / covers		No	+
Restrictions to land use		Yes	+
Groundwater treatment		No	+
Data/inform. Used			
006 Dump Sites Orissa - GTZ report received from CPCB on 03 05 2012 013 Dump Site Report Orissa (NPC REPORT) received from CPCB on 03 05 2012			

- poor
0 uncertain
+ fact / reported
E expert guess


200
23
Talcher
Talcher Town Road
Pond
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METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Rourkela, Sundargarh (Lotus, Konark), Orissa

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Rourkela, Sundargarh; 4 sites	+
City		Rourkela	+
State		Orissa	+
Owner		Site 1, 2 & 3: IDCO Industrial Area; Site 4: Panchayat, Rural Area	+ +
Name of polluter		Site 1: Lotus Chrome Chemicals Site 2: Lotus Orange Chemicals Site 3 & 4: Siddharth Chemicals and Konark Chemicals	+ + + +
Area	Acre		
Terrain	Coastal, delta, mountainous,	Plain land, mining	E
Landuse	Urban, industrial, rural, nature	Rural, mining	E
Accessibility / infrastructure		Road	E
Location under control	Local authorities	Site 1, 2 & 3: IDCO Industrial Area; Site 4: Panchayat, Rural Area	+ +
Distance to contractors / authority		13km from Rourkela Regional Office of OSPCB	E
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Chromium mining	+
Chemical composition		Sodium Dichromate	+
Physical properties	fluid / solid / solubility / volatility	Solids	E
Position in soil	on the surface / in soil /	On the surface	E
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Chromium leach residue	+
Period of contaminating	First and last year soil was affected		
Concentration in topsoil	average concentration per parameter	Chromium	+
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	Not available	+
Area contaminated soil	acre		
Concentration in groundwater	average concentration per parameter		
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			

Aspect	*Explanation*	*Actual description*	*Data quality**
Groundwater flow	yes / no		
Washing (during heavy rain)	yes / no	Yes	E
Evaporation	yes / no		
Flooding / (re)sedimentation	yes / no		
Contaminants are subject re-working by human as raw mate-rial (reuse)	yes / no		
Surface water flow	yes / no		
By seawater	yes / no		
Typical frequent natural disas-ters	Flooding, monsoon, washing		
RECEPTOR / THREATENED OB-JECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use			
Ingestion (soil, (ground)water, crops / cattle / game / fish)			
Inhalation (polluted air)			
Contact surface water			
Environmental hazards		Yes	E
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / reme-diation measures already implemented			
General			
Access restriction		No	E
Liners / covers		No	E
Restrictions to land use		No	E
Groundwater treatment		No	E

- poor
0 uncertain
+ fact / reported
E expert guess


Basanti Colony
Rourkela, Odisha, India
Rourkela
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Google earth

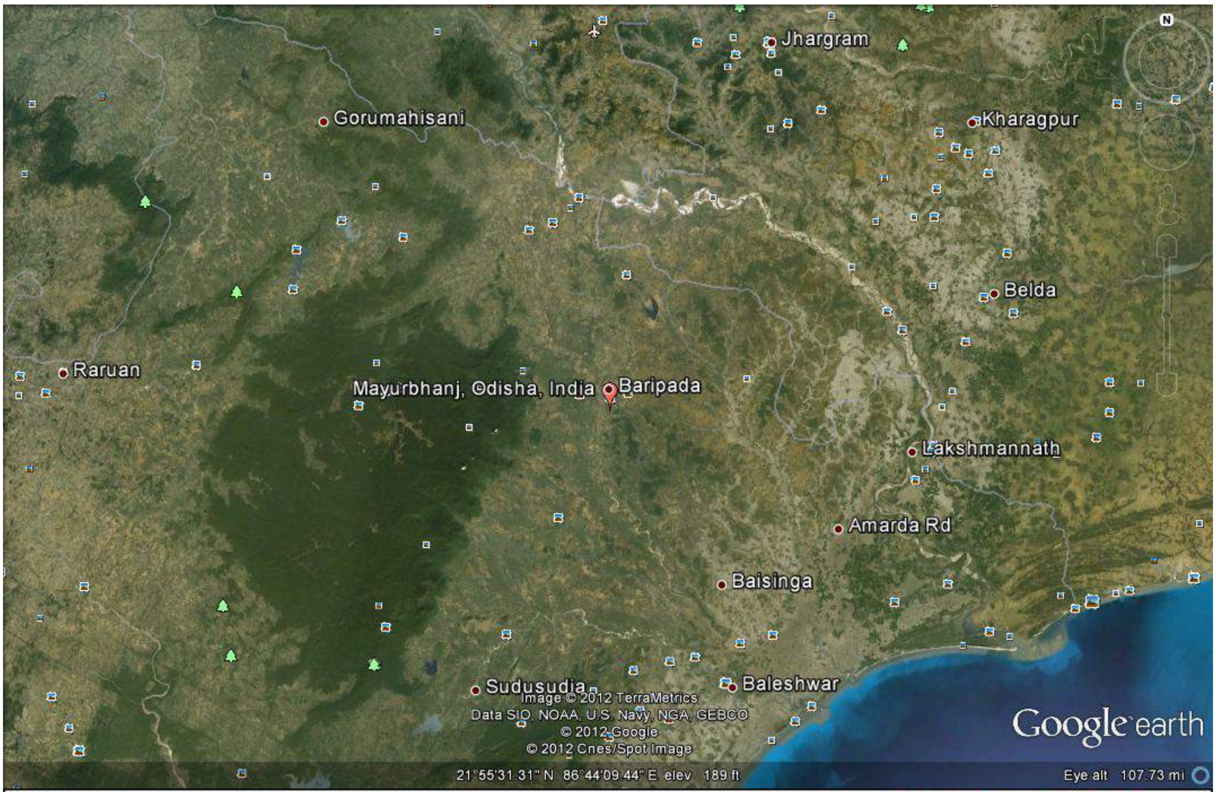
METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Mayurbhanj (East Coast Fertilizers & Chemicals), Orissa

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Mayurbhanj	+
City		Baripada	0
State		Orissa	+
Owner		Panchayat	0
Name of polluter		East Coast Ferilizers & Chemicals Ltd. (Closed)	+
Area	Acre	1 site in industry premises	+
Terrain	delta, mountainous,	Plain land	0
Landuse	Urban, industrial, rural, nature	Industrial, rural	+
Accessibility / infrastructure		Road, Railway	E
Location under control	Local authorities	Rural Area Panchayat	0
Distance to contractors / authority			
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Sulphuric Acid, Single Super Phosphate (SSP)	+
Chemical composition		Sulphuric Acid, Ca (H20P4)2.H2O	+
Physical properties	fluid / solid / solubility / volatility	Solid	E
Position in soil	on the surface / in soil /	On the surface	+
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Leached Residue	+
Period of contaminating	First and last year soil was affected		
Concentration in topsoil	average concentration per parameter	Fluoride & Vanadium	+
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	2250MT	+
Area contaminated soil	acre	Within industry premises	+
Concentration in groundwater	average concentration per parameter	Fluoride & Vanadium	+
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			
Groundwater flow	yes / no	Yes	+
Washing (during heavy rain)	yes / no	Yes	+
Evaporation	yes / no		
Flooding / (re)sedimentation	yes / no		
Contaminants are subject re-	yes / no		

Aspect	*Explanation*	*Actual description*	*Data quality**
working by human as raw material (reuse)			
Surface water flow	yes / no		
By seawater	yes / no		
Typical frequent natural disasters	Flooding, monsoon, washing	Yes	+
RECEPTOR / THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use		Yes	E
Ingestion (soil, (ground)water, crops / cattle / game / fish)		Yes	E
Inhalation (polluted air)			
Contact surface water			
Environmental hazards		Yes	+
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / remediation measures already implemented			
General			
Access restriction		No	0
Liners / covers		No	0
Restrictions to land use			
Groundwater treatment		No	0

- poor
0 uncertain
+ fact / reported
E expert guess


Jhargram
Gorumahisani
Kharagpur
Belda
Raruan
Mayurbhanj, Odisha, India
Baripada
Lakshmannath
Amarda Rd
Baisinga
Sudusudia
Baleshwar
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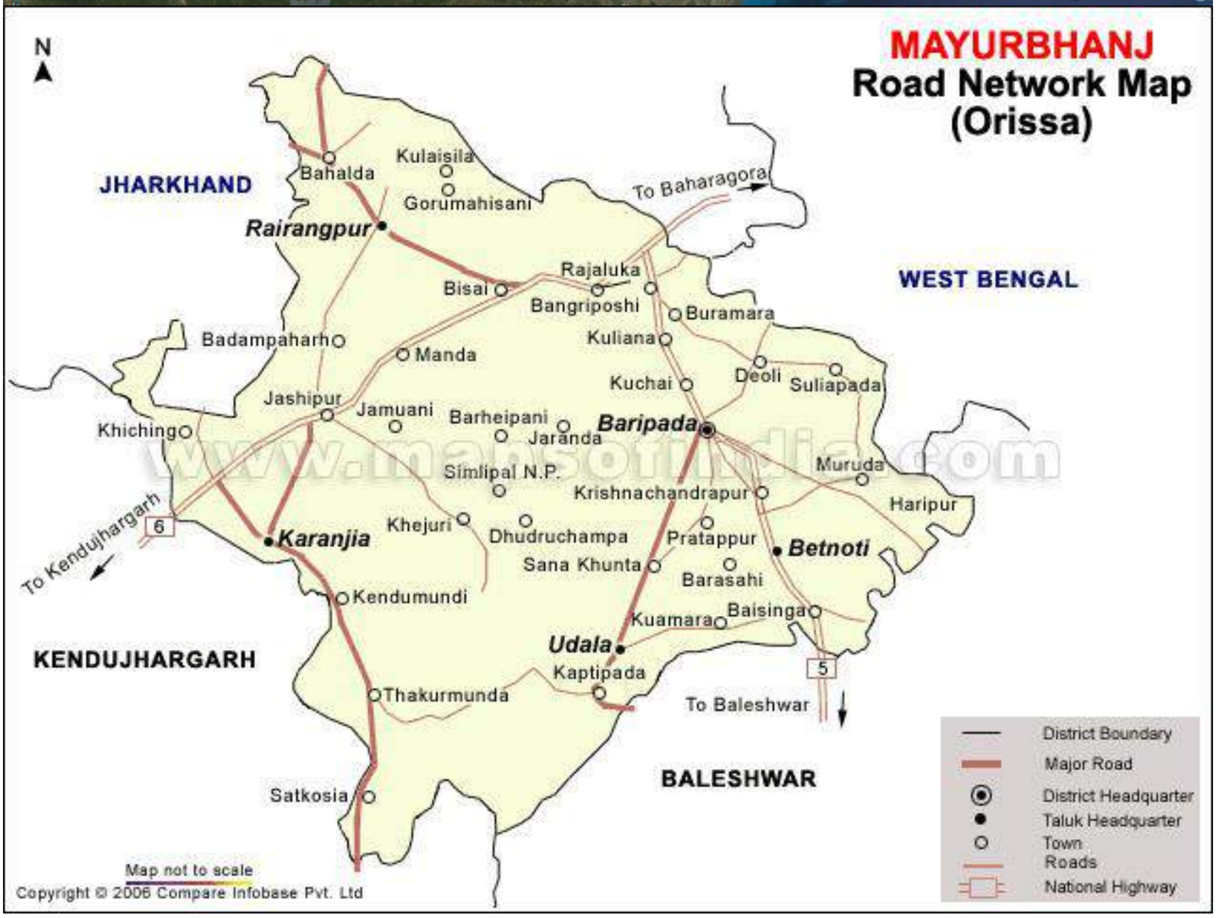
Google earth
21°55'31.31" N 86°44'09.44" E elev 189 ft
Eye alt 107.73 mi


MAYURBHANJ
Road Network Map
(Orissa)
N
JHARKHAND
WEST BENGAL
KENDUJHARGARH
BALESHWAR
Bahalda
Kulaisila
Gorumahisani
Rairangpur
To Baharagora
Rajaluka
Bisai
Bangriposhi
Buramara
Badampaharh
Manda
Kuliana
Deoli
Suliapada
Kuchai
Jashipur
Jamuani
Barheipani
Jaranda
Baripada
Khiching
Simlipal N.P.
Muruda
Krishnachandrapur
Haripur
To Kendujhargarh
6
Karanjia
Khejuri
Dhudruchampa
Pratappur
Betnoti
Sana Khunta
Barasahi
Kendumundi
Kuamara
Baisinga
Udala
Kaptipada
5
Thakurmunda
To Baleshwar
Satkosia
District Boundary
Major Road
District Headquarter
Taluk Headquarter
Town
Roads
National Highway
Map not to scale
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METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET   Humbran Road, Ludhiana, Punjab

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Humbran Road	+
City		Ludhiana	0
State		Punjab	+
Owner		Muncipal Corporation	0
Name of polluter		Muncipal Dump	+
Area	Acre	35 acre	+
Terrain	delta, mountainous,	Plain land	0
Landuse	Urban, industrial, rural, nature	urban	+
Accessibility / infrastructure		Road, Railway	E
Location under control	Local authorities	Muncipal Corporation	0
Distance to contractors / authority		20 KM	0
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Electroplating and dying industry	+
Chemical composition		Heavy metals and organics	+
Physical properties	fluid / solid / solubility / volatility	Solid	E
Position in soil	on the surface / in soil /	On the surface	+
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Leached Residue	+
Period of contaminating	First and last year soil was affected		
Concentration in topsoil	average concentration per parameter		
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	-	+
Area contaminated soil	acre	35 acre	+
Concentration in groundwater	average concentration per parameter	Heavy Metals and Organics	+
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			
Groundwater flow	yes / no	Yes	+
Washing (during heavy rain)	yes / no	Yes	+
Evaporation	yes / no		
Flooding / (re)sedimentation	yes / no		
Contaminants are subject reworking by human as raw material (reuse)	yes / no		

Aspect	*Explanation*	*Actual description*	*Data quality**
Surface water flow	yes / no		
By seawater	yes / no		
Typical frequent natural disasters	Flooding, monsoon, washing	Yes	+
RECEPTOR / THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use		Yes	E
Ingestion (soil, (ground)water, crops / cattle / game / fish)		Yes	E
Inhalation (polluted air)			
Contact surface water			
Environmental hazards		Yes	+
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / remediation measures already implemented			
General			
Access restriction		Yes	0
Liners / covers		No	0
Restrictions to land use			
Groundwater treatment		No	0

- poor
0 uncertain
+ fact / reported
E expert guess

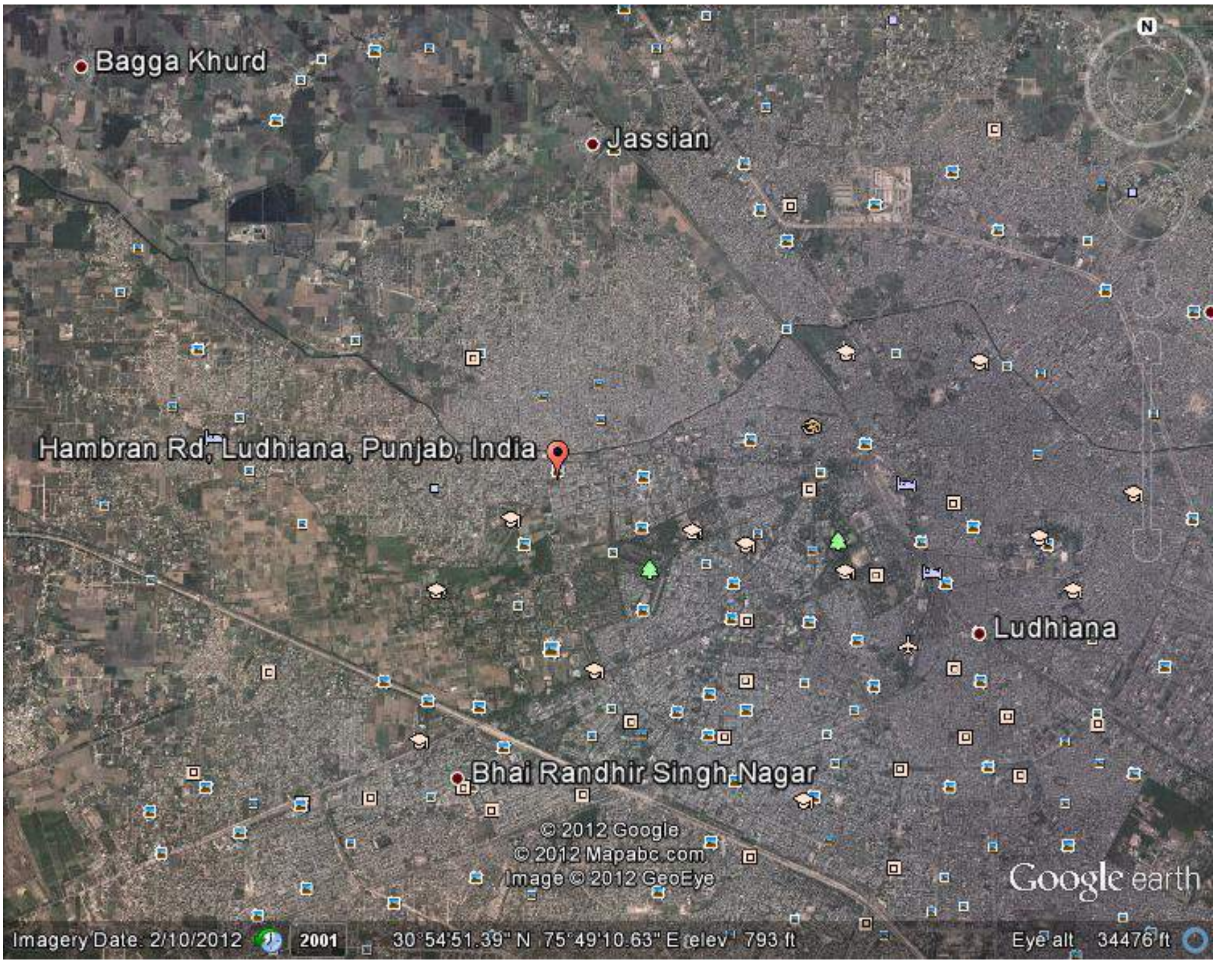
Bagga Khurd
Jassian
Hambran Rd, Ludhiana, Punjab, India
Ludhiana
Bhai Randhir Singh Nagar
© 2012 Google
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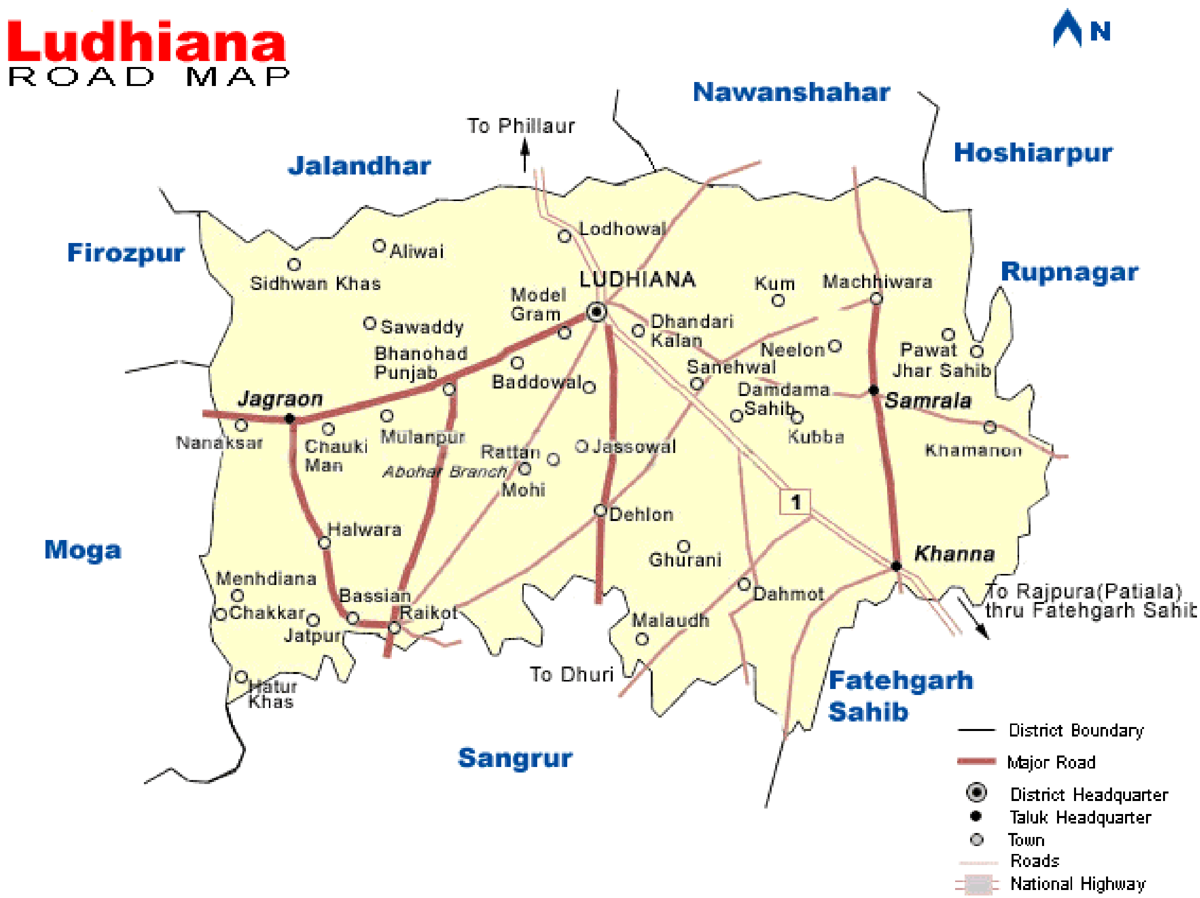
Image © 2012 GeoEye
Google earth
Imagery Date: 2/10/2012
2001
30°54'51.39" N 75°49'10.63" E elev 793 ft
Eye alt 34476 ft



Note- There are about 200 dyeing industries, 500 small scale electroplating industries. 200 MLD of wastewater from the industries is generated within Ludhiana city. Soil contamination happened due to discharging of untreated industrial effluent into open drains/ nallahs.

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Bichadi (Hindustan Agro Chemicals), Rajasthan

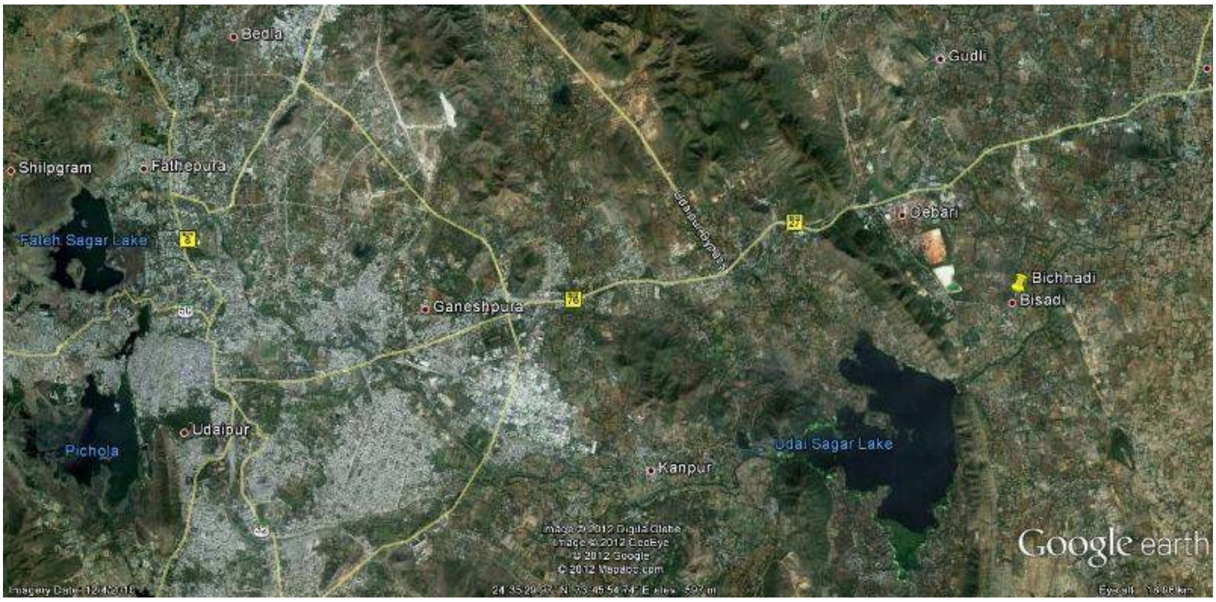
Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Bichhadi	+
City		Near Udaipur City	E
State		Rajasthan	+
Owner		Dropped???	+
Name of polluter		subsidiary units Silver Chemicals, Jyoti Chemicals, Phosphate India and Multi Fertilizers	+
Area	Acre		
Terrain	Coastal, delta, mountainous,	Plain Land	E
Landuse	Urban, industrial, rural, nature	Industrial	+
Accessibility / infrastructure		Road	E
Location under control	Local authorities	RSPCB	E
Distance to contractors / authority		17km from RSPCB Udaipur Regional Office	E
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Agro Chemical, Fertilizer and H-Acid	+
Chemical composition		Gypsum Sludge, Iron Sludge Inorganic and organic salts	+
Physical properties	fluid / solid / solubility / volatility	Solid	E
Position in soil	on the surface / in soil /	On the surface	E
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Waste	+
Period of contaminating	First and last year soil was affected		
Concentration in topsoil	average concentration per parameter	Contamination	+
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)		
Area contaminated soil	acre		
Concentration in groundwater	average concentration per parameter	Contamination	+
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			
Groundwater flow	yes / no	Yes	E

Aspect	*Explanation*	*Actual description*	*Data quality**
Washing (during heavy rain)	yes / no	Yes	E
Evaporation	yes / no	No	E
Flooding / (re)sedimentation	yes / no	No	E
Contaminants are subject re-working by human as raw material (reuse)	yes / no		
Surface water flow	yes / no	Yes	E
By seawater	yes / no		
Typical frequent natural disasters	Flooding, monsoon, washing		
RECEPTOR / THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use			
Ingestion (soil, (ground)water, crops / cattle / game / fish)			
Inhalation (polluted air)			
Contact surface water		Yes	E
Environmental hazards		Yes	E
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / remediation measures already implemented			
General			
Access restriction		No	E
Liners / covers		No	E
Restrictions to land use		No	E
Groundwater treatment		No	E
Data/inform. used			

- poor
0 uncertain
+ fact / reported
E expert guess

Additional Details as per RPCB Report:
The State Board has identified only one hazardous waste dump site in the State at Bichhadi, Udaipur. M/s Hindustan Agro Chemicals Ltd., Bhicchadi, Udaipur was in operation up to 1996 & discharged/dumped its hazardous waste generated by it and its subsidiary units namely M/s Silver Chemicals, M/s Jyoti Chemicals, M/s Phosphate India & M/s Rajasthan Multi Fertilizers in and around the premises of the industry. These units were manufacturing H-Acid, Sulphuric Acid, Oleum, Chlorosulphonic Acid, Phosphatic Fertilizers & other chemical.
The units were closed down by the orders dated 13.2.1996 of the Hon'ble Supreme Court of India in the Writ Petition Civil No. 967/89- Indian Council for Enviro legal Action V/s. Union of India & others. The task of remediation of the

environment & of rehabilitation of the affected area is being performed by the Ministry of Environment & Forest, Government of India as per directions passed by the Hon'ble Supreme Court in the aforesaid Writ Petition & various Interim Applications filed before the Hon'ble Supreme Court in the above cited matter. The Ministry of Environment & Forest, Govt. of India had got the feasibility study conducted for remediation of the contaminated environment in Village, Bicchadi & Surrounding areas through a consortium of consultants i.e. NEERI & M/s SENES Consultants Ltd., Canada.



METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Ranipet (TNCC), Tamil Nadu

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		SIPCOT Industrial Complex, Ranipet	+
City		Ranipet	+
State		Tamil Nadu	+
Owner		SIPCOT	+
Name of polluter		Tamilnadu Chromates & Chemicals Ltd.	+
Area	Acre	7.41 Acres	+
Terrain	Coastal, delta, mountainous,	Plain land on the southern downward side and mountainous surrounding on the northern upward side	+
Landuse	Urban, industrial, rural, nature	Industrial, Urban	+
Accessibility / infrastructure		Road, Railway	+
Location under control	Local authorities	SIPCOT	+
Distance to contractors / authority		116km from TNPCB Head Quarters	+
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Basic Chromium Sulphate	+
Chemical composition		Chromium	+
Physical properties	fluid / solid / solubility / volatility	Solid	+
Position in soil	on the surface / in soil /	On the surface	+
Heterogeneity	homogeneous / heterogeneous / brownfield	Heterogeneous; brownfield	+
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Chromium Residue dump inside industry premises and also outside industry premises	+
Period of contaminating	First and last year soil was affected	1975 to 1995	+
Concentration in topsoil	average concentration per parameter	Cr	+
	maximum concentration per parameter	Hexavalent Chromium Reference NGRI Report: 300mg/kg near surface to 100mg/kg at 5m depth within industry and north of NE- SW natural dyke; 100mg/kg near surface to very low concentration at 5m depth outside NE- SW natural dyke and within industry premises Reference NEERI Report: 25510 to 5753mg/kg near surface within industry premises (Waste constituent having 50mg/kg Cr^{+6} is Hazardous Waste as per Part A of schedule II of Hazardous Waste (Management, Handling and	+

Aspect	*Explanation*	*Actual description*	*Data quality**
		Transboudary) Rules, 2008.	
Volume of contaminated soil	m3 / mmt (source in soil or HW deposit-ed)	220,000MT	+
Area contaminated soil	acre	7.41 Acres	+
Concentration in groundwater	average concentration per parameter	Cr	+
	maximum concentration per parameter	191.73mg/L as Cr^{+6} and 192.4mg/L as Total Chromium inside Industry premises bore well. <0.001 mg/L as Cr^{+6} and <0.003mg/L as Total Chromium outside Industry premises bore wells. Cr^{+6} limit prescribed in Drinking Water Indian Standard IS 10500:1991is 0.05mg/L.	+
Volume contam. groundwater	m3	~32568750m^3 (between 20 to 40m depth)	+
Area contam. groundwater	acre	~10000 Acres (1.125km x 0.965km in S-SE direction)	+
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…	Gravel Clay 3m depth	+
Depth water table	m below surface	3 to 4 m below ground surface	+
Depth bedrock	m below surface	Weathered / Hard Rock for-mation from 5m upto 10m depth below ground surface	+
Permeability topsoil	low/mod./high	High	+
Permeability aquifer	low/mod./high	High	+
Groundwater flow	direction / speed	North to South Filtration velocity 0.005m/d in-side the Industry dump site and 0.0055m/d outside industry. Actual velocity 8.11m/y inside the Industry dump site and 11.4m/y outside industry.	+
Process of spreading			
Groundwater flow	yes / no	No. Restricted by NE-SW dyke	+
Washing (during heavy rain)	yes / no	Yes (Rainfall 1000mm annually)	+
Evaporation	yes / no	No	E
Flooding / (re)sedimentation	yes / no	No	E
Contaminants are subject re-working by human as raw mate-rial (reuse)	yes / no	No	E
Surface water flow	yes / no	Yes. Treated Effluent from Common Effluent Treatment Plant in the area flows through the dumpsite and carries chro-mium downstream.	+
By seawater	yes / no	No	+
Typical frequent natural disas-ters	Flooding, monsoon, washing	Yes	E
RECEPTOR / THREATENED OB-			

Aspect	*Explanation*	*Actual description*	*Data quality**
JECT			
Exposure to contaminants			
Direct human contact during presence on site		Yes	E
Groundwater use		No	+
Ingestion (soil, (ground)water, crops / cattle / game / fish)		No	+
Inhalation (polluted air)		No	+
Contact surface water		Yes	+
Environmental hazards		Yes	+
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / remediation measures already implemented			
General			
Access restriction		Yes	E
Liners / covers		No	+
Restrictions to land use		Yes	+
Groundwater treatment		No	+
Data/inform. used			
NEERI report March 2010 on assessment and remediation options; NGRI report October 2008 on geoenvironmental investigations			

- poor
0 uncertain
+ fact / reported
E expert guess

At Tamilnadu Chromates and Chemicals Ltd., Ranipet, site assessment was carried by NGRI, Hyderabad and NEERI, Nagpur on behalf of TNPCB based on drilling, soil sampling & analysis. TNPCB has entrusted several reputed institutes such as NGRI (National Geophysical Research Institute), Hyderabad; NEERI, Nagpur; Sri Ramachandra University, Chennai and IIT (Indian Institute of Technology), Chennai to conduct thorough investigations related to geoenvironmental, remediation/rehabilitation work, health and bio-remediation assessments at the chromium contaminated site in and around TCCL, Ranipet. Reports in various stages have been submitted by the respective institutes in this regard to TNPCB. According to Geological Survey of India, the chromium contamination has spread up to a distance of 2 km on the southern side from the site.

Rehabilitation plan for TCCL, Ranipet is not yet finalized, however, report prepared by TIDCO (Tamilnadu Industries Development Corporation) for decontamination of soil and containment facility. TIDCO, one of the joint venture of the unit in earlier period has furnished proposal for containment of chromate sludge at cost of ` 24.8 crores. The same was sent to MOEF, GOI for financial assistance under their R& D programme.

Further TNPCB had prepared a project proposal for ` 80.36 crores, including spot monitoring of the site (TCCL). The said project proposal has been submitted to Principal Secretary to Government, Finance Department ,secretariat vide letter dt 16.8.2010 requesting the World bank loan under Capacity building Industrial pollution management Programme assisted by the World bank through the MoEF, New Delhi

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Kodaikanal (Hindustan Unilever), Tamil Nadu

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Kodaikanal	+
City		Kodaikanal	0
State		Tamil Nadu	+
Owner		Panchayat	0
Name of polluter		Hindustan Unilever Ltd.	+
Area	Acre	1 site in industry premises	+
Terrain	delta, mountainous,	Mountainous	0
Landuse	Urban, industrial, rural, nature	Industrial, rural	+
Accessibility / infrastructure		Road, Railway	E
Location under control	Local authorities	Rural Area Panchayat	0
Distance to contractors / authority			
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Mercury bearing scrap from thermometers	+
Chemical composition		Mercury	+
Physical properties	fluid / solid / solubility / volatility	Solid	E
Position in soil	on the surface / in soil /	On the surface	+
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Leached Residue	+
Period of contaminating	First and last year soil was affected		
Concentration in topsoil	average concentration per parameter	Mercury	+
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	3 acres of mercury contaminated soil to a depth of 1m. Apprx 5000 MT of waste(?)2250MT	+
Area contaminated soil	acre	Within and around industry premises, forest	+
Concentration in groundwater	average concentration per parameter	Mrcury	+
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			
Groundwater flow	yes / no	Yes	+
Washing (during heavy rain)	yes / no	Yes	+
Evaporation	yes / no		
Flooding / (re)sedimentation	yes / no		

Aspect	*Explanation*	*Actual description*	*Data quality**
Contaminants are subject re-working by human as raw material (reuse)	yes / no		
Surface water flow	yes / no		
By seawater	yes / no		
Typical frequent natural disasters	Flooding, monsoon, washing	Yes	+
RECEPTOR / THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use		Yes	E
Ingestion (soil, (ground)water, crops / cattle / game / fish)		Yes	E
Inhalation (polluted air)			
Contact surface water			
Environmental hazards		Yes	+
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / remediation measures already implemented			
General			
Access restriction		Yes	0
Liners / covers		No	0
Restrictions to land use			
Groundwater treatment		No	0

- poor
0 uncertain
+ fact / reported
E expert guess

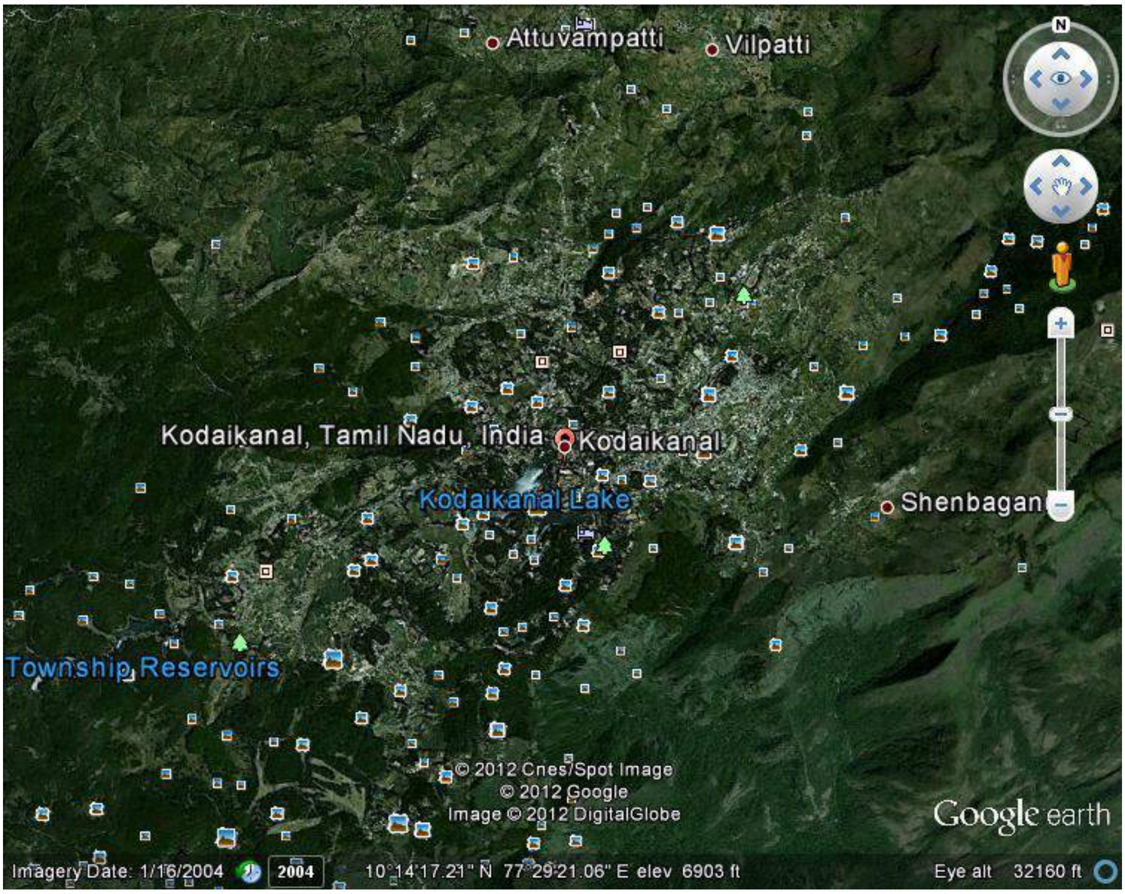

Attuvampatti
Vilpatti
Kodaikanal, Tamil Nadu, India
Kodaikanal
Kodaikanal Lake
Shenbagan
Township Reservoirs
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Image © 2012 DigitalGlobe
Google earth
Imagery Date: 1/16/2004
2004
10°14'17.21" N 77°29'21.06" E elev 6903 ft
Eye alt 32160 ft


KARUR
COIMBATORE
TIRUPPUR
TIRUCHCHIRAPPALLI
MADURAI
TENI
KERALA
Dharapuram
Aravakkurichchi
Udumalaippettai
Oddanchatram
Vedasandur
DINDIGUL
Kodaikkanal
Periyakulam
Nilakkottai
Vadipatti
Nattam
Attur
Map Not To Scale
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STATE BOUN.
DISTRICT BOUN.
TALUK BOUN.
NATIONAL HIGHWAY
NORTH-SOUTH CORRIDORS
GOLDEN QUADRILATERAL
STATE HIGHWAY
OTHER ROAD
RAILWAY
TOURIST PLACE
STATE CAPITAL
DISTRICT HEADQUARTERS
TALUK HEADQUARTERS
OTHER TOWN
AIRPORT
SEA PORT
WESTERN STYLE HOTEL
TRAVELLERS BUNGALOW
FORT
WATER FALLS
WILDLIFE SANCTUARY
RELIGIOUS CENTRE
HILL RESORT
BEACHES
ARCHAEOLOGICAL PLACE
BIRD SANCTUARY
DISTANCE IN KILOMETRES

Mercury pollution

Air and water-borne mercury emissions have contaminated large areas of Kodaikanal and surrounding forests. A study conducted by the Department of Atomic Energy confirmed that Kodaikanal Lake has been contaminated by mercury emissions.,[22][23]

Mercury pollution was reported in Kodaikanal which affected lakes in the area. The causes, originating from a Hindustan Lever thermometer factory nearby, were reported to be dispersal of elemental mercury to the atmosphere from improper storage and dispersal to water from surface effluents from the factory. Apart from tests conducted on Kodaikanal lake, moss samples collected from trees surrounding the Berijam Lake, located 20 km (12.4 mi) from the factory were also tested. This showed mercury level in the range of 0.2 µg/kg, while in Kodaikanal lake the lichen and moss levels were 7.9 µg/kg and 8.3 µg/kg, respectively. Fish samples tested from the Kodaikanal lake also showed Hg level in the range of 120 to 290 mg/kg confirming that pollution of the lake had taken place due to mercury emissions from the factory.[24]

The Hindustan Unilever thermometer factory caused widespread mercury pollution through improper disposal of broken thermometer waste containing large quantities of mercury. The factory sold much of this waste to a junkyard in Kodaikanal and also dumped large quantities in the forest behind the factory. The factory was eventually closed in 2001 after 18 years of operation. Hindustan Lever, have used considerable legal maneuvering to avoid paying compensation the ex-workers and their families, many of whom died or became physically handicapped as a result of mercury poisoning.[25][26]

The ex-workers have joined to form the 559-strong Ex-Mercury Employees Welfare Association and in 2006 filed a Public Interest Litigation (PIL) suit in the Madras High Court. The association wants an economic rehabilitation scheme and a healthcare treatment and monitoring programme at the company's expense for everyone who ever worked in the factory. It also wants the company prosecuted. Hindustan Unilever denies that any of the health problems of the workers or their families was the result of mercury exposure in the factory. In 2010 the workers were still fighting for compensation.[27]

June 2007 the Madras High Court constituted a five-member expert committee to decide on the mercury workers health claims. The last court hearing was in June 2008. The committee later failed to find sufficient evidence to link the current clinical condition of the factory workers to past mercury exposure in the factory.[28]

Additional site remediation studies are being undertaken by national institutions, as desired by the Tamil Nadu pollution Control Board (TNPCB) and the Court's Scientific Experts Committee (SEC) during the project review meeting in January 2010. IIT Delhi is revalidating the risk assessment study and site specific clean-up standard; National Botanical Research Institute, Lucknow is studying impact on trees and preservation of trees; and Centre for Soil and Water Conservation Research and Training Institute, Ooty is studying the impact on soil and soil erosion. Based on the above study findings, results of remediation trials and recommendation of SEC, the TNPCB will take a final decision on the clean-up standard. Hindustan Unilever Ltd. (HUL) will commence soil remediation work at the factory site once

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Lucknow (India Pesticides), Uttar Pradesh

Date latest update:	20120423
Purpose:	To get a feeling of the general typology of the study
Status:	Draft
Author:	Rob Heijer
Revisions:	Based on data provided during Mission 1
Actions:	

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Lucknow	+
City			
State		Uttar Pradesh	
Owner			
Name of polluter		India Pesticides Ltd.	+
Area	Acre		
Terrain	Coastal, delta, mountainous,		
Landuse	Urban, industrial, rural, nature		
Accessibility / infrastructure			
Location under control	Local authorities	Gram Panchayat Barabanki	+
Distance to contractors / authority			
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Lindane production	+
Chemical composition		HCH / pesticides	
Physical properties	fluid / solid / solubility / volatility		+
Position in soil	on the surface / in soil /		
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Waste	+
Period of contaminating	First and last year soil was affected		
Concentration in topsoil	average concentration per parameter		
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	Approx. 36.432 tonnes	+
Area contaminated soil	acre		
Concentration in groundwater	average concentration per parameter		
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		

Aspect	Explanation	Actual description	Data quality*
Process of spreading			
Groundwater flow	yes / no		
Washing (during heavy rain)	yes / no		
Evaporation	yes / no		
Flooding / (re)sedimentation	yes / no		
Contaminants are subject re-working by human as raw mate-rial (reuse)	yes / no		
Surface water flow	yes / no		
By seewater	yes / no		
Typical frequent natural disas-ters	Flooding, monsoon, washing		
RECEPTOR / THREATENED OB-JECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use			
Ingestion (soil, (ground)water, crops / cattle / game / fish)			
Inhalation (polluted air)			
Contact surface water			
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / reme-diation measures already implemented			
General			
Access restriction			
Liners / covers			
Restrictions to land use			
Groundwater treatment			
Data/inform. used			
1) “annexure” page 12 (provided bij CPCB during mission 1)			
Main conclusion	Possible Scope Remedia-tion	Additional data needed	
HW dumpsite Pesticides		Poor data on source material Not data on human exposure or environmental hazards	

- poor
0 uncertain
+ fact / reported
E expert guess

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Kanput (Juhi Baburaiya, Raki Mandi), Uttar Pradesh

Date latest update:	20120423
Purpose:	To get a feeling of the general typology of the study
Status:	Draft
Author:	Rob Heijer
Revisions:	Based on data provided during Mission 1
Actions:	

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Kanpur, Nagar Nigam urban area, Juhi Baburaiya, Raki Mandi	+
City		Kanpur	+
State		Uttar Pradesh	+
Owner		Not known	+
Name of polluter		Kampur Chemical	+
Area	Acre		
Terrain	Coastal, delta, mountainous,		
Landuse	Urban, industrial, rural, nature	Densely populated with settle-ment and households	
Accessibility / infrastructure			
Location under control	Local authorities		
Distance to contractors / au-thority			
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Industrial waste Plant of Basic chrome sulphate	+ 3)
Chemical composition		Basic chrome sulphate, Pb, DDT/Lindane	+
Physical properties	fluid / solid / solubility / volatility		
Position in soil	on the surface / in soil /	Chemical industrial waste is buried on the grounds of the old plant	
Heterogeneity	homogeneous / heterogeneous / brown-field		
Origin of the deposit	dump / leakage / fluviatile deposit (sedi-ment) / areal deposit / storage /		
Period of contaminating	First and last year soil was affected	Factory dismantled long back	+
Concentration in topsoil	average concentration per parameter		
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposit-ed)	10.000 ton waste	+
Area contaminated soil	acre	5-6	+
Concentration in groundwater	average concentration per parameter		
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			

Aspect	Explanation	Actual description	Data quality*
Type of topsoil	sand/clay/bedrock/…	River bank deposits 3)	0
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high	High	E
Groundwater flow	direction / speed		
Process of spreading			
Groundwater flow	yes / no	yes	+
Washing (during heavy rain)	yes / no		
Evaporation	yes / no		
Flooding / (re)sedimentation	yes / no		
Contaminants are subject re-working by human as raw mate-rial (reuse)	yes / no		
Surface water flow	yes / no		
By seewater	yes / no		
Typical frequent natural disas-ters	Flooding, monsoon, washing		
RECEPTOR / THREATENED OB-JECT			
Exposure to contaminants			
Direct human contact during presence on site		Site assessable for people	
Groundwater use		Wells and drinking water is af-fected Concentration of Cr 124-258 > Indian limits for area polluted by tanneries 4)	
Ingestion (soil, (ground)water, crops / cattle / game / fish)		Polluted wells	
Inhalation (polluted air)			
Contact surface water		Plume is influencing river water quality	
Environmental hazards			
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / reme-diation measures already implemented			
General			
Access restriction			
Liners / covers			
Restrictions to land use			
Groundwater treatment			
Data/inform. used			
1) “annexure” (provided by CPCB during mission 1) 2) list of HWCDS in the country (preliminary information, annexure-I (provided by CPCB during mission 1)			

Aspect	*Explanation*	*Actual description*	*Data quality**
3) not identified memo 4) CCPB-study 1997			

- poor
0 uncertain
+ fact / reported
E expert guess

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Kanpur Village (Cerulean), Uttar Pradesh

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Kanpur Village	+
City		Kanpur District	+
State		Uttar Pradesh	+
Owner		District Gram Panchayat, Rural Area, Rama Bai Nagar	+
Name of polluter		Cerulean Chemicals; Warsi Chemicals; Chandani Chemicals; Amoliya Textiles; Hilger Chemicals (All units closed long back)	+ + + + + +
Area	Acre	20000 Acers (Private land)	+
Terrain	Coastal, delta, mountainous,	Plain land	E
Landuse	Urban, industrial, rural, nature	Rural	+
Accessibility / infrastructure			
Location under control	Local authorities	District Gram Panchayat, Rural Area, Rama Bai Nagar	+
Distance to contractors / authority		43km from Kanpur Regional Office of UPPCB	E
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Chromium ore processing	E
Chemical composition		Basic Chromium Sulphate containing Chromium VI	+
Physical properties	fluid / solid / solubility / volatility	Solid	E
Position in soil	on the surface / in soil /	On the surface	E
Heterogeneity	homogeneous / heterogeneous / brownfield		
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Waste	+
Period of contaminating	First and last year soil was affected		
Concentration in topsoil	average concentration per parameter	Chromium VI	+
	maximum concentration per parameter		
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	45000MT	+
Area contaminated soil	acre	20000 Acres	+
Concentration in groundwater	average concentration per parameter		
	maximum concentration per parameter		
Volume contam. groundwater	m3		
Area contam. groundwater	acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…		
Depth water table	m below surface		
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		

Aspect	*Explanation*	*Actual description*	*Data quality**
Process of spreading			
Groundwater flow	yes / no	Yes	E
Washing (during heavy rain)	yes / no	Yes	E
Evaporation	yes / no	No	E
Flooding / (re)sedimentation	yes / no	No	E
Contaminants are subject re-working by human as raw material (reuse)	yes / no		
Surface water flow	yes / no	No	E
By seawater	yes / no	No	E
Typical frequent natural disasters	Flooding, monsoon, washing	Yes	E
RECEPTOR / THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on site			
Groundwater use		Yes	E
Ingestion (soil, (ground)water, crops / cattle / game / fish)		Yes	E
Inhalation (polluted air)			
Contact surface water			
Environmental hazards		Yes	E
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions			
Value of buildings			
Possibilities of temporary site clearance			
Value of site	Low/high		
Provisory prevention / remediation measures already implemented			
General			
Access restriction		No	E
Liners / covers		No	E
Restrictions to land use		No	E
Groundwater treatment		No	E

\- poor
0 uncertain
\+ fact / reported
E expert guess


District Head Quarter Kanpur Dehat, NH 25, Ramabai Nagar, Uttar Pradesh
Muridpur
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Google earth

METHODOLOGIES FOR NPRPS INDIA

SITE FACTSHEET Nibra Village, West Bengal

Aspect	*Explanation*	*Actual description*	*Data quality**
General data			
Location of the site		Nibra Village	+
City		District Howrah	+
State		West Bengal	+
Owner		Howrah Municipal Corporation, Ward No 46	+
Name of polluter		Not Known	+
Area	Acre	1.8	+
Terrain	Coastal, delta, mountainous,	Plain Land	+
Landuse	Urban, industrial, rural, nature	Rural	+
Accessibility / infrastructure		Road	+
Location under control	Local authorities	Howrah Municipal Corporation, Ward No.46	+
Distance to contractors / authority			
SOURCE			
Contaminants			
Origin of contaminants	what type of industry or activity	Basic Chromium Salt Manufacturing Industry	+
Chemical composition		Hexavalent Chromium	+
Physical properties	fluid / solid / solubility / volatility	Solid	+
Position in soil	on the surface / in soil /	On the surface	+
Heterogeneity	homogeneous / heterogeneous / brownfield	Homogeneous	+
Origin of the deposit	dump / leakage / fluviatile deposit (sediment) / areal deposit / storage /	Waste	+
Period of contaminating	First and last year soil was affected	198 to 2000	+
Concentration in topsoil	average concentration per parameter	Total Chromium 27120 to 55509.7mg/kg Chromium VI 988 to 1956.3mg/kg	+
	maximum concentration per parameter	Total Chromium 55509.7mg/kg Chromium VI 1956.3mg/kg	+
Volume of contaminated soil	m3 / mmt (source in soil or HW deposited)	3700m^3 / 4400MT	+
Area contaminated soil	Acre	1.8	+
Concentration in groundwater	average concentration per parameter	Total Chromium Below Detectable Level Chromium VI Below Detectable Level	+
	maximum concentration per parameter	Below Detectable Level	+
Volume contam. groundwater	m3		
Area contam. groundwater	Acre		
PATHWAY			
Geology / Geohydrology			
Type of topsoil	sand/clay/bedrock/…	Clay and sand	+
Depth water table	m below surface	Between 2 to 4 m	+
Depth bedrock	m below surface		
Permeability topsoil	low/mod./high		

Aspect	*Explanation*	*Actual description*	*Data quality**
Permeability aquifer	low/mod./high		
Groundwater flow	direction / speed		
Process of spreading			
Groundwater flow	yes / no		
Washing (during heavy rain)	yes / no	Yes	+
Evaporation	yes / no	No	+
Flooding / (re)sedimentation	yes / no	No	+
Contaminants are subject re-working by human as raw material (reuse)	yes / no		
Surface water flow	yes / no	Yes	+
By seawater	yes / no	No	+
Typical frequent natural disasters	Flooding, monsoon, washing	Yes	+
RECEPTOR / THREATENED OBJECT			
Exposure to contaminants			
Direct human contact during presence on site		Yes	+
Groundwater use		No	+
Ingestion (soil, (ground)water, crops / cattle / game / fish)			
Inhalation (polluted air)			
Contact surface water			
Environmental hazards		Yes	+
Social / economical aspects			
Social sensibility land user(s)	Organization and motivation		
Land use restrictions		No	+
Value of buildings			
Possibilities of temporary site clearance		No	+
Value of site	Low/high	High	+
Provisory prevention / remediation measures already implemented			
General		No	+
Access restriction		No	+
Liners / covers		No	+
Restrictions to land use		No	+
Groundwater treatment		No	+
Data/inform. used			
data provided during Mission 1 and 017 Dump Site Report WB received from CPCB on 03 05 2012 Site visit 02 07 2012, Discussions with WBPCB Official Mrs. Kundu			

- Site requires remediation; demolition of existing housing for soil excavation may be difficult.

0 uncertain

\+ fact / reported

E expert guess

Latitude 22°36'7.74"N
Longitude 88°15'15.97"E

Review of national and international approaches to remediation
Key output Final Report Task 2

Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India

Ministry of Environment and Forests, Government of India, Delhi
The World Bank, Washington, D.C.

CBIPMP_Methodologies_Task2_v5_final

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Executive summary

General
This report presents the key output of the activities carried out under Task 2 (Review of national and international approaches to remediation) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

Objective and report content
The objective of Task 2 is to provide an overview of the approaches and operational processes for remediation of contaminated sites in India and abroad. This overview is needed for Task 3, in which options for remedial actions are recommended. This report presents an analysis of approaches developed in six countries, in which we also go into their experience in the implementation of these approaches, and reasons for changes, where applicable. The report focuses on those aspects in the approaches that will be key to the user of the Guidance document, to be developed in Task 4. This report presents the approaches in the United States, the United Kingdom and The Netherlands in more detail, as these countries have gone through several policy development stages in more than three decades of dealing with contaminated land. Also, recent developments in sustainable remediation are highlighted, as this concept is gaining considerable weight internationally.

Results
This report presents the following results:
- an overview of the approach to the following aspects in the United States, the United Kingdom, The Netherlands, Australia, France, Brazil (state of São Paulo) and India, related to the use of the Guidance document to be developed in Task 4 (see Chapter 2 and Annex 1): number of contaminated sites, important categories of pollution, effects, key documents, management approach, both to historically contaminated sites and current sites (integrated in the prevention policy), responsibility, actors, methodology, standards and post-remediation target value;
- a more detailed insight in the following aspects of the approach in the US, the UK and The Netherlands (see Chapter 3): typology used, site assessment, risk assessment, remediation preparation and execution, the role of standards, and technical possibilities for remediation;
- an overview of recent developments in the sustainable remediation concept, offering options to extend the number of environmental aspects to consider during remediation options appraisal (see Chapter 4);
- a sequence of steps to take from initial investigation to remedial action, developed by CPCB for use in India (see Chapter 5);
- Conclusions for the development of the Guidance document (see Chapter 6).

Conclusions
This report presents the following conclusions, based on the results described above:

- National inventories have invariably led to the conclusion that policy and regulations are needed to manage the effects of soil contamination. Strategic and technical approaches are fundamentally different for severely and less severely contaminated sites.
- Threat to human health, to ecology and to drinking water supply are broadly recognized potential impacts of soil contamination;
- Generally the fit for use approach is used, and the polluter pays principle, in which the preferred actor to execute remediation is the owner or beneficiary of a site, while public funding is needed to intervene at orphan sites;
- Negotiation instead of regulation has been the more common approach;
- Development of brownfield sites has often been the driver for remediation of contaminated sites;
- In some countries regional or provincial state authorities have large responsibilities in drawing up policy and regulations for remediation. Always local and regional authorities play an important role in the agreement procedures when preparing remediation projects;
- The steps described in the methodology of CPCB are comparable to approaches abroad. The Guidance document will present these elements in detail for the entire remediation process;
- The Source-Pathway-Receptor approach is generally used for risk assessment and remediation design;
- Typology of contaminated situations is a much used tool for national or regional programming of site assessment and remediation. For common specific types of sites often special programmes are designed and executed, with programme specific funding.
- The goal of remediation in US, UK and NL in general is to prevent further risks for human health and the environment. The goals for a specific site have to be derived from generic standards and site specific risk calculations.
- Remediation options are selected using sets of criteria which in all countries are more or less the same: environmental results, technical feasibility/risks, costs, impact of the works, available time, spatial planning, social aspects.
- During implementation of the remediation works assessments are necessary to verify the results of the remediation. Often post-remedial measures are necessary to monitor the effects of the remediation in case not all contamination could be removed or treated. Sometimes, maintenance activities are necessary to ensure long term remediation measures.
- Most discrepancies and gaps in the current Indian situation are addressed by the current CBIPMP NPRPS Assignments.
- The steps in the process of site assessment and remediation are generally the same. Best practices and conclusions for the development of the Guidance document in Task 4 are included in Chapter 6.

Table of contents

1 Introduction

1.1 General

This report gives the key output of the activities carried out under Task 2 (Review of national and international approaches to remediation) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

Earlier drafts of this report were presented to and discussed with the Technical Expert Panel (TEP) on June 28th and August 13th, 2012. An earlier draft of this report was presented to and discussed with the World Bank and MoEF on 30th November 2012. An earlier draft of this report was presented to the project teams of the Assignments 1 and 3 on 10th December 2012. The comments by the TEP, the World Bank, MoEF, and the project teams of the Assignments 1 and 3 referring to this Task have been implemented in this final version of the report.

1.2 Objectives Task 2

The objective of Task 2 is to provide an overview of the approaches and operational processes for remediation of contaminated sites in India and abroad. This overview is needed for Task 3, in which options for remedial actions are recommended, and for Task 4, in which the Guidance Document will be developed.

Many different approaches have been developed in several countries, that have also built up considerable experience in the implementation of these approaches. In several countries approaches have been developed at state, regional or even local levels, taking into account local conditions, legislation and ambitions. As a result a variety of approaches and experiences with the implementation of those is available and it can be of great help to India to see what measures have been successful. Also, a lot can be learned from the measures that have been less successful.

1.3 Review international approaches of the three NPRPS projects

In the NPRPS project ‘Inventory and mapping of probably contaminated sites in India’ a specific review on international approaches of initial site assessment methods is done.
In the NPRPS project ‘Development of a National Programme for Rehabilitation of Polluted Sites’ a comprehensive review on legal, institutional and financial aspects in international policy is done.
In the present report a review of the general aspects for remediation of contaminated sites is presented in chapter 2.
Some elements in this report are partially overlapping the review in the aforementioned other two NPRPS-projects. In order to minimise this overlap this re-

port focuses, in chapter 3, on the technical aspects of site assessment and remediation approaches in three of the studied countries: United States, United Kingdom and The Netherlands.

2 Review of international approaches for remediation of contaminated sites

2.1 Methodology

We have inventoried important aspects of the approach for remediation of contaminated sites. We have based this inventory on literature and local expertise of Grontmij-employees. For the following countries and regions a summary of the approaches has been made: United States, United Kingdom, Netherlands, France, Australia, and Brazil (São Paolo). Furthermore the following international documents have been studied to gain insight in good practices for the assessment and remediation of contaminated sites: UNIDO-guideline on POP's and Canada/Alberta guidelines on ranking of sites. Because ranking of sites is part of Assignment 1, we have not included a summary of this last document in this report.

2.2 Aspects

There are several elements to be recognized in the approaches of various countries to soil contamination and remediation of contaminated sites. These elements vary from political, legal, financial, organizational to technical aspects. Generally we can describe a chain of these aspects as shown in figure 2.1.

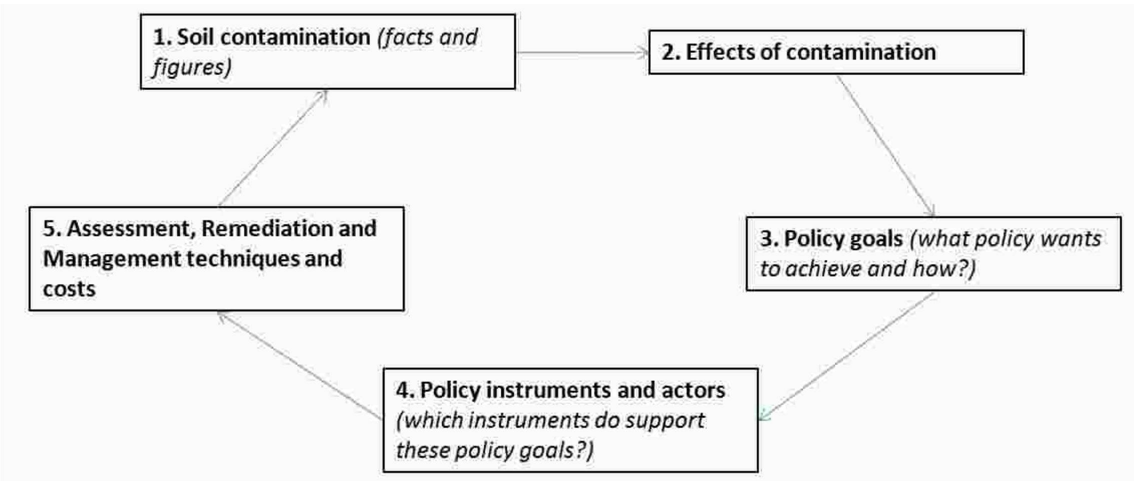


Figure 2.1 Aspects of approach for contaminated sites, inventory international approaches

The fact that figure 2.1 is a cycle shows that countries use knowledge gained to go through the chain repeatedly to keep improving previously developed policies and methods. In this section we list the aspects relevant for this Task by element in figure 2.1:

1. Soil contamination (facts and figures):
- Number of contaminated sites (inventory; results of inventorying-actions);
- Categories of contaminated sites and situation (typology; dominating categories);
- Physical aspects: geo(hydro)logy (bedrock, physical soil characteristics, groundwater recharge and natural disasters) and climate (temperature, rainfall/precipitation, precipitation excess/deficit).

2. Effects of contamination
- Specific effects dominating in a country (human health, environment);
- Other aspects that are eye-catching in a country (e.g. effect on value of real estate; in some cases the costs of assessment and remediation can exceed the potential value of the property).

3. Policy goals (what policy wants to achieve and how):
- Strategic and operational goals*:*
  - Elimination or management of negative effects and risks;
  - Priority setting;
  - Linking to approach on other environmental problems (water quality, external safety, hazardous waste management, etc.);
  - Political and social aspects;
  - Choosing what to emphasize in regulations, budget and communication: prevention or remediation of soil pollution?
  - Choosing between generic soil quality standards to comply with or site specific risk assessment;
  - Defining who has to pay: the polluter, the government, the owner of the property?

4. Policy instruments and actors *(which instruments support the operational policy goals and what actors play an important role?):*
- Legislation, standards and procedures;
- Remediation programme (planning & priorities, total estimated costs);
- Relevant public and private actors and organizations in the remediation process;
- Budgets and financing by government and cofunding by private organizations;
- Guidelines on site characterization methods, risk assessment and methods for selection and design of remediation options;
- Communication methods and stakeholder involvement.

5. Assessment, Remediation and Management techniques and costs
- Standards for remediation;
- Much used techniques in certain situations (i.e. in relation to the typology).

2.3 Evaluation of general aspects of remediation approach

2.3.1 Introduction

In this section conclusions are drawn from the comparison of the various (inter)national approaches to and experiences with remediation of contaminated sites.

A summarized overview of the results, as well as a summary of the UNIDO-report, is presented in Annex 1.
More detailed descriptions of the approach in the studied countries are presented in Annex 2.
A selection of remediation projects and the approach towards the same are, as per example, summarized in Annex 3.
The next chapter will highlight specific details of site assessment and remediation approach in three of the studied countries.

This evaluation will be of use when drawing up options for the remediation of known contaminated sites in India (Task 3) and for the Guidance documents we will develop (Task 4).

2.3.2 Evaluation

1. Soil contamination

- In most countries the term 'soil' includes the solid soil material, as well as the groundwater and air among the solid particles. Methodologies on dealing with soil contamination are often aimed at terrestrial soil, as well as at sediments.
- Most countries have executed national inventories of contaminated sites.
- These inventories have invariably led to the conclusion that policy and regulations are needed to manage the effects of soil contamination.
- It is important to distinguish sites with severe contamination and sites with less severe contamination. Strategic and technical approaches are fundamentally different for these categories.
- Some countries keep registers of contaminated sites, which can be consulted by the public.

2. Effects of contamination

The following possible impacts of soil contamination are broadly recognized:
- Threat to human health.
- Threat to ecology.
- Threat to drinking water supply.

3. Policy goals

- Generally, the fit for use approach is used, both for current and for future land use planning. In some countries with a long history on the approach to soil contamination this goal has evaluated from multifunctionality to fit for use.
- Most countries have implemented the polluter pays principle, in which the preferred actor to execute remediation is the owner or beneficiary of a site. For orphan sites public funding is necessary to initiate intervention measures.
- Negotiation, always based on regulation, instead of just regulation has been the more common approach. Development of brownfield sites (market driven, economic incentives for remediation and spatial planning) has been the driver for remediation of most of the contaminated sites.

4. Policy instruments and actors

- In some countries regional or provincial state authorities have large responsibilities in drawing up policy and regulations for remediation. Always, local and regional authorities play an important role in the agreement procedures when preparing remediation projects.
- Assessment and remediation steps: all countries have a more or less similar approach to these steps: gathering information on historic use and site inspection comes first, followed by preliminary site assessment. Only when the possibility of severe contamination is expected an extended assessment takes place. If the assessment results in the conclusion of unacceptable risks a conclusion is drawn on the need of intervention. Then a process of selection of intervention/remediation measures starts, eventually leading to the execution of the selected specific measures. The results of these measures have to be verified and reported in order to conclude whether the risks of the contamination have been removed or adequately managed. For each of the steps it is possible to detail it into smaller elements. This is important to get insight in the planning and efforts needed to implement this process for specific sites. In Task 4 (Guidance document) of this assignment we will work out these elements for the entire remediation process.
- Procedures for agreeing on remediation plans and taking care of stakeholder/community involvement are part of the preparation phase of remediation.

5. Assessment, Remediation and Management techniques and costs:

- The Source-Pathway-Receptor approach is generally used for risk assessment and remediation design.
- Most countries have general standard target values for remediation. For specific sites often a risk based approach is used when selecting a remediation option.
- Figure 2.2 shows a general overview of existing options for land management and remediation. This will be detailed out in the Guidance document, to be developed in Task 4. Land management includes actions to manage soil, sediment, ground water and surface water which has been affected by contaminated sites.

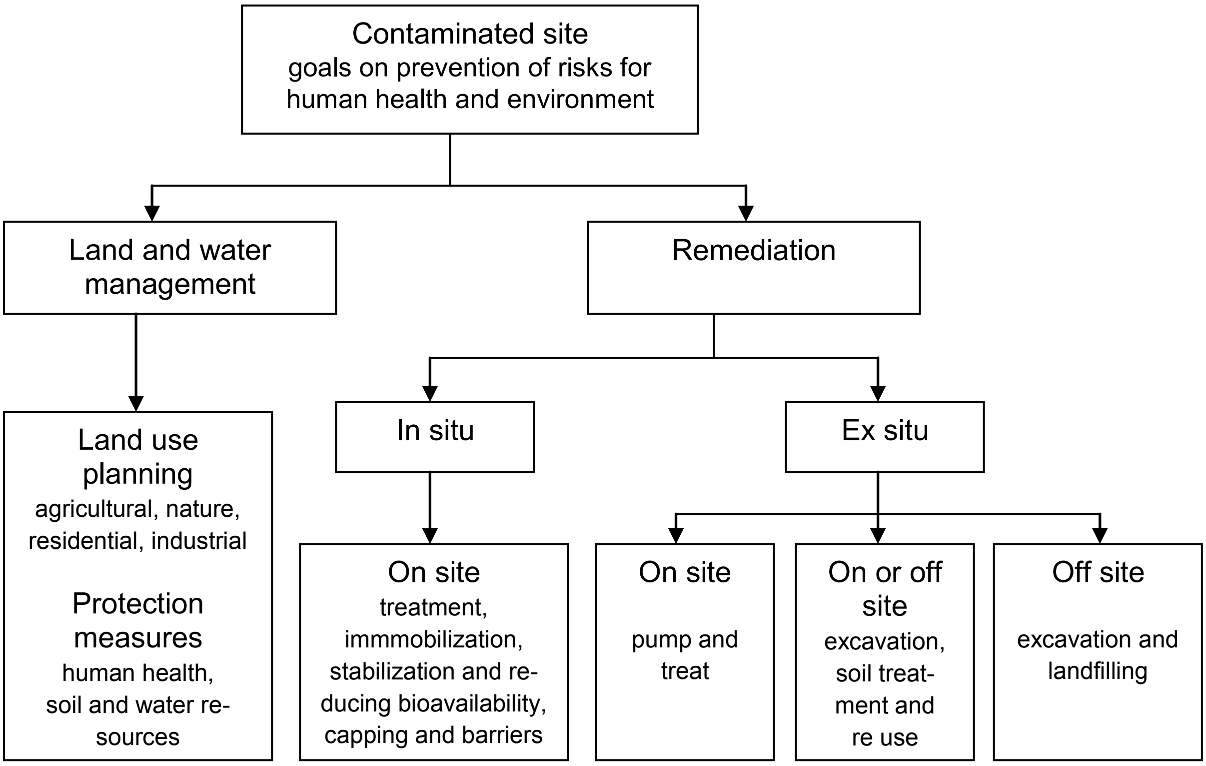


Figure 2.2 General overview of existing options for land management and remediation of contaminated sites

3 Review of site assessment and remediation process

3.1 Introduction

Chapter 2 presents general information on the approaches to site assessment and remediation of contaminated sites in various countries. To get more insight in the technical approach we go into more detail and show some examples of these approaches in this chapter. The approaches in the United States, the United Kingdom and The Netherlands are most developed to give input for the development of potential approaches for India. Best practices of the approaches in these three countries are concluded in section 3.6.

Each country uses its own structure in describing the sequence of activities from the initial identification of a site to post remediation activities. For the presentation of the approach of contaminated sites in the United States, the United Kingdom and The Netherlands we have therefore used a structure consisting of the following elements:

- steps in the remediation process;
- typology;
- assessment of sites:
  - identification;
  - initial assessment;
  - detailed assessment;
  - risk assessment.
- selection of remediation options and selection and design of technologies;
- implementation of remediation works and post-remediation activities;
- standards and support on technical possibilities for assessment and remediation.

3.2 Steps in the remediation process

Steps in the remediation process (US)

The steps in the US remediation process are best illustrated with the image of part of EPA's website (http://www.epa.gov/superfund/cleanup/index.htm) in figure 3.1 below.

Cleanup Process

The Superfund cleanup process begins with site discovery or notification to EPA of possible releases of hazardous substances. Sites are discovered by various parties, including citizens, State agencies, and EPA Regional offices. Once discovered, sites are entered into the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), EPA's computerized inventory of potential hazardous substance release sites (search CERCLIS for hazardous waste sites). Some sites may be cleaned up under other authorities. EPA then evaluates the potential for a release of hazardous substances from the site through these steps in the Superfund cleanup process. Community involvement, enforcement, and emergency response can occur at any time in the process. A wide variety of characterization, monitoring, and remediation technologies are used through the cleanup process.

PA/SI	Preliminary Assessment/Site Inspection Investigations of site conditions. If the release of hazardous substances requires immediate or short-term response actions, these are addressed under the Emergency Response program of Superfund.
NPL Listing	National Priorities List (NPL) Site Listing Process A list of the most serious sites identified for possible long-term cleanup.
RI/FS	Remedial Investigation/Feasibility Study Determines the nature and extent of contamination. Assesses the treatability of site contamination and evaluates the potential performance and cost of treatment technologies.
ROD	Records of Decision Explains which cleanup alternatives will be used at NPL sites. When remedies exceed 25 million, they are reviewed by the National Remedy Review Board.
RD/RA	Remedial Design/Remedial Action Preparation and implementation of plans and specifications for applying site remedies. The bulk of the cleanup usually occurs during this phase. All new fund-financed remedies are reviewed by the National Priorities Panel.
Construction Completion	Construction Completion Identifies completion of physical cleanup construction, although this does not necessarily indicate whether final cleanup levels have been achieved.
Post Construction Completion	Post Construction Completion Ensures that Superfund response actions provide for the long-term protection of human health and the environment. Included here are Long-Term Response Actions (LTRA), Operation and Maintenance, Institutional Controls, Five-Year Reviews, Remedy Optimization.
NPL Delete	National Priorities List Deletion Removes a site from the NPL once all response actions are complete and all cleanup goals have been achieved.
Reuse	Site Reuse/Redevelopment Information on how the Superfund program is working with communities and other partners to return hazardous waste sites to safe and productive use without adversely affecting the remedy.

Figure 3.1 Representation of steps in remediation process on US EPA website

Steps in the remediation process (UK)

The systematic procedure for the investigation and remediation of land contamination in the UK was standardized with the publication of the Guidance "Model Procedures for Management of Land Contamination" CLR 11 in 2004. In this Guidance neither a typology nor a standard set of remediation options are used.

Figure 3.2 below shows the process framework which intends to provide a structured and reasoned technical basis for making decisions on land contamination in an objective, consistent and transparent way, and to ensure that appropriate information is collected at relevant stages to underpin the process.

There are three main elements in the approach: risk assessment, option appraisal and implementation of the remediation strategy.

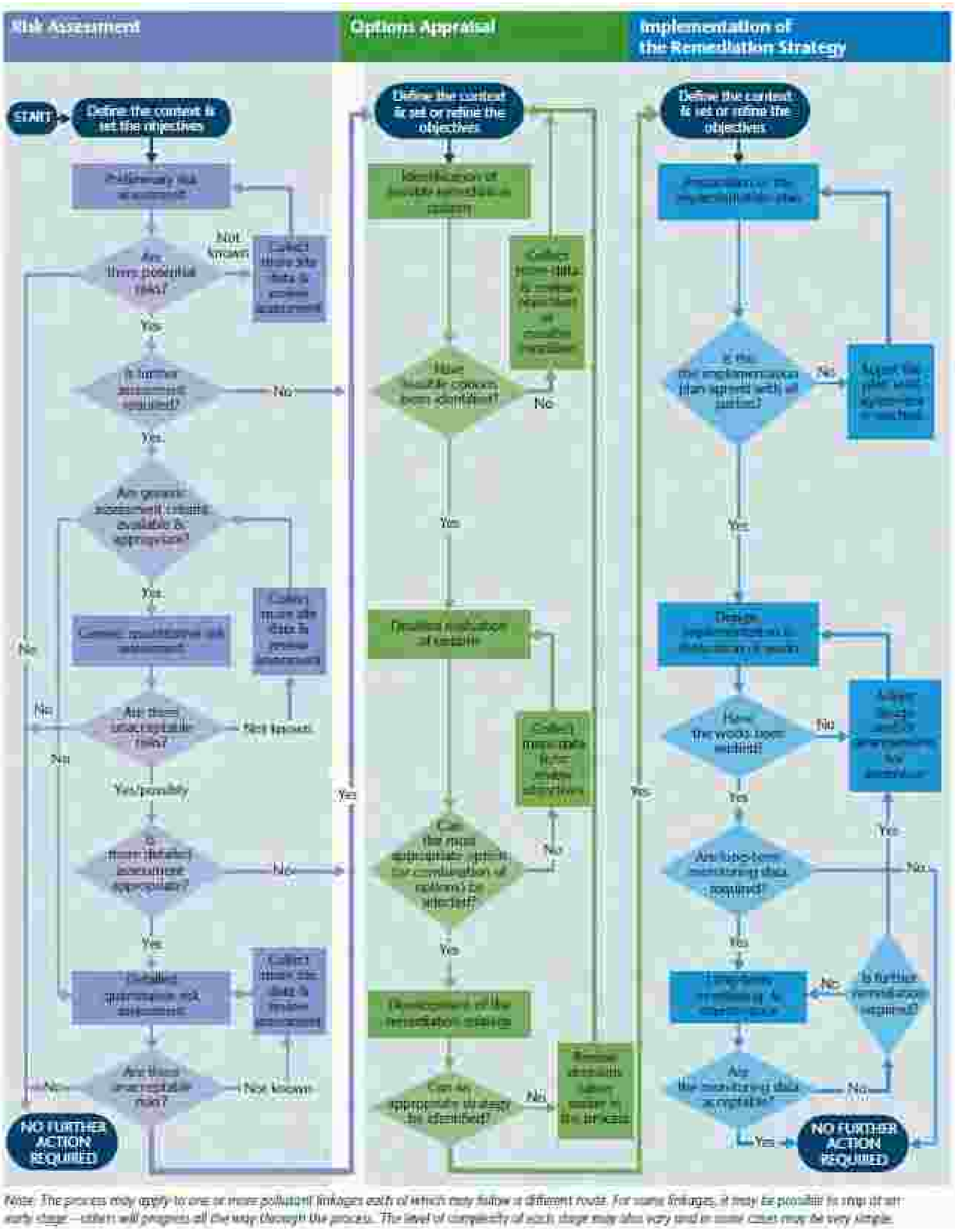


Figure 3.2 Flowchart for structured decision making on land contamination as used in the UK

Steps in the remediation process (NL)
The steps in the remediation process as implemented in the Netherlands are described in table 3.1 below.

Table 3.1 Steps in the remediation process in the Netherlands

Step	Goal and activities
Site assessment: preliminary risk assessment	Desk study to identify contaminated sites in combination with limited field work to confirm the presence or absence or contaminated soil, ground water or sediment.
Site assessment: detailed and risk assessment	Investigation (combination of field work, testing and analyses) on the extent and level of the contamination related to possible risks for receptors.
Selection of remediation options	For sites with unacceptable risks remediation options are inventoried and evaluated.
Remediation plan	The design of the selected remediation option wherein the remediation measures are combined into an effective system. The remediation plan needs approval by the relevant environmental authorities.
Implementation remediation project	After the tendering process the remediation is executed by the contractor. During these works verification and control measures are taken. This will result in a report which can be validated by the authorities.
Monitoring and control	When post remediation measures have to be taken, monitoring and control are necessary activities.
Re-use of the site	After remedial activities the site can be re-used or re-developed.

3.3 Typology

Typology (US)
Superfund is the federal government's program, related to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, in order to clean up the nation's uncontrolled hazardous waste sites. Aim of this program is to ensure that abandoned hazardous waste sites which are not remediated by private parties are cleaned up to protect the environment and human health. There are several steps in the cleanup process of Superfund. Some of these steps are relevant for prioritizing sites and reviewing decisions by the relevant authorities. Much attention is given to stakeholder communication. In this section we focus on the technical steps in the process of site assessment and remediation design and implementation of soil remediation which can be recognized in the United States. For more information on the policy aspects on soil contamination in the US we refer to Annex 2.

Specific attention is given to certain groups of contaminated sites, e.g. abandoned mine lands, pesticides at agricultural land and oil spills. The approach to these groups of sites can be done effectively and efficiently by application of specific legal or financial aspects. Technical aspects play a secondary role in these programs.

The general steps for site assessment and design and execution of remediation of these groups of sites do not differ from the generic approach. When drawing up specific site assessment plans or remediation plans of course differences appear, related to the combination of e.g. geology, contaminants and land use.

Typology (UK)
Inventories in the United Kingdom show that the greatest amounts of land affected, both in terms of area and numbers of sites, were identified as railway land, garages and filling stations, gas works, sewage works, textiles, engineering works, and ceramics and cement works. These various activities were carried out on a wide range of scale of operations, resulting in point sources of contamination of soil and groundwater as well as larger extents of diffuse contamination. It has been estimated that (before the global financial crisis) over 90% of remediation in England has taken place voluntarily by developers under market-led solutions.

Typology (NL)
The Netherlands has carried out various inventories of potentially contaminated sites throughout the last 30 years. These inventories had three goals: 1) to gain insight in the locations where possibly environmental risk could occur; 2) to gain insight in the total problem of soil pollution, in order to have a basis for the development of the national policy and approach to this; 3) to develop specific approaches to certain groups of contaminations.

The inventories started with the collection of information on the presence of various industries, because good quality information is available on that aspect throughout history. For each of these industries it was then elaborated which production processes could have led to soil pollution. Information on the used substances and methods of waste disposal was important for this inventory.

In the inventories the following important causes of point sources of contamination have been identified: metal industry, oil spills, gasworks, waste dump sites, cleaners, petrol stations. Diffuse contamination exists due to mainly the use of waste material for construction purposes (building, infrastructure).
For programming objectives this inventory has been proven very useful, because it enabled to make rough calculations of the total needed budgets for soil remediation, based on evaluation of average costs of remediation of such sites. For a site specific approach it is needed to go into detail in order to assess the situation of the soil pollution and the actual risks resulting from it and then to design remediation options. The demands of the owner, the environmental regulations and the technical possibilities play a role in the selection process of the remediation option.

For this detailed site specific approach in The Netherlands a typology is used in which the following aspects play an important role: 1) the nature of the contaminant and the characteristics of the soil, 2) the cause of, or the activity which has led to contamination of soil, and 3) information about land use.

3.4 Assessment of sites (identification, initial assessment, detailed assessment, risk assessment)

Assessment of sites (US)

Preliminary Assessment / Site Inspection: Investigation of site conditions. If the release of hazardous substances requires immediate or short-term response actions, these are addressed under the Emergency Response program of Superfund.

- Preliminary Assessment (PA): An assessment of information about a site and its surrounding area to determine whether a site poses little or no threat to human health and the environment or if it does pose a threat, whether the threat requires further investigation. The PA also identifies sites requiring assessment for possible response actions. If the PA results in a recommendation for further investigation, a Site Inspection is performed. Guidances for performing preliminary assessments and for site inspections are supporting this step.

> In the 'Guidance document on performing Preliminary Assessments under CERCLA ' source types and pathways are considered, which in combination form the basis for site assessment strategy.
> The following source types are distinguished (classified by physical structure or by describing how wastes have come to be deposited):
>
> - Landfill
> - Surface impoundment
> - Drums
> - Tanks and non-drum containers
> - Contaminated soil
> - Pile
> - Land treatment
> - Other sources
>
> The following four pathways are identified:
> ground water, surface water, soil exposure, air pathways.

- During the Site Inspection (SI), US-EPA further evaluates the extent to which a site presents a threat to human health or the environment by, among other things, collecting and analyzing wastes and environmental media samples to determine whether hazardous substances are present at the site and are migrating to the surrounding environment. The SI can be conducted in one stage or two. At the end of the SI, EPA decides whether the site qualifies for possible inclusion in the National Priority List (NPL) or should be dropped from further Superfund consideration.

The NPL gives the national priorities among the known contaminated sites. To assess if a site should be added to the NPL the available information on the site is used in the Hazard Ranking System (HRS). This is a numerically based screening system to assess the relative potential of sites to pose a threat to human health or the environment. Information on source, pathway and receptors (people or sensitive environments) is taken into account. Because prioritization is part of Assignment 1 we will not go into more detail on this step.

Detailed site assessment is not presented as a separate step in US-approach. It is part of the Remedial Investigation / Feasibility Study. During the Remedial Investigation delineation of the contamination and risk assessment are executed. Furthermore relevant site specific parameters for remediation techniques are investigated.

After Site Inspection it is sometimes possible to determine if quick response to immediate threats from hazardous substances is necessary in order to eliminate dangers to the public (e.g. fencing, removing hazardous substances, temporary alternative water supply, temporarily relocating area residents).

Assessment of sites (UK)

Site assessment (UK)
In the Guidance “Model Procedures for Management of Land Contamination” no specific guidance on site assessment is incorporated. The site assessment is seen as a continuous process of adding pieces of information to the subsequent steps RA (risk assessment) and OA (option appraisal) depending on the specific needs of the next step in the process of soil remediation.

Risk Assessment (UK)
The risk assessment assesses in a structured way how site specific circumstances define whether there is an actual risk.
The SPR (Source-Pathway-Receptor) methodology is used to analyze and describe risks. A linked combination of source-pathway-receptor is called a Risk pollutant linkage (RPL). For one site several RPL’s can be applicable. Each RPL can be subject to remediation. The risk assessment (RA) will define if remediation of a specific RPL is needed.
Without a RPL, no risks can be identified, even if soil contaminations are present above certain levels. The analysis of the RPL is therefore essential for the risk assessment.

Remediation is justified in case of unacceptable risks to human health and the environment in relation to the land use and its environmental setting. The site should be suitable for its current use. During the planning and development of new land use controlling risks should be an issue possibly leading to necessary additional remediation.
A Guideline supports the decision as to whether a contamination is unacceptable or not. “Cost benefits analyses” are part of the management of environmental risks in a sustainable way in which all aspects like risks, energy consumption, use of commodities etcetera, are integrated and evaluated.

In the process a three step risk assessment is defined:
- *a preliminary RA* including a desk study and site reconnaissance. The purpose is to build a first conceptual site model (CSM) of the site and to analyze whether there is a potential of unacceptable risks. Possible RPL’s are identi-

fied mainly based on desk-based data and a site visit. Decisions are made for additional site assessment and scope of the detailed RA.

- *generic quantitative RA* to establish if generic assessment criteria and assumptions can be applied and if so to establish if there are any potential unacceptable risks. A generic approach is applicable in case the results of the RA are not subject to any doubt.
  This step will be concluded with a list of applicable RPL's and what actions are needed in case a generic RA is not fit for purpose.
- *detailed quantitative RA*. This step is applied in case a generic RA is not applicable or to refine the generic assessment. Such a RA is based on detailed data and model calculations of the pollutants entering threatened objects through relevant RPL's. Model calculations can be based on for example pollutant specific characteristics like spreading ratio and local measurements of soil permeability.

The final result of the RA is the decision on what RPL should be assessed by the remediation option appraisal as it leads otherwise to unacceptable risks.

Conceptual Site Model (CSM) (UK)
A conceptual site model is used throughout all steps of the option appraisal process. It is helpful for the identification and assessment of several elements in the process, such as the relevant RPL's, and it supports site assessment.
For the RA the building of a CSM including all RPL's are essential.

Assessment of sites (NL)

Site assessment (NL)
Research on the possibility of soil contamination starts with an inventory of the historic land use. The following set of activities have been recognized that can lead to soil pollution: 1) mixing soil with contaminated material (soil or waste), 2) heightening or filling up with contaminated material, 3) landfill or storage of solid material 4) agricultural or industrial activities using pollutants (halogenated organic hydrocarbons for degreasing), storage of liquids in reservoirs and barrels, transport and transshipment of material) 5) discharge or leakage of pipes, and 6) deposition of pollutants from air or sediments from rivers or sea.

These potentially contaminating activities can take place in all kinds of industries: metallurgical, chemistry, oil, food, etc. The contaminant substances can vary for these industrial activities. Generally, the following groups of contaminants are recognized: heavy metals, aromatic hydrocarbons, polycyclic aromatic hydrocarbons, chlorinated aromatic hydrocarbons, pesticides, poly chlorinated biphenyls, chlorinated benzenes and phenols and some important specific substances like mineral oil and cyanide.

Apart from activities and substances the geometrical pattern in which pollution has taken place is important for the site assessment plan. E.g. the pattern for drilling and sampling has to be different for a former landfill site than for leakage from pipes.

Site assessment is subdivided into the following steps:

- Preliminary assessment of history of the site: in this step the activities and land use in the past are inventoried. Result of this is a conclusion on the possibility that contamination of soil, sediment or groundwater has occurred. For this step a guideline is available (NEN-5725, ‘Soil quality - Strategy for preliminary investigation prior to exploratory and main survey’);
- Exploratory assessment: in this step some fieldwork is done and samples of soil, sediment and groundwater are tested in a laboratory. Result of this is the confirmation whether contamination is present at a site and if yes, whether this contamination is severe. For this step a guideline is available (NEN-5740, ‘Soil quality - Strategy for exploratory survey - Investigation of the environmental quality of soil and soil lots’). For assessment of asbestos in soil a separate guideline is present (NEN-5707). For assessment of contamination in sediments another guideline is available (NEN-5720). In the NEN-5740 guideline different strategies for exploratory site assessment are presented. These strategies are different for the following situations: situation with no indication for potential contamination (subdivided into small and large scale); situation with indication for potential contamination with local impact on soil (subdivided for homogeneous and heterogeneous situations of soil contamination, with diffuse or local impact, and for situations with subsurface storage reservoirs);
- Detailed assessment: in this step more intensive fieldwork and laboratory testing is done. If the results of this indicate severe contamination, this contamination in soil and groundwater is delineated (as far as necessary for risk evaluation) and risk assessment is done. The result of this step is the conclusion whether the contamination poses unacceptable risks for human health, ecology or spreading in groundwater. For this step a guideline is available (NEN-5755, ‘Soil quality - Strategy for further investigation - Investigation of the type, concentration and extend of pollution of soil and soil lots’). In this guideline the Conceptual Site Model plays an important role to get a grip on the contaminated situation. A visual image of the contamination in the soil is made, as detailed as is possible based on the information available. This image is developed further whenever additional information becomes available.

Risk assessment (NL)

The risk assessment is very important because it determinates whether a contaminated site has to enter in the whole soil remediation methodology. In fact, the aim of the risk assessment is to assess if there is an urgent need of remediation or not. As shown in the flowchart in figure 3.3 below, the risk assessment is the tool which allows taking decision and which orients the contaminated site in the methodology.

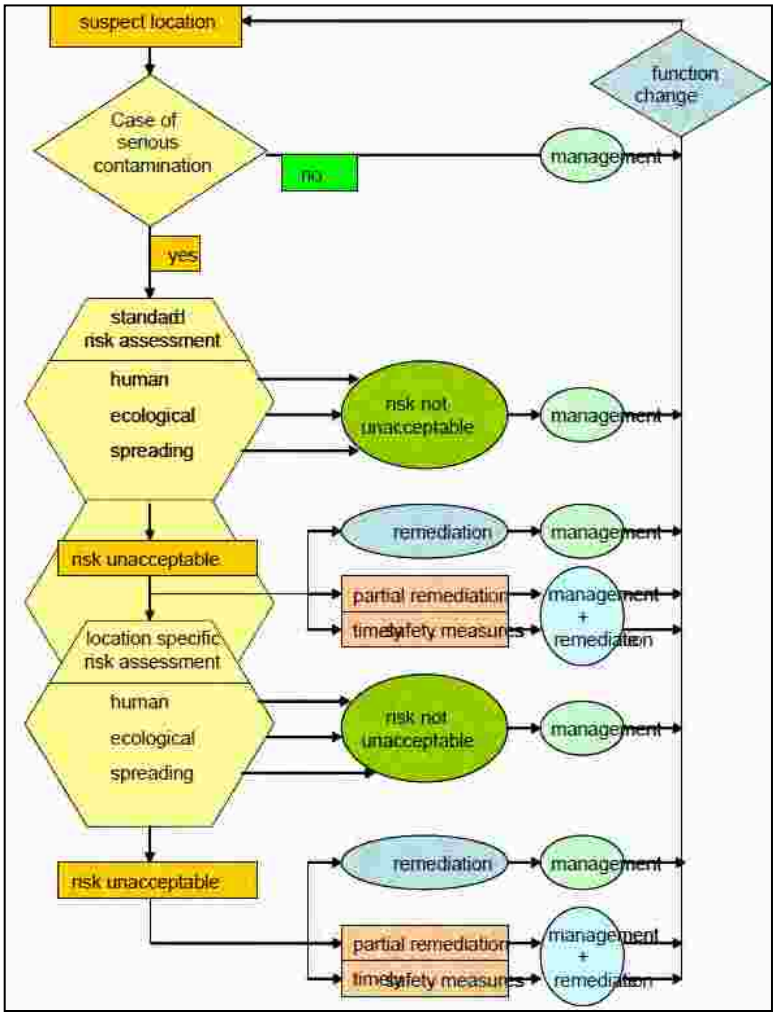


Figure 3.3 Flowchart representing the risk assessment tool used in the Netherlands

As can be derived from figure 3.3, there are three main steps in this process. The first step is to determine if there is a serious case of contamination. Then a standard risk assessment should be performed. Finally, a site specific risk assessment is done. For each step, the risk assessment is based on human, ecological and spreading risk into the environment. It is not always necessary to remediate the site when there is a serious case of contamination. Sometimes, the risk is acceptable and management should be sufficient. This means that the site will be monitored. When there is an urgent need to remediate, remediation must be undertaken quickly or partial remediation or timely safety measures are applied. When in future the function of a site changes this can necessitate re evaluation of the risks.

3.5 Selection of remediation options and selection and design of technologies

Selection of remediation options and selection and design of technologies (US)

Remedial Investigation / Feasibility Study: these steps are conducted concurrently because each step needs information from the other one, by doing this an effective and efficient preparation of remedial options is carried out:

During Remedial Investigation (RI) the data are collected to : characterize site conditions; determine the nature of the waste; assess risk to human health and the environment; and to conduct treatability testing to evaluate the potential performance and cost of the treatment technologies that are being considered.

During Feasibility Study (FS) alternative remedial actions are developed, screened and evaluated.

Further explanation on the RI/FS phases:

1. In the first (scoping) phase of this step boundaries of the area are identified and likely remedial action objectives assuring protection of human health and the environment. Then relevant legal requirements are inventoried. At last a work plan (with sampling and analysis plan) is made.
2. In the next (Site Characterization) phase the actual field sampling and laboratory analyses is carried out. A risk assessment is developed to identify the existing and potential risks that may be posed to human health and the environment by the site. Because this assessment identifies the primary health and environmental threats at the site, it also provides valuable input to the development and evaluation of remediation options during the feasibility study.
3. During the phase of Development and Screening of Alternatives remedial action objectives are identified. Furthermore an evaluation of technologies is carried out based on their effectiveness, implementability, and cost. Finally technologies are assembled and their associated containment or disposal requirements into alternatives for the contaminated media at the site or for the operable unit.
4. Treatability investigations are conducted primarily to provide sufficient data to allow treatment alternatives to be fully developed and evaluated during the detailed analysis phase and to support the remedial design of selected alternatives, and to reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a remedy can be selected.
5. Detailed analysis is the last phase of the RI/FS process in which alternative remedial options are evaluated with respect to nine evaluation criteria:
   - overall protection of human health and the environment;
   - compliance with ARARs (Applicable or Relevant and Appropriate Requirement);
   - long-term effectiveness and permanence;
   - reduction of toxicity, mobility, or volume;
   - short-term effectiveness;
   - implementability;
   - cost;
   - State acceptance; and
   - community acceptance.

   The alternatives are analyzed individually against each criterion and then compared against one another to determine their respective strengths and weaknesses and to identify the key trade-offs that must be balanced for the site. The results of the detailed analysis are summarized so that an appropriate remedy consistent with legal requirements can be selected.

During Remedial Design the preparation and implementation of plans and technical specifications for applying site remedies is developed. The Remedial Design is based on the specifications described in the record of decision (ROD). A ROD provides the justification for the remedial action (treatment) chosen at a Superfund site. It also contains site history, site description, site characteristics, community participation, enforcement activities, past and present activities, contaminated media, the contaminants present, scope and role of response action and the remedy selected for cleanup.
The Guidance for scoping the Remedial Design (EPA 1995) gives elements for drawing up a remediation design plan and for preparation of bidding process.

Selection of remediation options and selection and design of technologies (UK)

Remedial activities can have the following purposes:

- preventing or minimising, or remedying or mitigating the effects of, any significant harm (or significant pollution of controlled waters), by reason of which the contaminated land is such land; or
- restoring the land or waters to their former state.

The process of remediation option appraisal is generic and risk based. Only the RPL's (Risk pollutant linkage) inducing unacceptable risks are assessed.
During a transparent option appraisal process the search for a most effective and efficient remediation strategy is carried out. The result will in most cases be a strategy which cannot meet all predefined remediation objectives. In most cases the final solution will be a balance between technical, non technical, cost, environmental and social issues. Depending on the local situation either one or more of these issues are more or less negotiable. For this reason a standard based remediation approach will not anticipate the site specific requirements.
To handle this approach the appraisal process is generic and top down starting with the assessment of RPL's by designing remedial options based on either removal or treatment/modification of the RPL's.

The selection of a specific contamination related technique (e.g. air sparging) is not made in the first step of option appraisal and sometimes made even after the selection of the most favourable remediation strategy, after a pilot testing of the technique has proven the suitability of that specific technique for that specific site.

In an implementation plan all aspects of design, preparation, implementation, verification, long-term maintenance and monitoring of remediation have to be incorporated. This plan should reflect the complexity of the work and so for simple projects may be a relatively brief document.

Selection of remediation options and selection and design of technologies (NL)

Remediation of contaminated soil, sediment or groundwater can be necessary for two reasons:

- for environmental reasons because there are unacceptable risks;
- when developing sites remediation becomes necessary, because of foreseen use of the site or because of the fact that soil or groundwater has to be removed and this has to be done with regard to the contamination.

The following steps are recognized in The Netherlands in the process of preparation and execution of soil remediation:

- Setting goals and preconditions for the remediation: what is the future use of the site and goal of the site owner and what are the targets according to the environmental regulation. The relevant regulation for soil is the ‘Circular on soil remediation’, which is part of the Dutch Soil protection law. In this Circular targets for remediation are subdivided for different contamination situations:
  - Immobile contamination: the goal of remediation is the fit for use approach for immobile contaminants: the top soil quality must meet the requirements for the future use of the site, and exposure of humans and the ecosystem to the contamination has to be prevented. Targets are set related to sustainable use of the site. These target values are risk based and depend on the kind of future use of the site: nature, agriculture, residential area, industry;
  - Mobile contamination: the goal of remediation is a cost-effective approach of remediation: risks must be eliminated as much as possible (prevention of further spreading of contamination by groundwater to protect vulnerable objects, e.g. drinking water wells) and post remediation monitoring and maintenance activities should preferably be not be intensive.
- Selection of remediation options: depending on general aspects of the contamination and the soil, as well as the specific situation of the site, remediation options can be elaborated and a process of selection is carried out. The selection depends on so many aspects that there is no general guideline for this. Formerly there were some guidelines, but this was due to the fact that the national government financed the majority of the remedial action. As presently owners are the main financers, the government’s main interest is that the legal targets of remediation are met. There are however still some useful tools to support the selection process.
- Design of selected remediation option in a remediation plan: once the best option has been selected a detailed design is necessary for which the following questions have to be answered:
  - which targets have to be met at different depths in soil and groundwater?
  - which techniques will be applied?
  - which measures have to be taken before remediation starts?
  - which redevelopment measures are necessary after remediation is carried out?
  - is post remediation monitoring and maintenance necessary because not all contamination will be removed and there are some limitations to land use. Is monitoring of the remaining contamination necessary?
  - balance of soil excavation and transport;

- time needed for carrying out remediation measures, costs of the remedial activities.

Often some field investigation or modelling has to be done in order to get information on parameters which are essential for the technical and economical feasibility of the remediation measures.
Drawing up remediation plans are a site specific, but some generic checklists are available.

3.6 Implementation of remediation works and post-remediation activities

Implementation of remediation works and post-remediation activities (US)
Remedial action involves the actual construction or implementation phase of Superfund site cleanup.

Many of the remediated sites in US still have remedies that only allow for restricted future uses due to contamination remaining on-site, with combinations of engineering and institutional controls to limit unacceptable exposures. Ensuring the cost effectiveness and protectiveness of these remedies often requires ongoing operation and maintenance, five-year reviews, monitoring, periodic repairs, and sometimes, replacement of remedy components.
Also, many of these sites with ground water contamination will require ongoing remediation over many years to achieve protective cleanup levels. This makes post remedial monitoring and maintenance activities necessary. The goal of these activities is to ensure that long-term protection of human health and the environment is established.

Completion and site reuse / redevelopment of a site is possible when completion of physical cleanup construction and possible control and monitoring has taken place. The site can be re-used when targets of the remediation are achieved. EPA has close out procedures to remove sites from the National Priorities List.

Implementation of remediation works and post-remediation activities (UK)
The remediation process should include checks and balances as for the local authorities to implement the necessary procurements and the remediation is carried out within the legal framework and remediation plan. The implementation should be carried out while quality is ensured by verification of the process.

Long term monitoring and maintenance is necessary in situations where contamination is not totally removed or treated. The purpose of this stage of implementation is to monitor the effectiveness of remediation, to confirm predicted behaviour as an early warning of adverse trends, and to maintain remediation to ensure continued functioning and effectiveness in accordance with the original design philosophy.

Implementation of remediation works and post-remediation activities (NL)
After formal approval of the remediation plan by the environmental authorities, the remediation activities are further detailed in bidding documents for a tender procedure. The bidding document can be a very detailed description of all

measures that has to be applied. In some situations there is more emphasis on the performance and the result of the remediation. A less detailed bidding document is possible in such a situation.

After tendering the contractor can carry out the remediation and redevelopment activities. These activities have to be guided by environmental verification. The results of the activities and verification have to be reported in an evaluation document;

If part of the contamination in soil or groundwater cannot be removed or treated fully or remedial measures have to be maintained over a long period and there are restrictions to site use post remediation measures are necessary. For this a monitoring and maintenance plan has to be developed and implemented.

3.7 Standards and support on technical possibilities for assessment and remediation

Standards (US)
The Soil Screening Guidance presents a framework for developing risk-based, soil screening levels (SSLs) for protection of human health. The framework provides a flexible, tiered approach to site evaluation and screening level development. The Soil Screening Guidance is a tool developed by EPA to help standardize and accelerate the evaluation and cleanup of contaminated soils at sites on the National Priorities List (NPL) where future residential land use is anticipated. SSLs are not national cleanup standards but can be used as initial cleanup goals when site-specific data are lacking. SSLs alone do not trigger the need for response actions or define “unacceptable” levels of contaminants in soil. In this guidance, “screening” refers to the process of identifying and defining areas, contaminants, and conditions, at a particular site that do not require further Federal attention.

The level of cleaning, also named the Preliminary Remediation Goal (PRG), can be determined by two different approaches: either the Applicable or Relevant and Appropriate Requirements (ARARs) or the risk assessment. The first contains concentration limits set by other environmental regulations like the non zero maximum contaminant level goals (MCLGs) set under the Safe Drinking Water Act.The second one is a calculation of concentration limits using carcinogenic and/or non carcinogenic toxicity values under specific exposure conditions. When specific ARARs do not exist, the PRG is based on the risk assessment. PRGs are set in each Superfund-Region.
A conceptual site model can be used to summarize information like contaminants, pathways, if people are concerned and the future land use.

Technical possibilities for site assessment and remediation (US)
Several documents and databases in the US help government or other stakeholders in the process of selecting techniques for site assessment and remediation. Four examples of these information sources are:

- a matrix with information on which site assessment techniques are possible, depending on characteristics of the site situation and technical equipment (see excerpt in figure 3.4 below).

FIELD SAMPLING AND ANALYSIS MATRIX: FIELD SAMPLING AND COLLECTION TECHNIQUES

Italics Most commonly used field techniques from Subsurface Characterization and Monitoring Techniques EPA 625-R-93-003

See Legend below for explanation, or switch to the gif-based version (may be VERY slow to load!) if you see l, n, and D instead of squares, circles, and triangles in the matrix below.

Technique / Instrumentation	Analytes	MEDIA: Soil	Ground Water	Surface Water	Gas / Air
3 ACCESS TOOLS					
3.1 Drilling Methods - Unconsolidated Formations					
3.1.1 Hollow-Stem Augers	All	■	●	NA	△
3.1.2 Direct Mud Rotary	All	●	△	NA	△
3.1.3 Directional Drilling	All	●	●	NA	△
3.1.4 Solid Flight and Bucket Augers	All	■	△	NA	△
3.1.5 Jetting Methods	2, 4-8, 10, 11	△	△	NA	△
3.1.6 Sonic Drilling	All	■	●	NA	△
3.2 Drilling Methods - Consolidated Formations					
3.2.1 Direct Air Rotary with Rotary Bit / Downhole Hammer	2, 4-8, 10, 11	■	●	NA	△
3.2.2 Cable Tool	2, 4-8, 10, 11	■	●	NA	△

Figure 3.4 Excerpt from a matrix presenting characteristics of site assessment techniques, as used in the US

- During remedial investigation/feasibility studies (RI/FS) the “Remediation Technologies Screening Matrix and Reference Guide” can be used which give information on various remediation techniques. It is intended to be used to screen and evaluate candidate cleanup technologies for contaminated installations and waste sites in order to assist remedial project managers in selecting a remedial alternative.

- For brownfield remediation and development a road map is developed with information on Site Types, Investigation Technologies, and Treatment Technologies, which is cross-referenced by Contaminant Groups. More than 30 site types are recognized, categorized by the industrial process causing soil contamination (see figure 3.5 on the right and figure 3.6 below).

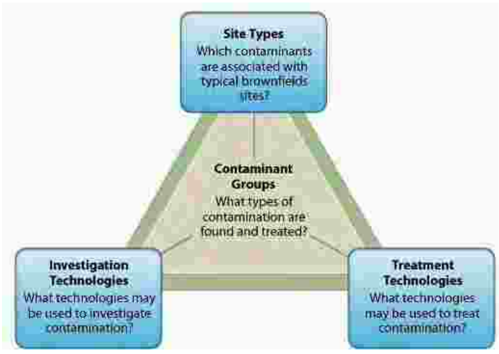
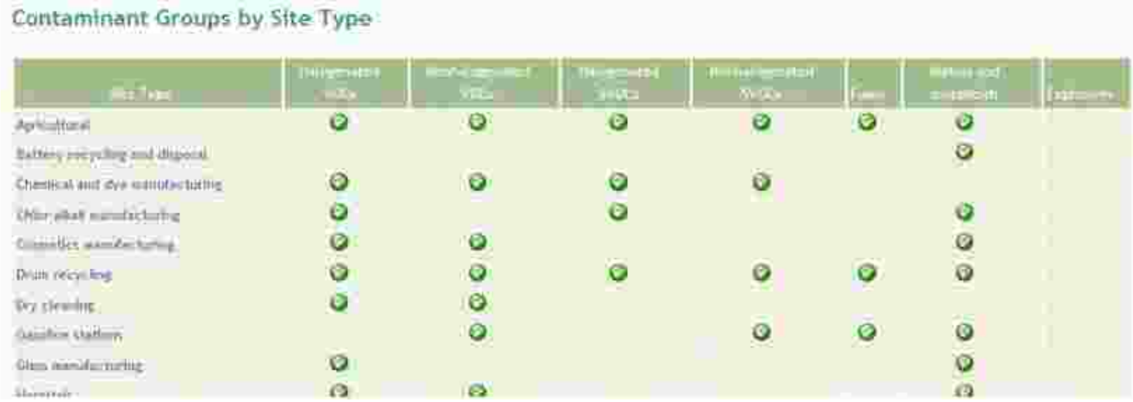


Figure 3.5 Figure presenting relations among site types and investigation and treatment technologies, as used in the US



Contaminant Groups by Site Type

Site Type	Halogenated VOCs	Non-halogenated VOCs	Halogenated SVOCs	Non-halogenated SVOCs	Fuels	Metals and inorganics	Explosives
Agricultural	✓	✓	✓	✓	✓	✓	
Battery recycling and disposal						✓	
Chemical and dye manufacturing	✓	✓	✓	✓			
Chlor-alkali manufacturing	✓		✓			✓	
Cosmetics manufacturing	✓	✓				✓	
Drum recycling	✓	✓	✓	✓	✓	✓	
Dry cleaning	✓	✓					
Gasoline stations		✓		✓	✓	✓	
Glass manufacturing	✓					✓	
[illegible]	✓	✓				✓	

Figure 3.6 Excerpt from a matrix presenting contaminant groups by site type, as used in the US

- The Hazardous Waste Clean-Up Information (CLU-IN) Web Site provides information about innovative treatment and site characterization technologies to the hazardous waste remediation community. This website gives Remediation Technology Demonstration Project Profiles. New information is added to this website to give up-to-date information. In this way newly developed innovative techniques are available for the user.

In addition to these information sources a plethora of support tools has been developed. An interesting example of this is the Risk Based Corrective Action Program (RBCA), which supports decision making on dealing with petroleum hydrocarbonated contaminated sites, aimed at reducing risks. Such a program has been implemented formally by the majority of US States (and a number of Canadian provinces). Within the territorial boundaries of these entities, the application of the RBCA is required. While an RBCA program sets the rules, like the definition of remediation targets, it leaves room for the method by which those targets are to be reached, whether it be by reduction of contaminant concentrations or by reducing the potential for exposure. This approach helps in reaching cost effective solutions.

The competent authorities keep this system up to date by periodically revising the RBCA and then requesting to apply the latest version after a certain period for adjustment. Private businesses support the consultants and the authorities by developing state- and province-specific software, which eases the application of the RBCA.

Standards (UK)

It is common practice in contaminated land risk assessment to use "generic assessment criteria" as screening tools in generic quantitative human health risk assessment to help assessors decide when land can be excluded from the need for further inspection and assessment, or when further work may be warranted. Guideline Values, e.g. soil guideline values (SGV's) or drinking water standards have been developed in the UK as such generic quantitative criteria. For site specific assessment criteria have to be developed from detailed quantitative risk assessment.

Technical possibilities site assessment and remediation (UK)
A tool for selection of sampling techniques is given in figure 3.7 below. For more detailed technique information external information is used. The reason for this should be that a basic sheet as presented in the figure below is not subject to changes in time. More detailed technique related information is subject to changes as in local conditions, economical situation (price of oil), and the technical development of techniques. Detailed factsheets will therefore be outdated in a relatively short time, undermining the value of a guidance.

Identification of Feasible Remediation Options:
Remediation options applicability matrix (Cont.)
Figure 3A
TOOL 1
T

REMEDIATION OPTION APPLICABILITY MATRIX: ORGANIC SUBSTANCES (CONT.)								
		Applicable substances						
Remediation option	Applicable media	VOCs	Halogenated hydrocarbons	Non-halogenated hydrocarbons	PAHs	PCBs	Dioxins and furans	Pesticides and herbicides
PHYSICAL METHODS								
Dual phase SVE	S, W	✓	✓	✓	x	x	x	x
Air sparging	W	✓	✓	✓	x	x	x	x
Soil vapour extraction (SVE)	S	✓	✓	✓	x	x	x	x
Permeable reactive barriers (PRBs)	W	✓	✓	✓	✓	✓	✓	✓
Soil washing	S	x	✓	✓	✓	✓	x	✓

Figure 3.7 Sample technique factsheet, as used in the UK

Traditionally, UK practice has been reliant on expedient heavy engineering based solutions to remediate contaminated soils and groundwater. Recent research promoted more sustainable process based technologies. This is in line with guidance provided by the UK Sustainable Remediation Forum (SuRF-UK) to support improved remediation working practices. In the Contaminated Land Remediation report (Defra Research Publication SP 1001, 2010) information on remediation techniques is presented in 21 Technology Profiles. Brief descriptions of each technique are provided in addition to describing the effectiveness of each of these methods in addressing different contaminants and when circumstances (e.g. geology, hydrogeology, contaminant form etc) may or may not be suitable to their use. The study also describes the advantages and disadvantages of each technique and the barriers to their use. An example of a fact sheet of one of the 21 techniques is shown in figure 3.8 below.

Technology name:	Chemical oxidation and reduction	Similar processes, synonyms and process variations	Fenton's reagent, ozone, permanganate, sodium persulphate, sodium percarbonate dechlorination, zero-valent iron, *in-situ* chemical oxidation (ISCO)
Brief summary:	*In situ* chemical method involving addition of chemicals to soil or groundwater to oxidise or reduce the contaminants thereby degrading them, reducing their toxicity, changing their solubility, or increasing their susceptibility to other forms of treatment.		

Technology description:

Chemical oxidation involves the injection of liquid or gaseous oxidising agents (or oxidants) to the subsurface to bring about the rapid degradation of many organic contaminants. Some organic compounds will undergo partial degradation and can then be treated by other methods, such as bioremediation. Arsenic (As) may also be oxidised from As(III) to As(V), however, as the latter is more harmful, additional techniques will be required in order to complete the remediation.

Typical oxidants include the following:
Fenton's reagent: hydrogen peroxide with a ferrous iron (Fe^{2+}) catalyst produces highly reactive free radical species.
Permanganate (MnO_4^-): can oxidise contaminants by direct electron transfer or via free radial species.
Ozone (O_3): can oxidise contaminants directly or via free radical species.
Sodium persulphate and sodium percarbonate are also used.

Chemical reduction involves the addition of reducing agents (reductants) to degrade chlorinated solvents and reduce the toxicity of metals.

Typical reductants include the following:
Zero valent iron: although commonly used as the reactive material in permeable reactive barriers, zero valent iron can be added to soil by mixing or injected as nanoparticles (still at demonstration stage);
Polysulphides: used in the reduction of metals to less lower toxicity forms (e.g. chromium (VI) to chromium (III)).

Applicability to contaminants and ground materials

Organic		Inorganic		Materials	
Halogenated VOCs	Y	Metals	?	Gravel >2mm	Y
Halogenated SVOCs	Y	Radionuclides	N	Sand 0.06-2mm	Y
Non-halogenated VOCs	Y	Corrosives	?	Silt 2-60µm	Y
Non-halogenated SVOCs	Y	Cyanides	?	Clay <2µm	?
Organic corrosives	N	Asbestos	N	Peat	N
Organic cyanides	N				
PCBs	Y	**Miscellaneous**		**Key**	
Pesticides/herbicides	?	Explosives	?	Usually or potentially applicable	Y
Dioxins/furans	N			May be applicable	?
				Not applicable	N

Potential advantages:

- reactions are fast and can result in complete degradation;
- applicable to a wide range of organic contaminants;
- uses reagents that are considered low cost and easily delivered to the subsurface.

Limitations:

- may require large volumes of reagent;
- environmental considerations as using aggressive reagents;
- toxic intermediate breakdown products may be formed;
- groundwater may be coloured by reagents (e.g. permanganate is purple in solution);
- precipitation reactions may be reversible with changes in redox conditions over time;
- may be difficult to facilitate contact between contaminants and reagents in the treatment zone.

References:	Nathanail et al., 2007; EA Remediation Position Statements, 2006; FRTR, 2007; Princeton Chemistry and Environment, 2003.

Figure 3.8 Sample fact sheet describing a remediation technique, as used in the UK

Similar to the US and Canada (see the discussion on RBCA in the US part of this Section), the UK Environment Agency (EA) has developed support tools to deal with contaminated sites, in its turn supported by dedicated software that can be used to derive criteria and human health risks by feeding generic assumptions into the software. An example of a support tool presented by the EA is SGV's, scientifically derived generic Soil Guideline Values, intended to, with the help of technical guidance tools, assist in the assessment of long-term human health risks from exposure to chemical soil contamination. The EA recognizes the limitations of such generic values, and the use of the SGV's and henceforth the technical guidance tools is not required.

Key in the technical guidance is the CLEA model, used to derive SGV's. By using generic assumptions, the CLEA model can be used for a quantitative assessment of human health risks due to long-time exposure to soil contamination (Jeffries and Martin, 2009). Next to site characteristics human uptake routes play a major role in the CLEA model. As in the US and Canada dedicated software is available to support the application of the CLEA model. Contrary to in the US and Canada, the software in the UK is presented by a public service, the EA.

Standards (NL)
During site assessment the concentration values found in soil, sediment or groundwater are compared with the following standards:

- Target value: the target value refers to the environmental quality level of a "clean" soil, which can fulfil all possible functions;
- Intervention value: the intervention value refers to the environmental quality level above which a serious reduction of the functional soil qualities occurs. If this value is exceeded in more than 25 m^3 in soil or sediment or in more than 100 m^3 in groundwater, reference is made to a case of serious soil contamination and in principle a clean-up is necessary.

For targets of remediation the following standards are available:

- For the topsoil, values were derived based on risk assessment for each substance, taking into account both human health and ecology:
  - The Background Value for agriculture and ecological functions;
  - The Maximum Residential area Value;
  - The Maximum Industrial area Value;
  - It is possible that other Local Maximum Values are developed and established by the local or regional environmental authorities.
- For the subsoil: risks of spreading and any risk towards human health must be removed as much as possible.

Technical possibilities for site assessment and remediation (NL)
Site assessment: generally used are drillings, monitoring wells and testing of samples of soil and groundwater in laboratories. More and more alternative site assessment techniques are applied, e.g. for heavy metals in soil the XRF-technique is available, geo-electrical or –magnetic probes for deep subsurface research, bio assays for ecological research. The application possibilities for those techniques are depending on soil characteristics, relevant contaminants and accuracy demands. A comprehensive database is available to help in selecting the best technique in a specific situation.

Figures 3.9 and 3.10 below give examples of the information in this database. Figure 3.9 presents information on one specific assessment technique, in this case the Multi-sampler. Figure 3.10 presents the potential research aspects of several techniques (on the X-axis). Visible aspects (the matrix contains more information) on the Y-axis are soil structure (Bodemopbouw), ecology (Ecologie), remediation (Saneren) and contamination (Verontreiniging).

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Onderzoekstechniek: Multi-sampler

TECHNIEKSHEET **Onderzoekstechniek: Multi-sampler**	Versie: 2008.10.16 [Naar zoekapplicatie]

Samenvattende omschrijving techniek (gebaseerd op praktijkervaring van onafhankelijk techniekexpert)

De multi-sampler is een handbediend monstername-apparaat dat zowel van (grond)water als van niet-cohesieve (water)bodems monsters kan nemen. Het is feitelijk een plexiglazen buis met daarin een zuiger. Door op diepte de zuiger te bedienen zal de plexiglazen buis zich vullen. Er zijn twee steekringen die uitwisselbaar zijn. Een steekring met kogelklep die de multisampler aan de onderkant afsluit. Door de kogelklep te wisselen door een open steekring kunnen niet-cohesieve bodems bemonsterd worden door de sampler weg te drukken en op diepte te vullen. De zuiger voorkomt in dat geval compactie van het te bemonsteren sediment.

Algemene informatie (gebaseerd op informatie van techniekaanbieder)

Naam	Multi-sampler					
Meeteenheid en parameter	-					
Bodemfase	Grond	Grondwater	Poriënwater	~~Puur product~~	~~Bodemlucht~~	
Aard techniek	Fysisch	~~Chemisch~~	~~Biologisch~~	~~Overig~~		
Plaats van toepassing	In situ	~~Ex situ~~				
Detectiewijze	Boren / steken	~~Verdringing / sonderen~~	~~Tomografie~~	~~Off site meting~~	~~Meting op maaiveld / waterbodem~~	~~Meting aan oppervlakte open water~~
Toepasbaar in afzonderlijke lagen	~~nee~~	ja	Minimale dikte laag: 10 cm			
Bodemtypen waarvoor techniek geschikt is	1 homogeen goed doorlatend zandpakket	2 één zandpakket, met slecht doorlatende laagjes	3 slecht doorlatende deklaag, doorsnede met zandlaagjes	4 slecht doorlatende laag op een goed doorlatend zandpakket	~~5 antropogeen~~	
Landbodem/waterbodem	Landbodem	Waterbodem				
Stap in keten van	~~a- Aanloop~~	~~b- Boren /~~	c- Monstername	~~d- Meten~~	~~e- Dataverzamelen en~~	~~f- Bodem informatie~~

Figure 3.9 Excerpt of database describing site assessment techniques, as used in the Netherlands

LEGENDA + = waar - = niet waar o = gedeeltelijk of soms waar	Akkermannsteektoestel	Aqualock	Beeker steker met onderwaterstatief	Continuous Soil sampler met steunkous	Guts	Handboor: Edelman-boor, "riverside"-boor, grindboor	Multi-sampler	Radar - GPR	Sondering - mechanisch	Veenboor
Bodemopbouw										
Afsluitende laag	+	+	+	+	+	+	+	o	-	-
Diepte afsluitende laag	+	+	+	+	+	+	+	+	-	-
Objecten in bodem	-	-	-	-	-	-	-	+	-	-
Verstoring bodemopbouw	+	+	+	+	+	+	+	+	-	-
Bodemopbouw	+	+	+	+	+	+	+	+	+	+
Slibdikte	-	+	+	-	+	-	+	+	-	-
Antropogeen materiaal	+	-	-	-	+	+	-	o	-	-
Ecologie										
Biologisch gezond?	-	-	-	-	-	-	-	-	-	-
Ecologische risico's	-	-	-	-	-	-	-	-	-	-
Saneren										
In-situ sanering	-	-	-	-	-	-	-	-	-	-
Verontreiniging										
Smeerlaag	+	-	-	-	-	+	+	-	-	-
Uitloogbaarheid	-	-	-	-	-	-	-	-	-	-
Biologische afbraak	-	-	-	-	-	-	-	-	-	-
Ecotox effecten	-	-	-	-	-	-	-	-	-	-

Figure 3.10 Excerpt of database describing potential research aspects of several techniques (X-axis) against visible aspects (Y-axis)

Remediation: Remediation techniques can be subdivided into a number of groups, e.g. in situ techniques and capping techniques. The application possibilities for those techniques depend on soil characteristics, relevant contaminants and demands on accuracy, available time, budget and space. A database is available to help choosing the best technique in a specific situation.

3.8 Evaluation of site assessment and remediation process

The information on the technical approaches to site assessment and design and execution of remediation in the US, the UK and the Netherlands leads to the following conclusions:

- **Steps in the remediation process**
  In all countries studied we concluded that the steps in the process of site assessment and remediation are generally the same. An interesting difference in the approaches is that site and risk assessment or remediation option appraisal sometimes is carried out in separate steps (NL) and sometimes in more steps, for instance in the US and UK. In the US during the phase of Remedial Investigation / Feasibility Study the concurrently executed site as-

sessment and remedial option appraisal is done for efficiency reasons: of course the risks of the contamination for human health and environment should result from the assessment but first ideas on the remediation options possibilities will prevent the collection of unnecessary data.
The steps in the methodology of CPCB are more or less the same compared to the approaches in other countries.

- **Typology**
  Typology of contaminated situations is a much used tool for national or regional programming of site assessment and remediation. For common specific types of sites it can be necessary for reasons of liability, budgeting and efficiency to make a specific program. Government and private organizations can develop agreements on the roles and contributions in these programs recorded in agreements or contracts. An example of such a program is the agreement on remediation and redevelopment of former gas works sites in The Netherlands. Sometimes specific technical approaches to site assessment or remediation are developed in such programs, but mostly it requires further fine tuning of existing techniques and adapting the techniques to local conditions. For site specific situations the conditions can lead to other approaches than generally described. Therefore the Guidance document, which will be developed in Task 4, has to be robust and flexible in order to be applicable in different situations. In case the local conditions are not uniform such a program mainly has a non technical benefit. Regardless of this kind of programs there are often other reasons to start a remediation. Redevelopment of a site is by far the most common reason to start a remediation of a site.
- **Assessment of sites (identification, initial assessment, detailed assessment, risk assessment)**
  For site specific projects typology helps in one way in the technical approach: to start the assessment process by focussing on the soil threatening activities and the most relevant aspects of the source and pathway of the contamination.
  In the first step of site assessment always a combination of desk study and field work and laboratory testing are applied.
  The Source-Pathway-Receptor approach is essential for assessment of risks and for designing appropriate remediation measures. The Conceptual Site Model is an essential tool to understand the nature of the contaminated site and to develop applicable remediation approaches. Furthermore, it helps to design an effective and efficient investigation program for detailed site assessment.
- **Selection of remediation options and selection and design of technologies**
  The goal of remediation in US, UK and NL in general is to prevent further risks for human health and the environment. The goals for a specific site have to be derived from generic standards and site specific risk calculations. Remediation options are selected using sets of criteria which in all countries are more or less the same: environmental results, technical feasibility/risks, costs, impact of the works, available time, spatial planning, social aspects.
- **Implementation of remediation works and post-remediation activities**
  During implementation of the remediation works assessments are necessary to verify the results of the remediation. Often post-remedial measures are

necessary to monitor the effects of the remediation in case not all contamination could be removed or treated. Sometimes, maintenance activities are necessary to ensure long term remediation measures.

- **Standards and support on technical possibilities for assessment and remediation**
  The US, UK and NL have various well developed guidelines and tools, which are good examples for the Guidance document that will be developed in Task 4.

4 International developments and systems for sustainable remediation techniques

4.1 Methodology

The content of the ongoing international discussion on sustainable remediation, in which Grontmij-employees actively participate, is analyzed. Subsequently, the results of a brief desk study are incorporated.

4.2 Reasons for green and sustainable remediation

The concepts of green and sustainable remediation currently play a major part in the international debate on contaminated lands. Definitions vary from country to country, but the following definition presents a good idea of what both concepts are about: “Green and sustainable remediation is the site-specific employment of products, processes, technologies, and procedures that mitigate contaminated risk to receptors while making decisions that are cognizant of balancing community goals, economic impacts, and environmental aspects” (ITRC, Green and Sustainable Remediation: A Practical Framework, 2011). A remediation solution selected exclusively on technical and economical aspects can remediate a site very well, while doing damage to the other environmental components. The discussion on green and sustainable remediation is aimed at preventing that damage to be greater than the gain in the soil. The idea is that these concepts can contribute considerably to reach the main goal of remedial action, being to improve conditions for human health and the whole of the environment at a certain site and its surroundings. That way, remedial action aimed at soil only can be developed into integrated sustainable land development.

4.3 Countries and involved organizations

It is important to note that either concept has not yet been implemented in formal present day guidance and standards. Therefore, this report restricts itself to present the latest issues in this international debate and to identify the way these concepts are implemented in the countries where the debate is most advanced, including at least the UK, USA, Canada, Netherlands, and Australia. Over the past years, in all of these countries dedicated initiatives have been set up to establish the implementation of green or sustainable remediation. Typically, these Sustainable Remediation Forums (e.g. SuRF-UK, SURF(-US), SuRF-NL) consist of interested parties, both public and private, cooperating in a more or less informal way to turn the concepts into reality. Usually, a national environmental authority on soil participates in SuRF, like CL:AIRE in the UK and EPA in the US. Other countries with an emerging SuRF initiative are Brazil, Italy and China. Increasingly, national SuRF initiatives team up to exchange knowledge and experiences at international soil conferences. International European soil networks like COMMON FORUM[1] and NICOLE[2], and large US institutions like ITRC[3] and ASTM[4] are actively involved in the discussions. SuRF groups from eight countries are meeting on a quarterly basis.

UK

It is generally acknowledged that the discussion on sustainable remediation was first taken up in the UK. There, the principle of sustainable remediation is mainly aimed at making sure that 1) "the benefit of remedial action is greater than its impact" and 2) "the optimum remediation solution is selected through the use of a balanced decision-making process" (excerpts taken from definition of sustainable remediation, www.claire.co.uk).

1) Starting in 2003 the SUBR:IM (Sustainable Urban Brownfield Regeneration: Integrated Management) consortium began its research into brownfield regeneration in the aftermath of the UK government's publication of its Sustainable Communities Plan (2003). In the subsequent years experience was gained on sustainability aspects in brownfield development. Public participation has been evaluated to be an important aspect in remediation and regeneration projects. An open approach to risk management is effective in winning local support for potentially controversial decisions, but only if it is undertaken in a sensitive and appropriate manner. To help implementing agencies to make sure the benefit of remedial action is greater than its negative impact, SuRF-UK has developed a Framework, published in March 2010, in which they have laid down generic principles.

2) The traditional remediation method selection process always includes technical and economical aspects, and most often also social aspects. Of the environmental aspects only the aspects directly related to the considered remedial techniques are included. When applying the sustainable remediation principle, more, mainly environmental, aspects need to be taken into account. Examples are the CO_2-emission score and the use of natural resources. In the UK, the debate centres on the scope of this: in theory, every single aspect can be included in the process, so the question is how far to take this to keep it applicable in practice. Based on this discussion, SuRF-UK has published, in November 2011, an Indicator Set, describing fifteen categories of indicators that may be used for sustainability assessment in support of remediation decision-making.

The Indicator Set has social, economic and environmental aspects:

Social indicator set:
- human health and safety
- ethics and equality
- neighbourhood and locality
- communities and community involvement
- uncertainty and evidence

[1] COMMON FORUM is a network for both national authorities dealing with contaminated land in Europe
[2] NICOLE, Network for Contaminated Land in Europe, is a network for both industries and service providers dealing with contaminated land in Europe
[3] ITRC, Interstate Technology and Regulatory Council, is a network for both public and private parties dealing with environmental challenges in the US
[4] ASTM International, formerly the American Society for Testing and Materials, develops voluntary consensus standards

Economic indicator set:
- direct economic costs and benefits
- indirect economic costs and benefits
- employment and employment capital
- induced economic costs and benefits
- project lifespan and flexibility

Environmental indicator set
- air
- soil and ground conditions
- groundwater and surface water
- ecology
- natural resources and waste

Now the Framework and the indicator set is developed the SURF-UK organization is collecting experiences in case studies. They expect to have first experiences to share by mid 2013.

USA
In the objective of SURF in the US, "balance economic viability, conservation of natural resources and biodiversity, and the enhancement of the quality of life in surrounding communities", the explicit use of the term 'biodiversity' stands out. Like in the UK, SURF has published a set of documents on sustainable remediation. One document, published in 2009 and known as the White Paper, contains general thoughts on the incorporation of sustainable remediation principles in remediation decision-making. A set of three documents, all published in 2011, are aimed at practical application of these principles: a Framework for Integrating Sustainability into Remediation Projects, Metrics for Integrating Sustainability Evaluations into Remediation Projects, and Guidance for Performing Footprint Analyses and LCAs for the Remediation Industry. SURF was founded in 2006 as an industries' initiative, and has grown into a large organization in which hundreds of professionals participate and which has been institutionalized more than its counterparts in other countries, as it is incorporated as a non-profit corporation.

Canada
The SuRF initiative in Canada was inspired by, and is modelled largely on, SURF in the US.

Netherlands
The Netherlands have for quite some time followed a standard based approach, officially targeting every remediation at turning the involved site into a state fit for every use (multifunctional approach). The step towards risk based land management (RBLM) has been taken, and SuRF-NL would like the country to take the next step as well, towards sustainable land management. Broadly following the UK approach, SuRF-NL is developing a generic process scheme and tools for the application of sustainable remediation principles in day-to-day practice. The public and private parties in SuRF-NL have set their sights on developing uniform definitions, and to broaden soil-specific approaches into more inte-

grated solutions. They realise this may be a tough process, as it necessitates discussion on long existing conventions.

Australia and New Zealand
SuRF ANZ has published a Framework for Sustainable Remediation. Of special interest may be the fact that the Australasian Land and Groundwater Association (ALGA) supports the organisation and operation of SuRF Australia, thereby extending involvement to New Zealand.

Like SuRF-UK, the SuRF initiative for Australia and New Zealand is in the process of collecting and reviewing experiences of case studies in which sustainable remediation is applied. One example of a remediated site near Sydney, Australia, seems to have all kinds of aspects making it interesting for a detailed review. By way of example of a practical case, these aspects are shown in the box below.

The site became contaminated over a number of decades when foreshore land was reclaimed using lime and ash wastes. The wastes came from the chemical manufacturing plants and contained a variety of chemical residues. Remedial solution included excavation and treatment of contaminated soil and sediment to reduce risks to human health and the ecological environment. This involved using direct-heat thermal desorption (DTD) as the preferred remediation technique. Sustainability was assessed, including aspects from all three indicator groups, i.e. environmental, economic as well as social aspects:

Environmental
- Impacts on air – considered in terms of volatiles
- Impacts on surface and groundwater – considered in terms of migration of contaminants
- Impacts on soil health – considered in terms of migration of contaminants
- Impacts on ecology – reduced ongoing impacts to marine ecology, and also cumulative effects of fishing in the area
- Intrusiveness and aesthetics – harbour foreshore aesthetics (desirable living space)
- Resource use and waste – reuse of suitable materials for earthworks

Economic
- Direct costs and economic benefits - key consideration in development of remedial solution

Social
- Human and ecological health – key driver of remediation to address risks
- Project perceived to be high risk by the community has become well accepted
- Community involvement and satisfaction - local stakeholder groups support
- Fit with planning and policy strategies and initiatives

NICOLE
The NICOLE network has developed a Road Map for sustainable remediation, detailing how to incorporate sustainable remediation in the remediation decision-making process. The Road Map is designed as a series of steps to ensure a consistent and collaborative approach to robust decision-making, regardless of the project size. This Road Map distinguishes itself from the products devel-

oped elsewhere by explicitly incorporating considerations contributed from several (European) countries.

The key conclusions from the accompanying NICOLE Guidance on Sustainable Remediation provide a short summary on a number of principles:

1. A sustainable remediation project is one that represents the best solution when considering environmental, social and economic factors – as agreed by the stakeholders.
2. Similar to the concept of risk management and risk assessment, sustainable remediation can be divided into two inter-related components:
    a. *Sustainability management:* the discipline of integrating sustainability assessment into contaminated land management decision making.
    b. *Sustainability assessment:* the process of gaining an understanding of possible outcomes across all three elements (environmental, social and economic) of sustainable development.
3. Sustainability assessment is a tool that supports sustainability based decision-making within a management plan, and also the review and verification of sustainability performance during the implementation of remediation.
4. The aim of a sustainability assessment is to build trust and consensus between stakeholders; the simplest tools, indicators or qualitative approaches will be sufficient in the earliest stages and can be further developed in line with the project complexity.
5. The earlier stakeholders consider sustainability principles, the more opportunities there are to improve sustainable outcomes and so provide greater benefit. E.g.: benefits can be expected to be considerably greater when sustainability principles are considered in the remediation specification phase, rather than at the technical approach setting phase. Examples of gains that may be obtained through early consideration of sustainable remediation in project planning include opportunities for combining remediation with wider sustainability goals such as urban heat storage, sustainable urban drainage systems, and consideration of a compliance point further down-gradient in a groundwater risk assessment.

The Guidance emphasizes that it is particularly useful to consider sustainability gains where a large portfolio of sites is being managed, or when considering contaminated land remediation across a wide geographic area, e.g. optimizing use of resources to achieve good groundwater quality in urban conurbations.

4.4 Sustainable remediation appraisal tools

Over twenty techniques that might be applied in sustainability appraisal have been identified. These are essentially decision support tools. Some of these focus on specific indicator groups, e.g. carbon footprint or energy efficiency (environmental), financial risk assessment or cost effectiveness analysis (economic), and lay participation of quality of life assessment (social). Others, like the multi-criteria analysis or the quality of life capital assessment, aim to provide the user with a single tool that enables them to include a wide variety of aspects, environmental, economic as well as social, in the decision making process. Some of the available techniques require a certain level of institutionalisation. A good example of this is eco-management and audit scheme. Where some techniques provide qualitative results, others, like the public benefit recording system (PBRS), centre on metrics for quantification. Most of these tend to focus on environmental aspects, as they are apparently easier to quantify than economic or social aspects.

At the time of writing of this report, NICOLE is gathering information on cases where sustainable remediation principles have actually been applied. The preliminary results show that actual cases are still thin on the ground and relatively difficult to find. This means that this exercise has not yet yielded any results or conclusions that can be used effectively here. This timing coincides with the gathering of information on case studies by SuRF-UK and SuRF-ANZ. This seems to confirm that in many countries there has been a tendency to include more than just soil quality related aspects in remediation options appraisal, but that only since the SuRF initiatives experiences are being exchanged internationally and work on best practices has started in earnest. SuRF-US is leading the effort to develop a White Paper on the international initiatives.

As the sustainable remediation approach is being included in many countries worldwide, it should also be taken into account when developing a methodology for India. However, without a more thorough understanding of the Indian context it is not possible yet to draw firm conclusions on the relevance of the sustainable remediation techniques applied elsewhere. It may well be that not all aspects of sustainable remediation applied in Europe, in the US or in other countries may be applicable in India, or may need to be introduced step-wise. Therefore, we propose that we include this subject in the interviews we have planned in preparation for the development of the Guidance document, and that we present our conclusions in the Guidance document, as well as in the final report on this project, to be developed in Task 6.

5 Inventory of guidance and standards applied in India

5.1 Inventory

An inventory is made of the guidances and standards which have already been applied in India in the assessment and remediation of soil contamination. In response to our question to representatives of MoEF, CPCB and some SPCB's it was revealed that the existing documents on this matter consist of a methodology developed by CPCB. The findings presented in this Chapter have been, together with data from other sources, incorporated in Annex 1, so as to enable comparison of the current Indian situation to international practices.

5.2 Steps for assessment and remediation

CPCB has developed a methodology in which the sequence of steps for the assessment and remediation of contaminated sites is described. At the time of writing this report the still developing methodology contains the following phases and steps:

Phase-I (step 1-7)

- (i) to review existing data of the site / historical investigation;
- (ii) to assess the levels and nature of contaminants in surface/sub-surface, groundwater and soils in and around the contaminated site;
- (iii) conduct reassessment studies;
- (iv) prepare detailed project report along with technical and engineering designs for remediation /rehabilitation plans.

Phase-II (step 8-10)

- (v) implementation of remediation works and guiding monitoring and assessment activities; and
- (vi) validation of remediation works and remediation targets and preparation of post-remediation monitoring plan.

The remediation of contaminated sites shall result in a direct economic benefit in re-use of contaminated land in terms of real estate price stabilization (increase of supply of saleable/leasable land). Although the proposed project may not necessarily bring direct economic benefits; it will generate long term environmental and social benefits. These benefits will be mainly associated with a reduction in air, water and soil pollution and hence an improvement in human health and the environment.

Step 1. Reconnaissance and Preliminary Assessment of Site, including the adjoining areas, through field visits, review of existing documents, maps and literature and carry out the following activities:

- Collection of history/background information of the contaminated site.
- Basic features of the site, i.e. collection of available information on the site like site maps (topographical, geological), hydro-geological information, information from local authorities, information on the type of polluting-sources, storage and disposal of raw materials, by-products and wastes at site.
- Study of previous site investigation reports.
- Nature, location, type and characteristics of the site.
- Site photographs.
- Identification of previous and current land use pattern of the site.
- Identification of parameters causing immediate threat to the ecology and environment.
- Discussion with local people and other informed people, district administration, municipal and regulatory authorities, NGOS, etc.

Step 2. Preliminary investigations of the contaminated site and development of site conceptual plan and sampling protocols

- Selection of the available observation wells (Bore Well) in the watershed covering the site, for monitoring the water level and quality monitoring at appropriate locations, and inventory of details like total depth of the well, water column, frequency of sampling (pre monsoon/ post monsoon or bimonthly).
- Preparation of groundwater level contour maps with relation to mean sea level, ascertaining groundwater flow direction.
- Collection of preliminary samples and analysis of soil, sub-soil, surface water, and groundwater for comprehensive analysis of major ions and heavy metals, organic constituents, pesticides and other relevant parameters related to the contaminated site as per national / international accredited testing procedures.
- Preparation of detailed sampling protocol aimed at assessing the contamination level of the site and at establishing the baseline environmental status of the project area. The protocol shall include identification of criteria pollutant (parameters) for analysis, sampling frequency (number of seasons), number of samples, etc. and shall be submitted for approval of CPCB.
- Identification of benchmark/background samples.
- Use of rapid assessment tools / methods (for field and laboratory analysis).
- Outlining the extent of contaminant plume through surfer maps, submission of report based on preliminary findings.
- Development of conceptual site plan/model. The conceptual site plan comprises three elements: (i) Potential sources of contamination, (ii) Potential receptors that may be harmed and (iii) Potential pathways linking the two.

Step 3. Detailed site investigation and characterization

- Drilling of bore-holes in grid manner in and around contaminated sites.
- Water quality assessment, geochemical analysis - analysis of criteria pollutants, specification of heavy metals, isotopic signatures, etc.

- Geological, hydrogeological and hydrological features of the contaminated site - Hydraulic conductivity, permeability, porosity, groundwater flow, lineaments, tracer tests if required and pump tests.
- Groundwater flow processes and contaminant transport processes to visualize the contaminant plume in groundwater.
- (Delineating the aquifer geometry though geophysical methods and ascertaining lithology of formations).
- Clearly delineate the boundaries, longitudinal and cross section of the contaminated site through topographic and other engineering surveys and prepare a base map of the project site.
- Development of groundwater flow and mass transport models.
- Estimate the quantity of contaminants and their concentrations including secondary pollutants.

- Possible elements in a site specific approach:
  i. The area of investigation should be identified considering the main pathways, air and water transport of contaminants.
  ii. Prior to any drilling or sampling work, a detailed map showing the site and its surroundings is required to document sampling points, findings and later the concentrations of contaminants. If such a map is not available, it should be generated, based on a survey of the area.
  iii. All locations where waste was dumped shall be clearly identified. All wells in the surroundings should be identified and tested for identified pollutant. The depth of the wells should be recorded and surveyed against mean seal level.
  iv. Drilling of wells is recommended if existing wells are not appropriately placed or designed to gain consistent results.
  v. Prepare a detailed sampling and analysis plan, including a map providing the locations of the proposed drillings and wells, the number of samples and the parameter for analysis.
  vi. The depth of the bore wells should depend on the geological and hydro-geological conditions (minimum recommended depth is 30 feet). If these conditions are unknown, a test bore for geological logging needs to be installed. If results of the drilling reveal the presence of two aquifers, wells should not penetrate impermeable layer in-between. The filter sections of the wells should all be in same depth considering the geological conditions.
  vii. Background samples should be taken from up gradient wells. The groundwater flow directions shall be determined based on the water level measurements in the wells. Tidal influences if any shall be also considered.
  viii. Intrusive investigation should include the soil underneath and surrounding the waste in order to identify the depth and extent of contamination. Additional waste samples or samples from obvious contaminated soil/materials are not necessary. Sample depth shall depend on local and regional geological settings.
  ix. Surface water samples and sediment samples shall be collected from all identified surface water bodies. Sediment samples should also be collected from the river and the river mouth. Composite samples are

not recommended. Groundwater-monitoring along the riverbanks down gradient should be carried out as per requirement.

x. Soil sampling shall be carried out in a grid pattern. The depth shall be flexibly adapted to the findings. According to the findings, the grid spaces can be reduced or extended.

xi. If there is any potential source of contamination from industry premises within or adjoining the area, sampling should be carried out inside and outside the company's premises wherever hidden dumps are likely to be present or contamination might have migrated to.

xii. All soil and ash samples collected should be tested for total concentration expressed in mg/Kg. The selected contaminated soil and ash samples should be tested for leachable concentration in mg/L in the leachate extracted as per US EPA 1311 test method for Toxicity Characteristic Leaching Procedure (TCLP).

xiii. Evaluation of the results should be carried out in order to identify potential sources pathways and receptors, and to identify the entire quantity of waste buried and contamination present.

Step 4. Risk Assessment

- Socio - economic and environmental assessment of the contaminated area.
- Assess the potential environmental/ecological/health impacts on soil, groundwater, surface water bodies, population, flora and fauna.
- Pathways of contaminant transport, fate of the contaminant and exposure.
- Assessment of toxicity, bioavailability, biodegradability and mobility of contaminants.
- Identification of significant receptors and establishing trigger values.
- Establishment of risk assessment models.
- Interaction with local groups. Reporting of meetings/opinions.
- Recommendations/suggestions for risk assessment studies.

Step 5. - Identification of remediation goals/objectives and preparation of Remediation plans

- Identification of remediation goals/objectives. It should be noted the objective 'restoring the land or waters to their former state', which in the UK is one of the formal potential remediation objectives, while commendable, is not always realistic;
- List and evaluate best options for remediation of the contaminated site including (soil, surface water, groundwater, etc.) based on economic feasibility, complexity, technology transfer from the international suppliers / agencies, effectiveness, execution aspects, previous performance, safety, locally available skills, etc.
- Assess the environmental and social impacts of remediation options, based on detailed field surveys and investigations.
- Recommend at least 3 remedial options and appropriate implementation strategies, considering the future land use and target contaminant concentrations. The options should be recommended based on (i) health and environmental risks due to the contamination, (ii) compliance with the standards based on techno-economic feasibility, and (iii) performance based approach that is based on verifiable success in similar situations.

- The implementation strategy should consider options such as technology neutral performance or conventional turnkey or Engineer-Procure-Construct (EPC) contracts. For each of the identified strategy, the consultant will analyze engineering, environmental and contractual requirements.
- Selection of a suitable site specific remediation technology.

Step 6. Design of remediation plan and submission of DPR along with technical document with detailed specification

- Submission of detailed project report along with remediation plan for the approved remediation option, comprising detailed designs, engineering drawings, cost estimates and implementation schedule.
- In Phase-II, the consultants have to monitor and assess the remediation works being implemented by another contractor or an agency so as to ensure that remediation works are implemented as per the technical specifications and standards proposed for remediation followed by verification of remediation works and submission of post remediation monitoring plan in Steps 7 to 9.

Step 7. Preparation of bid documents and bid process Management

- Based on the approved, implementation strategy.
- Provide the details of staff and deployment schedule to accomplish the task.

Step 8: Monitoring and assessment of actual Remediation works

- Monitor and assess the implementation of the remediation works to ensure that all the activities are being carried out as per approved design and agreed terms and also provide technical advice on the quality of work. Duration of such assessment and monitoring will depend on type of remediation work.
- During assessment and monitoring, (i) ensure that all the activities agreed as part of the contract complied with the technical standards, (ii) monitoring the progress of work in accordance with quality control / quality assurance and (iii) conduct random investigations/sampling/tests to verify the implementation works.

Step 9. : Validation of Remediation works

- On completion of the remedial plan - carry out a confirmatory sampling, to demonstrate that the contamination has been removed or stabilized effectively and the remediation objectives have been achieved.
- Recommend a long term monitoring plan for post remediated site and suggest key environmental attributes for such activity.

6 Conclusions for the Guidance document

6.1 Introduction

The countries discussed in the chapters 2, 3 and 4 have developed and tested their approach over many years. This section presents an overview of elements that have turned out identical or virtually identical in these countries. From this we conclude that we, while developing the Guidance document in Task 4, should at least study how implementation of these elements in India would work out. The elements related to a specific step in the remediation process are presented in the tables below. For each step the following points are mentioned:

- scope of the step / questions to be answered;
- activities;
- input;
- output;
- possible tools to be used during the activities;
- exit or deviation from process.

For the steps during site assessment Assignment 1, 'Inventory', will provide elements to be used in the Guidance document.

6.2 Gap analysis

From comparison of the current situation in India, as described in Chapter 5 and summarized in Annex 1, to international practices, the following conclusions are drawn.

Strengths

- Legal documents are in place for prevention of the uncontrolled dissemination of hazardous substances;
- A methodology for the assessment and remediation of contaminated sites is available;
- Drinking water standards are in place.

Discrepancies

- The number of formally identified sites in India is still limited;
- In the identified sites, a relatively small part of contaminants in use in the Indian industry is represented, i.e. mainly heavy metals, pesticides and fluoride;
- For a relatively large number of the identified sites the land use has not been recorded, preventing the assessment of the impact of the contamination;
- The available methodology for the assessment and remediation of contaminated sites needs detailing out, based on assessment of international prac-

tices. Proposals for this are developed in the Guidance document, to be developed in Task 4 of this Assignment;
- The existing institutional framework for the environment needs adaptation to deal effectively with contaminated sites. Proposals for this are developed in Assignment 3;
- A complete set of standard values for soil, groundwater and surface water needs to be developed. Proposals for this are developed in Assignment 1.

Gaps
- Legal documentation for dealing with contaminated soil, groundwater and surface water is still limited. Proposals for these are developed in Assignment 3;
- Responsibilities for dealing with contaminated sites have yet to be assigned. Proposals for this are developed in Assignment 3;
- Remediation target values have not yet been defined. Proposals for this are developed in the Guidance document, to be developed in Task 4 of this Assignment.

6.3 Conclusions for the Guidance document
General conclusions for the development of the Guidance document, not related to any specific step, are:

- Use of a Conceptual Site Model from the beginning of the assessment and remediation process. With each step the CSM is updated and fine tuned with new data. The CSM is useful to develop first thoughts on risks, potential remediation options and necessity of site characterisation. The CSM includes the source-pathway-receptor-approach (SPR);
- Temporary safety measures or quick response actions are potential measures after every step;
- In the Guidance document (Task 4) references can be made to external sources with detailed technical information on site assessment, risk assessment or remediation techniques. The advantage of this is that this information will be kept up to date without the need to change the Guidance document with every new technological development.

Table 6.1 below presents the Conclusions on steps in the assessment and remediation process. It should be noted that the methodology for the assessment and remediation of polluted sites, developed by CPCB, generally contains the steps that are listed in table 6.1.

Table 6.1 Conclusions on steps in the assessment and remediation process

Step	Scope / questions to be answered	Activities	Input	Output	Possible tools	Exit or deviation of process
1) Site Assessment						
1a) Preliminary site Assessment Reconnaissance	Evaluate if there have been activities at a site which might have caused soil contamination?	• Desk study • Interviews local authorities, land user, owner, population • Site visit	• Site coordinates • aerial photographs • topographical data • geological data • records of authorities regarding environmental permits en land use / ownership • Socio-economic factors for site access	Report with: • Type of site • Contaminants / parameters • First CSM of site • Boundaries of the site to be assessed • Potential contaminated area • Site photographs • Phases (waste material, soil, groundwater, sediment) to be assessed • Socio economic factors for further assessment and remediation	• List of activities causing contamination / Typology • CSM • HW-Rules, Schedule II -III • Definition of probably contaminated site • Checklist for analysis socio-economic aspects	In case no activities have been recognized which might have caused potential contamination.
1b) Preliminary site Assessment Preliminary sampling	Evaluate if activities on the site have caused soil contamination?	• Field survey plan • Sampling • Laboratory testing	• Report reconnaissance • Sampling and screening methods • Desired quality and accuracy of data	Report with: • Conclusion if any contaminations are present on a site and to be related to previous activities • Updated CSM	• Typology • CSM • Guidelines field survey • Checklist of field survey techniques • Checklist for	In case no contamination are present above screening level.

Step	Scope / questions to be answered	Activities	Input	Output	Possible tools	Exit or deviation of process
			• Information regarding local community	• Identification possible immediate human and / or ecological threats • Check results with screening levels	laboratory testing methods • Screening levels for assessing potential risk • Checklist safety measures site access	
1 c) Detailed site assessment	• Information on amount and extent of soil contamination necessary for risk assessment • Which sources, pathways, receptors can be identified and quantified?	• Field survey plan • Sampling • Laboratory testing	• Report preliminary assessment • Sampling and screening methods • Desired quality and accuracy of data • Information soil structure and geohydrology • Information regarding local community	Report with: • Delineation of contamination (if necessary) • Soil structure and geohydrology • Check results with screening levels • Updated CSM • Sometimes conclusion on amount and extent of contaminations at the site	• Typology • CSM • Guidelines / thumb rules field survey • Screening levels for assessing potential risk • Parameters on mobility, toxicity, biodegradation, bioavailability of contaminants • Overview of assessment tools • Checklist safety measures site access	In case of no contamination are present above screening level

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
2) Risk Assessment						
2a) Preliminary risk assessment	Identification of potential significant risk	Inventory of Source, Pathway, Receptor data	• Reports site assessment • Information on value of ecosystem and surface of contaminated area • Information soil structure and geohydrology	Report with: • SPR-combinations with potential significant risk	• CSM • Table with SPR assessment and exposure (human: ingestion (soil, ground water, crop, meat, fish), inhalation, dermal uptake • Definition contaminated site • Screening levels for assessing potential risk	In case there are no SPR-combinations which can cause potential risk
2b) Detailed quantitative risk assessment	Does exposure to contaminants exceed significant risk levels?	• Calculation of transport/dispersion of contaminants in soil, ground water and to surface water • Calculation of human and ecosystem exposure • Comparing human exposure levels to risk levels	• List of SPR-combinations with potential significant risk • Quantitative information on exposure parameters • Information soil structure and geohydrology	Report with: • Evaluation of exposure and dispersion and risk based levels violations (human, ecological) • Possible need of safety measures in expectation of final remedial actions	• Information on toxicity, bioavailability and mobility of contaminants • Dispersion model (air, surface water, ground water) • Exposure models (dose/response) • Maximum levels for exposure of human and ecosystem	In case there are no SPR-combinations for which significant risk levels are exceeded

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
3) Remediation option Selection						
3a) Remediation goals and preconditions	• What are goals / objectives for remediation? • Future use and additional option requirements	Consultation of • authorities • initiator	• Soil remediation legislation and standards • Redevelopment plans • Information ownership and stakeholders	• Site specific remediation targets for each SPR-combination	• CSM • Stakeholder analysis • Social economic analysis • Target levels for remediation	In case remediation for some reason is not to be executed within a foreseeable period, temporary safety measures should be taken.
3b) Reconnaissance Remediation options	Which remediation options are feasible for this type of contamination?	• Selection of SPR-combinations together with parties involved • Inventory of remediation options targeting these SPR-combinations	• Report risk assessment with SPR-combinations for which significant risk levels are exceeded	• Established SPR-combinations with exceedance of significant risk level • List of applicable options including connotations regarding its applicability and risks	• Tables of Task 3	
3c) Design Remediation options	Remediation option design for each SPR-combination	• Analyses of options and techniques regarding the site factors, remediation objectives and practical objectives	• Results of previous step 3b) • predefined range of objectives of remediation and site characteristics	• Remediation options applicable. • Analyses of pros and cons for each remediation option	• CSM • Technique fact-sheets • Site assessment to investigate the site specific applicability of a specific technique	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
3d) Selection remediation option	Selection of most favourable remediation option	Weighting each remediation options on a set of criteria		• Ranking of remediation options including analyses of pro's/con's • Combining options to possible remediation strategies for the whole site • Indication of short term and long term management aspects • Evaluation missing data needed for analysis of applicability of remediation techniques	• Criteria for selection (Task-3) report • Methods for weighting	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
4) Remediation Design						
4a) Highlighting remediation strategy requirements that the design should be in accordance with. Planning and preconditions.	• Ensuring that remediation objectives and all environmental requirements will be met • Plan each phase of the remediation strategy (including monitoring and post remediation phases).	• Desk study	• Selected remediation option • Actual situation of the site (when much time has past since last step)	• Remediation objectives • Environmental requirements • Remediation schedule (maintenance schedule, monitoring schedule) • Phase determining criteria	• Checklist with relevant aspects • Criteria determining when to start and when to stop.	In case remediation for some reason is not to be executed within a foreseeable period, temporary safety measures should be taken.
4b) Drawing the remediation works	• Detailed description of remediation activities	• Drawing the plans and combine the design eventually with the design of the redevelopment of the site.	• Civil engineering information (water drainage systems,..) • Redevelopment plan for the future use of the site	Remediation plan comprising: • Design maps, • Design reports	• Checklist / generic aspects remediation plan	
4c) Ensuring that the requirements of the authorities for the implementation are met	Concern permits necessary for the works but also environmental permits to manage the produced wastes and other environmental disturbing.	• Applying for regulatory permits: -civil engineering permits, -waste management license -groundwater authorization	• Building regulations • Environmental regulations	• Permits	• Checklist permits	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
5) Contracting, bidding documents						
5a) Developing bidding documents	• Detailed technical description of the activities to be carried out. • Total costs calculation	• Developing documents needed for tendering process. • Calculation of the costs of all remediation's phases.	Remediation plan with design of measures.	Bidding documents.	Referring to generic tendering procedures in civil engineering, infrastructural or environmental works.	Tendering process is the last step before the remediation is executed.
		Reporting		Bills		

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
6) Implementation of remediation works						
6a) Information to stakeholders	Information of all parties that can be involved (inhabitants, commerce, …)	• Execution of the Communication plan • If necessary: revision of remediation plan	• Remediation plan	• Evaluation report of executed communication.	• Generic communication plan / checklist	
6b) Safety, health and environmental measures	Facilitate safe conditions for the contractor and the environment	• Activities in safety plan • Logbook of activities and unforeseen events	• Safety, health and environmental plan	• Logbook	• Generic table of contents of logbook	
6c) Monitoring remediation progress	'Plan- do-check-act' of the remediation	• Monitoring and registration of the remediation progress, evaluation and if necessary adjustment of the remediation plan. • Communication with actors in case of deviation of the original remediation plan	• Remediation plan. • Monitoring plan. • Maintenance plan. • New data of contamination of the site	• Logbook with all data and other information	• Generic table of content of a logbook • Examples of exit-procedures. • List of key procedural point to keep focus on quality of the remediation process	In case the remediation goal cannot be achieved when applying the original remediation plan and additional adjustments.
6d) Termination of remediation	Inventory and report of all activities and data	• Evaluation report with all activities, deviations from original plan, corrective measures and final result	• Logbook with all data collected during remediation process	• Evaluation report describing the remediation process and the final soil quality.	Generic table of content of a evaluation report	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
7) Close out						
7a) Evaluation remediation goal	Evaluation if the reached situation meets the remediation goal	• Termination of remediation contract and data-transfer to authorities • Validation of remediation works • Site clearance • Evaluate site use restrictions and post remediation measures	• Remediation objectives as described in the remediation plan • Actual data on site contamination level (revision of site assessment) • Target level evaluation (standard based approach) or risk assessment (risk based approach)	Conclusion: remediation goal is reached or Conclusion: remediation goal is reached. Instructions for site use restrictions and post remedial measures or Remediation goal is not reached, further remedial steps are necessary All data of remediation available for authorities. If necessary a report on site use restrictions and post remediation measures	• Definition of remediation site use restrictions i.r.t. post remedial measures i.r.t. extensive remediation activities. • Examples of site use restrictions and	In case of approval of the executed remediation works site re-use can take place.
7b) Registration of land use restriction and post remediation measures	In case residual contaminants are present, land use restrictions are institutional registrated Institutional registration of post remediation measures	• Institutional registration	• Report on site use restrictions • Report on post remediation measures	• Registered site use restrictions • Registration of post remediation measures	described by Ass_3 task (land register?)	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
8) Post remediation measures						
8a) Design and execution of post-remediation measures	Operation and maintenance of technical measures to keep measures operational in order to preserve the situation as reached with the remediation process	• Monitoring • Operate • Maintenance • Replacement / restoration	• Maintenance and monitoring plan • Report on site use restrictions	• Report with results • Registered site use restrictions	Checklist post remediation measures	In case goals are reached.

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
9) Temporary Safety Measures						
9a) Design and execution of temporary safety measures	Temporary safety measures are needed to prevent unacceptable risks pending final remedial measures.	• Design and execution measures	• SPR-combinations causing too much risk to human health or the environment that	• Report with results	Checklist temporary safety measures	In case final remedial measures are taken

7 References

- BRGM, BASOL, BASIAS, 2012. Inventory of potentially polluted sites in France.
- CETESB, 2011, Inventory of contaminated sites in the Brazilian state of São Paulo.
- COWI et.al, Feb. 2013. Inventory and mapping of probably contaminated sites in India, Task 1 report: Existing data and general information on contaminated sites
- CPCB, undated. Methodology for assessment and remediation of polluted sites
- Jeffries, J. and I. Martin, January 2009. Updated technical background to the CLEA model. Environment Agency Science report SC 050021/SR3.
- PWC, April 2013. Development of National Program for Rehabilitation of Polluted Sites, Task 3 draft report, Identification of Options for Legal and Institutional Strengthening
- US EPA, 2012. Inventory of Brownfield and Superfund sites in the USA.
- US EPA, undated. National Priorities List (NPL).
- VROM, 2009. Inventory of potentially contaminated sites in the Netherlands.

Annex 1: Summarized results inventory international approaches remediation

1. Soil contamination				
	France	**United States**	**Brazil**	**Netherlands**
Number of contaminated sites	4,318 sites which need action (assessment, remediation or management of restrictions); 406 of these sites have been treated and are clean Start of the inventory: year 1994 Nearly 300,000 ancient industrial sites, which could affect the environment[5]	Between 100,000 and 600,000 brownfields sites and around 1,664 abandoned sites selected for the Superfund program[6] Start of the inventory of the Superfund program: year 1982	Around 4,150 sites in the State of São Paulo[7] Start of the inventory: year 2002	Around 11,000 sites[8] with possible unacceptable risks in total. • 413 sites with unacceptable risks towards human health; • 2,000 estimated number of sites with unacceptable risk to ecology and groundwater. Start of the inventory: year 1980
Important categories of pollution	A large variety of contaminated sites: various industrial processes on metals, chemistry, textile; harbor areas; old mining facilities; cleaners; petrol stations. Frequent contaminants are hydrocarbons and metals (lead, zinc, chromium and copper).	Special attention is given to a.o. pesticides in agricultural areas, mining waste, lead, Dense Nonaqueous Phase Liquids (e.g. trichloroethene), oil spills.	In the list with 4,150 sites the following activities are mentioned: Commercial activities; Industrial activities; Residues; Gas Stations; Accidents.	Important causes of point sources of contamination: metal-industry, oil spills, gasworks, waste dump sites, cleaners, petrol stations. Diffuse contamination exists due to use of waste material for construction purposes (building, infrastructure).

[5] Source: BRGM, BASOL, BASIAS, 2012. Potential polluted sites inventoried. The information 4318 sites date from the 3rd of April 2012. The inventory of 300,000 industrial activities is made based on archives only and the data is from 2012.
[6] Source: US EPA, 2012. The difference between Brownfields sites and Superfund sites is that the brownfields sites are characterized by low or medium contamination, they are easy to cleanup and to redevelop whereas superfund sites are the worst contaminated sites with limited prospect for economically viable reuse.
[7] Source: CETESB, 2011. This number corresponds to number of industries that shut their doors, that is not reused and which critically affect the environment.
[8] Source: VROM, 2009. Number of sites in need of urgent remediation, according to the Dutch criteria.

1. Soil contamination			
	United Kingdom	**Australia**	**India**
Number of contaminated sites	For UK no total estimation has been made. In England 100,000 sites may be contaminated. Of these, 5,000 to 20,000 may be problem sites (2002 the Environment Agency (EA))	No information: there are no national registers of contaminated land.	557 sites have been identified in formal data sources. Some SPCB's have been hesitant about sharing data in view of potential effects.[9]
Important categories of pollution	Greatest surfaces of land affected (area and sites) are: railway land, garages and filling stations, gas works, sewage works, textiles, engineering works, and ceramics and cement works. These various activities were carried out on a wide range of scale of operations, resulting in point sources of contamination of soil and groundwater as well as larger extents of diffuse contamination.	Known categories of possible soil contamination are: service stations, cattle dips, tanneries, wood treatment sites, landfills, fuel storage, refuse tips, mining waste.	The same sources as referenced above states that most of the identified sites are contaminated with various heavy metals, especially chromium and lead, but that also mercury, cadmium and arsenic are common, and that pesticides and fluoride also occur commonly.

[9] Source: COWI et.al, Feb. 2013 – Inventory and mapping of probably contaminated sites in India, Task 1 report: Existing data and general information on contaminated sites

2. Effects of contamination				
	France	**United States**	**Brazil**	**Netherlands**
Effects	Recorded impacts of contaminated are: drinking water, groundwater tables, shallowed water and sediments, vegetation for human or animal consumption, animals for human consumption, smell complaints, human health.	Risks of contamination are categorized in risks to human health and risks to the environment.	When prioritizing sites the following impacts are taken into account: life and health of population (direct impact); supply of drinking water; land use residential and gardens; water (underground and surface); use of agricultural land or lifestock; other public or ecological assets to be protected.	Impacts of contamination assessment are categorized in effects for human health, for ecology and for groundwater. Because in Netherlands much drinking water is produced out of groundwater this pathway is important.

2. Effects of contamination			
	United Kindom	**Australia**	**India**
Effects	Generally effects for human health, (ground)water and ecology are taken into account.	Effects on human health and the environment (ecology and water) are taken into account.	Land use has not yet been recorded for 193 of the identified sites. 138 of the identified sites are on industrial land, a further 109 is in mixed use. Effects for human health and the environment are taken into account.[10]

[10] Source: CPCB Methodology for assessment and remediation of polluted sites

3. General policy/approach				
	France	**United States**	**Brazil**	**Netherlands**
Key documents	No specific law on soil, framework is based on: • Environmental Code • Ministerial letter 8th of February 2007 • Reference values for the water, the foodstuffs and the external air • Directive on wastes 2008/98/CE	• Hazardous and Solid Waste Amendments (HSWA) of the RCRA (Resource Conservation and Recovery Act), 1984 • Superfund or CERCLA: Comprehensive Environmental Response Compensation and Liability Act, 1980 • Oil Spill Act, 1990	• Law No. 997 of May 31, 1976: establishment of a system of prevention and control of the environmental pollution • Law No. 13577 of July 8th 2009: guidelines and procedures for the protection of soil quality and management of contaminated area	• Soil protection Act *Wet Bodembescherming*, first edition 1987 (replacing the Interim Soil Remediation Act, 1983) • Soil Quality Decree *Besluit bodemkwaliteit*, 2008 • Circular on Soil Remediation *Circulaire Bodemsanering*, 2009 Supportive documents: Guidance document on recovery of soil and sediment quality; sets of standards on quality of executed work.
Management approach for historically contaminated sites	Fit for (future) use approach for historical pollution	Fit for use approach, prioritization (Hazard Ranking System).	Fit for use approach and prioritization (scoring data sheet)	Fit for use approach for immobile contaminants: the top soil quality must meet the requirements for the future use of the site. Cost-effective approach of remediation of mobile contaminants: risks must be eliminated as much as possible and after care should preferably be not intensive.
Responsibility	• Polluter pays principle: responsible of the contamination (the operator, the owner or the former owner)	• Polluter pays principle: The landowner, disposal operator, transporter or generator of hazardous waste are potential re-	• Polluter pays principle+ solidarity principle: -the one that caused the contamination or its successor or	• Polluter pays principle: the owner or the operator • Orphan sites: The Financial Provisions Soil

3. General policy/approach				
	France	**United States**	**Brazil**	**Netherlands**
	• Orphan sites: ADEME. Funding by TGAP : General Tax on Pollutant Activities	sponsible parties • Orphan sites: EPA, Superfund program. Funding by the federal budget and penalties from responsible parties Many remediations take place when developing brownfields.	-the owner of the area or -the holder of the rights of the ground or -whoever benefits directly or indirectly from the ground • Orphan sites: FEPAC is a program from the Environment Department of the State of Sao Paulo: State Fund for Prevention and Cleaning of Contaminated Area. Funding by international aid, co-operation and intergovernmental agreements, donations, environmental compensation from polluting activities.	Remediation Decree: fund from the government: average deal: 50% government, 50% owner/beneficiary Many remediations take place when developing areas of due to trading estates.
Management of current sites integrated in the prevention policy	• Code de l'environnement • ICPE: environmental permit with requirements to protects the soils and the environment	• Environmental Act • RCRA: law about the disposal of solid hazardous waste and release of the facilities.	• Environmental Act • Licensing and environmental permits with requirements and monitoring	• Environmental Act: environmental permits • Soil protection Act: several regulations on specific activities

3. General policy/approach			
	United Kindom	**Australia**	**India**
Key documents	England: Contaminated Land Law (1995, effective in 2000) EPA 1990: Part 2A Contaminated Land Statutory Guidance, Defra, 2012 CLR 11, Technical Good Practice document (2004).	National Environment Protection (Assessment of Site Contamination) Measure 1999. *Primary responsibility for ensuring the assessment of site contamination rests with the States and Territories.* *Schedule A: recommend general process for assessment of site contamination.* *Schedule B: general guidelines for the assessment of site contamination.*	Land Acquisition Rehabilitation and Resettlement Bill, 2011 Environmental (Protection) Act (1986), under which have been constituted: Municipal Solid Wastes (Management & Handling) Rules, 2000 Hazardous Wastes (Management Handling and Transboundary Movement) Rules, 2008 E-waste (Management & Handling) Rules, 2011 Biomedical Waste (Management & Handling) Rules, 2011[11] Also: Methodology for assessment and remediation of polluted sites, developed by CPCB
Management approach for historically contaminated sites	In spatial planning: the ‘suitable for use’ approach, for the current and proposed new use of the land when assessing the importance of contamination and determining remediation objectives. For orphan sites: a risk based	• prevention of contamination or further contamination; • when significant risk exposure: implementation of health and safety measures; • planning authorities should ensure a site is suitable for its intended use;	Not yet defined. Proposals to be developed in NPRPS project within CBIPMP NPRPS, incorporating technical information provided by Methodologies project.

[11] Source: PWC, April 2013 – Development of National Program for Rehabilitation of Polluted Sites, Task 3 draft report, Identification of Options for Legal and Institutional Strengthening

3. General policy/approach			
	United Kindom	**Australia**	**India**
	approach.	• all relevant information on site contamination should be accessible to the community;	
Responsibility	Polluter pays principle. If not present: the present owner is responsible. For orphan sites the regulating authorities bear the costs. Land contamination is today routinely considered under a variety of drivers including regulatory compliance, corporate policy, land transactions and development. Over 90% of remediation in England has taken place voluntarily by developers under market-lead solutions.	Polluter pays principle. In addition the use of market forces to achieve the objectives of any contaminated site liability scheme.	Not yet defined. Proposals to be developed in NPRPS project within CBIPMP NPRPS, incorporating technical information provided by Methodologies project.
Management of current sites integrated in the prevention policy	Environmental Protection Act, 1990: environmental permitting prevents uncontrolled release of hazardous substances.		Waste management rules, as described under 'Key documents' above, prevent uncontrolled release of hazardous substances.

4. Policy Instruments				
	France	**United States**	**Brazil**	**Netherlands**
Actors: Government: set up the policy, the general approach Enforcement organism: -Permits delivery -Technical guidelines -Communication/public information -Control Scientific support: quality standards, threshold values, toxicological data /soil studies, technique studies Engineering companies, contractors, commercial laboratories	• Ministry of Ecology, Sustainable Development and Energy • ADEME: (national scale) receive fund from Ministry of Ecology, Ministry of financial Economy and Industry, and Ministry of the Research and third level Education. • DREAL: (regional scale) fund by Ministry of Ecology • BRGM: inventory of sites • INERIS: Fund by the Ministry of Ecology • Engineering companies, contractors, commercial laboratories: assessment and execution of remediation	• EPA: Environmental Protection Agency • EPA Regional offices • EPA's Office of Solid Waste and Emergency Response (national scale) • EPA's National Center for Environmental Assessment • ITRC (technology on mining waste treatment) • Engineering companies, contractors, commercial laboratories: assessment and execution of remediation	• Ministry of Environment • CETESB: Environmental Agency of the State of Sao Paulo. Fund by the Ministry of Environment • Environment Department of the State of Sao Paulo role: support the CETESB • GTZ: German Society for Technical Cooperation role: technical and financial support • VIGISOLO program, funded by the Health Ministry role: carry on public health studies related to contaminated sites • Secretaries of Health and Water Resources *Role of private companies not known.*	• I&M: Ministry of the Infrastructure and the Environment • Enforcement of specific assessment and remediation projects by regional (provinces) and local authorities (larger cities) • Soil+: (national scale) agency established by the I&M • RIVM: National Institute for Public Health and the Environment • TNO: Research organization about soil • Engineering companies, contractors, commercial laboratories: assessment and execution of remediation

4. Policy Instruments				
	France	**United States**	**Brazil**	**Netherlands**
Methodology	1. pollution investigation using historical data and other information 2. Conceptual Site Model 3. EQRS – calculation of the sanitary risks 4. Determination of the actions to undertake 5. Costs-benefit analyses 6. Analysis of the residual risks 7. Execution of site management plan	1. Preliminary Assessment/Site Inspection 2. NPL-Listing[12]: list of the most serious contaminated sites according to a ranking system 3. Remedial Investigation/Feasability Study (use of Conceptual Site Model) 4. Records of Decision: explains which cleanup alternatives will be used 5. Remedial Design/Remedial Action 6. Construction Completion: identifies completion of the cleanup construction 7. Post Construction Completion (operation and maintenance, control, five-year review, remedy optimization 8. NPL deletion 9. Site reuse	1. Preliminary Assessment 2. Confirmatory investigation 3. Registration in a database with a ranking system 4. Detailed investigation 5. Risk assessment (following US EPA methodology) 6. Design of remediation 7. Remediation project 8. Remediation of contaminated area 9. Monitoring	• Preliminary assessment (historical research) • First field and laboratory research • Estimation possibility of severe contamination • Detailed investigation • Risk assessment • Determination existence of unacceptable risks • Starting procedure remediation • Selection of remediation option • Design of remediation • Remediation execution • Verification results • Possible after care of monitoring In the administrative procedures much attention is paid to the interests of local residents. Some steps need submission of reports to authorities.

[12] NPL: National Priorities List. Orphan sites that are remediated by the State must be registered in a list which inventories the worst cases of contamination that are hardly reusable. A ranking system called Hazard Ranking System (HRS) aims at giving a score to a site and if the score is higher than 28,5 the site can be added on the NPL. After remediation, the site must be removed from the list.

4. Policy Instruments			
	United Kindom	**Australia**	**India**
Actors: Government: set up the policy, the general approach Enforcement organism: -Permits delivery -Technical guidelines -Communication/public information -Control Scientific support: quality standards, threshold values, toxicological data /soil studies, technique studies Engineering companies, contractors, commercial laboratories	No single authoritative body in the UK responsible for land quality. • Environment Agency = environmental regulatory authority for England and Wales. • Executive agency of the Department for Environment, Food and Rural Affairs (DEFRA) for England and Wales; SEPA (Scottish Environmental Protection Agency); Northern Ireland Environment Agency • Local authorities are the principal regulators. They have contaminated land officers to assess remediation strategies related to spatial development. • Engineering companies, contractors, commercial laboratories: assessment and execution of remediation	Primary responsibility for ensuring the assessment of site contamination rests with the States and Territories.	Not yet defined. • Assignment 3 of CBIPMP NPRPS project is developing proposals. In these proposals MoEF sets up policy, which may be managed by CPCB or a new dedicated Central NPRPS Authority. • The same source proposes to entrust Enforcement to SPCB's or State NPRPS Authorities. • Scientific support from e.g.: NEERI: National Environmental Engineering Research Institute • NGRI: National Geophysical Research Institute • IIT: Indian Institute of Technology • Accredited engineering companies, contractors and commercial laboratories: assessment and execution of remediation.
Methodology	1. preliminary risk assessment (desktop study and site reconnaissance); 2. Intrusive investigation	• Preliminary investigation (assessment of human health and ecological risks); • Detailed investigation;	Not yet defined. To be developed in this project. Proposed methodology will be described in Task 4 report,

4. Policy Instruments			
	United Kindom	**Australia**	**India**
	3. Risk assessment 4. Remediation strategy 5. Remediation works Each step requires submission of reports to authorities.	• Health and environmental (site specific) risk assessment; • Remediation plan (approval of authorities needed) • Execution remediation works • Validation of results • Possibly site management plan	Guidance document. CPCB has developed a methodology containing the following phases and steps: Phase-I • Review site data; • Preliminary investigations and development of site conceptual plan and sampling protocols; • Detailed site investigation; • Risk assessment; • Remediation objectives and remediation plan; • Detailed Project Report (DPR); • Bidding and implementation remediation works; • Monitoring and assessment of remediation works; • Post remediation monitoring plan.

5. Remediation				
	France	**United States**	**Brazil**	**Netherlands**
Standards aiming at initiating the remediation process	Reference values are: • *Natural soil background values* for the metals • *Regulated values for the drinking water, foodstuffs and the outer air* for organic coumpounds • *Regulated values towards ecological area* • For the ICPE, comparison with the state before the use of the site OR, if values non available: • EQRS: risk index by calculation	Recommended action levels: • Environmental Indicator for human exposure: is there an unacceptable level of risk; • The Environmental Indicator for Groundwater ensures that contaminated groundwater does not spread. • HRS: sites with a score > 28.50 are proposed for the NPL • Standard screening levels based upon human health risks (not mandatory)	• Quality reference Value: no contamination, natural quality of the soil/groundwater • Prevention Value: adverse changes may occur, monitoring necessary • Intervention Value: potential risks to human are health, intervention necessary. These values are calculated based on risk assessment for each substance.	• **The Target Value** defines a non polluted state for the **groundwater** • **The Intervention Value**: indicates when functional properties of the **soil or the groundwater** for humans, plants and animal are threatened. If a contaminant is in a higher concentration than this value, a risk assessment is needed.
Post-remediation values	• Suppression of the source of the contamination • Level of risk acceptable towards the people and the environment, The remediation goals depend on the future use of the site. • Regulated values for the drinking water, foodstuffs and the outer air for organic coumpounds • Regulated values towards ecological area	Level of cleaning = Preliminary Remediation Goal, set by: • ARARs : Applicable or Relevant and Appropriate Requirements . Concentration limits set by environmental regulation. • Risk Assessment calculations	Remediation goals must meet the requirements of the risk assessment. The risk must be controlled,	For the **topsoil**: • The Background Value for agriculture and ecological functions *achtergrondwaarde* • The Maximum Housing Value • The Maximum Industrial Value • OR Local Maximum Values For the **subsoil**: risks of spreading and any risk towards human's health must be removed as much as possible These values are calculated based on risk assessment for each substance taking into account both human's health and ecology.

5. Remediation			
	United Kindom	**Australia**	**India**
Standards aiming at initiating the remediation process	• Soil Guideline Values (EA): indicators of 'significant possibility of significant harm'. SGV do not have a legal status. • Science based risk assessment.	Appropriate investigation levels, varying for various States.	Not yet defined. Proposals to be developed in Inventory project of CBIPMP NPRPS.
Post-remediation values	Risk based approach. Various models can be used for risk assessment (EA-standard and commercial models as well). The remediation should remove or treat the pathway or protect or remove the receptor and remedy the effect on controlled waters. Most remediations take place by excavation and off-site disposal, followed by containment.	Hierarchy of options for site clean-up and/or management: On-site treatment to at least acceptable risk level, or off-site treatment of excavated soil, If not practicable, containment or removal to an approved site or facility, or, when remediation has no net environmental benefit, implementation of an appropriate management strategy.	Not yet defined. Proposals to be developed in Methodologies project of CBIPMP NPRPS. Will be presented in Task 4 report, Guidance document.

Summary UNIDO POP Contaminated Site Investigation and Management Toolkit

The Stockholm Convention of May 23rd 2001 on Persistent Organic Pollutants is a legally binding multilateral environmental agreement intended to protect human health and the environment from POPs.
The Convention requires the 160 countries who have signed it to reduce or eliminate 12 known POPs which are Aldrin, Chlordane, DDT, Dieldrin, Endrin, Hexachlorobenzene, Heptachlor, Mirex, Toxaphene, PCBs, Dioxins and Furans.
Eight of these chemicals are pesticides and fungicides that are in common use in many developing countries, while two are industrial chemicals and two are common industrial by-products.

The goal of effective management of POP-contaminated sites is a priority for the Stockholm Convention, the Convention does not cover the specifics of how to manage site contamination.
The United Nations Industrial Development Organization (UNIDO) Expert Group on POPs has therefore developed this comprehensive Toolkit.

The Toolkit is developed to aid developing countries with the identification, classification and prioritization of POP-contaminated sites, and with the development of suitable technologies for land remediation in accordance with best available techniques and best environmental practices (BAT/BEP). The Toolkit focuses exclusively on the 12 POPs listed.
The Toolkit is designed to provide a clear step-by-step approach that can be easily followed and implemented by a variety of users following various worksheets, tables, and checklists, currently used in developed countries, that users in developing countries can adopt, and then modify to meet their own needs.

Guidelines for site investigation are presented in the Toolkit from countries with different ecological and environmental conditions and offer an adequate degree of human health protection to developing countries. Two detailed case studies, one from Ghana and the other from Nigeria are included in the Toolkit.

Toolkit has been devised:
- with an approach to the management of POP-contaminated sites by integrating remediation strategy with technical, political, legal, social and economic considerations to develop risk reduction and prevention strategies.
- presenting screening levels, limits for quantitatively evaluating risk levels for soil and groundwater for the 12 POPs.
- presenting easy-to-use and simple screening matrix system that can be used for selecting the most appropriate remediation technology for a specific site according to the local situation.
- presenting a step-by-step approach to economic analysis of POPs-contaminated sites.

There are five main modules in the toolkit which are:
- Module 1:- Policy and Legal Issues
- Module 2:- Conducting a Site Investigation
- Module 3:- Assessing Site Risks
- Module 4:- Managing Contaminated Sites and
- Module 5:- Costing and Financing Site Remediation.

Annex 2 Detailed reports international remediation approach

Content:

Annex 2 Detailed reports international remediation approach

United States

Table of contents

1 Soil contamination

1.1 Inventory of polluted sites

1.1.1 Abandoned sites inventory: the NPL [3]

The United States Environment Protection Agency (EPA) created a National Priorities List (NPL) as part of the Superfund program (see further). The sites inventoried on the list are abandoned sites which need further investigation and an appropriate remediation plan because of the human health and environmental risks associated with a site. This cleanup process is financed by the CERCLA/Superfund (Comprehensive Environmental Response Compensation and Liability Act). Since 1982, there are **59 proposed sites** and **1305 final sites** (Federal and non-Federal sites). **359 sites have been already removed** from the list. These data have been updated at the 8th of May 2012. So, since 1982, near **1664 final contaminated sites** have been discovered nation wide. The list serves as an information and management tool and is accessible by the public on the EPA's website at: http://www.epa.gov/superfund/sites/npl/.

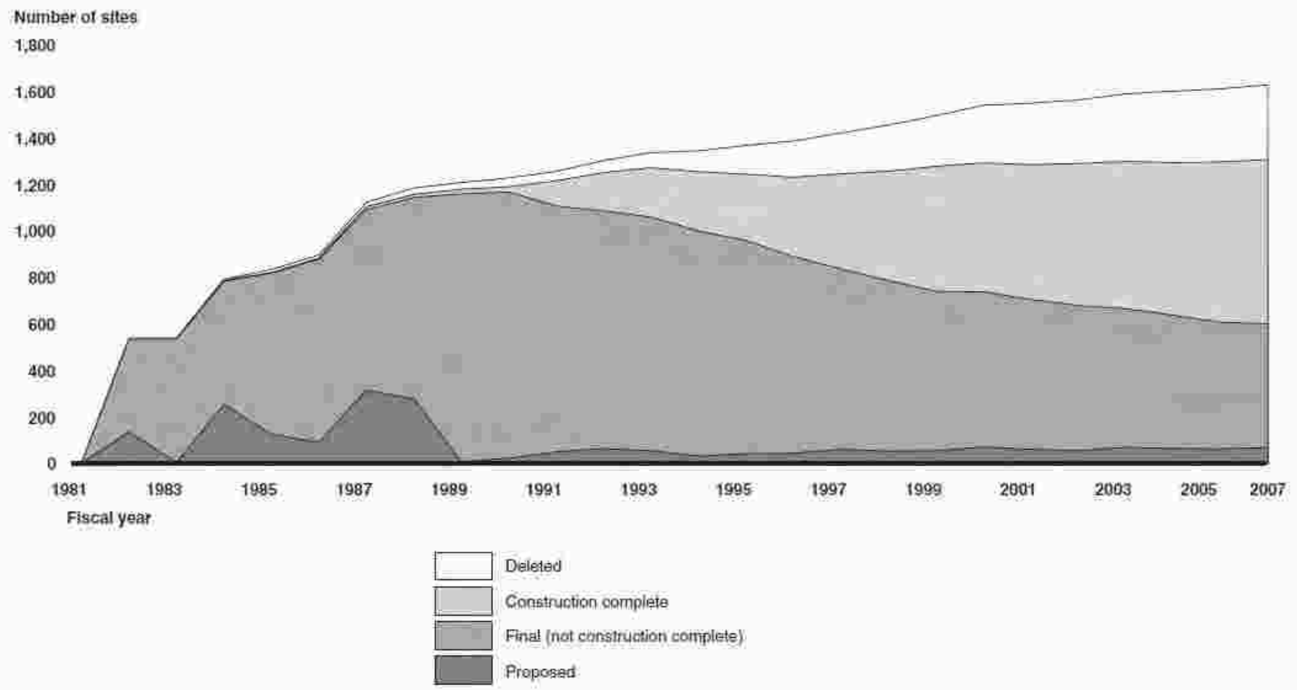
Process of listing: before finally entering the list, *proposed sites* must be investigated and a Preliminary Assessment (PA) must be done. If the preliminary assessment tells that the site represents a threat, more information such as the kind of contaminants and the targets threatened must be collected. This step is the Site Inspection (SI). During this phase the public can play an important role. In fact, the proposed sites are published in the *Federal Register* by the EPA and the public can comment on the sites during a period of 60 days after the publication in the *Federal Register*. The comments are placed on the *Headquarters Docket*. They can be submitted electronically at: http://www.regulations.gov/ or in paper at the Headquarters Docket. They can include all type of document like reports, or any data. One week after the comment's period closure, they are available at the *Regional Docket* (which contains all documents of the Headquarters Docket but for the Region). After that, EPA will decide if the site can be placed on the list as *final site* pursuant the following process.

The Hazard Ranking System (HRS), which is an indicator, is calculated based on the information collected in the previous phase. Thus, the comments posted by the public can help for this calculation by giving information. If the HRS is higher than 28,50 the site can enter the NPL. Otherwise the contamination doesn't require urgent response.

A database was created to search more information about the Superfund sites. The database is called CERCLIS (Comprehensive Environmental Response, Compensation and Liability Information System). The information available is: site name, street address, EPA ID, city, county, state, ZIP code, region, contaminant, contaminated media, contaminant group, HRS score, Federal facility, action, action start date, action completion date, action lead type, environmental indicator, construction complete, construction completion date, Base Realignment and Closure (BRAC) designation and NPL Status. The CERCLIS database for each Region is updated every 90 days[4]. CERCLIS also inventories sites that are not eligible for the Superfund program (and thus not listed on the NPL) but that still are contaminated and abandoned. There are near 40000 CERCLIS sites in total, with the NPL sites.

The figure below shows the evolution of the number of sites on the NPL list since 1981(data from 2008) [22].

Figure 1: Status of Proposed, Final, and Deleted NPL Sites, by Fiscal Year



Source: GAO analysis of EPA data.

Sites listed in the NPL are sites which need a short-term remediation. These are, in other words, urgent sites to clean up. Long-term remediation sites that are eligible but non listed on the NPL, are sites with a Superfund Alternative Approach Agreements. The remediation won't be funded by the EPA but by a potentially responsible party (PRP).There are 34 sites in this case (Illinois, Indiana, Michigan, Ohio and Wisconsin).

1.1.2 Abandoned Mine Lands [13]

Abandoned Mine Lands are listed both in the CERCLIS inventory (NPL Mine Sites /AML CERCLIS Inventory) and in another list called Non-NPL sites. Approximately **100 final sites** are listed in the NPL (updated in March 2012) while about **450 sites** are listed in the Non-NPL list. The NPL Mine Sites list is accessible on EPA's website at: http://www.epa.gov/aml/amlsite/npl.htm and the non-NPL Mine Sites list is accessible at: http://www.epa.gov/aml/amlsite/nonnpl.htm.

1.1.3 Non abandoned polluted sites: the RCRA Cleanup baseline [1], [2]

Sites inventoried in the RCRA Cleanup baselines (RCRA Corrective Action sites) are facilities that have treated, stored or disposed of hazardous wastes and thus have required a RCRA permit to do their activities and are under the RCRA program, and which are contaminated. There are about 6700 RCRA sites and 1714 RCRA CA sites in 1999. The RCRA Corrective Action sites are different from the NPL sites, which are abandoned facilities, inactive facilities, spills or illegal dumping.

EPA decided to first care about the sites presenting the greatest risks to human health and the environment. Two Environmental Indicators were created: the Human Exposure EI ensure that people exposed near a site are not exposed to unacceptable level of risk. The Groundwater EI ensures that contaminated groundwater does not spread and further contaminates groundwater resources. These indicators reflect the current conditions at a facility, they are not remediation goals.

The 2005 Corrective Action Baseline

In 1999 was created the first Cleanup Baseline. 1714 facilities were inventoried as appropriate sites for early cleanup. The 2005 GPRA Goals (Government Performance and Results Act) were having human exposures controlled at 95% of these facilities and the migration of contaminated groundwater controlled at 70% of these facilities. By the deadline of September 30, 2005, EPA had surpassed both goals, reaching 96% and 78%, respectively.

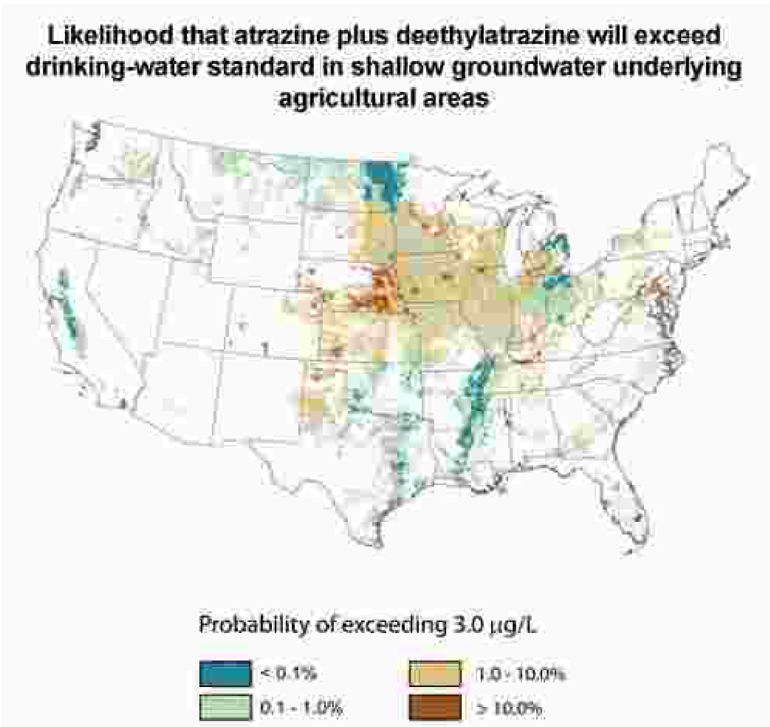
The 2008 Corrective Action Baseline

This baseline contains 1968 facilities on which EPA focused its attention from 2006 to 2008. The 2008 GPRA goals were to have human exposures controlled at 95% of these facilities, the migration of contaminated groundwater controlled at 81% of these facilities, final remedy decisions made at 36% of these facilities, and final remedies constructed at 27% of these facilities. The RCRA Corrective Action Program surpassed all four goals, reaching 96%, 83%, 43%, and 34% respectively. The 2008 Corrective Action Baseline also contains the site from the 2005 Corrective Actions Baseline. Final remedy events are included in this list.

1.2 Categories of pollution and situation

1.2.1 Pesticides

According to the U.S. Geological Survey (USGS), atrazine is the most used herbicide in the USA (annual average near of 32 000 kg per year). In the US, the maximal contaminant level for atrazine in public drinking water is 3 µg.L^{-1}. The highest probability of exceeding this level in shallow groundwater is predicted in Nebraska where the soil is permeable and the groundwater table is often recharged. In the Corn Belt (region of Midwestern United States), the use of atrazin is more important but the probability is lower because this region is poorly drained and require artificial drainage that avoid atrazine to reach local streams [5]. This map is the result of a study made in 2011-2012. It is obtained by using a model.



A Study titled *Pesticides in the Nation's Streams and Ground Water* made from 1992 to 2001 by the USGS [6] says that from the samples of shallow groundwater and surface water, generally pesticides were found in the surface waters with agricultural, urban or mixed land use watersheds rather than in the groundwater. In addition organochlorine pesticides are accumulated in sediments from those surface waters, due to their persistence. This studies show that in the USA surface waters are more sensible than shallow groundwater. Nevertheless, the concentrations found in the surface waters were lower than the water quality benchmarks, which are the level above which there is an effect on human’s health.

1.2.2 Contaminants associated with mineral deposits

In the Rocky Mountains of Montana, Colorado, New Mexico, Utah and Arizona, there are thousands of abandoned mines and mineralized area. The contaminants released by the mines are metals like aluminum, arsenic, cadmium, copper, iron, lead and zinc and the generation of acids.

1.2.3 Lead contamination

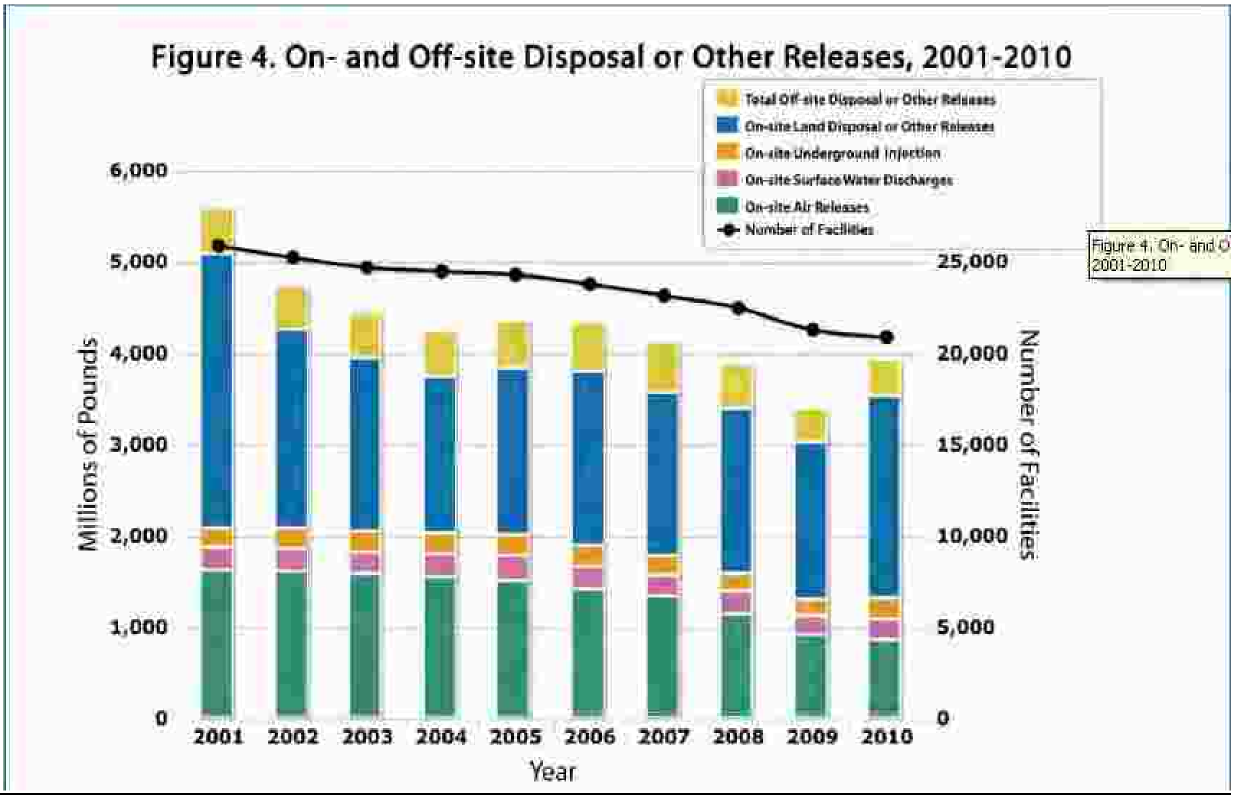
Lead is the most occurring contamination. 300 sites of the National Priorities List (see “The Superfund program”) had lead as part of the contamination.

1.2.4 Halogenated hydrocarbons

The most commonly chemicals found at contaminated sites are chlorobenzenes, chloromethanes, PCBs, tetra and trichloroethane, tetra and trichloroethene, creosote (wood treaters) and coal tars (manufactured gas plants). Among these chemicals, trichloroethene is the most frequently detected compound at Superfund sites contamination sometimes occur as DNAPLs (dense non aqueous phase liquids which require special remediation measures. PCBs have been found in at least 500 Superfund sites. Chlorobenzene has been found at 97 Superfund sites.

1.2.5 Inventory of toxic release

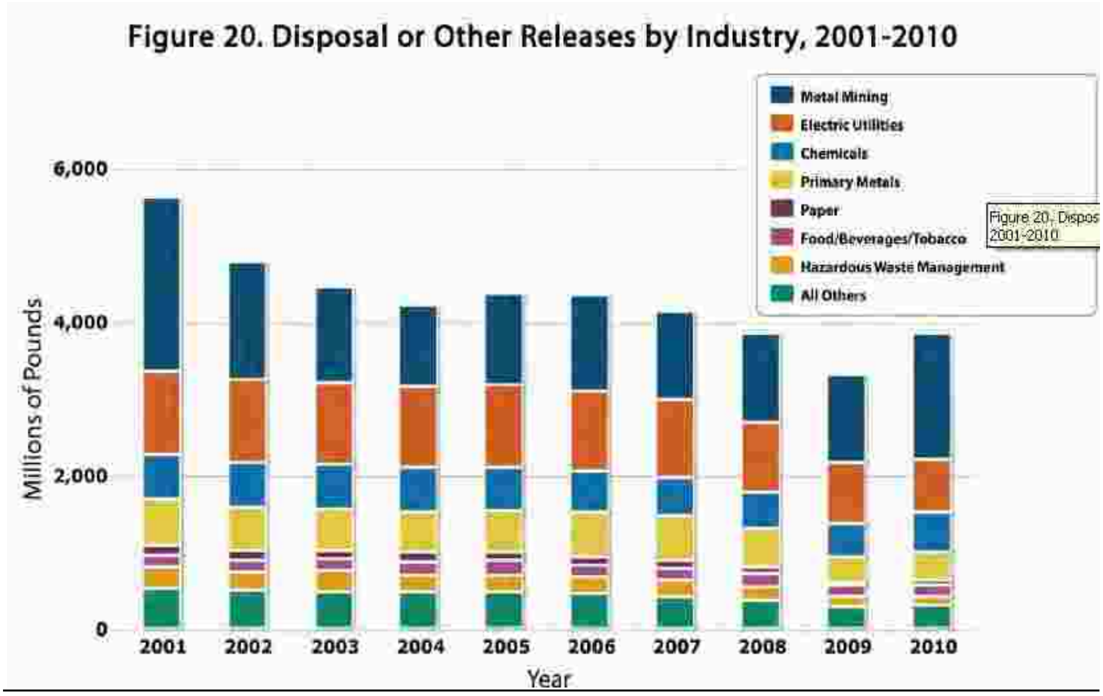
The Toxic Release Inventory (TRI) is a database that inventories release or other disposal from thousands of US facilities. The TRI was created by the Emergency Planning and Community Right-to-Know Act (EPCRA). This inventory is based on the reporting of the facilities to the EPCRA. Facilities are manufacturing, metal mining, electric power generation, hazardous waste treatment and Federal facilities. The following information concerns the year 2010. The number of facilities inventoried is 20,904.



The figure above shows the evolution of the disposal and other releases from 2001 to 2010. According to the report [12], the decrease during this period is due to in air emission and land disposal and the increase of *on-site land disposal or other release* is due to increases in the metal mining sector. ***On- and off-site disposal or other releases*** **focus on the ultimate disposition of a chemical**. Off-site disposal is when a facility transfers its waste containing TRI chemicals as an off-site disposal or other release. On site releases and off-site disposal can affect human exposure to toxic chemicals.

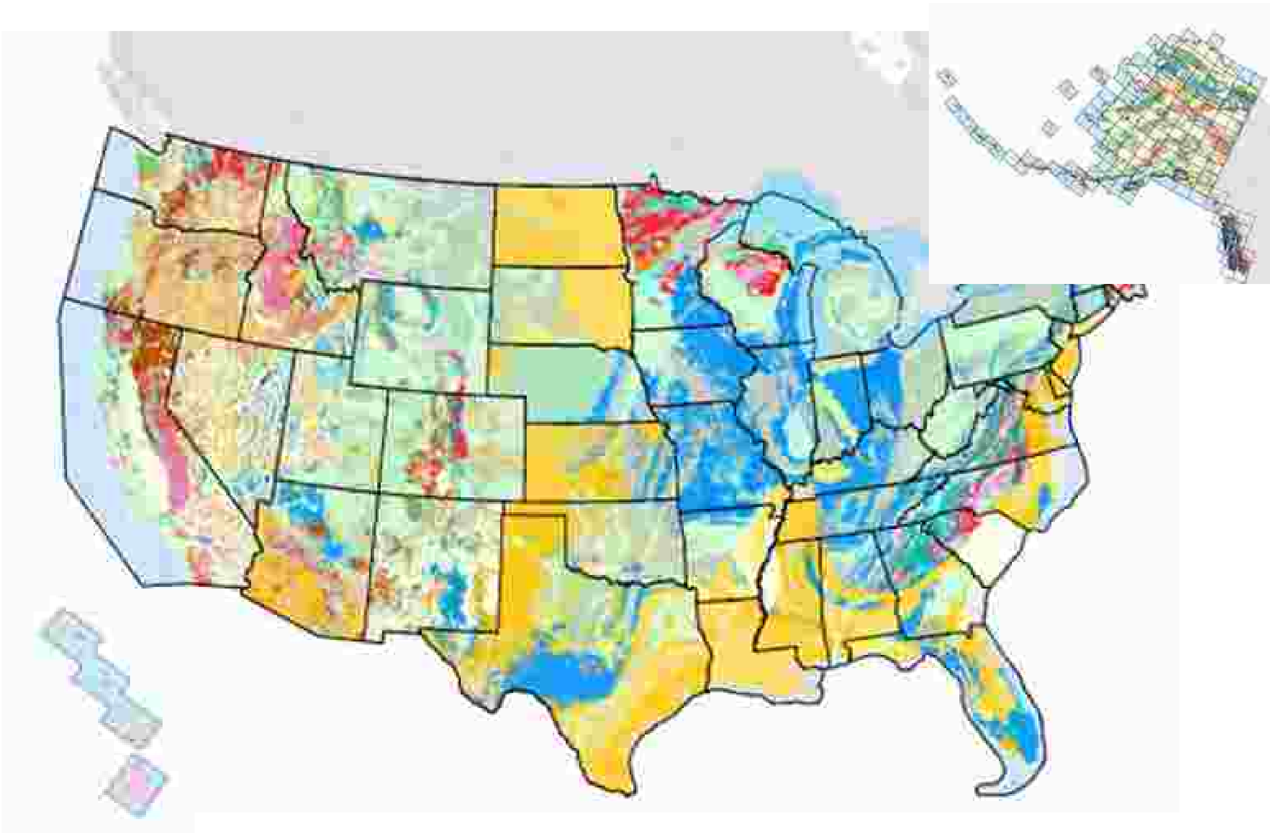
The TRI chemical list contains 593 individual chemical and 30 chemical categories. You can find that list on the EPA's website at: http://www.epa.gov/tri/trichemicals/index.htm

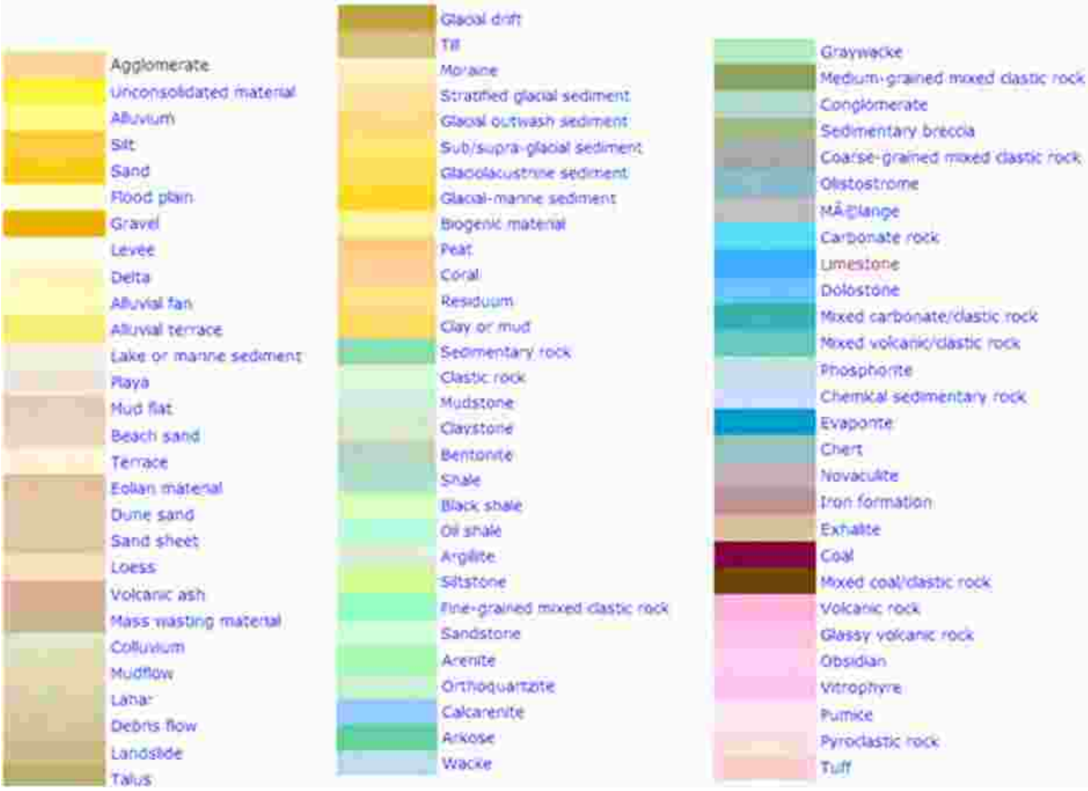
The figure below shows all the releases and the disposal by industry category. It doesn't take into account waste that is recycled, burned for energy recovery, and treated.



1.3 Geology

The maps below show the repartition of the mineral resources [7].

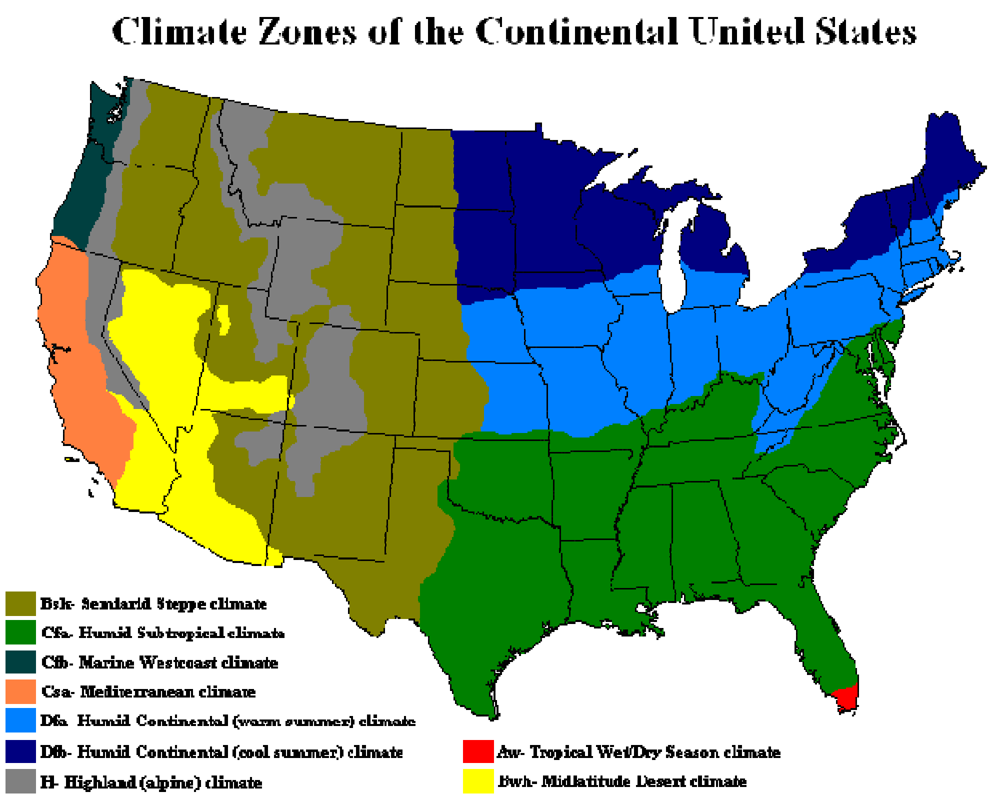


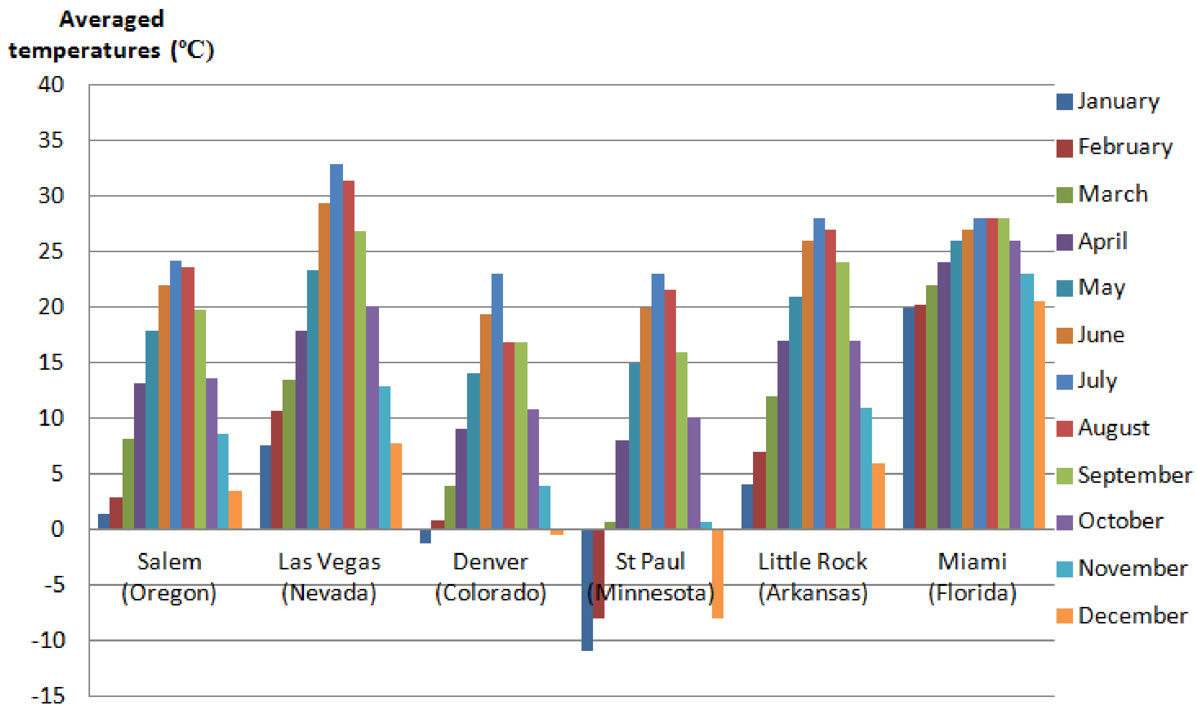

Agglomerate
Unconsolidated material
Alluvium
Silt
Sand
Flood plain
Gravel
Levee
Delta
Alluvial fan
Alluvial terrace
Lake or marine sediment
Playa
Mud flat
Beach sand
Terrace
Eolian material
Dune sand
Sand sheet
Loess
Volcanic ash
Mass wasting material
Colluvium
Mudflow
Lahar
Debris flow
Landslide
Talus
Glacial drift
Till
Moraine
Stratified glacial sediment
Glacial outwash sediment
Sub/supra-glacial sediment
Glaciolacustrine sediment
Glacial-marine sediment
Biogenic material
Peat
Coral
Residuum
Clay or mud
Sedimentary rock
Clastic rock
Mudstone
Claystone
Bentonite
Shale
Black shale
Oil shale
Argillite
Siltstone
Fine-grained mixed clastic rock
Sandstone
Arenite
Orthoquartzite
Calcarenite
Arkose
Wacke
Graywacke
Medium-grained mixed clastic rock
Conglomerate
Sedimentary breccia
Coarse-grained mixed clastic rock
Olistostrome
MÃ©lange
Carbonate rock
Limestone
Dolostone
Mixed carbonate/clastic rock
Mixed volcanic/clastic rock
Phosphorite
Chemical sedimentary rock
Evaporite
Chert
Novaculite
Iron formation
Exhalite
Coal
Mixed coal/clastic rock
Volcanic rock
Glassy volcanic rock
Obsidian
Vitrophyre
Pumice
Pyroclastic rock
Tuff

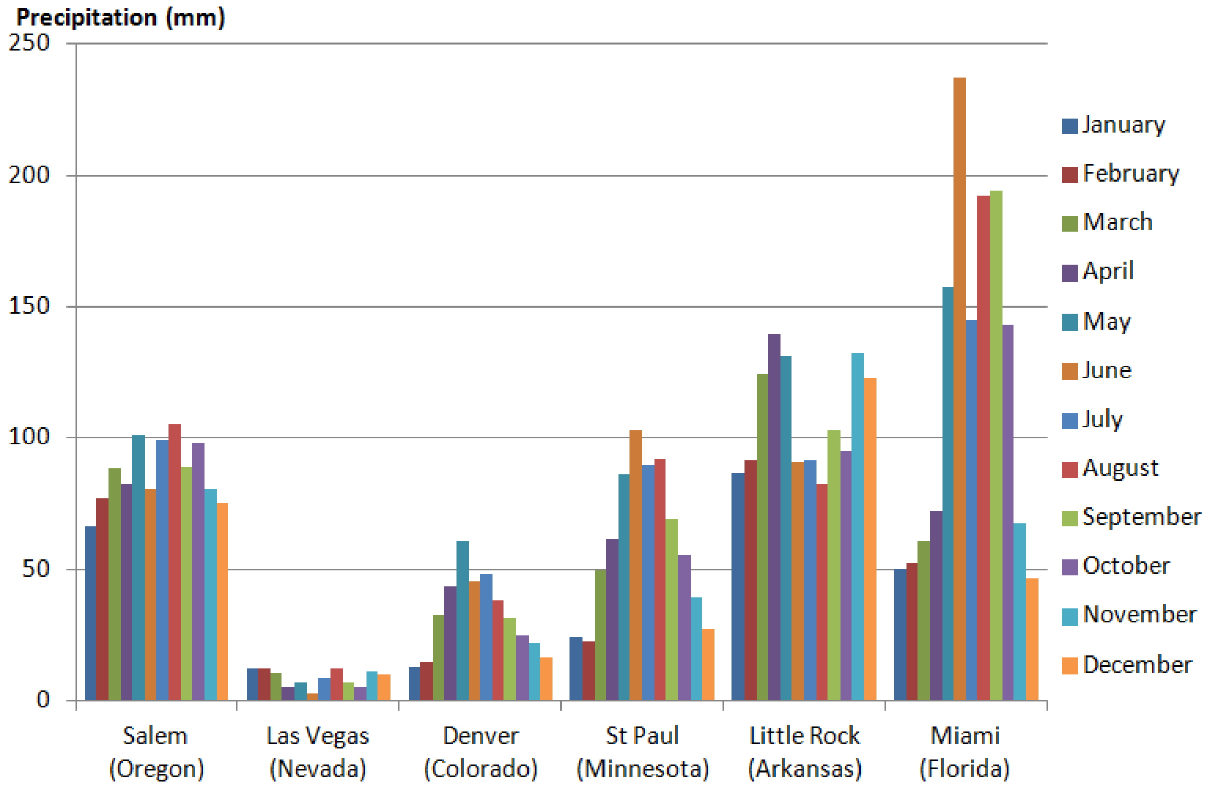
Tuff
Welded tuff
Ash-flow tuff
Ignimbrite
Volcanic breccia
Lava flow
Bimodal suite
Felsic volcanic rock
Alkali-feldspar rhyolite
Rhyolite
Rhyodacite
Dacite
Alkali-feldspar trachyte
Trachyte
Quartz latite
Latite
Intermediate volcanic rock
Trachyandesite
Andesite
Mafic volcanic rock
Trachybasalt
Basalt
Tholeiite
Hawaiite
Alkaline basalt
Alkalic volcanic rock
Phonolite
Tephrite
Ultramafitite
Volcanic carbonatite
Plutonic rock
Aplite
Porphyry
Lamprophyre
Pegmatite
Granitoid
Alkali-feldspar granite
Quartz monzodiorite
Monzodiorite
Quartz diorite
Diorite
Diabase
Granite
Peraluminous granite
Metaluminous granite
Subaluminous granite
Peralkaline granite
Granodiorite
Tonalite
Trondhjemite
Alkali-feldspar syenite
Quartz syenite
Syenite
Quartz monzonite
Monzonite
Gabbroid
Quartz monzogabbro
Monzogabbro
Quartz gabbro
Gabbro
Norite
Troctolite
Anorthosite
Alkalic intrusive rock
Nepheline syenite
Ultramafic intrusive rock
Peridotite
Dunite
Kimberlite
Pyroxenite
Hornblendite
Intrusive carbonatite
Metamorphic rock
Hornfels
Eclogite
Greisen
Skarn
Calc-silicate rock
Serpentinite
Metasedimentary rock
Meta-argillite
Slate
Quartzite
Metaconglomerate

1.4 Climate [8], [9], [10]

There are different climatological areas in the USA. The cities on the graphics below are chosen because they are situated in the different climate areas.




Averaged temperatures (°C)
40
35
30
25
20
15
10
5
0
-5
-10
-15
Salem (Oregon)
Las Vegas (Nevada)
Denver (Colorado)
St Paul (Minnesota)
Little Rock (Arkansas)
Miami (Florida)
January
February
March
April
May
June
July
August
September
October
November
December


Precipitation (mm)
250
200
150
100
50
0
Salem (Oregon)
Las Vegas (Nevada)
Denver (Colorado)
St Paul (Minnesota)
Little Rock (Arkansas)
Miami (Florida)
January
February
March
April
May
June
July
August
September
October
November
December

2 Policy goals

2.1 Abandoned sites, Superfund

The cleanup of abandoned sites, which is performed by the EPA (Superfund program) is funded by the government. In the case of the responsible party is identified, EPA can ask the reimbursement of the cleanup.

2.2 Non abandoned sites: the RCRA Corrective Action Baseline [1]

After the 2005 and 2008 Corrective Action Baseline, the 2020 Corrective Action Universe is the next goal to achieve by the EPA.
3747 facilities included in this baseline are in need of corrective action. This list inventoried sites heavily contaminated, sites which have since been already cleaned up and other which have not been investigated yet. It also includes sites inventoried in the 2008 baseline.
All sites that need a Corrective Action must be remediated by 2020 and more precisely 95 percent of the 3747 facilities subject to the RCRA.

Prioritization to help achieve the 2020 CA Goal
Each Region must focus on facilities pursuant to this scheme:

1. Facilities not under a permit or order:
   - facilities were there has been no progress regarding to the 2020 CA Goal since 3 years
   - facilities designed as high risk
   - federal facilities, given their size and complexity
2. Facilities under a federal CA order that are out of compliance with the order
3. Facilities under State or federal permit that are out of compliance with the permit
4. Facilities where federal permits are being renewed or modified

After prioritizing the facilities, each Region should update its existing Regional RCRA CA 2020 Strategy. Each Region in consultation with States should develop its own strategy. The updated strategy should be submitted to the Office of Resource Conservation and Recovery (ORCR) and the Office of Site Remediation Enforcement (OSRE) by October 29 of the year 2010.

EPA and States work in partnership to achieve the 2020 CA Goal and some Regions and States have developed agreements for communication in implementing RCRA CA programs. It is benefit to establish timeframes. The communication protocol is agreed by the regulators (EPA, States, Tribes) and can be used to facilitate decisions related to facilities. It enhances the combined effort of the regulators toward specific facilities. For example, in case of litigation, the authority of the combined regulators is more important.

Who has to pay?
The paragraph 107(a) of the CERCLA says that the person who owns or operates a facility from which there is a release leading to a response action is liable for all response costs and for natural resource damages.
Financial Assurance (FA) is a part of the RCRA CA program, in fact, it is necessary to ensure that owner/operators of permitted facilities have funds to cleanup. They are required by RCRA to secure funds for Corrective Actions regardless of the financial status of the facility. The FA is included among the requirements needed to obtain an order or a permit.
If the owner or operator claims he can't pay for the CA and FA while asking a permit or an order, EPA can use the CA Ability to Pay Model to know if this assertion is true or not. If the company can't legitimately pay a payment schedule can be negotiated. If the company is in bankruptcy, Region and States must call in for the funds before the bankruptcy filing.

3 Policy Instruments

3.1 Prevention legislation

3.1.1 The RCRA

The soil management policy is part of the waste policy and is based on the RCRA. The "Resource Conservation and Recovery Act" (RCRA) was enacted by the Congress in 1976. It is a part of the *Solid Waste Disposal Act* of 1965. RCRA is the nation's primary law about the disposal of solid hazardous waste. It gives EPA the authority on dispose of the wastes. RCRA program is implemented in the authorized states. It means that EPA delegates the primary responsibility of implementing the RCRA hazardous waste program to individual states. It provides flexibility to states to implement their rules. There are currently 50 states authorized to implement their own hazardous waste management program [14]. But non-authorized states also implement CA through analogous authorities. The RCRA authorities are:

- Section. 3001. Identification and listing of hazardous waste: EPA Administrator should establish criteria for hazardous waste and list them.
- Section 3002. Generator standards.
- Section 3003. Transporter standards.
- Section 3004. Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities.
- Section 3005. Permits for treatment, storage, or disposal of hazardous waste.
- Section 3006. Authorized State hazardous waste programs.
- Section 3007 **-** Information Gathering and Inspections: provide authority to issue CA orders at interim status facilities
- Section 3008(a) **-** Compliance Orders
- Section 3008(h) **-** Interim Status CA Orders,
- Section 3013 **-** Monitoring, Analysis, and Testing Orders
- Section 7003 **-** Imminent Hazardous Orders

The 1984 RCRA Amendment, the *Hazardous and Solid Waste Amendments* (HSWA) focused among others on minimizing waste and the potential releases of facilities. RCRA is a preventive measure to avoid pollution caused by the wastes.
The RCRA's goals are mainly protect the human's health and the environment from the pollution caused by wastes, reducing the amount of wastes, protect natural resources. To achieve these goals, RCRA established three distinct preventive programs:

- The solid waste program (Subtitle D of the RCRA). This program encourages states to manage their non hazardous solid industrial wastes and municipal solid wastes by disposing them in landfills and other disposal waste facilities except of open dumping.
- Hazardous waste program (Subtitle C of RCRA). This program controls hazardous wastes from their generation to their disposal (from "cradle to grave"). Facilities that generate, transport, treat, store, or dispose of hazardous waste are regulated under RCRA Subtitle C.
- The UST program (Subtitle I of RCRA). In 1984, underground storage tanks (UST) which are also the subject in the *Hazardous and Solid Waste Amendments* became a program of the RCRA. This program is about the damages that can cause the storing petroleum on the environment by leaking. Under this program corrective actions and prevention will be undertaken at these sites and owners/operators have to pay the cleaning actions.

3.2 The FFCA

In 1992, the Federal Facilities Compliance Act (FFCA) says that the federal facilities are subject to State hazardous waste laws and requirements as well as the non-federal facilities.

3.3 The Oil Pollution Act [24]

The Oil Pollution Act of 1990 amended the Clean water Act (CWA). Under this act, EPA does prevention action related to discharge of oil. The Oils spill program was created to enforce the Oil Pollution Act.

Facility Response Plan (FRP) Rule and Spill Prevention, Control, and Countermeasure (SPCC) Rule

Certain facilities that use and store oil must prepare a plan to respond to cases of oil discharge. The FRP, published in 1994, is a part of the Oil Pollution Prevention regulation which precise who must prepare and submit the FRP, what must be in it, and the potential to cause substantial harm in the event of discharge. The SPCC is also a part of the Oil Pollution Prevention regulation and includes the FRP. This rule asks specific facilities to prepare a plan for oil spill prevention, preparedness and response to prevent oil discharge.

National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Product Schedule
EPA must prepare a schedule of all products that may be used to remove or control oil discharges. These products are dispersants, surface washing agents, surface collecting agents, bioremediation agents, miscellaneous oil spill control agents. The list can be found at: http://www.epa.gov/emergencies/docs/oil/ncp/schedule.pdf. Last update was on the 10th of May 2012.

3.4 Cleanup legislation

The Hazardous Waste and Solid Waste Amendments (HSWA) created the EPA's corrective Action Program. Under Corrective Actions (CA), cleanups are required for leaking wastes at a hazardous waste facility designed by RCRA. In 1996, EPA published the Advance Notice of Proposed Rulemaking (ANPR) which is guidance for the Corrective Action program.

3.4.1 The NESCA

To help achieve the 2020 CA Goals of the RCRA Corrective Action, EPA set up the National Enforcement Strategy for Corrective Action (NESCA). NESCA:

- identifies and prioritize facilities for CA enforcement
- emphasizes the communication between Regions and States
- provides ongoing support to Regions and States
- provides training and other support to the regulatory partners
- helps the facility that haven't made any progress in achieving the remedial objectives,
- deals with bankrupt facility.

3.4.2 The CERCLA/Superfund program [11]

The CERCLA is another important point in the US approach. Comprehensive Environmental Response Compensation and Liability Act (CERCLA), also known as **Superfund,** was enacted by Congress on December 11, 1980. This act forbids close and abandoned hazardous waste sites and provides liability of the responsible for release of hazardous wastes at these sites. This act also provides funds to treat this kind of pollution. The funds are collected via a tax on chemicals and industries. Over five years, $1.6 billion was collected and the tax went to a trust fund for cleaning up abandoned or uncontrolled hazardous waste sites (see further for the detailed budget of the Superfund program). Petroleum and natural gas are excluded from the pollutants or hazard substances considered here.

The CERCLA is meant for abandoned or closed hazardous waste sites. So there is a distinction between RCRA sites and CERCLA/Superfund sites. There are two types of response actions to a threat. Short term removals are the case where a site needs a prompt action. Long term remedial responses are when the action reduces permanently and significantly the risks that are serious but not immediately life threatening. These actions can be conducted only at sites listed on EPA's NPL.
If the remedies plan exceeds 25 million, the plan proposed by the Superfund program is reviewed by the National Remedy Review Board (NRRB) to assure it is consistent with Superfund law, regulations and guidances [3].
Once the remediation goals have been achieved, the site is removed from the NPL. Then the site can be reused. The Superfund program works with communities and other actors to return the site to a safe site. The future use of the site is decided before the implementation of the remediation plan.

3.4.3 Oil Spill Act

Among 14000 oil spills are reported each year and EPA carries oil spills occurring in the water inland whereas U.S. Coast Guards carries on spills in coastal waters and deepwater ports. Responsible parties are required by law to report oil discharge to the federal government. It is then registered in the Emergency Response Notification System (ERNS). ERNS contains spill information in the country since 1986. The information of incidents occurred since 1982are available at: http://www.nrc.uscg.mil/foia.html. This list is maintained by the National Response Center, which is the central agency for all pollution incident reporting. The National Response Team (EPA) or the Regional

Response Team are designed to respond to the oil discharges. Regional Response Team gives authorization for the use of the products listed on the NCP Product Schedule. Federal agencies fund the removal costs, which can be reimbursed by the responsible parties. Funds come from the Oil Spill Liability Trust Fund.

3.4.4 The Brownfield program [26]

The Brownfield program is a part of the CERCLA legislation and began in 1995. According to the RCRA, the definition of a brownfield is: “real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant”. It is estimated that there are between 100000 and 600000 brownfields sites in the US (urban, rural and in-between). The difference between Brownfields sites and Superfund sites is that the brownfields sites are characterized by low or medium contamination are easy to cleanup and redevelop whereas superfund sites are the worst contaminated sites with limited prospect for economically viable reuse.

The program aims to promote the reuse of the contaminated property by providing grants and technical assistance. There are five types of grants:

- Assessment grant. The funding is 200000 $ for doing assessment, inventory, community involvement and outreach and cleanup planning;
- Revolving Loan Fund Grant. It’s a grant recipient which borrowers can loan 1000000 $ from to fund cleanup activities. When loans are repaid, the loan amount is returned into the fund and re-lent to other borrowers.
- Cleanup grants: it’s 200000$ which represents 20% of the costs.
- Job training grants: It consists of an environmental training for the residents.
- State and Tribal response program: It is a fund of 50M$ annually to support collaboration between tribes and states.

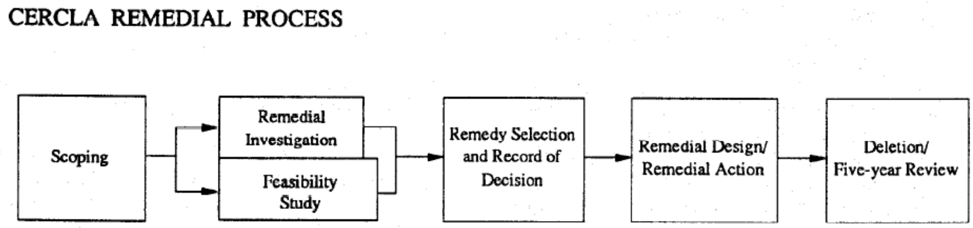
There are two types of technical assistance:

- Targeted Brownfields Assessment (TBA). An EPA agent leads the environmental assessment, the most often in communities.
- Technical Assistances to Brownfield Communities (TAB). It provides geographically based technical assistance.

4 Assessment, Remediation and Management techniques and costs

4.1 Remediation process

In the CERCLA remediation process the site assessment, risk assessment, remediation design and implementation is executed in several phases [26]. A conceptual site model can be used to summarize information such as contaminants, pathways, if people are concerned and the future land use.



Remedial Investigation/Feasibility Study (RI/FS)

The RI assesses the nature and extent of contamination and the associated health and environmental risks. The FS develops and analyzes the range of potentially viable cleanup alternatives for the site, considering three criteria: implementability, effectiveness, costs. The FS report format is provided below.

Feasibility Study report format

Executive Summary

1. Introduction
1.1. Purpose and Organization of Report
1.2. Background Information (Summarized from RI Report)
1.2.1. Site Description
1.2.2. Site History
1.2.3. Nature and Extent of Contamination
1.2.4. Contaminant Fate and Transport
1.2.5. Baseline Risk Assessment

2. Identification and Screening of Technologies
2.1. Introduction
2.2. Remedial Action Objectives – Presents the development of remedial action objectives for each medium of interest (i.e., groundwater, soil, surface water, air, etc.). For each medium, the following should be discussed: a) contaminants of interest, b) allowable exposure based on risk assessment (including ARARs), and c) development of remediation goals.
2.3. General Response Actions – For each medium of interest, describes the estimation of areas or volumes to which treatment, containment, or other technologies may be applied.
2.4. Identification and Screening of Technology Types and Process Options – For each medium of interest, describes:
2.4.1. Identification and Screening of Technologies
2.4.2. Evaluation of Technologies and Selection of Representative Technologies

3. Development and Screening of Alternatives
3.1. Development of Alternatives – Describes rationale for combination of technologies/media into alternatives. Note: This discussion may be by medium or for the site as a whole.
3.2. Screening of Alternatives (if included)
3.2.1. Introduction
3.2.2. Alternative 1
3.2.2.1. Description
3.2.2.2. Evaluation
3.2.3. Alternative 2 …
3.2.4. Alternative 3 …

4. Detailed Analysis of Alternative
4.1. Introduction
4.2. Individual Analysis of Alternatives
4.2.1. Alternative 1
4.2.1.1. Description
4.2.1.2. Assessment
4.2.2. Alternative 2 …
4.2.3. Alternative 3 ….
4.3. Comparative Analysis

Bibliography
Appendices

The RI/FS phase has several steps.

- Scoping: consists in collecting site information data and starting to discuss about the ways the remediation will be done.
- Site characterization: field sampling and analyses are made during this phase
- Development and screening of alternatives
- Treatability Investigation and Detailed Analysis (TI and DA). The TI and the DA are the steps of the cleanup process during which the appropriate remedial technique is chosen. Treatability Investigation aims to provide enough data to develop and discuss about treatment alternatives and to reduce uncertain costs and performance in order to select one remedy. The DA is the phase where remedy options are evaluated in details according to the following criteria:
  - overall protection of human health and the environment;
  - compliance with ARARs or PRG;
  - long-term effectiveness and permanence;
  - reduction of toxicity, mobility, or volume;
  - short-term effectiveness;
  - implementability;
  - cost;
  - State acceptance;
  - community acceptance.

  The techniques are first analyzed individually and then they are compared with each other to establish their strength and weakness for the site.

In the **Selection of remedy phase** the remedial alternative for the site are selected and described in the **Record Of Decision (ROD)**. This document is a part of the remedial process only for remediation of the Superfund program and explains which is the chosen solution, why and the remediation goals. During the **Remedial Design (RD)** technical plans and specifications are prepared for implementing the remedial action alternative chosen. During **Remedial Action (RA)** the construction or other work necessary to implement the remedial action alternative is carried out. Finally Deletion of the site of the remediation process is carried out. Operation and maintenance (O&M) (including Site close out) are post-RA activities to ensure the cleanup methods are working properly and to ensure site remedy continues to be effective.

Superfund's ROD

For Superfund remedies, the ROD is made in several steps:

1. A developed proposed plan should be written. The major sections are:
   A. Introduction
   B. Site Background
   C. Site Characteristics
   D. Scope and Role
   E. Summary of Site Risks
   F. Remedial Action Objectives
   G. Summary of Alternatives
   H. Evaluation of Alternatives
   I. Preferred Alternative
   J. Community Participation
2. The proposed plan should be available for the public, together with the RI/FS and a notice should be published in the newspapers. The public comments period should be initiated.
3. The ROD must be draft by the lead agency and consider the comments of public, program offices, and support agency. Then the ROD is finalized.
4. The ROD must be signed by the lead agency decision maker, by the support agency manager, and EPA. Then the lead agency must publish a notice in the newspaper saying that the ROD is available for the public. It must be placed in the administrative record file.

4.2 Risk assessment and remediation targets

During Remedial Investigation / Feasibility Study the target for remediation is set. The level of cleaning, also named the Preliminary Remediation Goal (PRG), is approached in two ways. Either the Applicable or Relevant and Appropriate Requirements (ARARs) is used either the risk assessment. The first contains concentration limits set by other environmental regulations like the non zero maximum contaminant level goals (MCLGs) set under the Safe Drinking Water Act (SDWA).The second one is a calculation of concentration limits using carcinogenic and/or non carcinogenic toxicity values under specific exposure conditions [20]. When specific ARARs does not exist, PRG is based on the risk assessment. PRGs are set in each Region, but Regions 3, 6 and 9 have harmonized their PRG for each type of land use (also called Regional Screening Levels) into a single document, available at: http://www.epa.gov/region9/superfund/prg/

4.2.1 ARARs [21]

ARARs for the groundwater are the non zero maximum contaminant level goals (MCLGs) set under the Safe Drinking Water Act (SDWA), state drinking water standards, or the federal water quality criteria (FWQC). Other types of law can be used, like state anti-degradation laws. If the groundwater is not used as drinking resource, the remediation mustn't be necessary at a 10^{-4} to 10^{-6} level of risk and the above ARARs are not used as PRGs, but environmental considerations and avoiding the expansion of the plume determine cleanup levels.

For the soils, chemical-specific ARARs may not be available but certain states are promulgating soil standards that could be ARARs. Otherwise, some EPA's policy can be used as soil standards, like the EPA guidance on PCB cleanup levels.

The guidance and standards used as ARARs can be found on the EPA's website at:
http://www.epa.gov/superfund/policy/remedy/sfremedy/arars.htm

4.2.2 Human's health Assessment

IRIS (Integrated Risk Information System) is a database created by the EPA's National Center for Environmental Assessment in 1985 to provide information about the effects on human's health of hazardous substances. Currently there are more than 550 substances divided in two categories [18]:

- Noncancer effects : Oral reference doses and inhalation reference concentrations (RfDs and RfCs, respectively) for effects known or assumed to be produced through a nonlinear (possibly threshold) mode of action. In most instances, RfDs and RfCs are developed for the noncarcinogenic effects of substances.
- Cancer effects: Descriptors that characterize the weight of evidence for human carcinogenicity, oral slope factors, and oral and inhalation unit risks for carcinogenic effects. Where a nonlinear mode of action is established, RfD and RfC values may be used.

The list of the substances does not include pesticides unless they are used for other properties than pesticide. This list can be found on internet at:
http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showSubstanceList

There are five steps in the way EPA conducts a risk assessment.

Step 1: Planning and scoping process. This step answers to the questions:

- who, what, where is at risk?
- what is the environmental hazard of concern?
- where do these environmental hazards come from?
- how does exposure occur? (pathways and routes of exposure)
- what is the link between the human body and the studied environment?
- what are the health effects?
- how long does it take for the hazard to cause a toxic effect?

Then the following four steps are:

Step 2 *Hazard Identification*: In case of the stressor is a chemical, this step consists of doing a link between the negative effects on the human body and the contaminant, by examining available scientific data like clinic data, epidemiological studies or animal studies. It is important to know how the chemical enters the body (**toxicokinetics studies**) and the mechanism of the impact (**toxicodynamics studies**).

Step 3 *Dose-Response Assessment:* Dose-response assessment is calculated in two steps. First, data about experiments must be collected, in order to have a range of existing dose and their response. Then an extrapolation is done to find the critical points where an adverse effect on humans begins to occur. By knowing the mode of action of the toxic, the type of extrapolation which has to be used can be determinated: it can be a linear or a non-linear dose-response.

Step 4 *Exposure Assessment*: EPA defines exposure as 'contact between an agent and the visible exterior of a person (e.g. skin and openings into the body)'. The exposure assessment takes into account the type of population and the concentration of the contaminant by using models of chemical transport and behoaviour in the environment. The list of models used for the Risk Assessment can be found here: http://www.epa.gov/riskassessment/guidance.htm

Step 5 *Risk Characterization*: in this step the presence or absence of risk is determinated. It's the final result of both human health risk assessment and ecological risk assessment. The risk is calculated according to specific land uses and medium combinations.
N.B.: The Hazard Identification and the Dose Response Assessment are general, this studies are made by the EPA as one of their activities while the Exposure Assessment and the Risk Characterization are site specific.

There are many risks descriptors used according to the type of assessment. One population risk descriptor is the number of people above a certain risk level. For carcinogens it can be an excess risk level of 10^{-6} (or 10^{-5}, 10^{-4}), which means about 1 chance of 1,000,000 to develop cancer. For non carcinogens it can be the portion of the population that exceeds the RfD (a dose), the RfC (a concentration) [16]. This excess can be expressed through the Hazard Quotient (HQ).

$$\mathrm{HQ} = \frac{Exposure\ \mathrm{level}}{\mathrm{Reference}\ dose\ (RfD)}$$

If HQ>1, there is a probability that an adverse effect on the health will occur. For multiple substances that act in the same way (the same organ is concerned) or for multiple pathways of a same substance, the HQs can be summed.
The scientific results are communicated to the public so it must be clear, transparent, consistent and reasonable and the ultimate selected PRG (after being modified as needed at the end of the Remedial Investigation (RI) or the Feasibility Study (FS)) are registered in the Record of Decision (ROD).

4.2.3 Remediation's techniques

The table below shows the source treatment project and source treatment technologies selected for both period 1982-2004 and 2005-2008. The statistics are those from the sites of the Superfund program (sites that are in the NPL). The number of total source treatment project of the previous Superfund Remedy Report (12th edition) is given in the line "ASR 12th technologies". Source treatment project addresses soil, sediment, sludge, solid-matrix wastes, or NAPL (often the source of contamination) and do not address groundwater directly. Of the 594 decision documents issued from the period 2005–08, 61 percent (362) addressed the source of contamination [19].

Technology	Total Source Treatment Projects for FY 1982–2004	% of Source Treatment Projects FY 1982–2004	Total Source Treatment Technologies for FY 2005–08	% of Source Treatment Technologies FY 2005–08
In Situ				
Soil Vapor Extraction	244	26%	32	14%
Solidification/Stabilization	41	4%	15	7%
In Situ Thermal Treatment	10	1%	12	5%
Multi-Phase Extraction	42	4%	12	5%
Bioremediation	53	6%	9	4%
Chemical Treatment	15	2%	9	4%
Bioventing	*	–	4	2%
Flushing	17	2%	2	1%
Phytoremediation	6	1%	2	1%
Other	5‡		3§	
ASR 12th Technologies	8¶		–	
Ex Situ				
Solidification/Stabilization	170	18%	33	14%
Physical Separation	19	2%	29	13%
Recycling	*	–	15	7%
Surface Water Treatment	†	–	11	5%
Unspecified Off Site Treatment	†	–	10	4%
Incineration (Off Site)	105	11%	6	3%
Free Product Recovery	*	–	5	2%
Composting	*	–	3	1%
Leachate Treatment	†	–	3	1%
Air Sparging	*	–	2	1%
Chemical Treatment	9	1%	2	1%
Neutralization	7	1%	2	1%
Soil Vapor Extraction	7	1%	2	1%
Unspecified On Site Treatment	†	–	2	1%
Other	14**		5††	
ASR 12th Technologies	178§§		–	
Total	950		230	

* These technologies were combined with other categories in ASR 12th edition.
† These technologies were not included in any category in ASR 12th edition
‡ Electrical Separation, Mechanical Soil Aeration, and Vitrification accounted for less than 1% each of identified in situ technologies from FY 1982–2004 project data.
§ Bioslurping, Fracturing, and Volatilization accounted for less than 1% each of identifed in situ technologies in FY 2005–08 decision documents.
¶ Neutralization was identified for 8 projects (1%) from FY 1982–2004, but was not selected in any FY 2005–08 decision documents.
** Mechanical Soil Aeration, Open Burn/Open Detonation, Solvent Extraction, Phytoremediation, and Vitrification accounted for less than 1% each of identified ex situ technologies in FY 1982-2004 project data.
†† Biopile, Evaporation, Open Burn/Open Detonation, Thermal Desorption, and Unspecified Thermal Treatment accounted for less than 1% each of identified ex situ technologies in FY 2005-08 decision documents.
§§ Bioremediation was identified for 60 projects (6%), On-site Incineration for 42 projects (4%), Soil Washing for 6 projects (1%), and Thermal Desorption for 70 projects (7%) from FY 1982-2004. On-site Incineration and Soil Washing were not selected in any decision documents from FY 2005-08, and Thermal Desorption was selected in less than 1% of FY 2005-08 decision documents. Bioremediation was divided into several subcategories for FY 2005-08 decision documents.
• Decision documents may be counted in more than one category. Decision documents include RODs, ROD amendments, and select ESDs.

USEPA 2009c and USEPA 2007a

The table below shows the remedy technologies selected in the Decision Documents [19]. As said before these statistics takes into account only sites listed on the NPL. Of the 594 decision documents from the period 2005–08, 336 addressed groundwater contamination. MNA means Monitored Natural Attenuation.

Remedy Types and Technologies	2005	2006	2007	2008	Total
Groundwater Pump and Treat	**22**	**20**	**23**	**18**	**83**
In Situ Treatment of Groundwater	**24**	**31**	**28**	**18**	**101**
Bioremediation	13	20	17	12	62
Chemical Treatment	9	11	14	4	38
Air Sparging	5	2	1	2	10
Permeable Reactive Barrier	3	3	1	1	8
Phytoremediation	0	2	1	0	3
Fracturing	1	0	0	0	1
Multi-Phase Extraction	1	0	0	0	1
Unspecified Physical/Chemical Treatment	0	0	1	0	1
MNA of Groundwater	**34**	**35**	**30**	**17**	**116**
Groundwater Containment (Vertical Engineered Barrier)	**4**	**4**	**6**	**1**	**15**
Other Groundwater	**73**	**90**	**88**	**61**	**312**
Institutional Controls	63	79	77	52	271
Monitoring	62	80	58	39	239
Alternative Water Supply*	6	6	5	9	26
Engineering Control†	0	1	3	0	4
Total of Remedy Types	**157**	**180**	**175**	**115**	**627**

• Decision documents may be counted in more than one category.
• Decision documents include RODs, ROD amendments, and select ESDs.
* Alternative water supply includes alternative drinking water, well-head treatment, installation of new water supply wells, increasing capacity of existing water treatment plant, and treat at use location.
† Engineering control includes sewer/sump abandonment and the use of trees for hydraulic gradient control.

USEPA 2009c.

4.3 Costs [22]

Some technique's costs are presented below. These costs are to consider with caution because the most recent update was 2007.

Technique Soil, sediments and bedrock and sludge treatment	**cost ($.m^{-3})**	
In situ	**small site**	**large site**
soil vapour extraction	1200-1500 (450 ft2)	400-1000 (2700 ft2)
solidification/stabilization		
in situ thermal treatment	65-80 (5000 ft2)	35-50 (15000 ft2)
multi phase extraction (dual phase extraction)	30-75 (21 780 ft2)	30-70 (43 560 ft2)
bioremediation	30-100	
bioventing	1200-1275 (450 ft2)	100-145 (9000 ft2)
flushing	40-65 (2500 ft2)	20-35 (10 000 ft2)
phytoremediation	626-2322 (135 000 ft2)	145-485(2 700 000 ft2)
Ex situ		
solidfication/stabilization	216-248 (1000 CY)	94-144 (50000 CY)
incineration	1047 - 1540 (15000CY)	914-1399 (100000CY)
chemical extraction	1582 -1717 (1000CY)	358-361 (50000CY)
chemical reduction/oxydation	190-660	
soil washing	187 (10000 CY)	70 (200000CY)
thermal desorption	81-252 (10 000 tons)	44-110 300000 tons)

CY = cubic yard

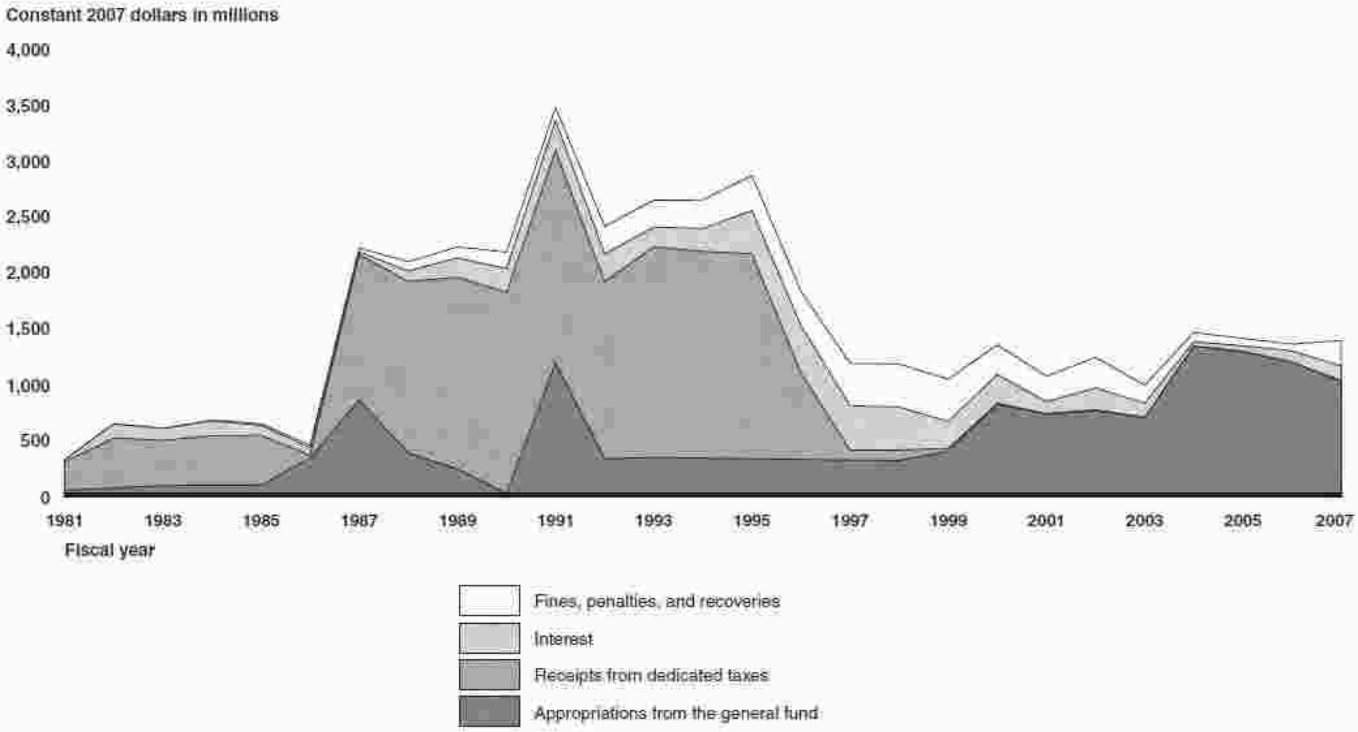
Technique for groundwater treatment	**cost ($.m-3) included the prize of pumping**	
in situ	**small site**	**large site**
air sparging	84-37 (2700 ft2)	24-27 (54000 ft2)
thermal treatment	130-400	
reactive treatment wall (per vol. of treated GW)	0,20-0,30 (L:100ft, W:2ft, D:15ft)	0,10-0,20(L:600ft, W:2ft, D:25ft)
hydrofracturing (prize per fracture)	1000-1500 (for 4 -6 fractures per day)	
ex situ		
Advanced Oxidation Process	0,03$ -3$ per 1000 liters	

4.4 Budget for the Superfund program [23]

CERCLA's activities are funded by taxes on crude oil and chemicals, an environmental tax assessed on corporations based upon their taxable income, appropriation by the general fund (coming from the federal budget and aiming to fund general purpose), penalties from responsible parties, and interests. These funds gathered by the Superfund are called Superfund trust funds. In 1995, Superfund-related taxing authority expired and the most important part of the fund, which came before 1995 by the taxes, comes now (1996-2008) by the general funds. Each year, the funds accorded to the EPA Superfund program coming from the Superfund trust funds are stipulated in appropriations laws. It tells how many the EPA can expend for the Superfund program. In fact, even if the trust funds were made for the Superfund program, EPA doesn't have the permission to use the fund without appropriation from the Congress.

The figure and table below show the sources of revenue for the Superfund program.

Figure 2: Major Sources of Revenue for the Superfund Trust Fund, Fiscal Years 1981 through 2007



Source: GAO analysis of data from the President's Budget Appendices.

Table 1: Trust Fund Revenue in the Periods before and after the Superfund Taxes Expired

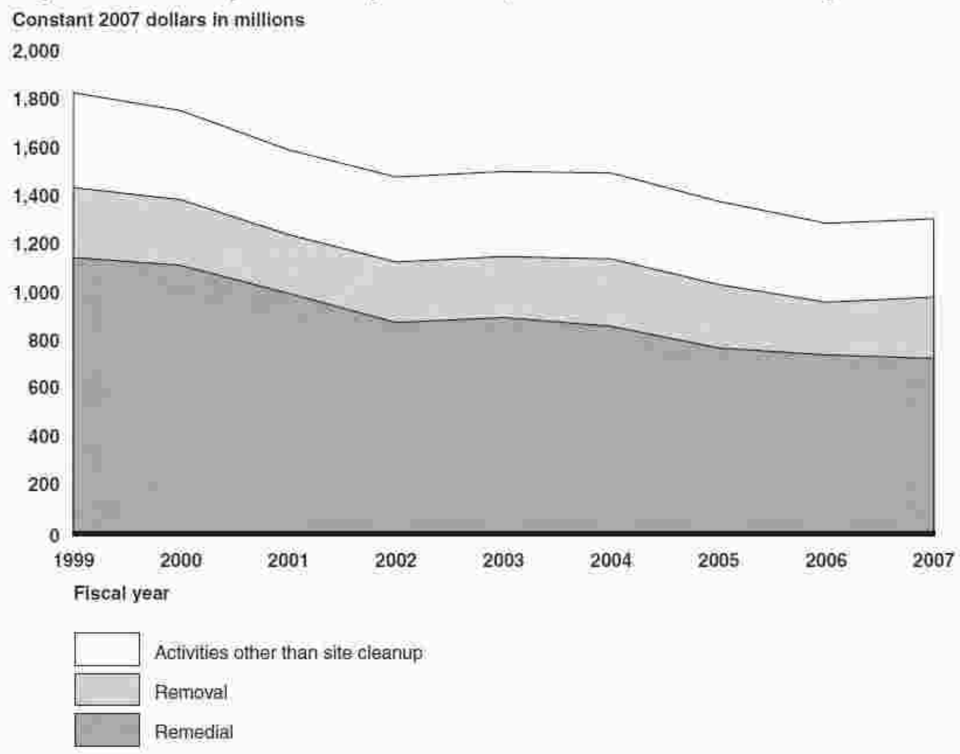
Constant 2007 dollars in millions

Revenue source[a]	Fiscal years 1981-1995 (percent of total revenues)	Fiscal years 1996-2007 (percent of total revenues)
Receipts from dedicated taxes[b]	$18,018 (67.5%)	$936 (6.0%)
Appropriations from the general fund[c]	4,616 (17.3)	9,281 (59.2)
Interest	2,412 (9.0)	2,543 (16.2)
Fines, penalties, and recoveries	1,634 (6.1)	2,906 (18.6)
Total	**$26,680 (100%)**	**$15,667 (100%)**

Source: GAO analysis of data from the President's Budget Appendices.

The Congress tells EPA how to use this budget and as shown on the following figure, from 1999 to 2007, 77 percent was spent on remedial and removal activities and the rest on enforcement and administrations activities.

Figure 5: EPA Superfund Expenditures, Fiscal Years 1999 through 2007



Source: GAO analysis of EPA data.

The activities fund under the category *remedial* are:

- collecting and analyzing site data,
- conducting investigations to select the appropriate remedy technique,
- constructing remedies technique,
- conducting maintenance for 5 years.

Activities fund under the category *removal* are:

- assessing threats of waste releases to determine which type of removal action is necessary;
- reacting to releases causing an immediate threat to public health or environment;
- developing and maintaining the technologies;
- coordinating with federal agencies when there are environmental incidents or disaster.

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Annex 2 Detailed reports international remediation approach

United Kingdom

Table of contents

1 Soil contamination, introduction and background

1.1 Introduction

This paper presents the background to the processes and systems adopted in the UK to identify and manage land affected by contamination. It explains the principles underlying the technical approaches to risk assessment and remediation, as well as the legal framework and other sector drivers.

With regard to UK policies, particular emphasis has been placed on the details of the UK regulatory intervention regime, with some consideration of other statutory instruments which are in place to provide context. However, it is not the intention to provide a definitive list of all associated statutory instruments currently operational across the UK.

Data sources are diverse, reflecting the devolved nature of administration within the UK constituent areas of England, Wales, Scotland and Northern Ireland. In addition, regulatory responsibility is vested in several central government departments and their associated agencies, as well as Local Authorities.

Consequently, there is no single authoritative body in the UK responsible for land quality. To simplify matters, reference to Statutory Instruments etc has been limited to those pertaining to England although similar provisions exist in the other UK domains.
Accordingly, information has been mainly sourced from the Environment Agency, which is the environmental regulatory authority for England and Wales and an executive agency of the Department for Environment, Food and Rural Affairs (DEFRA). The equivalent body in Scotland is SEPA (Scottish Environmental Protection Agency), and for Northern Ireland it is the Northern Ireland Environment Agency.
Details of the principal sources of industry good practice in terms of methodologies and technical guidelines and standards have also been provided.

1.2 Extent of the problem

Land contamination or land affected by contamination, are broad terms which include a range of sites and soil conditions. It encompasses derelict or Brownfield sites which have been directly impacted by former industrial uses, land affected by waste disposal activities, or from the accidental release of hazardous substances, as well as areas with elevated levels of naturally occurring substances. However, the term 'contaminated land' has a legal definition and is subject to specific requirements set out in the associated regulatory regime[1] which was introduced in 2000. This is discussed in further detail in section 2.2.2.

The extent of land affected by contamination has not been established in the UK, although various estimates have been made. One estimate published in 1993 gave a range of between 100,000 to 200,000 hectares and between 50,000 and 100,000 potentially contaminated sites[2].
In 2002 the Environment Agency (EA)[3] reported that previous estimates of the amount of land affected by contamination varied from 50, 000 to 300,000 hectares, amounting to as many as some 100,000 sites within England which may be contaminated. Of these, the EA estimated 5,000 to 20,000 may be expected to be problem sites.

However, more recently EA[4] has reported there could be in the region of 325,000 (300,000 hectares) potentially contaminated sites across England and Wales. They also state that around half of Local Authorities in England and Wales estimate that less than 10% of their areas might be contaminated. Data for Scotland is reported by (SEPA)[5] who estimated there are approximately 67,000 sites (82,034 hectares) which could be affected by land contamination in Scotland.

The Northern Ireland Environment Agency has also reported that the extent of land affected by contamination in the province is unknown. Their web site currently states there are 11,000 former industrial sites in Northern Ireland.

[1] Environmental Protection Act 1990: Part 2A.
[2] Contaminated Land. Parliamentary Office of Science and Technology 1993
[3] Dealing with contaminated land in England, Environment Agency 2002
[4] Dealing with contaminated land in England and Wales, Environment Agency 2009
[5] Dealing with land contamination in Scotland, a review of progress 2000-2008

1.3 Nature and distribution of potentially contaminated sites

Research carried out in the 1990s by the Department of the Environment[6] aimed to identify the principal industry sectors and their associated potential contaminants, as well as their geographical distribution across the UK.

The data set comprises 47 volumes in all (available from EA http://www.environment-agency.gov.uk/research/planning/33708.aspx), dealing with individual industries including chemical works, refineries, iron and steel production, energy and waste disposal sites amongst many others. It included historic sites identified on records dating from 1846 as well as operational sites.
The project was not intended to establish a national inventory of sites potentially affected by contamination, but rather served to inform regulators, developers and other interested parties on how to best identify, assess and tackle issues associated with land contamination.
The data shows the greatest extent and number of potentially contaminated sites within England were situated in the northwest, northeast and central areas, where heavy industry was predominant. Analysis of the date of site operations indicated the majority of sites were historic and predated the 1950s.

The principal uses accounting for the greatest amounts of land affected, both in terms of area and numbers of sites, were identified as railway land, garages and filling stations, gas works, sewage works, textiles, engineering works, and ceramics and cement works. These various activities were carried out on a wide range of scale of operations, resulting in point sources of contamination of soil and groundwater as well as larger extents of diffuse contamination.

1.4 Drivers

Land contamination is today routinely considered under a variety of drivers including regulatory compliance, corporate policy, land transactions and development. This situation has evolved over the last 30 years or so, and reflects the emergence of both domestic and EU legislation initially aimed at the prevention of environmental pollution[7] and protection of water resources[8,9] by regulation of industry and waste management practices.

The UK environmental regulatory bodies were established under the EA[10], drawing together technical expertise from the former Local Authority waste management functions, the former National Rivers Authority, and the former HMIP (Her Majesty's Inspector of Pollution) to form the Environment Agency (EA) in the case of England, with similar arrangements in the rest of the UK with the amalgamation of their equivalent bodies.

The EPA implemented pollution control and permitting statutory instruments which have evolved into the Environmental Permitting[11] regime which serves to prevent uncontrolled releases of hazardous substances, and the Environmental Damage[12] regulations which address any such occurrences which do occur, and thereby the creation of new cases of land contamination.

Further policy instruments pertaining to the management of historic contamination (legacy sites) and sustainable development followed in the 1990s, resulting in growth in the sector, (it has been reported that the industry is worth around £1.1 billion p.a.) and advances in the development of technical standards and good practice guidance documents.

In this regard, government policy was established which promoted the voluntary investigation and remediation (clean-up) of land affected by contamination, controlled through the planning[13] and

[6] Industry Profiles, Department of the Environment (DoE) 1995.
[7] Environmental Protection Act 1990 (EPA)
[8] Water Resources Act 1991
[9] EC Groundwater Directive 80/68/EC
[10] Environment Act 1995
[11] Environmental Permitting Regulations 2007
[12] The Environmental Damage (Prevention and Remediation) Regulations 2009
[13] Town and Country Planning Act, 1990

Building Control[14] regimes. A complementary intervention regime[15] (abbreviated to 'Part 2a' regime – see paragraph 2.2) was then introduced some years later following consultation. These are all considered in further detail below.

2 Policy: Management of legacy sites

2.1 Voluntary Remediation and Planning Control

UK government policy has previously advocated the re-use of brownfield land for new development, and was cited[5] as the most significant driver for remediating land affected by contamination. The previous UK government administration set out a specific target that 60% of new housing in England should be constructed on previously developed land, however, this target has been scrapped by the current Coalition administration, and new planning policy has also been introduced.

There had also been programmes in place to stimulate regional development aimed at particular social and economic regeneration objectives (for example the former coalfield areas). These involved the creation of regional development agencies funded by central government under the Single Regeneration Budget.

It has been estimated that (before the global financial crisis) over 90% of remediation in England has taken place voluntarily by developers under market-led solutions[5]. Details of the measures which were in place at the time are provided below, however, the system has been revised in recent months and the details therefore pertain to the previous regime.

2.1.1 Background

Land contamination was identified as a material consideration under the Town and Country Planning Act 1990 which generally applied in all cases where a change in land use arose. Planning authorities considered the possible implications of contamination when developing structure or local plans, and also when determining individual applications for planning permission.

The planning regime adopted the 'suitable for use' approach, and had regard for the current and proposed new use of the land when assessing the importance of contamination and determining remediation objectives. Technical guidance[16,17] was provided which defined the roles and responsibilities of the interested parties. It also provided good practice advice for the collation of data and submission of technical reports.

2.1.2 Roles and Responsibilities

The **developer** took on the responsibility for the contamination risks, to satisfy the Local planning Authority that any unacceptable risk from contamination would be identified through an appropriate investigation and assessment. In addition, the developer had to demonstrate that the contamination risks would be successfully addressed without undue environmental impact before completion of the proposed development.

It was the responsibility of the Local Authority contaminated land officer to assess planning proposals and the associated risk assessment and remediation strategies to ensure the safe and sustainable development of sites affected by contamination. This routinely involved internal consultation with building control[18] and environmental health officers at the Local Authority. In addition, the Environment Agency was a statutory external consultee and provided advice to the Local Authority with regard to the contamination risks to controlled waters (groundwater and surface water bodies).

2.1.3 Control Measures

Planning permissions imposed conditions on a developer to ensure that any contamination would be remediated to a standard suitable for the proposed use. However, the developer could remediate to a

[14] Building Regulations 2010

[15] Environmental Protection Act 1990: Part 2A.

[16] Planning Policy Guidance: Planning and Pollution Control (PPG23) DoE, 1994

[17] PPS 23 Annex 2: Development of Land Affected by Contamination (withdrawn March 2012)

[18] Approved Document C of Building Regulations 2010 include provisions for the protection of new buildings from land contamination. These provisions were originally introduced in 2000 and are enforced by building inspectors during the construction phase.

higher standard, and as a minimum, the land should not be capable of falling under the Part 2a contaminated land intervention regime following clean-up.

Standard planning conditions were generally adopted by each local planning authority which required the developer to provide technical reports at key stages of the development. These mirror the stages of efficient investigation and risk assessment detailed in the authoritative technical good practice document CLR 11, published by the Environment Agency and DEFRA[19]. This document is considered in further detail in paragraph 3 below.

The principal steps comprise the submission of a preliminary risk assessment comprising a desk-top study and site reconnaissance. If uncertainty remains, an intrusive investigation and risk assessment will then be called for. Where unacceptable risks are identified at this stage, the developer will be required to provide a remediation strategy and then carry out the remediation works to the satisfaction of the local authority.

Each step requires a report to be compiled by the developer's independent consulting engineer or environmental consultant. These are submitted to and approved by the Local Authority and often their scope is discussed and agreed in advance.

The final planning condition cannot be discharged until the Local Authority has confirmed the risks have been satisfactorily addressed. Without this, the developer would be unable to occupy the development and the property would be flagged during standard legal searches as part of routine property conveyance / transactions.

2.1.4 Criticism of the System

Planning policy was recently amended under the New National Planning Framework[20] which has resulted in the reduction of the amount of mandatory guidance documents, including PPS 23 which is now superseded.

In its place, the new framework has three key paragraphs relating to land contamination which stipulate that: the site must be fit for use; that adequate site investigation is carried out by a competent person; and that after remediation as a minimum the land should not be capable of determination as contaminated land under the Part 2A regime.

The industry anticipates that the principals and approach to land contamination introduced by PPS 23 will be maintained in practice.

In this respect, criticisms have been reported and extend to the standard of consultants' reports and their level of competence; the inadequate scope of investigations due to the developer's reluctance to invest sufficient resource; the tendency to adopt less sustainable remediation approaches owing to constraints of the development construction programme, and a default to 'over-engineering' and; the paucity of remediation verification reports to confirm the objectives were met.

2.2 The Contaminated Land Regime

A regulatory intervention regime was first established under legislation enacted in 2000 in England[21] to implement Part 2A of the EPA. It is commonly referred to as the Part 2A regime (or Part 2A) and similar regimes are also in operation in Wales, Scotland and Northern Ireland. The regime is described below.

2.2.1 Background

The contaminated land law was actually introduced in 1995[22] but did not come into effect until 2000 when the regulations[21] and accompanying statutory guidance were published by the government[23].

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[19] Model Procedures for the Management of Land Contamination, Contaminated Land Report 11 (CLR 11), Environment Agency and DEFRA 2004.
[20] National Planning Policy Framework, DCLG, March 2012
[21] The Contaminated Land (England) Regulations 2000.
[22] Environment Act 1995
[23] DETR Circular 02/2000

This was updated in 2006 and included specific measures in relation to radioactive contaminated land[24].

New statutory guidance was published by DEFRA in April 2012[25] and separate, updated statutory guidance on radioactive contaminated land[26] was published in April 2012 by the Department of Energy and Climate Change (DECC). These incorporate changes in light of issues identified during the first 10 years of the regime, which are addressed below. To simplify this overview, the regime as it applies to *non-radioactive* substances will be considered.

Section 57 of the Environment Act 1995 created a new Part 2A to be inserted into the Environmental Protection Act 1990, and the characteristics of this regime reflect concerns voiced during public consultation post 1990. Originally, the intention was to create a national register of sites of potentially contaminative land uses for investigation. However, this gave rise to concerns that the perception of blight would affect land values, and it could also provide a further disincentive to a possible market solution as sites would be investigated and assessed by the regulatory authorities at tax payers' expense, but also to a timescale in accordance with their priorities.

The broad aim of Part 2A is to provide a means of finding and dealing with contaminated legacy sites for which there is no 'market solution', complimenting the voluntary remediation policy driven by development. It is risk based, and serves to address unacceptable risks posed by land contamination to human health and the environment, and it is principally enforced by the Local Authorities, with the Environment Agency fulfilling specific functions.

In some Local Authorities there are dedicated contaminated land officers, but in others the role is subsumed within wider environmental health protection responsibilities, whereas the EA retains technical specialists across its regional offices. Normally, these officers are responsible for land quality regulation under both the planning and Part 2a regimes.

2.2.2 Definitions

The regime introduced a statutory definition of 'contaminated land' and the notion of source-pathway-receptor pollutant linkages. This considers whether a linkage exists between a pollutant and defined receptors which is resulting in 'significant harm' or the 'significant possibility of significant harm', or 'significant pollution of controlled waters' or the 'significant possibility of significant pollution of controlled waters'[27]. Such relationships are referred to as 'Significant Contaminant Linkages' and where present they are the basis for a formal determination of the land as 'contaminated land'.

Local Authorities are the principal regulators who have a statutory duty to inspect their land for sites which may meet the statutory definition. This is achieved firstly at a strategic level, and each Local Authority has to publish and review an inspection strategy document. However, these documents do not include any particulars of specific plots of land or named sites and, hence, there are no regional or national inventories of possible contaminated sites for the reasons previously outlined above.

Secondly, the Local Authority contaminated land officers carry out detailed inspection of individual candidate sites which have been identified and prioritised for inspection as a consequence of implementing their strategies. This is achieved using statutory powers of entry although the land owner can offer to carry out the work themselves.

The Local Authorities are also under a duty to serve a 'remediation notice' on the 'appropriate person' once land has been formally determined. This sets out what is to be done by way of remediation, and the statutory guidance goes into detail about how the standard should be established taking account of effectiveness, durability, practicability, and also cost.

[24] The Radioactive Contaminated Land (Modification of Enactments) (England) Regulations 2006.

[25] Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance. DEFRA publication PB 13735 April 2012

[26] Environmental Protection Act 1990: Part IIA Contaminated Land Radioactive Contaminated Land Statutory Guidance. DECC April 2012

[27] Different provisions and definitions apply to radioactive contaminated land.

A ‘remediation statement’ is issued by the ‘appropriate person’ in cases of voluntary remediation instead of a ‘remediation notice’ where enforcement is not appropriate. A ‘remediation declaration’ is issued by the Local Authority in cases where no remediation is warranted on the grounds that a legal provision prevents the issuing of a ’remediation notice’.

These details are retained on public registers by each individual local authority, and summary data should also be issued to the Environment Agency. The public register also contains data pertaining to appeals, the designation of ‘special sites’ and remediation statements and declarations.
The regime adopts a ‘polluter pays’ principal, and the law sets out who is to bear liability for the cost of remediation. The definition covers legal persons including companies who actually caused the pollution, and also a person who ‘knowingly permitted’ it. These are referred to as ‘Class A persons’ and exclusion tests are prescribed to identify which persons are liable.

If a polluter cannot be found, the person who currently owns or occupies the land becomes the ‘appropriate person’, and these are known as ‘Class B persons’. This can include owner-occupiers of houses built on contaminated land although the regulator can waive liability in certain circumstances. These extend to ‘hardship’ rules which the regulator must consider when deciding what burden of the liability they must carry. Incidentally, a remediation notice cannot be served on a ‘Class B’ person where the determination solely relates to water contamination risks.
Where no ‘Class A’ or ‘Class B’ persons can be found liable, the regulator assumes responsibility by default and such sites are known as ‘orphan sites’.

The law allows the Local Authorities and the Environment Agency to carry out remediation works and later reclaim the costs from the ‘appropriate person’. The cost to remediate ‘orphan sites’ falls to the regulators.

2.2.3 Role of the Environment Agency
The Local Authorities are the principal regulators but the regime also provides powers to the Environment Agency to act as lead regulator on ‘special sites’ which are defined in regulations[28]. These include industrial sites under central control where a permit is in place issued by the EA (and the risk cannot be controlled under the permit) and also particular cases of water pollution, as well as sites associated with defence activities.

In addition, the EA has powers to provide advice to Local Authorities on matters relating to controlled waters irrespective of whether the land in question is a ‘special site’.

The EA is also responsible for carrying out research and development of technical standards and tools which underpin risk assessment and decision making under the regime. This includes the CLEA (Contaminated Land Exposure Assessment) programme which comprises development of an exposure software model and supporting publications on the derivation of the associated health criteria values. These are discussed in more detail in paragraph 3 below.

The Environment Agency is also required to prepare a national report on the state of contaminated land in England and Wales, and to date two reports have been published[4, 5].
The most recent report[5] presents data gathered from Local Authority returns between 2000 and 2007. The report does not provide a complete picture of regulatory activity as only 91% of the 353 Local Authorities in England and the 22 Local Authorities in Wales submitted data to the EA. No information was presented on the number of sites dealt with voluntarily under the planning regime.

In summary, the report detailed that the Part 2A regime dealt with around 10% of identified contaminated sites and also that the majority of the Local Authorities had inspected less than 10% of their areas for land contamination by the end of March 2007. Half of the Local Authorities estimated that less than 10% of their areas might be contaminated.

In terms of numbers of sites inspected and determined as ‘contaminated land’, the report states a total of 781 sites had been determined by the end of March 2007. Of these, 90% were housing sites, with

[28] The Contaminated Land (England) Regulations 2006

'Class B' appropriate person liability, i.e. remediation costs were considered likely to require public funding.

The energy and waste industries were cited as the biggest source of pollution associated with the determined sites in England. The deposit of ash was reported as the most common cause of 'contaminated land' in Wales. Metal and metalloids plus organic compounds were the most common pollutants identified.

Of the 781 'contaminated land' sites, 35 were designated 'special sites' and most of these were so designated on the grounds of serious water pollution.

2.2.4 Funding

Funding was originally provided by central government around 2000 to implement the new contaminated land regulatory duties. This entailed recruitment from the private sector into the EA and the Local Authorities, as well as the establishment of research and development programmes into technical guidance and tools.

However, funding for the Part 2A regime is no longer specifically provided from central government to the Local Authorities and the Environment Agency. Instead, block funding is provided for all regulatory functions and each Local Authority decides how much resource to allocate for Part 2A duties.

In addition, the Environment Agency runs the Contaminated Land Capital Grants Programme on behalf of DEFRA. This supports site investigation work and the Local Authorities apply to it for funding on a case by case basis. Remediation projects are only eligible for funding under certain circumstances, as the polluter is generally expected to pay.

Previously the programme's annual budget was in the region of £17M, but in recent years it has been reduced to approximately £4.5M. This has resulted in the programme being oversubscribed.

Historically, costs reported by EA[5] for England and Wales comprise a cumulative spend between 2000 and 2007 of £26M by Local Authorities associated with the investigation of sites. Of this, £21M was spent on inspection of land that was not subsequently found to be in a condition that met the legal definition of 'contaminated land'. The EA spent £3.7M during the same period to investigate potential 'special sites'.

Remediation costs for this period (not including costs incurred by parties carrying out voluntary remediation) were reported as £20.5M for the Local Authorities (approximately 260 sites), and £7.3M for the EA (total spend on 13 'special sites' to date of report). However, these figures did not reflect the anticipated cost of future work required to complete projects which were in progress at the time the report was published. This was estimated at a further £62M.

2.2.5 Current Issues

Following the launch of the regime there was considerable stakeholder interest with respect to the retrospective nature of liability, and also campaigning by practitioners for better technical guidance to support regulatory decisions.
The former has been tested with case law, and legal precedents have now been established. One important case has had implications on the number of orphan sites and the associated costs falling to the tax payer in respect of contamination at former nationalised industrial sites[29].

However, with regard to technical guidance, the debate has been protracted and centres around the application of guideline values. These were introduced with the regime, and the original intent was to create a series of what became known as Soil Guideline Values (SGVs) for representative concentrations of priority hazardous substances in soil as indicators of 'significant possibility of significant harm'. These were published by the Environment Agency under the CLEA programme.

[29] Regina v the Environment Agency 2008 ('The Bawtry Case').

The debate arose in relation to the degree of risk associated with contamination by substances in the soil at or above their respective SGV, in comparison to the degree of risk the regime was intended to address. The effect was to stifle regulatory action for several years whilst the matters were resolved following lengthy consultation, which also gave rise to new technical guidance.

Other issues include whether naturally occurring substances giving rise to background contamination should be caught by the regime, and also cases of slight pollution of controlled waters. The latest statutory guidance[24] seeks to provide clarity in these respects.

3 Policy instruments: model Procedures, Technical Guidance and Standards

The systematic *procedure* for the investigation and remediation of land contamination in the UK was standardised with the publication of CLR 11[19] in 2004. Prior to this, practitioners followed guidance provided in a variety of sources including British Standards, government publications and research publications, e.g. Construction Industry Research and Information Association[30,31], Department of the Environment[32], the Interdepartmental Committee on the Development of Contaminated Land[33] and DD 175[34].

CLR 11 is a road map to illustrate best practice in the staged approach to risk assessment, options appraisal, implementation and verification of remediation. It is applicable in a range of scenarios to provide guidance to all interested parties dealing with land contamination such as site operators, finance providers, owners, developers, practitioners and regulators.
The aim is to provide a transparent and standard framework for consistent decision making, adopting a risk-based approach. It is intended to be consistent with UK government policies and approaches to risk management[35] across all environmental issues such as air quality, biodiversity, flooding and soil quality.

CLR 11 is structured in a way that presents a high level overview of the model procedure, followed by provision of supporting information on the issue, and then a more detailed information map presenting references to specific and detailed technical guidance on sampling, in-situ testing, laboratory analysis etc, included in EA documents[36,37], British Standards[33] and many more authoritative sources.

With regard to technical tools, the EA has produced standard approaches for risk assessment including the CLEA model[38] and P20[39] which are in common use. However, these are not mandatory and other commercial tools (E.g. CONSIM for controlled waters risks or RBCA for human health risks) are available although they should be adjusted to ensure compatibility with UK policy[40] on exposure assessment and selection of appropriate health criteria values.

4 Remediation Practice

Traditionally, UK practice has been reliant on expedient heavy engineering based solutions to remediate contaminated soils and groundwater. Typically, these break the pollutant linkages by removing the source or exposure pathway, but the methods are expensive and have high environmental and social impacts. The EA[5] reported excavation and off-site disposal accounted for the significant majority of remediation schemes for contaminated sites determined under Part 2A, followed by containment.

[30] Remedial treatment for contaminated land CIRIA special publications 101-112 1998
[31] Brownfields: Managing the Development of previously Developed Land – a Client's Guide. CIRIA 2002
[32] Sampling strategies for contaminated land. Contaminated Land Research Report . DoE 1994
[33] ICRCL 1983 and 1987. Guidance on the assessment and redevelopment of contaminated land. ICRCL 59/83 DoE.
[34] Code of Practice for the identification of potentially contaminated land and its investigation. Draft for Development BSI 1988 (Now replaced by BSI 10175 2011 Code of Practice for investigation of potentially contaminated sites).
[35] Greenleaves III. Guidelines for Environmental Risk Assessment and Management. DEFRA 2011.
[36] Secondary Model Procedure for the Development of Appropriate Soil Sampling Strategies for Land Contamination. Environment Agency 2001.
[37] Guidance for the Safe Development of Housing on Land Affected by Contamination, R&D Publication 66, Environment, CIEH and NHBC 2008.
[38] Updated Technical Background to the CLEA Model. Environment Agency 2009
[39] Methodology for the Derivation of Remedial Targets for Soil and Groundwater to Protect Water Resources, R&D Publication 20. EA, 2006
[40] Human Health Toxicological Assessment of Contaminants in Soil. Environment Agency 2009

Recent research by DEFRA[41] examined UK practice with a view to promoting more sustainable process based technologies. This is in line with guidance provided by the UK Sustainable Remediation Forum (SuRF-UK) to support improved remediation working practices.
The assessment evaluated which sustainability indicators could be used at a technology specific level, and using them to qualitatively assess each selected remediation technique.

A desk-based study was carried out to compile information on remediation techniques presented as 21 Technology Profiles. Brief descriptions of each technique were provided in addition to describing the effectiveness of each of these methods in addressing different contaminants and when circumstances (e.g. geology, hydrogeology, contaminant form etc) may or may not be suitable to their use. The study also described the advantages and disadvantages of each technique and the barriers to their use.

Information on the typical costs of remediation techniques were provided although only limited data was available. It was found that remediation costs are strongly site-specific and dependent upon the details of a number of different aspects such as the geological, hydrogeological and chemical data available from the site investigation at an individual site. The costs are also strongly influenced by how stringent the remedial targets are which in turn affects the duration.

From an analysis of the cost data obtained no broad conclusions could be drawn that either *in situ* or *ex situ* treatment methods were more costly or had more variable costs.

It was observed that costs generally decreased for higher volumes of material treated (>5000 m^3) and this effect was displayed strongly for permeable reactive barriers, *ex situ* thermal desorption and soil washing. It was reported this trend may be expected as these technologies generally have considerable mobilisation/initialisation costs making them a more cost-effective option where larger volumes are required.

It was also reported that for a number of remediation techniques the variance in costs decreased for volumes greater than 5000 m^3. This trend was considered to be expected as average costs per m^3 should be better constrained for larger volumes where the considerable mobilisation/initialisation costs are averaged across larger volumes.

A desk-based study was also conducted to collect data on the current and historic usage of each remedial technique in the UK. The research also investigated emerging and potential remediation techniques in order to identify areas for potential further research and development, which may also attract investment, both of which will be of benefit to the UK.

It was noted that a number of research and development projects were still ongoing and had yet to disseminate their results. Therefore, it was difficult to assess the potential benefits that they might bring to the UK remediation industry.

[41] Contaminated Land Remediation. Defra Research Publication SP 1001, 2010

Annex 2 Detailed reports international remediation approach

The Netherlands

Table of contents

1 Soil contamination

1.1 Numbers of contaminated sites

The necessity of remediation of contaminated soil started in 1979 with the discovery of the pollution in a residential area in the city of Lekkerkerk. Due to public awareness quick and intensive response resulted from this. This site was remediated with high costs and an inventory of polluted sites started. This inventory has been evaluated and extended after that.

First ideas were that it would be possible to have The Netherlands ‘clean’ again within 5 years but this assumption had to be revised soon. Because the number of polluted sites in these inventories and consequently the costs of remediation related to this appeared to be enormous, more thorough inventories were done. Meanwhile, the approach on soil contamination changed and nowadays the environmental policy is mainly focused on contaminated sites which need to be remediated urgently due to environmental risks. For less contaminated sites management of contaminated soil is supported by extensive legislation and procedures.

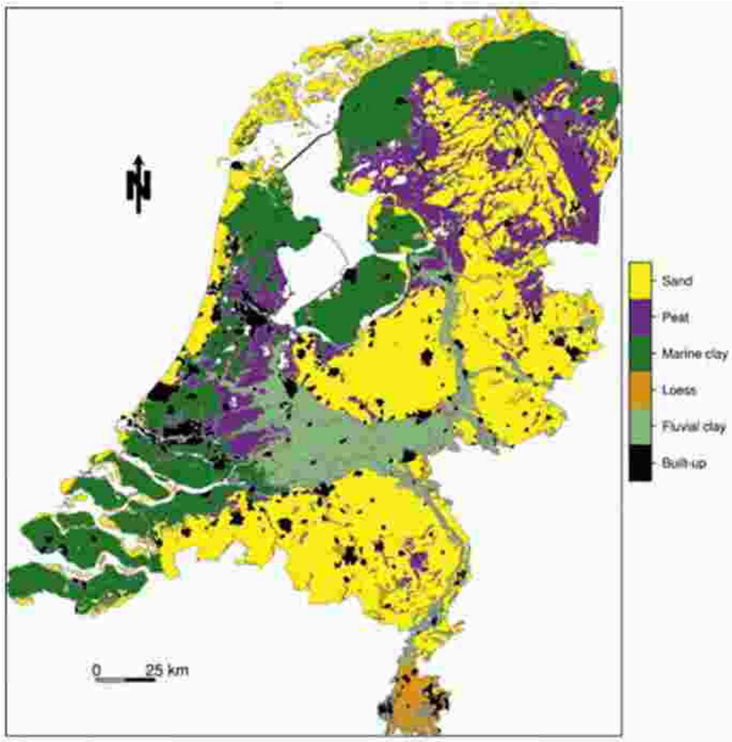
Estimation of number of sites to be remediated and costs

year	Potentially severely contaminated sites	Sites to be remediated	Cost estimates (€ billion)	Planning estimates
1982	3.000	350	0,5	5 years
1993	600.000	110.000	25	25 (only sites with urgent risk)
2005	650.000	45.000 14.000 urgent	12 3,8	30 years 10 years
2008	400.000	11.000 urgent	?	2015
2011	60.000	413 (due to risks for human health) 1,000-2,000 (due to risks for ecology and groundwater)	?	2015-2020

Most remediation is done combined with redevelopment and reconstruction of sites. From 2006-2009 the number of remediated sites has been about 1,400 to 2,000 each year. Some of these remediations only have effect on part of a contaminated site.

1.2 Geology

The Netherlands is a typical delta area. Two major rivers, Rhine and Meuse, are flowing into the North Sea. Dutch soils are formed by processes of water and wind. Peat soil developed under wet circumstances. Groundwater is an important source for drinking water. Groundwater is pumped from sandy and gravel aquifers at depths between 10-100 meters below ground surface. These aquifers are sometimes well protected by superjacent clay layers.
The next figure shows the distribution of Dutch soils across the country.



2 Effects of soil contamination

Following primary effects of soil contamination are taken into account in the Netherlands:

- Human health;
- Ecological functioning of the soil system;
- Spreading pollution with ground water of surface water.

Secondary effects are the influence of soil contamination on value of real estate and social harassment.

3 Policy, legislation and policy instruments

3.1 Development of legislation and policy

In 1983 the Interim Soil Remediation Act (IBS) was published. A framework of guidelines were developed. Important was the list with A, B and C values for the appraisal of the soil and groundwater quality. These values, combined with site specific information on land use and hydrogeology were used for investigation and remediation. The government put lots of effort in programming of site assessment and remediation. After a couple of years attention was given as well to prevention of new pollution. In 1987 the Soil Protection Law was published and in the general Environmental Law al kinds of regulations for prevention of soil pollution in industrial processes.

Initially, with a rapidly available national budget a large number of sites investigated and remediated. The underestimation was the high ambition of the soil, the pursuit of a multifunctional soil, in the early nineties increasingly perceived as a bottleneck: social and economic stagnation of site development is imminent and the progress of the remediation operation falters. The multifunctional approach is technically and financially not fit for various situation, e.g. the situation of urban embankment layers in historic city centers. For this purpose topsoil remediation was devised. It also created an incentive to search for new remediation techniques for a more efficient approach possible.
In the late nineties of the last century, the debate on multifunctionality of the soil finally settled. From there it was possible to remediate sites to a level for functional use; different target levels for nature, residential and industrial areas were developed. By 2006, the starting point of the function-oriented and cost effective remediation was finally anchored in the Soil Protection Law.

In recent years there was paid more and more attention on other soil aspects besides soil contamination that are relevant for good functioning of the soil. Energy from subsoil is now an important method to play a role in sustainable energy. In the future, the opportunities of the sub soil regulation have to be well tuned with other environmental aspects and with spatial planning.

3.2 Responsibility and budget

The Dutch soil remediation operation started as a governmental controlled operation. Costs were made and tried to retrieve from polluters and owners of the properties. In these legal processes it appeared to be difficult to let polluters pay. More and more owners of properties had a central role to pay for site remediation. This can be illustrated by the obligation for site assessment and remediation, if necessary, people have before building new premises.
The necessity for remediation in combination with site reconstruction and redevelopment emphasized the role of owners and beneficiaries in soil remediation. Nowadays in The Netherlands the budgets for remediation of government and private sector are about equal.

In the period 2011-2015 the national government provided a budget of about 900 million € for site assessment and remediation. This budget is divided amongst regional and lower authorities for programming and specific projects.

3.3 Remediation operation and programs

The government has inventoried potentially contaminated sites for three reasons:

- to gain insight in the locations where possibly environmental risk could occur;
- to gain insight in the total problem of soil pollution, in order to have a basis for the development of the national policy and approach to this;
- to develop specific approaches for certain groups of contaminations.

The inventories started with the collection of information on the presence of various industries, because good quality information is available on that aspect throughout history. For every of these industries it was then elaborated which production processes could have led to soil pollution. Information on the used substances and methods of waste disposal was of course important for this inventory.

In the inventories the following important causes of point sources of contamination have been identified: metal industry, oil spills, gasworks, waste dump sites, cleaners, petrol stations. Diffuse contamination exists due to mainly the use of waste material for construction purposes (building, infrastructure).
For programming objectives this inventory is very useful, because it enables to make rough calculations of the total needed budgets for soil remediation, based on evaluation of average costs of remediation of such sites. For a site specific approach it is needed to go into detail in order to assess the situation of the soil pollution and the actual risks resulting from it and then to design remediation options. The demands of the owner, the environmental regulations and the technical possibilities play a role in the selection process of the remediation option.

For this detailed site specific approach in The Netherlands a typology is used in which the following aspects play an important role: 1) the nature of the contaminant and the characteristics of the soil, 2) the cause of, or the activity which has led to contamination of soil, and 3) information about land use. The next pages illustrate how typology of sites plays a role in the site assessment and remediation steps.

3.4 Steps in the remediation process

The remediation process has a stepwise approach, each step is supported by regulations, guidelines and best practice information:

- Site assessment: preliminary, detailed;
- Risk assessment;
- Selection of remediation options;
- Remediation plan
- Remediation project

- Monitoring and control

3.4.1 Site assessment

Research on the possibility of soil contamination starts with an inventory of the historic land use. The following set of activities have been recognized that can lead to soil pollution: 1) mixing soil with contaminated material (soil or waste), 2) heightening or filling up with contaminated material, 3) landfill or storage of solid material 4) agricultural or industrial activities using pollutants (e.g. pesticides for degreasing), storage of liquids in reservoirs and barrels, transport and transshipment of material) 5) discharge or leakage of pipes, and 6) deposition of pollutants from air or sediments from rivers or sea.

These potentially contaminating activities can take place in all kinds of industries: metallurgical, chemistry, oil, food, etc. The contaminant substances can vary for these industrial activities. Generally, the following groups of contaminants are recognized: heavy metals, aromatic hydrocarbons, poly aromatic hydrocarbons, chlorinated hydrocarbons, pesticides, poly chlorinated bipheyls, chlorinated benzenes and phenols and some important specific substances like mineral oil and cyanide.

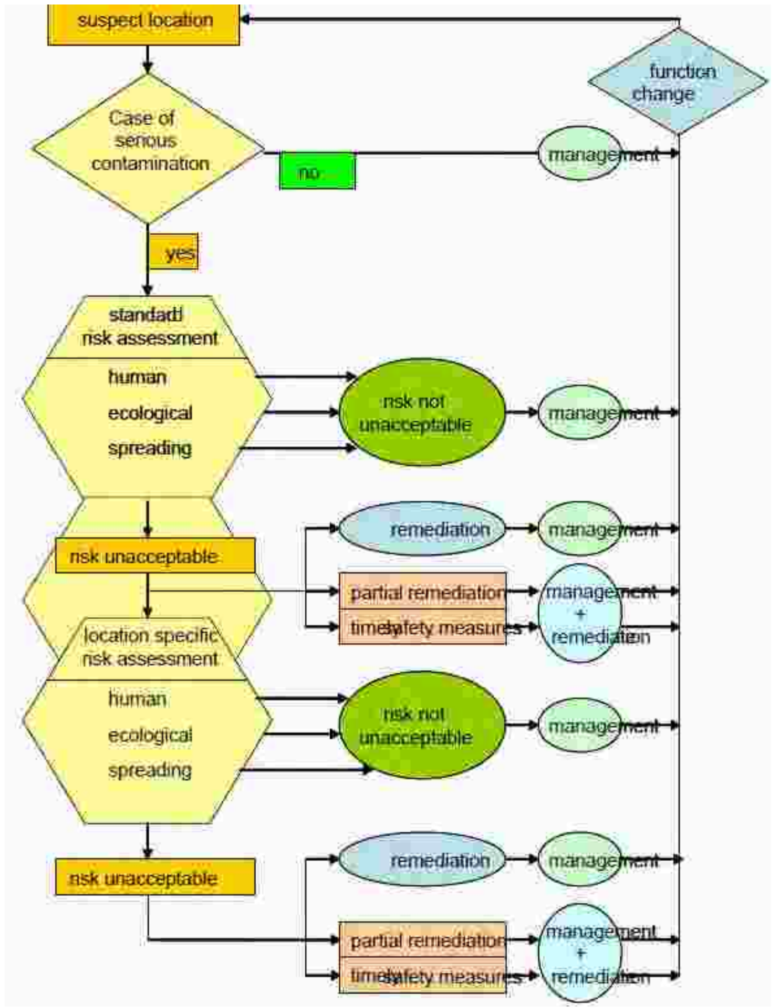
Apart from activities and substances the geometrical form in which pollution has taken place is important for the site assessment plan. E.g. the pattern for drilling and sampling has to be different for a former landfill site than for leakage from pipes.

Site assessment is subdivided into the following steps:

- Preliminary assessment of history of the site: in this step the activities and land use in the past are inventoried. Result of this is a conclusion on the possibility that contamination of soil, sediment or groundwater has occurred. For this step a guideline is available (NEN-5725, ‘Soil quality - Strategy for preliminary investigation prior to exploratory and main survey’);
- Exploratory assessment: in this step some fieldwork is done and samples of soil, sediment and groundwater are tested in a laboratory. Result of this is the confirmation whether contamination is present at a site and if yes, whether this contamination is severe. For this step a guideline is available (NEN-5740, ‘Soil quality - Strategy for exploratory survey - Investigation of the environmental quality of soil and soil lots’). For assessment of asbestos in soil a separate guideline is present (NEN-5707). For assessment of contamination in sediments another guideline is available (NEN-5720). In the NEN-5740 guideline different strategies for exploratory site assessment are presented. These strategies are different for the following situations: situation with no indication for potential contamination (subdivided into small and large scale); situation with indication for potential contamination with local impact on soil (subdivided for homogeneous and heterogeneous situations of soil contamination, with diffuse or local impact, and for situations with subsurface storage reservoirs);
- Detailed assessment: in this step more intensive fieldwork and laboratory testing is done. If the results of this indicate severe contamination, this contamination in soil and groundwater is delineated and risk assessment is done. The result of this step is the conclusion whether the contamination poses unacceptable risks for human health, ecology or spreading in groundwater. For this step a guideline is available (NEN-5755, ‘Soil quality - Strategy for further investigation - Investigation of the type, concentration and extend of pollution of soil and soil lots’). In this guideline the Conceptual Site Model plays an important role to get a grip on the contaminated situation. A visual image of the contamination in the soil is made, as detailed as is possible based on the information available. This image is developed further whenever additional information becomes available.

3.4.2 Risk assessment

The risk assessment is very important because it determinates whether a contaminated site has to enter in the whole soil remediation methodology. In fact, the aim of the risk assessment is to assess if there is an urgent need of remediation or not. As shown in the following scheme, the risk assessment is the tool which allows taking decision and which orients the contaminated site in the methodology.



There are three main steps in this process. The first step is to determine if there is a serious case of contamination. Then a standard risk assessment should be performed. Finally, a site specific risk assessment is done. For each step, the risk assessment is based on human, ecological and spreading risk into the environment. It is not always necessary to remediate the site when there is a serious case of contamination. Sometimes, the risk is acceptable and management should be sufficient. This means that the site will be monitored. When there is an urgent need to remediate, remediation must be undertaken quickly or partial remediation or timely safety measures are applied. When in future the function of a site changes this can necessitate re evaluation of the risks.

The risk assessment is supported by a generic model for calculating exposure to contaminated soil. In this model exposure trough soil ingestion, crop consumption and inhalation of indoor air is incorporated. A human exposure calculation combined with toxicological reference values results in a risk characterization for the site.

3.4.3 Remediation design and execution

Remediation of contaminated soil, sediment or groundwater can be necessary for two reasons:

- for environmental reasons because there are unacceptable risks;
- when developing sites remediation becomes necessary, because of foreseen use of the site or because of the fact that soil or groundwater has to be removed and this has to be done with regard to the contamination.

The following steps are recognized in The Netherlands in the process of preparation and execution of soil remediation:

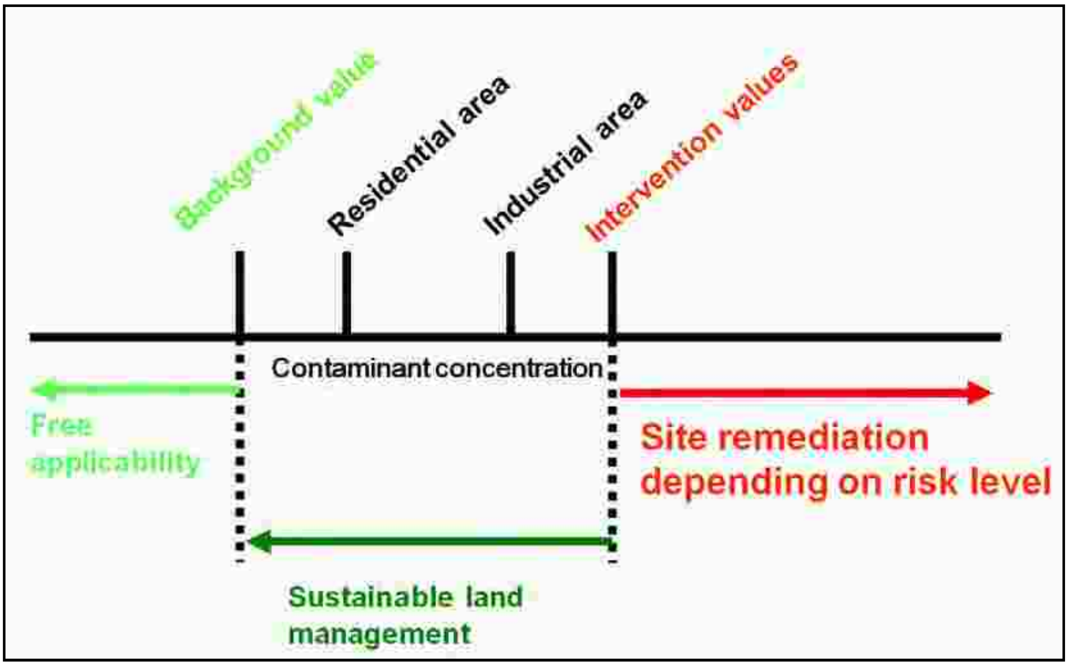
- Setting goals and preconditions for the remediation: what is the future use of the site and goal of the site owner and what are the targets according to the environmental regulation. The relevant

regulation for soil is the ‘Circular on soil remediation’, which is part of the Dutch Soil protection law. In this Circular targets for remediation are subdivided for different contamination situations:
  - Immobile contamination: the goal of remediation is the fit for use approach for immobile contaminants: the top soil quality must meet the requirements for the future use of the site, and exposure of humans and the ecosystem to the contamination has to be prevented. Targets are set related to sustainable use of the site. These target values depend on the kind of future use of the site: nature, agriculture, residential area, industry;
  - Mobile contamination: the goal of remediation is a cost-effective approach of remediation: risks must be eliminated as much as possible (prevention of further spreading of contamination by groundwater to protect vulnerable objects, e.g. drinking water wells) and after care should preferably be not intensive.
- Selection of remediation options: depending on general aspects of the contamination and the soil, as well as the specific situation of the site, remediation options can be elaborated and a process of selection is carried out. The selection depends on so many aspects that there is no general guideline for this. Formerly there were some guidelines, but this was due to the fact that the national government financed the majority of the remedial action. As presently owners are the main financers, the government’s main interest is that the legal targets of remediation are met. There are however still some useful tools to support the selection process.
- Design of selected remediation option in a remediation plan: once the best option has been selected a detailed design is necessary for which the following questions have to be answered:
  - which targets have to be met at different depths in soil and groundwater?
  - which techniques will be applied?
  - what measures have to be taken before remediation starts?
  - which redevelopment measures are necessary after remediation is carried out?
  - is aftercare necessary because not all contamination will be removed and there are some limitations to land use. Is monitoring of the remaining contamination necessary?
  - balance of soil excavation and transport;
  - time needed for carrying out remediation measures, costs of the remedial activities.
- After formal approval of the remediation plan by the environmental authorities, the remediation activities are further detailed in bidding documents for a tender procedure;
- After tendering the contractor can carry out the remediation and redevelopment activities. These activities have to be guided by environmental verification. The results of the activities and verification have to be reported in an evaluation document;
- If some contamination in soil or groundwater cannot be remediated aftercare and monitoring is necessary. For this an after care plan has to be developed and implemented.

3.5 Standards

During site assessment the concentration values found in soil, sediment or groundwater are compared with the following quality standards (in the Circular on Soil Remediation):
- Target value: the target value refers to the environmental quality level of a "clean" soil, which can fulfill all possible functions;
- Intervention value: the intervention value refers to the environmental quality level above which a serious reduction of the functional soil qualities occurs. If this value is exceeded in more than 25 m^3 in soil or sediment or in more than 100 m^3 in groundwater, reference is made to a case of serious soil contamination and in principle a clean-up is necessary.

For targets of remediation the following quality standards are available (in the Soil Quality Decree):
- For the topsoil, values were derived based on risk assessment for each substance, taking into account both human health and ecology:
  - The Background Value for agriculture and ecological functions;
  - The Maximum Residential area Value;
  - The Maximum Industrial area Value;
  - It is possible that other Local Maximum Values are developed and established by the local or regional environmental authorities.
- For the subsoil: risks of spreading and any risk towards human health must be removed as much as possible.



3.6 Technical possibilities for site assessment and remediation

Site assessment: generally used are drillings, monitoring wells and testing of samples of soil and groundwater in laboratories. More and more alternative site assessment techniques are applied, e.g. for heavy metals in soil the XRF-technique is available, geo-electrical or –magnetic probes for deep subsurface research, bio assays for ecological research. The application possibilities for those techniques are depending on soil characteristics, relevant contaminants and accuracy demands. A comprehensive database is available to help in selecting the best technique in a specific situation.

The next figures give examples of the information in this database. The first figure gives information on one specific assessment technique, in this case the Multi-sampler. The second figure presents the potential research aspects of several techniques (on the X-axis). Visible aspects (the matrix contains more information) on the Y-axis are soil structure (Bodemopbouw), ecology (Ecologie), remediation (Saneren) and contamination (Verontreiniging).

Remediation: Remediation techniques can be subdivided into a number of groups, e.g. in situ techniques and capping techniques. The application possibilities for those techniques depend on soil characteristics, relevant contaminants and demands on accuracy, available time, budget and space. A database is available to help choosing the best technique in a specific situation.

3.7 Quality guidelines

A large set of standards, protocols and guidelines is available for defining the technical quality of the work. Almost all steps of the remediation process are formalized by these documents, for which there are three main categories.

Home › Bibliotheek › Bodemonderzoek › Onderzoekstechnieken › Onderzoekstechniek: Multi-sampler

Onderzoekstechniek: Multi-sampler

TECHNIEKSHEET **Onderzoekstechniek: Multi-sampler**						Versie: 2008.10.16 (Naar zoekapplicatie)
Samenvattende omschrijving techniek (gebaseerd op praktijkervaring van onafhankelijk techniekexpert)						
De multi-sampler is een handbediend monstername-apparaat dat zowel van (grond)water als van niet-cohesieve (water)bodems monsters kan nemen. Het is feitelijk een plexiglazen buis met daarin een zuiger. Door op diepte de zuiger te bedienen zal de plexiglazen buis zich vullen. Er zijn twee steekringen die uitwisselbaar zijn. Een steekring met kogelklep die de multisampler aan de onderkant afsluit. Door de kogelklep te wisselen door een open steekring kunnen niet-cohesieve bodems bemonsterd worden door de sampler weg te drukken en op diepte te vullen. De zuiger voorkomt in dat geval compactie van het te bemonsteren sediment.						
Algemene informatie (gebaseerd op informatie van techniekaanbieder)						
Naam	Multi-sampler					
Meeteenheid en parameter	-					
Bodemfase	Grond	Grondwater	Poriewater	~~Puur product~~	~~Bodemlucht~~	
Aard techniek	Fysisch	~~Chemisch~~	~~Biologisch~~	~~Overig~~		
Plaats van toepassing	In situ	~~Ex situ~~				
Detectiewijze	Boren / steken	~~Verdringing / sonderen~~	~~Tomografie~~	~~Off site meting~~	~~Meting op maaiveld / waterbodem~~	~~Meting aan oppervlakte open water~~
Toepasbaar in afzonderlijke lagen	~~nee~~	ja	Minimale dikte laag: 10 cm			
Bodemtypen waarvoor techniek geschikt is	1 homogeen goed doorlatend zandpakket	2 één zandpakket, met slecht doorlatende laagjes	3 slecht doorlatende deklaag, doorsnede met zandlaagjes	4 slecht doorlatende laag op een goed doorlatend zandpakket	5 ~~antropogeen~~	
Landbodem/waterbodem	Landbodem	Waterbodem				
Stap in keten van			c. Monstername			

LEGENDA + = waar - = niet waar o = gedeeltelijk of soms waar	Akkermannsteektoestel	Aqualock	Beeker steker met onderwaterstatief	Continuous Soil sampler met steunkous	Guts	Handboor: Edelman-boor, "riverside"-boor, grindboor	Multi-sampler	Radar - GPR	Sondering - mechanisch	Veenboor
Bodemopbouw										
Afsluitende laag	+	+	+	+	+	+	+	o	-	-
Diepte afsluitende laag	+	+	+	+	+	+	+	+	-	-
Objecten in bodem	-	-	-	-	-	-	-	+	-	-
Verstoring bodemopbouw	+	+	+	+	+	+	+	+	-	-
Bodemopbouw	+	+	+	+	+	+	+	+	+	+
Slibdikte	-	+	+	-	+	-	+	+	-	-
Antropogeen materiaal	+	-	-	-	+	+	-	o	-	-
Ecologie										
Biologisch gezond?	-	-	-	-	-	-	-	-	-	-
Ecologische risico's	-	-	-	-	-	-	-	-	-	-
Saneren										
In-situ sanering	-	-	-	-	-	-	-	-	-	-
Verontreiniging										
Smeerlaag	+	-	-	-	-	+	+	-	-	-
Uitloogbaarheid	-	-	-	-	-	-	-	-	-	-
Biologische afbraak	-	-	-	-	-	-	-	-	-	-
Ecotox effecten	-	-	-	-	-	-	-	-	-	-

Annex 2 Detailed reports international remediation approach

France

Table of contents

1 Soil contamination

1.1 Inventory of sites

In the beginning of the 1990s the inventory of polluted sites started by the BRGM. Two data bases have been created: BASIAS and BASOL. BASIAS: inventory of the historical industrial sites and their activities (until 1975) in France. In 2010, 251.000 sites counted in 96 départements. BASOL: inventory of the potential polluted sites that need actions by the public government (remediation or other management). In each Région, the DREALs (see chapter *The Actors*), among other tasks, have to give information to the BRGM about ancient industrial sites. These information will be collected in the data base BASIAS.

In France, the number of sites directly or indirectly involved in the topic of soil contamination according to the data base BASOL[1] updated on the 3rd of April 2012 are **4318**. They are classified in five categories. Below you can see the localization of sites which need actions from the government.

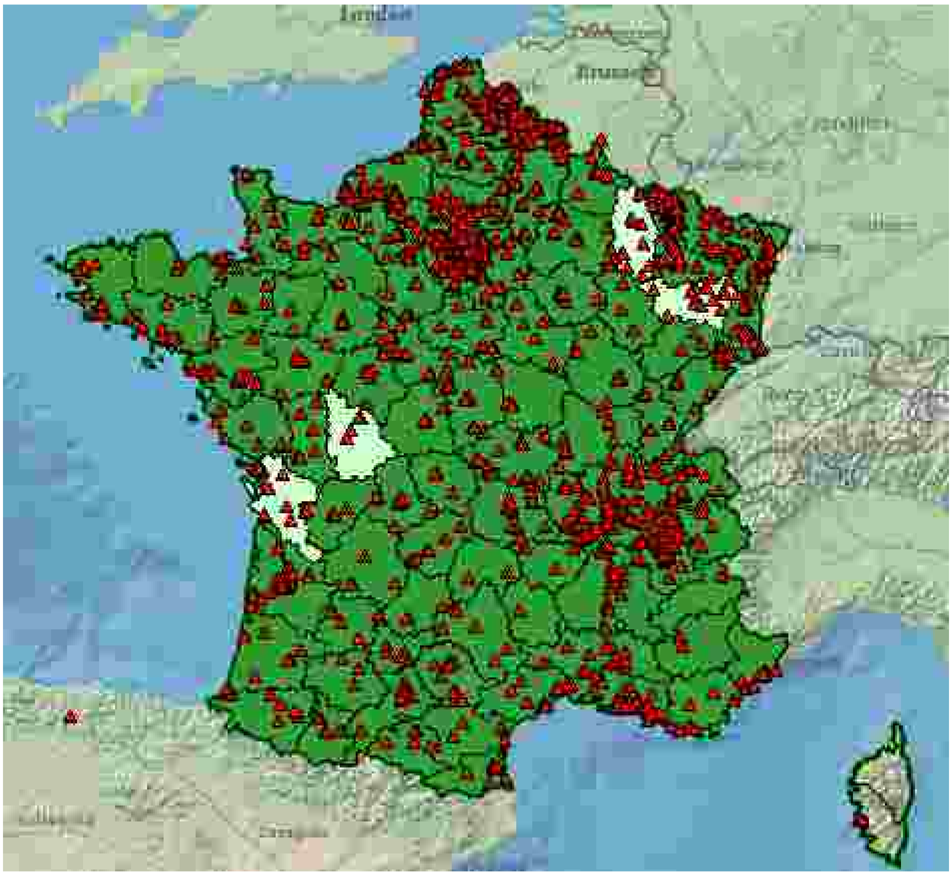


Figure 1: inventory of polluted sites in France. Source: Infoterre, BRGM

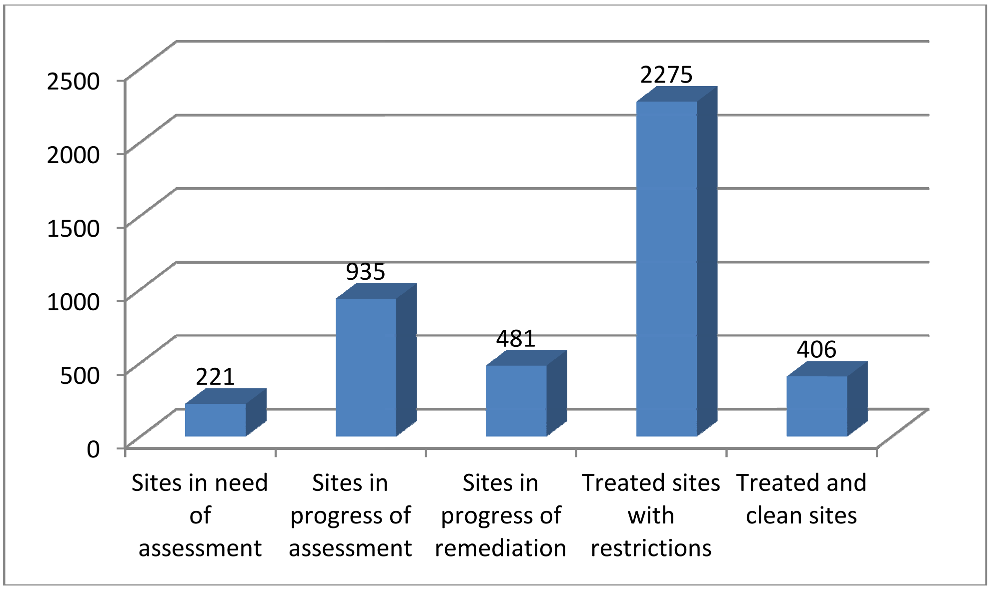
[1] BASOL is a data base set up by the BRGM by the demand of the Ministry of Ecology, Sustainable Development, Transports and Housing. The BRGM is the Mining and Geological Research Agency supporting the French soil policy. The inventory of potentially polluted sites has begun in 1993.
Legendary:
Red triangles: potentially polluted sites
dark green: data available for the public
light green: in process of inventory

Sites inventoried in BASIAS:

- station service
- hydrocarbons storage coming from the Army
- SNCF (national train company), GDF (national gas supply company) storage
- cleaner's
- sawmill
- harbour areas
- old mining facilities
- waste collection warehouse
- scrap iron storage
- all other sites under the law of ICPE (see chapter Prevention)

Current and old agricultural facilities aren't inventoried here.

Category	Description
Sites in need of assessment	One or several contaminations are suspected, further investigations are necessary. No action has been done yet.
Sites in progress of assessment	The site has been studied and the pollution is established. The diagnostic is done but the work has not begun yet.
Sites in progress of remediation	The objectives and the techniques of remediation have been chosen.
Treated sites with restrictions regarding to the use	Sites being monitored, the contamination has not been removed entirely. It is under the regulation of a prefectural decree.
Treated and clean sites	Remediated sites without any necessary monitoring or any restriction.

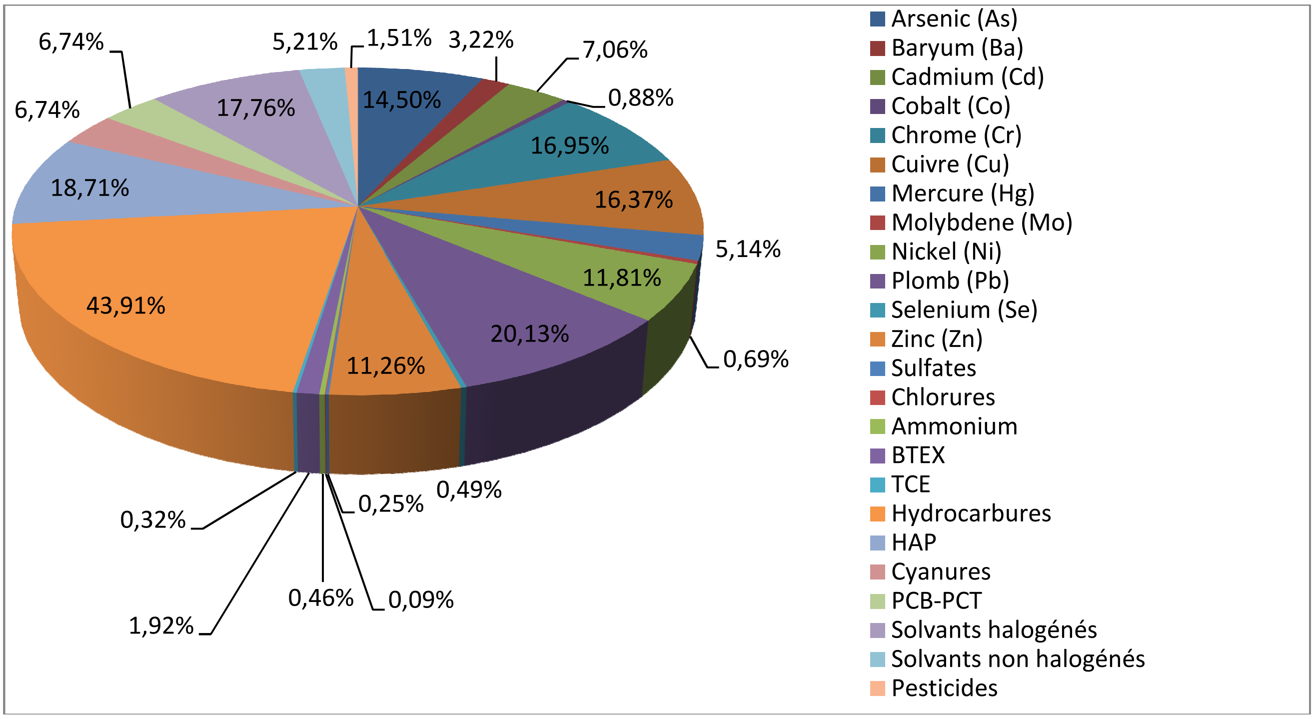


Most of the soil pollution is where most important industrial sites are, that is to say: Lyon and the Rhône area, Paris area, Lille, Rhin area (Alsace) and Lorraine.

Regions	Traditional industrial fields
Paris area : 1st industrial region	**Printing, foundry**, metals work, electric and electronic equipments
Lyon area : 2nd industrial region	Steel industry, mechanic industry, **chemistry**, rubber, plastics, food industry, electronic components (recently).
Alsace (3rd industrial region)	Textile industry, metals work,
Lorraine	**Mining industries**, metal works, steel industry

Source : http://www.industrie.gouv.fr/biblioth/docu/kiosque/cahiers/c115p2.html

According to BASOL, updated on the 3rd of April 2012, the contaminants occurring in contamination cases are:



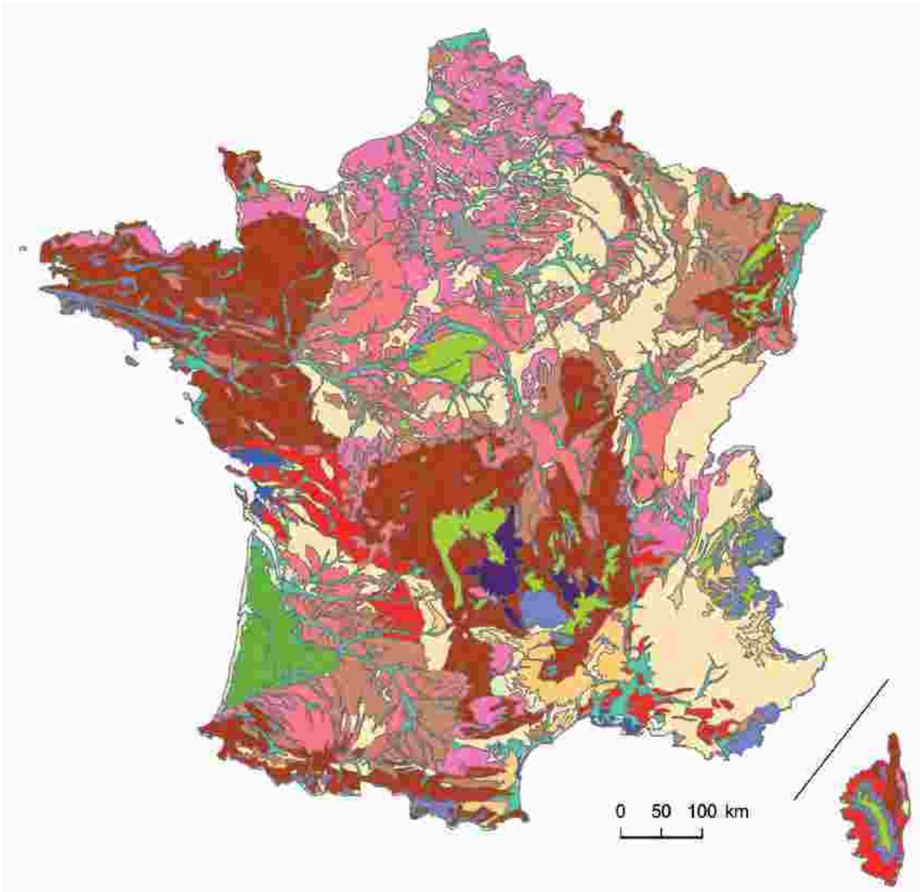
As shown on the graphic, the most frequent contaminants are hydrocarbons, lead and copper.
The contamination caused by agriculture is inventoried first through the inventory of the trace metals in the surface of the soils intended to receive sewage sludge. These data are not the result of a sampling campaign, but they come from analysis made by different organism or firms and collected by the GISSOL (Groupement d'Interêt Scientifique sur le SOL – *Scientific Interests about Soil Group*). The GISSOL was set up in 2001 by the Ministry of feeding, agriculture and fishing, the Ministry of Ecology, The INRA (Institut National de la Recherche Agronomique- *Agronomic Research National Institution*), ADEME, IRD (Institut de recherche pour le Développement - *Research for the Development Institution*) and the IFN (Inventaire Forestier National- *National Forests Inventory*).
The data base is accessible to the public: http://www.gissol.fr/programme/bdetm/Collecte_2/index.php

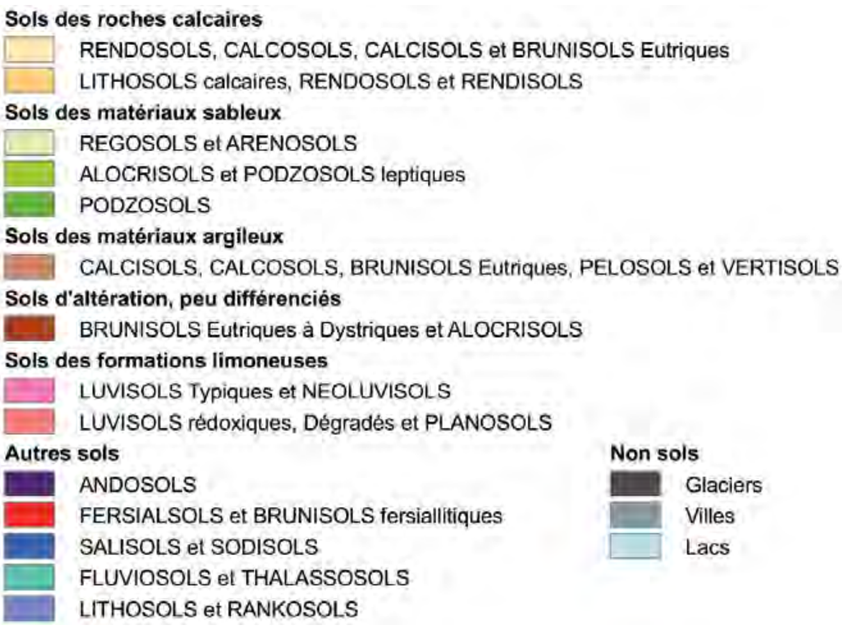
Secondly, agricultural contaminations are surveyed through the European water framework directive. Under this directive, groundwater tables and water are monitored and the values of the analysis of the groundwater tables are entered in the data base ADES: http://www.ades.eaufrance.fr/?CInfo=en-GB.
Parameters like the concentration of sulphates, nitrates, and pesticides in the water can be found.
The measures taken by the government regarding the pollution by the agriculture are more situated in prevention rather than in remediation. Law was edited to reduce the use of pesticides and polluter pays principle is applied since 2000 by establishing a tax on fertilizers.

1.2 Soils typology

The soils repartition in France is illustrated in next figure:

Source : Inra, Base de données Géographique des Sols de France à 1/1 000 000, 1998.

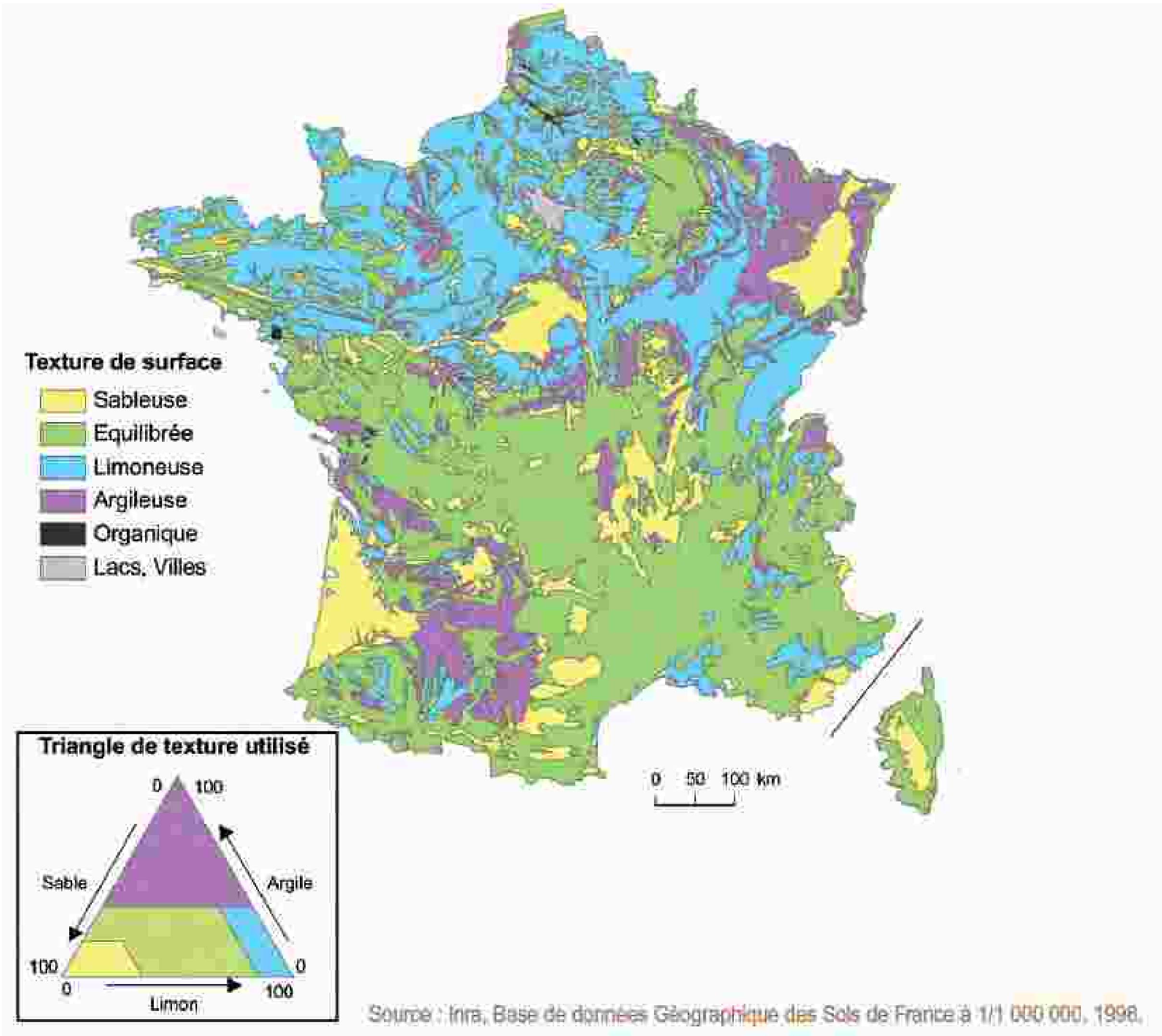




Calcaire: limestone
Sable: Sand
Argile: clay
Limon: silt
Sols d'altération, peu différenciés: sols changing relatively fast, only few differences among the layers
Glaciers: glaciers
Villes: town
Lacs: Lakes

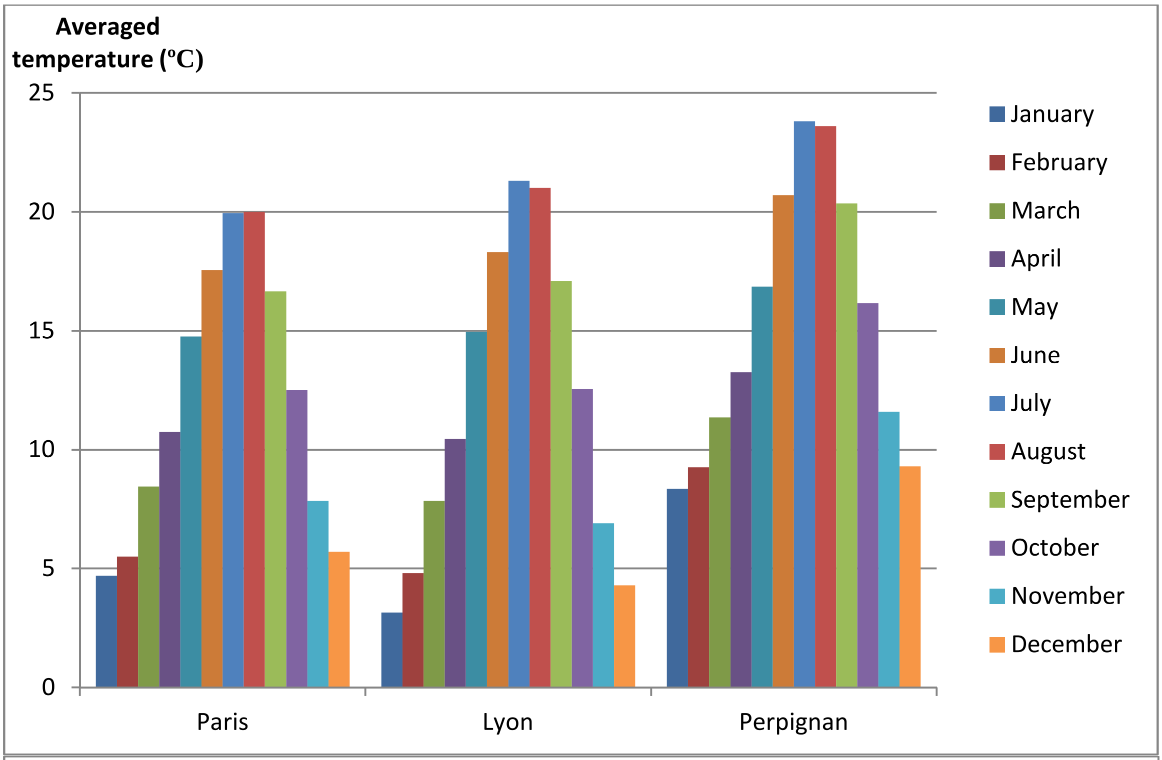
The texture of shallow horizons of the soil is:

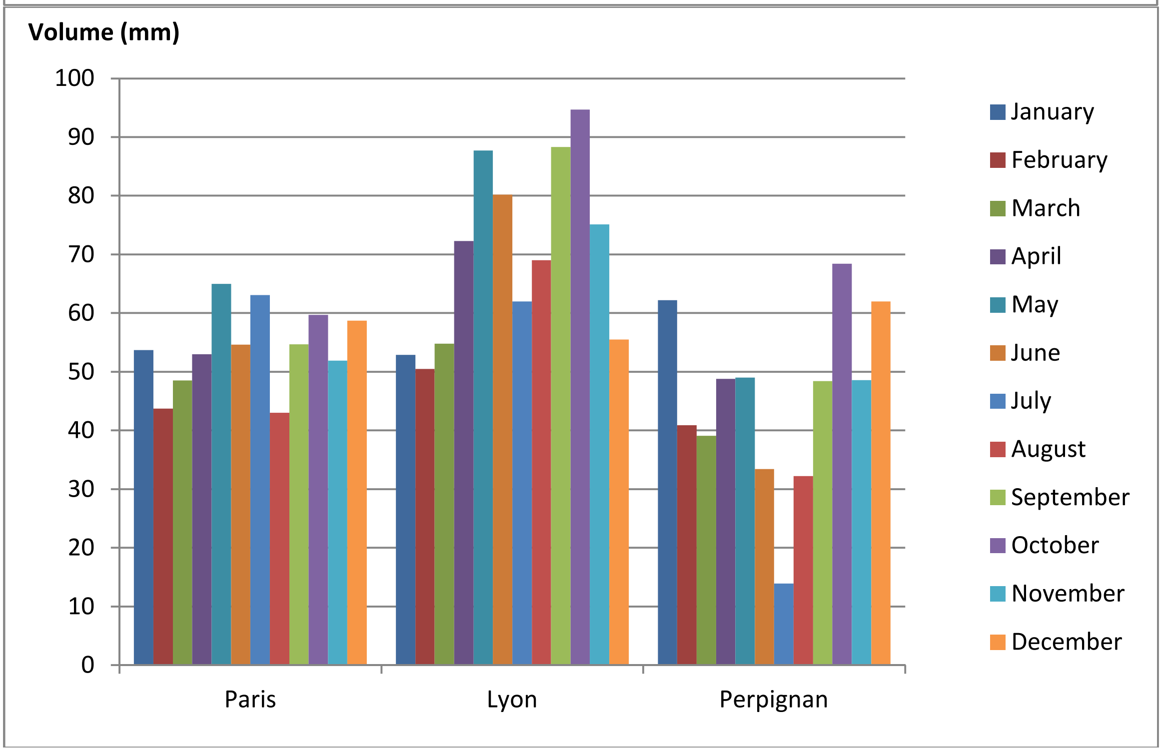
As you can see, French soils are very various. It´s difficult to establish one French soil typology. Of course, contaminants will behave differently according to the cases.



1.3 Climate

The maps below feature the averaged temperatures (the 30-years average) and the averaged volume of rainfall (30-years average) in different cities of France.





Source: http://climat.meteofrance.com/chgt_climat2/climat_france?76100.path=climatnormales%252FFRANCE

2 Effects of contamination

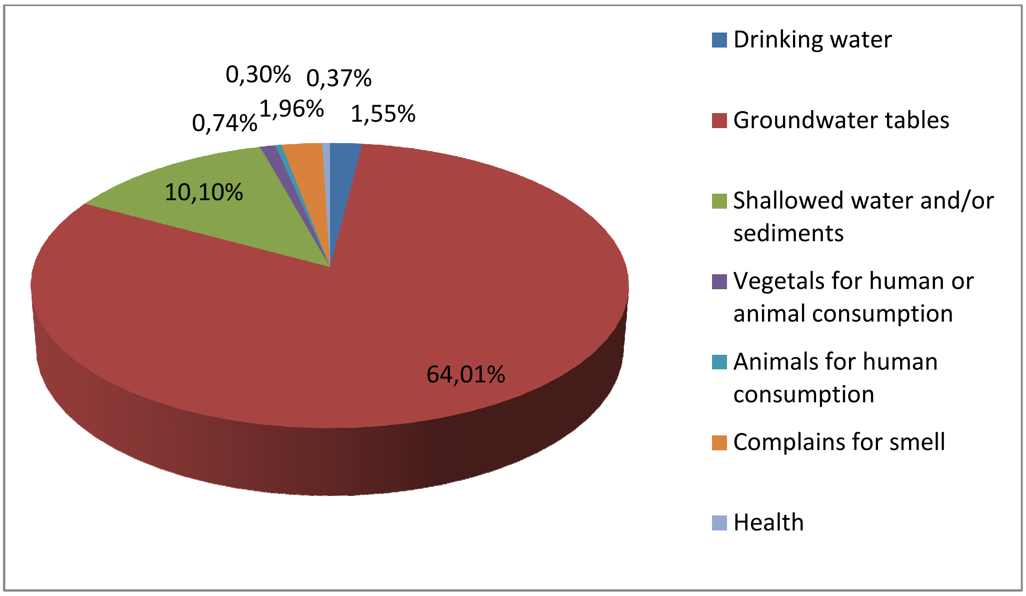
2.1 Use of soils in France

Agriculture extends almost to the half of the territory and forests to one third of the territory. Agriculture is carried out mostly in many departements of the western part of France. Intensive agriculture is made on deep silty soils of sedimentary basin (Aquitain Basin, Parisian Basin, Limagne (great plain in Auvergne)). However, thanks to the development of fertilization and irrigation agriculture has also been developed on limestone soils (Champagne, Poitou Charentes). Moderately acid soils are used for meadows while acid soils are used for forests exploitation.

Finally, due to the diversity of the landscapes, it is recognized by the government that soils are also useful regarding to that and they must be protected.

2.2 Effects inventoried

Among the inventoried potentially polluted sites, 47,73 % of cases (2339 sites) have an impact on the environment while 14, 36% don't have any impact. The rest is unknown. The different impacts since the beginning of the inventory (1993) are (the percentages have been calculated for the sites for which the impact is known):



Since 1993, 46 drinking water pumping station have been closed because of contamination.

3 Policy

Remediation: End of 1990s: Remediation according to the future use of the site for the **historical pollutions**. See paragraph 4 for technical information.

Prevention: Contaminations occurring in the present must be avoided (see chapter *Prevention*)
Soil pollution prevention is a part of the ICPE law (*Installations Classées pour la Protection de l'Environnement* - Classified Installations for the Environmental Protection), which inventories all the facilities in France. This policy was set up in order to manage environmental risks. The facilities are classified according to either their activities or the raw material they own. The classification counts five categories of facilities and each category features a level of risk:

- **Declaration**: The facility must be declared to the municipality. The risk is acceptable and the facility can work if conditions given by the prefectural decree are satisfied.
- **Declaration and control**: The facilty must be declared before running, must satisfied the prefectural requirements and will be periodicaly controlled by an approved organism (Inspector of Classified Installation).
- The prefectural decree set up in those cases is a standard decree, which is non specific to the facilities.
- **Registration:** Activities must satisfy a specific prefectural decree and will be periodicaly controled.
- **Authorization** : Before runing the facility, the owner must ask an authorization to the prefect, who can give it or refuse it, according to the level of the risk. A prefectoral authorization decree is elaborate case by case. If the authorization is given, requirements to be satisfied are more severe.
- **Authorization with high level (Seveso level)**: The risk level is the highest, the same requirements than before are asked plus operational constraints regarding the safety of the public.

The nomenclature can be found at:

- http://www.ineris.fr/aida/?q=consult_doc/navigation/2.250.190.28.6.2240/5
- ICPE Law : http://www.installationsclassees.developpement-durable.gouv.fr/accueil.php

An other part of the soil contamination prevention is Memory. The government has set up a data base called ARIA about technological accidents which could or which have caused damages on the environment and/or the human's health worldwide. The data base was established in 1992 but it inventories accidents which have occured since 1921.
ARIA : http://www.aria.developpement-durable.gouv.fr/index.html

4 Policy instruments

4.1 Legislation

There is no specific law about soil but a framework based on several texts: Ministerial letter from 8/02/2007, reference values for the water, the foodstuffs and the external air; Directive on wastes **2008/98/CE**; Code of Environment.
A contaminated site is remediated according to the future land use. The methodology distinguishes two approaches:

- the future use of the site is known and not negotiable. The final state of the soil must match with the future use. A **determination of the current soil's state** (*Interprétation de l'état des milieux* IEM) has to be made in order to know if it's already the case or not.
- the future use of the site isn't decided. It can be chosen according to the current state of the soil. **A site management plan** is made (*Plan de gestion*) taking into account that both remediation or change of the future use can be done.

In the first case (IEM) and if the soil is contaminated, the contamination must be appreciated by comparison of samples with references values which are the regulated values for **the drinking water, foodstuffs and the outer air** in one hand, and the **natural soil background** in the other hand. In case these values are unavailable, a **quantitative health's risks assessment** (*Evaluation Quantitative des Risques Sanitaires* – EQRS) is done. The EQRS is a calculation that gives a risk index towards the human health. It uses parameters such as the toxicology of the contaminants, the lifetime spent on the future site by the people (adults and/or children) and other parameters. The risk index doesn't take into account the damages which could be caused on the ecosystems. The IEM can't be done while an industry is running. In this case the risks on health's employees come under another regulation text on work rules (*Code du travail*).

In case of the future use is unknown, the **quantitative health's risks assessment** (EQRS) is based on a suitable future use to this site, which is chosen according to the current level contamination. If the risk level given by the EQRS is too high, either another use is chosen, either remediation is done. The suitable use to this site is chosen after doing a cost-benefit analysis. **The site management plan** must integrate sustainable development and the concept of global environmental analysis. The plan is approved if the level of residual risks, which is determined by a **Residual Risk Analysis** (*Analyse du Risque Résiduel* ARR), is low enough. The ARR is the same calculation as the EQRS but it's made on the residuals expositions.

The future land use approach doesn't justify to let contaminant's sources or spots in place. In fact technical possibilities must be researched to remove the source of the contamination as much as possible. What is allowed is to let plumes or spread substances only if the risk is under control.
In both case, the main purpose is to establish compatibility between the final state of the soil and the use. The steps to achieve it are described in the **Ministerial letter from the 8th of February 2007**, which describes the whole methodology to follow.

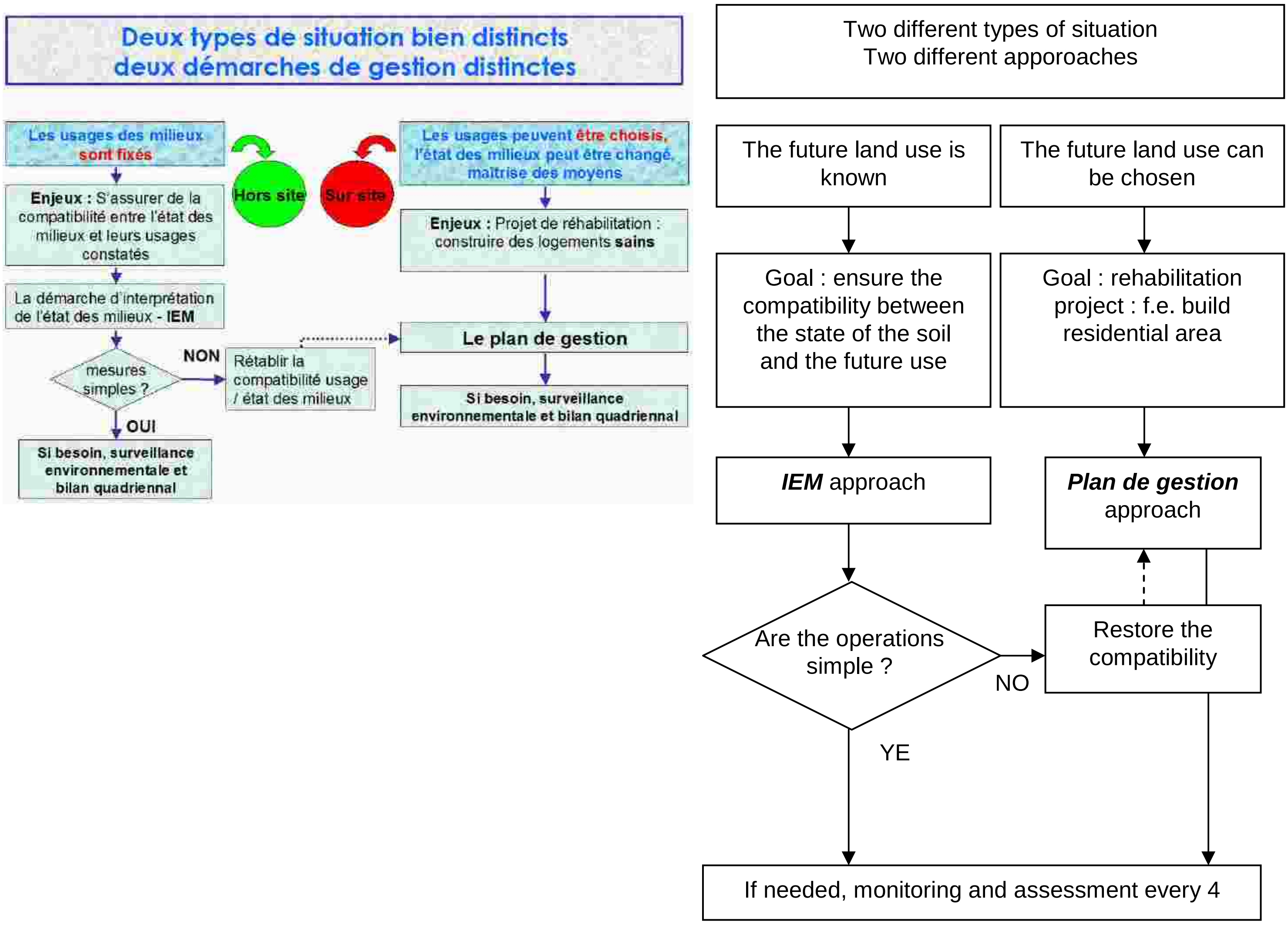


Figure 3: The two approaches to manage the contamination sites

4.2 Remediation: methodology (technical guidelines)

The process of assessment and remediation has five steps. All steps are standardized under the norm NF X 31-620 relative to the services in the field of contaminated sites. This norm tells exactly how to do each step and exactly what kind of service is include in each step.

1. In the first step, pollution is diagnosed by searching historical information, any document giving signs about the kind of contamination and where is it located: activities in the past and the present, accidents, etc... . After that, site investigation is done: samples are taken in the suspected area(s) and analyzed by a normalized laboratory to be compared with the references values mentioned before.

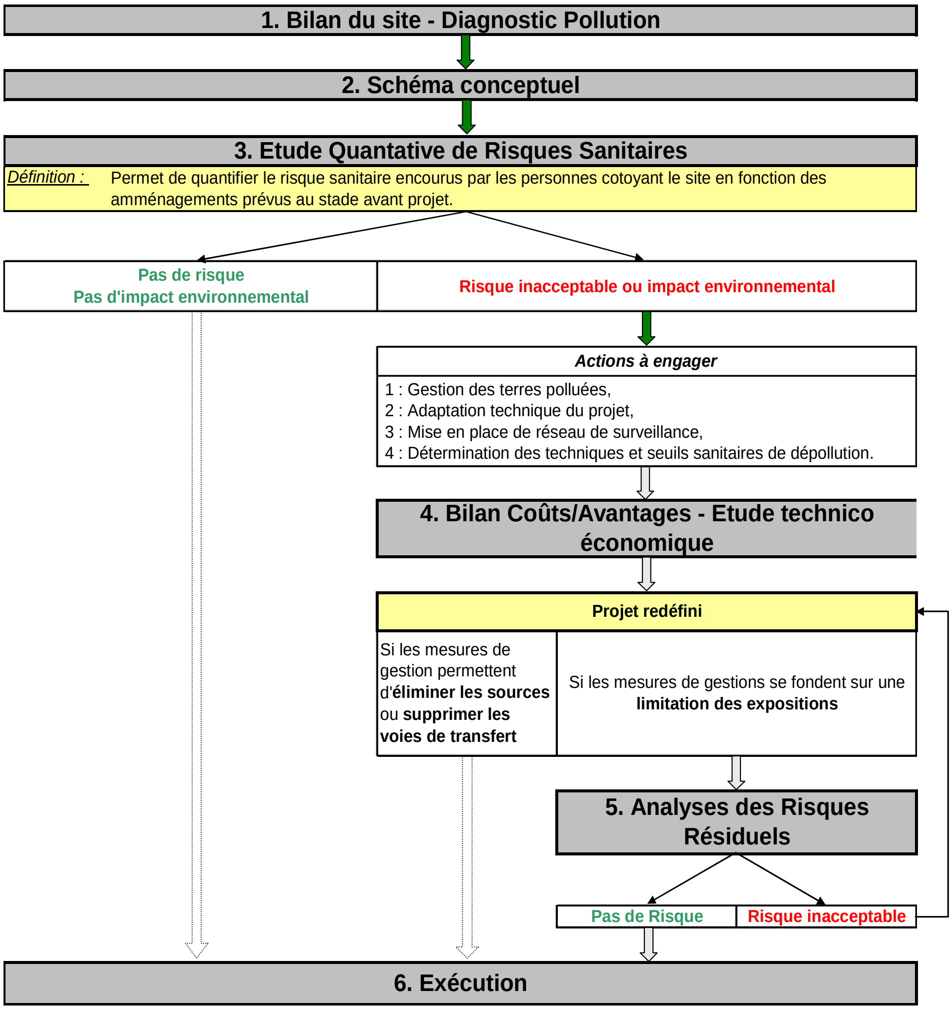


Figure 2: the methodology

2. In the second step a **Conceptual Site Model** (*schéma conceptuel*) is made. It schematizes the contaminants in the soil, the exposure routes and the targets (adults and/or children, natural resources, sensitive ecological area). This model is important because the EQRS is based on it. Therefore it must be updated after each step to integrate eventual new information. The risks towards environment are not quantified by the EQRS but it's protected by specific European regulations like The Habitats Directive (92/43/CEE) and The Birds Directive (79/409/CEE). Thus ecological interests area or sensitive nature must be known and indicated in the **Conceptual Site Model.**

3. The third step is the calculation of the risks generated by the pollution, the EQRS. The principle is to calculate the daily intake dose and to compare it with toxicological reference data. For the calculation it is needed to know the concentrations of the substances which penetrate to the human bodies through all exposition routes. Models are used for that. The model used to estimate the concentration of volatile substances in the air of a confined atmosphere is **Johnson & Ettinger**. To estimate the concentration of volatile substances in the outside air, the model **RBCA – Thibideaux** is used. To determinate the concentrations of contaminants in the plants, the model used are CALTOX, HHRAP, Csoil. Models are recommended by the INERIS (National Institution of the Industrial Environment and the Risks) but there is no unique model certified by the government.

The **danger quotient** must be lower than **1** for the threshold level toxic effects substances (defined as substances for which there is a dose below which no deleterious effect is expected to occur), which are **non carcinogenic substances**. And it must be below $\mathbf{10^{-5}}$ for the substances without any threshold level toxic effect. These are **carcinogenic substances**.

4. The cost-benefit analysis must provide the optimal solutions among all the solutions, taking into consideration environmental, sanitary, technical and economical aspects. This analysis must compare

all relevant solution. In **the site management plan**, priority is given to issues aiming at the removal of contaminants rather than isolating contaminants. As mentioned before, the benefit cost analysis must consider the environmental impact of the remediation because it must be sustainable.
5. The **Residual Risk Analysis** (ARR) is the quantification of the risk based on the new exposure routes and the remaining concentration of contaminants (if there is). The principle is the same as for the EQRS. If the ARR is low enough, the plan is approved and can be carried out. Otherwise, the site management plan must be redefined.

4.3 Reference values
French policy doesn't use soil quality values to achieve in case of pollution, but the objective is determined by a risks analysis. The pollution itself is not the problem but the risk caused by it to the human or environment is the problem.
However references values exist to appreciate pollution. The **natural soil background values** (*fond géochimique*) are the reference values for the **metals** found in the soil. When the soil is contaminated with metals, the samples will be compared to the natural soil background of the non polluted area closest to the site. The concerned metals are: Arsenic, Barium, Cadmium, Chrome, Copper, Mercury, Molybdenum, Nickel, Lead, Antimonium, Selenium and Zinc.
The other reference values are found in the regulated chemical values for **the drinking water, foodstuffs and the outer air**. These values are given by the INERIS (National Institution of industrial environment and risks – *Institut National de l'Environnement Industriel et des Risques*).

4.4 Who has to pay?
The responsibles have to stop damages caused by pollution. They are: operator who caused the contamination, the owner and if a site isn't owned anymore the contamination has to be removed by the most recent owner. Moreover, when a classified site with a high risk level is sold, the future owner must be informed about the state of the site.
If the responsible can't make amends for the damages (because he disappeared or he's insolvent), the case is left to the ADEME (*Agence de l'Environnement et de la Maîtrise de l'Energie* – Environmental and Energy Control Agency) which will remediate the ground using funds coming from the TGAP (*Taxe Générale Sur les Activités Polluantes* – General Tax on Pollutants Activities). In order to avoid this case, a new process has been set up: for some classified facility, the operator must prove that he will financially be able to remediate the site if pollution would occur.
Nowadays, when an operator stops his activity, he must remediate the site before leaving it. All risks towards health or environment have to be removed.

4.5 Budgets-Financing
As mentioned before, remediation costs must be financed by owner or operator who caused pollution. The Government intervenes in remediation funding when the responsibles are nowhere to be found or insolvent. The ADEME (*Agence de l'Environnement et de la Maîtrise de l'Energie* – Environmental and Energy Control Agency) which is a public actor, undertakes to restore contaminated sites. Its actions concerning polluted sites are: reassure sites by excavating and removing contaminants; monitoring; remediation facilities; risks assessment and impact studies; cleaning works. Before the Grenelle I law (2007), the annual fund was 10M € a year for excavating and removing contaminants. Grenelle I law increased this budget to **25 M€/year** in 2009**, 90M€** for period 2009-2013. In 2012, the budget was **38 M€.** What also introduced the law Grenelle I is that if a subsidiary goes bankrupt and thus can't pay the remediation costs, the parent company will be judged as responsible and will have to pay instead of its subsidiary. Since 1996, ADEME was involved in 150 cases of orphan contaminated sites (sites for which the responsible can't pay) and 78 sites during 2010.
The ADEME is also involved in the *Program for restoration of contaminated brownfields* by funding until 50% of the remediation costs.
Since 1999, ADEME financially helps owners of contaminated sites with diagnosis studies.
According to the ADEME, in 2009, the national global benefits of the soil remediation were **626M€**. Half of this number is earned by private actors. Between both engineering and contractors, 65% to 70% of these profits were made by contractors.

4.6 Organization: the actors
Next figures are illustrating the actors involved in French soil remediation approach.

Public actors involved in the soil policy:

National

Ministry of financial Economy and industry

Ministry of Ecology, Sustainable development, transport and housing

Ministry of Third level education and Research

INERIS: National Institution of the Industrial Environment and the Risks
Creation : 1990
Role: -technical support for environmental policy
-set up sanitary threshold values for chemicals
-toxicology studies
-information and education to the public
Fund by: Ministry of Ecology and benefits (70M€ in 2010)

ADEME : Environmental and Energy Control Agency
Creation: 1990
Role: -policy application
- environmental research
-taking charge of orphan polluted sites
-information and education to the public
Fund by: -TGAP General Tax on Pollutants Activities (499M€*)
-Minisry of Ecology (66M€*)
-benefit (31M€*)

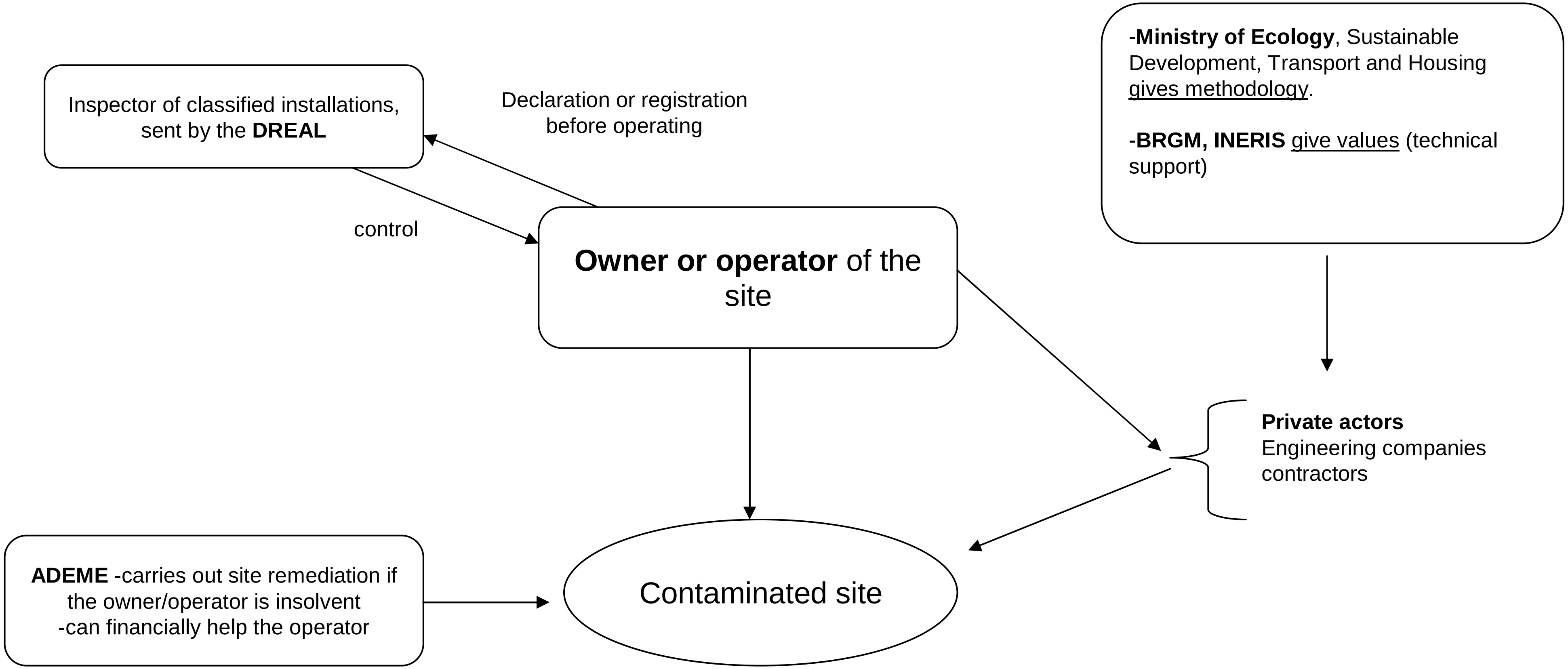
*regarding year 2012

BRGM: Mining and Geological Research Agency
Creation: 1959
Role: -support public policy
-inventory of polluted sites and set up of BASIAS & BASOL
- Geochemical soil background
-research
-information and education to the public
Fund **by**: -Ministry of Ecology and Ministry of Research
-Benefits

Regional

•DREAL : Regionaly Direction of Environment, Planning and Housing
Creation: merger of several regional environmental offices in 2009-2010
Role: -enforcement of the environmental policy to a regional scale
-environmental police (Classified Installations Inspectors)
-communication to the BRGM of number of industrial sites in the assigned Region
-Information and education
Fund by: Ministry of Ecology

Connexion between public and private actors:



As part of the prevention policy, **operators** must at least declarate the site that will be running. The **DREAL** will then controle if all requirements are satisfied, by sending to the operator an Inspector of classified installations. When activites are stopped, the operator must check if the environment is as clean as it was before operating. If no, the law obliges him to remediate it. If he can't, for the reasons mentioned before, **ADEME** will intervene.
The remediation is controled by an independent organism, which will check that the goals of the remediation have really been achieved. Moreover, a check will be done by the DREAL when the operator leaves the site. In fact he has to satisfy requirements before leaving.

4.7 Technical development research, remediation options

Research is done on in situ chemical treatment, about the by-products engendered by oxidation or reduction. They have to be more controlled.
On other part of the technical research is the optimization of the already known techniques:

- combination of biological and chemical techniques is studied: oxidation is used in first and biological treatment can be used to reduce residual pollution. It allows reducing the cost of chemical treatment which are higher than biodegradation.
- research is also carried out on biodegradation aiming to improve knowledge about degradation kinetics. Biological research also focuses on how to improve the biodegradability of a less biodegradable product.
- thermal treatment is also studied in order to decrease treatment costs.

By government demand, biological treatment like phytoremediation and phytostabilization are emerging. Moreover Grenelle I law says that for orphan sites carried out by the ADEME, phytoremediation must be priority considered. For instance, phytostabilization was used by the ADEME to rehabilitate an ancient mining site (La Combe du Saut – 11). On this site was combined in situ containment for the most pollute wastes and ground and the phytostabilization of arsenic (10 ha of ground).

4.8 Ways of communication

Data and information are available to the public via Internet and information campaign and periodic journals. Conferences for professionals and public are organized by, among others, the ADEME. BRGM write publications accessible to everyone and both database BASIAS and BASOL are consultable by everyone. Geological maps and scientific data are also accessible via the website infoterre.brgm.fr

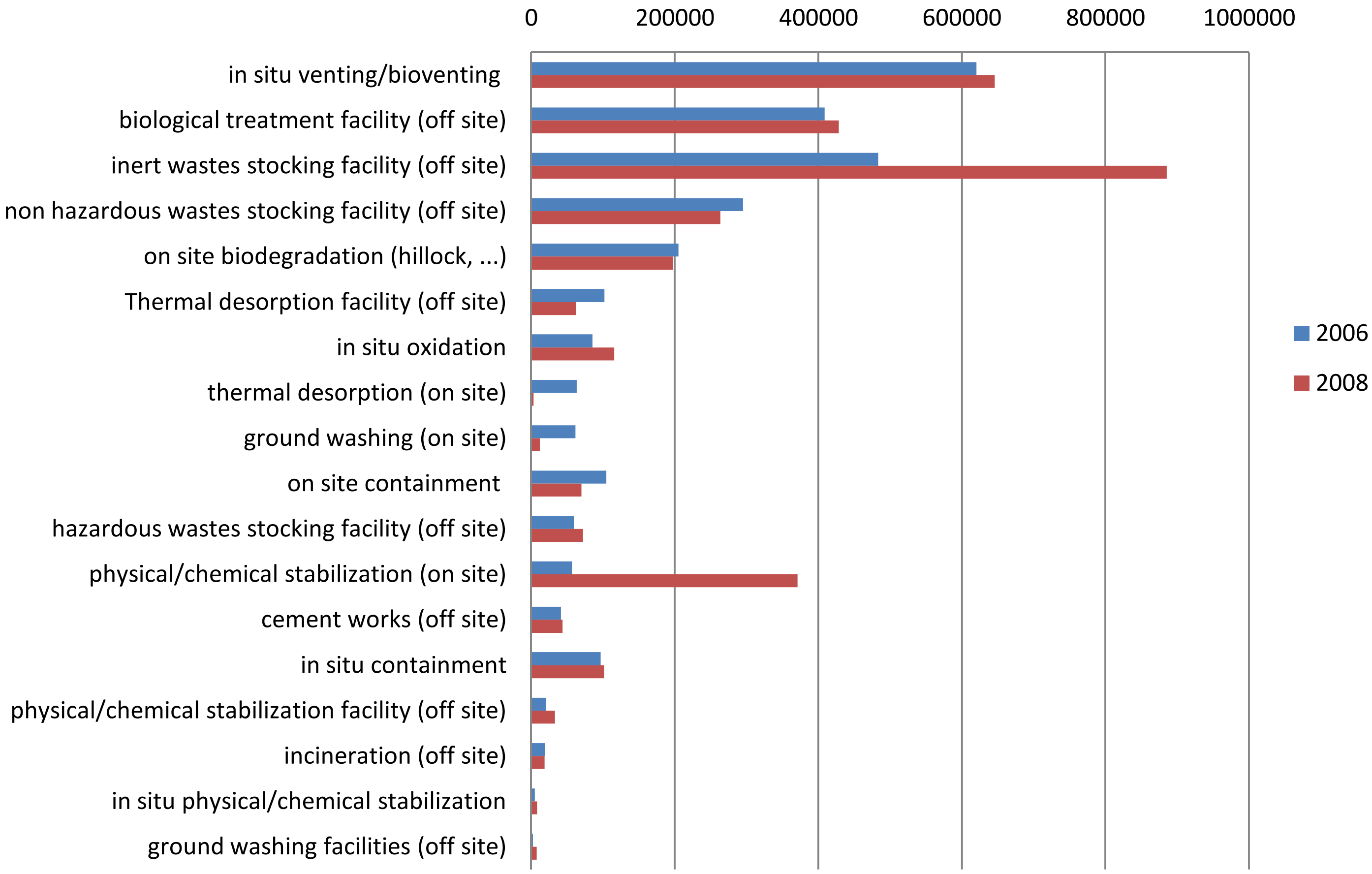
4.9 Actors of the remediation

In France, actors are divided into two groups : the engineering and consultancy companies in one hand and the contractors in the other hand. The main companies of the first category are: Apave, Anteagroup, Socotec, Arcadis, Artelia, Bureau veritas, Dekra, egis structures&environnement.
The main companies of the second category are: Veolia porpreté, Sita remediation, Apinor, Biogenie Europe SAS, Brézillon, Séché éco-services, Serpol.
The complete list of the private actors for the soil remediation is available on: www.upds.org (Union of Sites Cleaning Professionals)

5 Remediation and costs of techniques

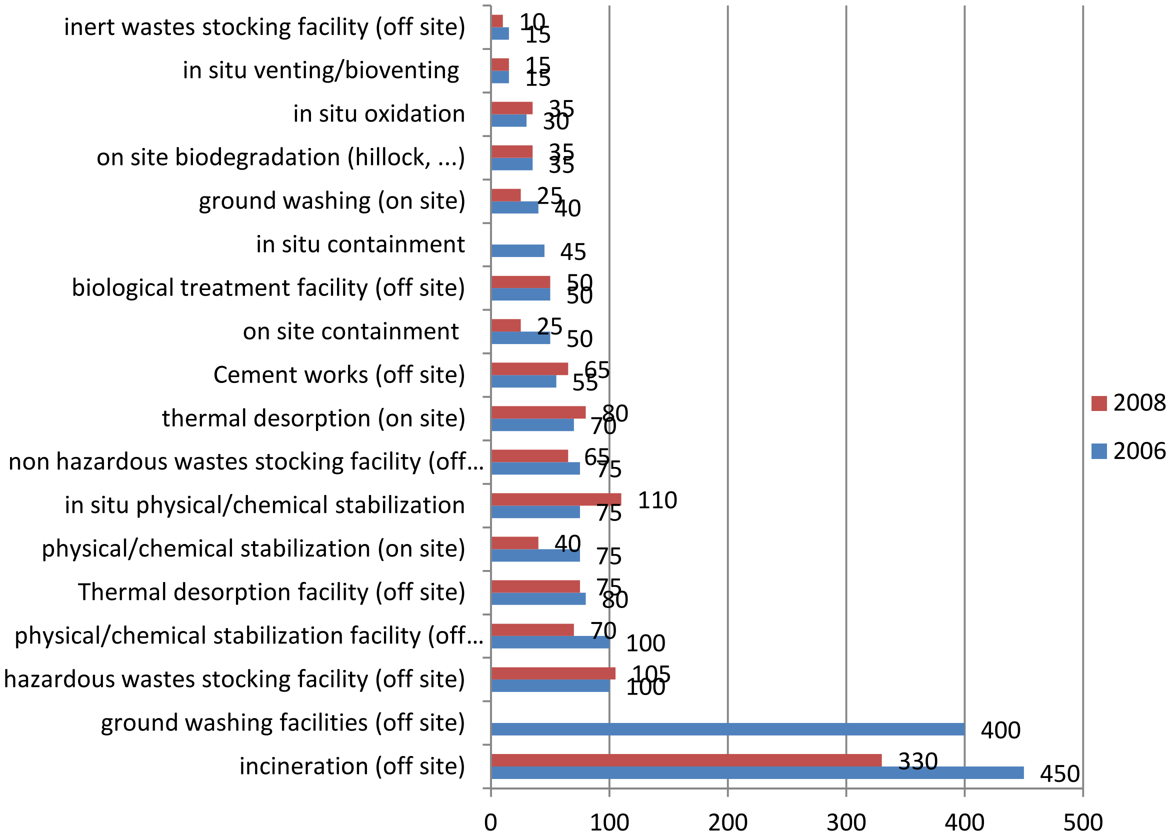
The data used here are coming from the report "Use rates and costs of the remediation techniques and ways of treatment of polluted soils and groundwater in France" written by the ADEME in 2011. **The data date from 2006 and 2008**.

Used techniques to remediate contaminated soils in France in 2006 and 2008 (**tons of ground**):



Some observations:

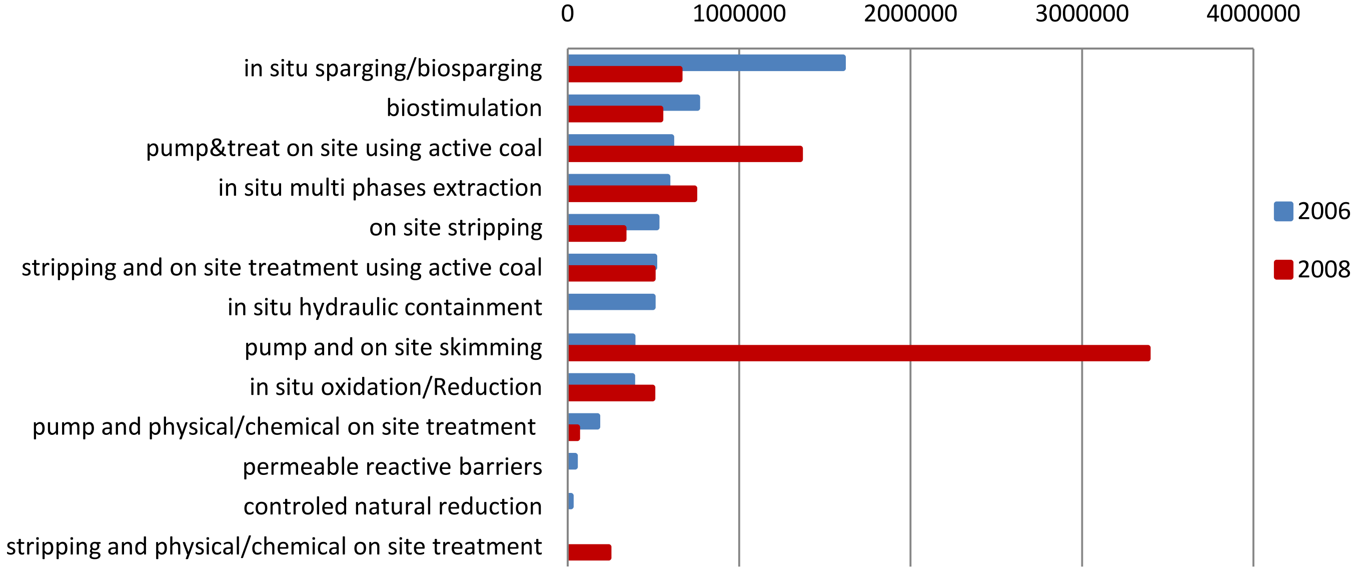
- Biological treatments such as bioventing, biological center, or on site biodegradation are matured. They are well controlled by most of actors and thus widely used.
- Despite of the progression of in situ chemical oxidation in 2008, this technique is less used because of the by-products which are not always controlled.
- Off site techniques are preferentially used because of the rapidity inherent in these techniques. In fact, real estate and media pressures play an important role.
- Weighted average costs for remediation techniques in 2006 and 2008 (price in **€/t without taxes**). These costs have been weighted by tonnage. The price of one ton can in fact be reduced with high tonnage:



The costs include all the services linked to the site work:

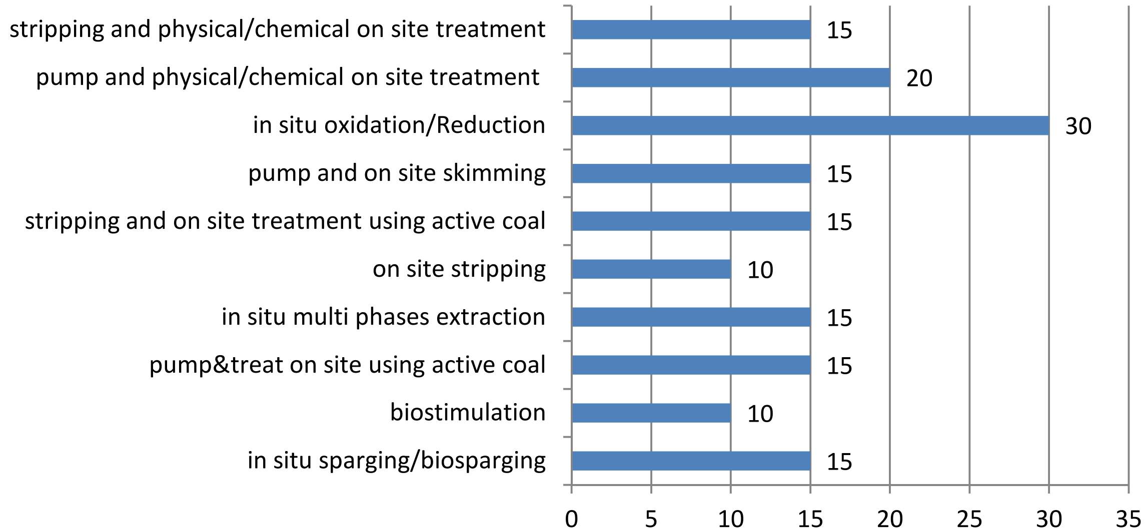
- first phase costs (pilote, implementation of the project: installation of a treatment facility, preparation of the site)
- costs linked to the site: equipment, labour, chemicals, waste removal
- costs linked to studies (except studies prior to site implementation like sanitary risks studies) and monitoring of pollution: analysis, report writing, meetings on the site.

The techniques used to treat groundwater contaminations in 2006 and 2008 are (volumes in **m^3 of groundwater**):



In 2006, 64% of cases were treated in situ whereas in 2008 71% of cases were treated on site. Treatments such as Pump&Treat are widely used.

The treatment costs for the years 2006 and 2008 are presented below. These prices include the cost of pumping (in **€/m^3 without taxes**):



Some observations:

- The most expensive technique was chemical oxidation/reduction because of the large demand in chemicals and several campaigns are sometimes useful to remove contaminants.
- Pump and physical/chemical on site treatment is also expensive because of the costs of chemicals.
- Biostimulation and stripping are most cheap techniques because there is no pumping costs and biological substrates are cheap.

Annex 2 Detailed reports international remediation approach

Brazil, overview of approach of contaminated soils in the state of São Paulo

Table of contents

1 Policy

1.1 State policy São Paulo

A national specific legislation doesn't exist in Brazil, but the State of São Paulo, which is of high concern about contaminated sites, has developed guidelines and state policy. In this paragraph we will therefore give a brief summary of some aspects of the approach of soil contamination in the state of São Paulo.

1.2 Stakeholders

- MMA: Ministério de Meio Ambiente (ministry of environment)
- National Environmental Council CONAMA
- Government of the state of São Paulo, Secretaria do Meio Ambiente
- CETESB: environmental Company of the state of São Paulo (= environmental agency of the state). This is the institution that by law is in charge, among other assignments, of enforcing
  - Established by the Decree 50079 of July 24, 1968 as the Technological Center of Sanitation.
  - The mission of the CETESB is to improve and assure the quality of São Paulo state's environment in order to achieve social and economic sustainable development. Its tasks are: work on waste control and waste minimization, environmental permitting, enforce regulations, control and monitoring.
  - The delivery of environmental licensing is based on the following criteria: the processes used by the facility, the techniques that avoid the release of pollutants, and a health risk assessment for the source of pollution.
- administrative policies for environmental issues throughout the entire State of São Paulo, as established by Laws no. 118/73 and no. 997/76.
- Technical Cooperation Society (GTZ: Deutsche Gesellschaft für
- Technische Zusammenarbeit) : cooperation with germany since the beginning of the nineties. Technical and financial support.
- VIGISOLO program: program of the Federal Health Ministry, which carries on public health related to contaminated sites
- Secretaries of Health and Water Resources: fixation of quality standards for water and human health exposition. They act as advisors to the State Environmental Agencies.
- RELASC: Latin American prevention and control on soil and groundwater contamination network

1.3 Number of polluted sites

State of São Paulo has 3675 contaminated sites since the year of 2002. The reason of this number would be the high number of industries that shut their doors, that is not reused and which critically affect the environment.

Region	Activities					
	Commercial	Industrial	Residues	Gas Stations	Accidents	Total
São Paulo	39	114	28	1.004	5	1.190
São Paulo Metropolitan Region - others	29	125	20	419	6	599
Country Side	60	158	40	1.105	12	1.375
Coastal Area	15	40	21	223	1	300
Paraíba Valey	4	34	1	171	1	211
Total	147	471	110	2.922	25	3.675

Contaminated sites in São Paulo, Brazil. December 2011

1.4 Legislation

- On July 2009, the State of São Paulo approved a public policy where the legal framework and main regulatory aspects are established;
- The Brazilian Federal Constitution:
  - Article 24,I and IV: environmental problems should be fought by the Union, States, Federal districts and Municipalities.
  - Article 24, VI: the ability to legislate about the natural resources, soil protection, natural protection and pollution control is given to the Union, States and Federal Districts. The Municipalities however have the duty to enforce controls.
- 2000: Executive Acts n.007 and n.023
- 2007: new Executive Act n.103: Methodology to manage contaminated sites: rehabilitation for future use, legal responsibilities for the contaminated site management, technical studies to be made in order to identify and delimit the contamination, emergency actions to be undertaken, remediation techniques, institutional and engineering control measures, monitoring deadlines and communication procedures towards governmental entities (such as the state health department and the municipalities, amongst others).
- 2009: State Act CETESB : The Act n. 13.577/2009
  6 chapters:
  i) general provisions (including the object, objectives, technical definitions and measures),
  ii) soil contamination prevention and control,
  iii) contaminated site (divided in responsibilities, identification and remediation),
  iv) economical tools,
  v) infractions and penalties and
  vi) general provisions.

  The general objective of this text is the sustainable soil use, by
  i. preventive measures, including the protection of soil and underground water natural properties;
  ii. corrective measures including procedures for contaminated sites identification, protection of the health and safety of the population exposed to the contamination; remediation
  iii. incentive measures for the reuse of remediated sites;
  iv. promotion of exchange programs among institutions;
  v. guarantee to information and to participation by the population affected by decisions related with the contaminated areas.

1.5 Tools

- Contaminated site registration
- Database contains following information:
  - potentially pollutant activities and enterprises;
  - which, in the past, had promoted activities liable to provoke soil contamination;
  - which are under contamination suspicion
  - any other applicable cases. This information is published in the State of São Paulo Official Gazette and on the State of São Paulo Environment Department website.
- Licenses: they are delivered by the administration to the facilities which need special watch, like facilities that use natural resources, which may pollute, or cause any environmental degradation. There are three kinds of licenses:
  - Preliminary License: it is accorded during the planning phase, before the installation of the buildings. It approves or not the location, conception and environmental viability.
  - License for installation: allows the installation depending on the preliminary approval
  - License for Operation: authorizes the operation of the undertaking's installation. This license enables environmental pollution prevention by checking if the activities will contaminate the soil or the waters. For example it can be required in the license to have an appropriate disposal of chemicals that are stored.
- Deactivation Plan: When a facility closes or stops its activity, the entity legally responsible for undertakings must inform the competent state agency. The Deactivation Plan consists of contemplating the environmental conditions which are resulting of the past activities of the facility. If there is a contamination, the plan must give information about how to remediate it.

- The Master Plan, approves if a construction can be undertaken, or if the land can be parceled or any other land use regarding to the state of the land. It takes into account if the site is contaminated and how much it is. The land use policy and the Master Plan is executed by the municipalities. In fact in addition to protect the environment and fight against local pollution, they must promote the land use, carry on all administrative procedures for this issue and if necessary, restrict the land use.
- Criteria Values: The environmental legislation has set up quality values for the environment and standards for emission but there are guideline values for the soil. The values in rules are those published by the CETESB in 2005, in the Executive Act n. 195/2005/E. These values are used to know whether a soil is legally contaminated or not. They are part of the soil and groundwater management as a tool.
    - Quality reference Value: concentration of a substance in soil and groundwater, which defines a ground as clean, or the natural quality of groundwater
    - Prevention Value: concentration of a substance above which adverse changes may occur to the quality of soil and groundwater ; a monitoring is necessary
    - Intervention Value: concentration of a substance above which there are potential direct and indirect risks to human health, an intervention is needed to stop the contamination
- Funding: A State Fund for the Prevention and Remediation of Contaminated Sites (FEPRAC) was created by the Environment Department of the State of São Paulo to protect the soil and help funding identification and remediation of contaminated sites. The resources come from international aid, cooperation and intergovernmental agreements, donations, environmental compensation from polluting activities. The amount of the compensation is determined by the environmental agency in the framework of the licensing.
- Responsible in case of pollution: According to the Act, the responsible can be:
    - the one that caused the contamination or
    - its successor (the responsibility of the contamination is transmitted during the sale of the polluted land) or
    - the owner of the area or
    - the holder of the rights of the ground or
    - whoever benefits directly or indirectly from the ground

  A concept of solidarity is applied, consisting of the funding of the remediation from all the people together mentioned before.

2 Soil management process

2.1 Stepwise approach

There are three steps in the soil management process:

- Identification process.
- Registration in the database of contaminated soil/*cadastro.* Any contaminated site must be registered in the real state registration, so that any future owner is aware of the state of the site.
- Rehabilitation.

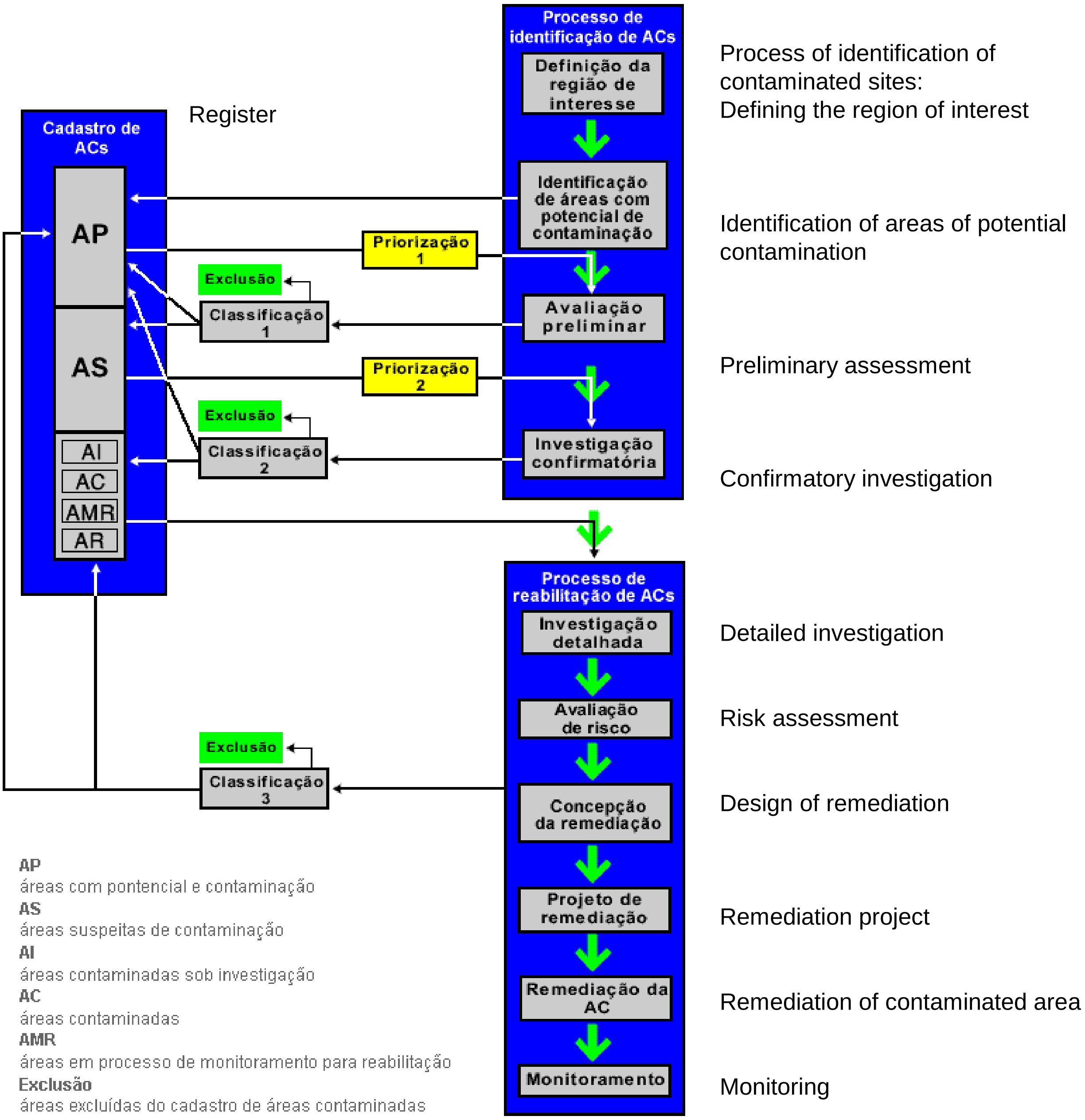


Figure 1 Contaminated land management process

Explanation abbreviations Register:
Area with potential for contamination (AP): area, terrain, location, installation, building or improvement where the activities developed accumulate quantities or concentrations of matter under conditions that can contaminate the soil.

Suspected area of contamination (AS): area, terrain, location, installation, building or improvement with an indication that it contaminates area**.**
Contaminated area under investigation (AI): area, terrain, location, installation, building or improvement where there is proven contamination and in research of confirmation. The procedures performed aim to determine the extent contamination and to identify the existence of possible recipients, and to check if there is a risk to human health. The area is also classified as an area contaminated under investigation (AI), when finding of:

I - contaminants in soil and groundwater at concentrations above the Intervention Values;
II **-** free phase product, from the area;
III - substances, conditions or situations that, according to specific parameters, could pose a hazard.

Contaminated area (CA): area, terrain, location, installation, construction or improvement, formerly classified as contaminated area under investigation **(IA)** in which, after performing **a risk assessment,** quantities or concentrations of matter were observed that cause or may cause harm to human health.
Area in the monitoring process for rehabilitation (AMR): area, terrain, location, installation, construction or improvement, previously classified as contaminated **(AC)** or contaminated under investigation **(AI),** where intervention measures were implemented and the goals set for the remediation were achieved, or if the **risk assessment** indicated that there is no need to implement any type of intervention and the area is considered suitable for the stated use, being ongoing **monitoring for closure.**
Area rehabilitated for use stated (AR): area, terrain, location, installation, building or improvement, previously classified as area monitoring process for rehabilitation **(AMR)** that after the completion of **monitoring for closure** is considered suitable for the stated use.

2.2 Methodology to identify contaminated sites

The identification is carried by the CETESB. The methodology begins with detection of trace of contamination in a region of interest, using SIPOL which is the System Source of Pollution (*Sistema de Fontes de Poluição*).

The identification of the sites must be done by the local environmental agencies, which can possess useful information like aerial photography, complaints of the people, or other data about the presence of potential contaminating or hazardous activities. Information are summarized into a map which contains the location or region of interest, the topography, the soil and land use, the groundwater tables, protected area, etcetera .

The CETESB defined hazardous activities as:

- Existence of processes that may cause contamination of soil and groundwater;
- Presence of substances that have the potential to cause damage to soil and groundwater;
- Industrial and commercial activities with a past of handling, storage and improper disposal of raw material, products and waste;
- Industrial and commercial activities where leaks and accidents have already happened;
- Industrial activities and trade which have already generated AS and CA.

2.2.1 Prioritization

This step must be done before the preliminary assessment and the confirming investigation and after the identification of potentially contaminated area. The prioritization is based on the assets or area to protect. There are three levels of prioritization.

- Prioritization 1: the organs of the government in the region of interest can choose their criteria of prioritization. For example, if there are surface waters to protect in a given region, the APs to be prioritized are those situated next to the watersheds.
- The second stage of prioritization occurs after the preliminary assessment and aims to prioritize the sites which must be investigated for the confirming investigation. A scoring system is used to give sites higher priorities. Information acquired during the preliminary assessment are used to fill in a scoring sheet. A scoring is assigned to each area regarding the risk of environmental and/or health damages, the kind of contamination and the transport routes. The scoring system Nordrhein-Westfalen. State in Germany is used.
- The third stage of prioritization is undertaken during the process of rehabilitation before the detailed investigation, using a scoring sheet too based on technical criteria.

The scoring sheet

The principle of the scoring sheet is to give a scoring to contamination cases, to prioritize them, according to the characteristics of the source, the substances, pathways of spreading and assets to protect existing or potential.

There are four main criteria called *Critério Principal*:

- Main criteria 1: General information about the area: There is a distinction between the fact that the contamination comes from a disposal waste or an industrial/commercial area or other. The information to fill in are the type and the volume or size of the area.
- Main criteria 2: Waste / Substances; This part aims to characterize the risk according to the type of substances.
- Main criteria 3: Land cover / protect areas with goods; This criterion adds the components "use of the soil" and "goods to protect" to the calculation of the risk level.
- Main criteria 4: Propagation; This criterion is about the possible spreading of the contaminats to the air, groundwater, surface water, or further in the soil.

The scoring sheet is built as following:

(FC)	R	BP1	BP2	BP3	BP4	BP5	BP6							
Resp. 1	3													
Resp.2	2													
Resp.3	1													
Resp.4	0													
Resp.n														
Val. max.		Rmx 1	Rmx 2	Rmx 3	Rmx 4	Rmx 5	Rmx 6	M	C1	C2	C3	C4	C5	C6

The first column corresponds to the possible answers that could be given in the Registration Form. For example, for the Main Criterion 1 it is the kind of contamination: mining, energy, chemicals, pharmaceuticals, electrical and electronic equipment, production and processing of metal.

The second column is the degree of influence on the risk of each response, it's the contribution of each response of the global risk. If the risk is low, the manager should fill in the number 1, medium 2 and high 3, 0 when there is no influence. The following columns (BP1, BP2…) represent the goods to protect in the region of interest (*Bem a proteger* BP):

- BP1 - Life and health of the population (direct impact);
- BP2 - Supply of drinking water;
- BP3 – Land use residential and gardens;
- BP4 - Water (underground and surface);
- BP5 - Use of agricultural land or livestock;
- BP6 – Other assets to be protected (public, ecological, etc.)

Each response should be given a grade according to the influence they have on the risk of damaging the goods. The maximal value of each column must be reported in the last row. In the ninth column, M is the relative weight the manager wants to give to the main criteria. By multiplying each maximal values (R) by M, the value C is obtained, which is the portion of the risk obtained by the influence of each item (C = M x R).

Then, all the C values of the sub-criteria must be added to give the C values of the main criteria ($CP1=C1_a + C1_b$; $CP2=C2$; $CP3= C3_a + C3_b$; $CP4=C4_a+C4_b+C4_c+C4_d$).

Finally, the total scoring of the risk for each asset to be protected is given by:

$$P = (CP1 + CP2) \times CP3 \times CP4$$

The maximum level of the risk of damages towards the assets to protect (P) is 1000.

2.2.2 Preliminary Assessment

The purpose of the preliminary assessment is to realize a diagnosis of the potential contamination based on the information gathered during the previous phases of the identification process. A conceptual model is even recommended that must be updated during the whole process of management. The preliminary assessment also contains:

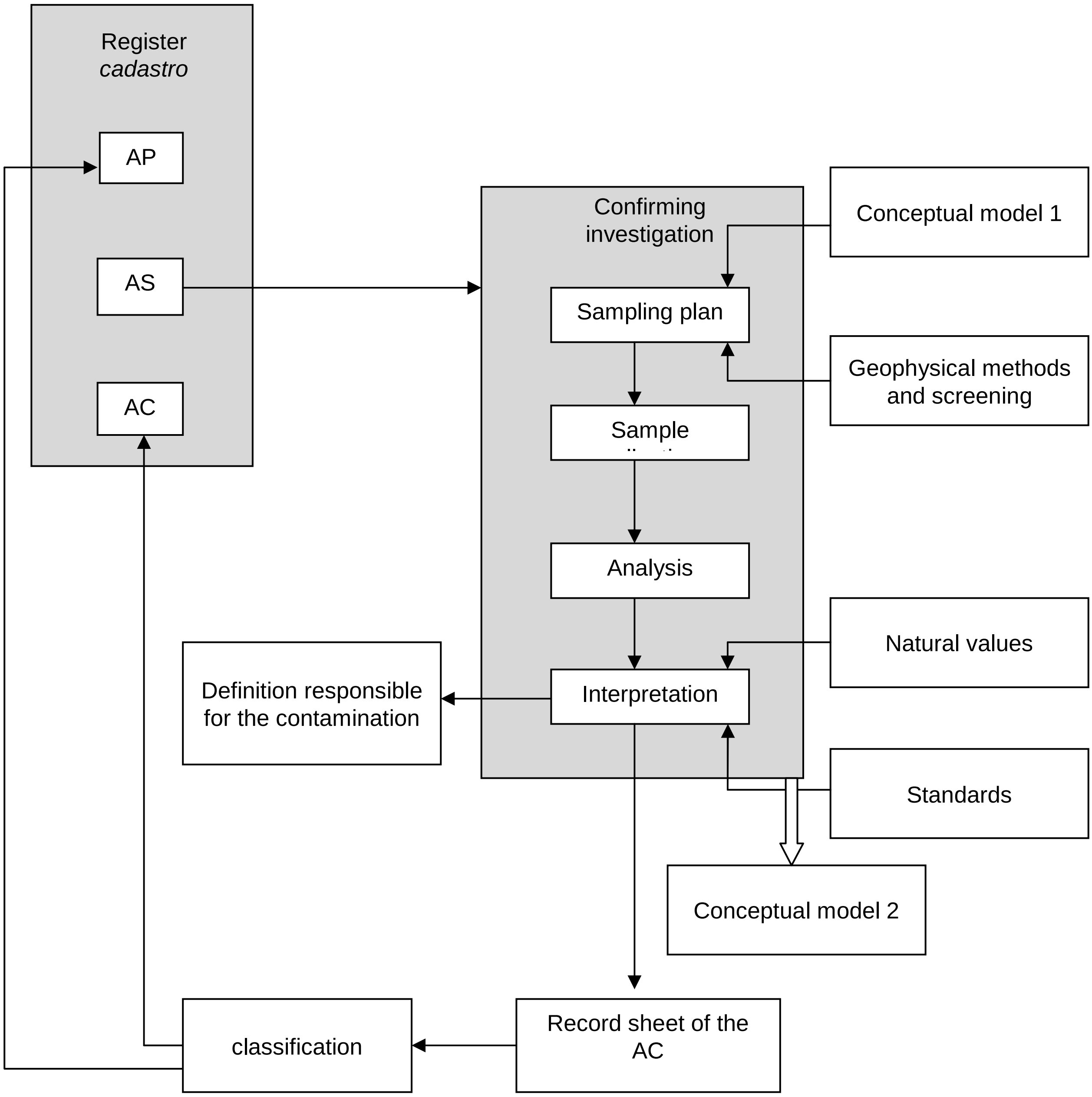
- a historical study: this task is defined by the CETESB as an interdisciplinary task because it requires historical and social, urban and administrative knowledge but also knowledge about chemical industrial processes and environment in general.

- A study on the physical routes: it is about the transported routes and the localization of the targets that can be exposed and about geological data (hydrogeology, hydrology, geomorphology, meteorology). These data can be obtained from the university, the organizations of environmental control and planning, research institution, water supply companies, companies of drilling.

2.2.3 Confirming investigation

To confirm or infirm the presence of contamination in the soil, samples and analysis of the soil and groundwater must be taken in strategic points. The results must then be compared with the standards established by the organism responsible for managing the soil in the contaminated area.
If the area is contaminated, it is classified as Contaminated Area (CA) with the obligation of cleaning the site. If not, it still is classified as Potentially Contaminated area (PA). The process of the confirming investigation is illustrated with next figure.

The sampling plan takes into account the type of contaminant, the means of transportation and the receptors. The step of confirming investigation doesn't aim to know in details the contaminant but to find greater concentrations than the limit standards. Thus, it's not necessary to sample every compartment of the soil (like soil sediments, soil gas, rocks,…) but the area where contaminant will most likely concentrate. For example if the suspected contamination is a leak of a fuel storage tank, samples are more relevant to be taken at the groundwater surface.



2.3 Registration

During the process of site identification and site remediation, the contaminated area can be classified as AP (Area with Potential contamination), AS (Suspected area of contamination), AI (Contaminated area under investigation), AMR (Area in the monitoring process for rehabilitation), AR (Area rehabilitated). All the information obtained at each stage of the management must be notified in the **register of contaminated area** (*cadastro de áreas contaminadas*).

The registration consists of a physical registration and a computerized registration. The physical registration must contain all the information available about the site like files or maps and the computerized system comprises a database that can be linked to a Geographic System of Information, aiming to visualize the area of interests and other information (region of interest, urban area, traffic routes, geology, hydrology, protected area and/or legal restrictions, location of supply wells, depth of underground water, perimeter protection wells, land use and locations of the APs and CAs, ASs.).
The data entered in the database are:

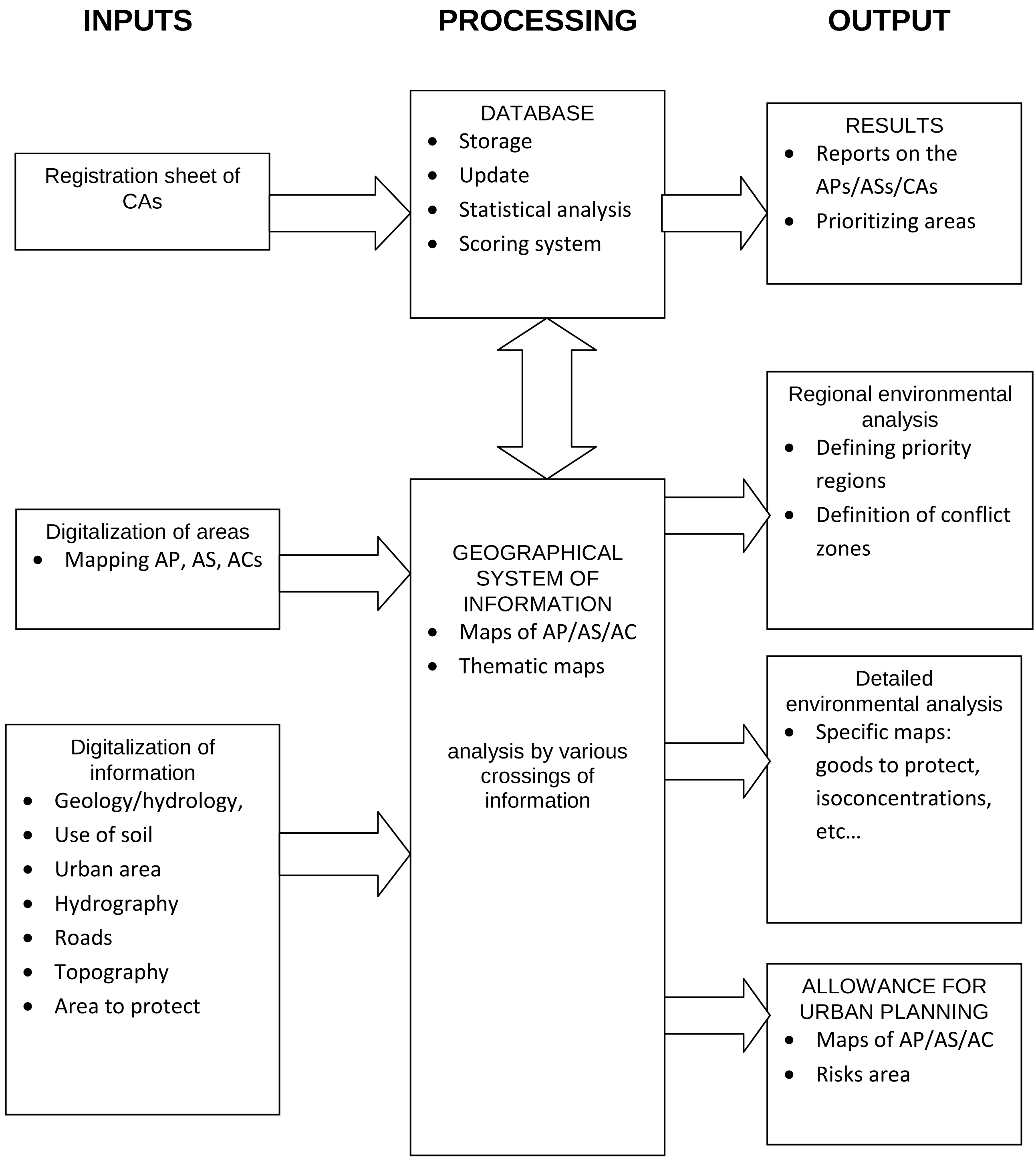
- name of the place;
- location (coordinates, address);

- activity developed or developing;
- suspected sources of contamination;
- area / volume approximately;
- likely contaminants;
- targets to protect;
- evidence of contamination;
- transport routes of potential contaminants.

In the case of contaminated areas (CA), the following information are registered:

- form of evidence of contamination;
- contaminants identified;
- means of transport of the contaminants;
- property affected;
- responsible for contamination;
- actions taken or to be developed in the area

The following scheme represents the treatment of information and the results:



2.4 *Rehabilitation; focus on investigation and assessment*

The process of rehabilitation of contaminated sites has 6 phases:

- detailed investigation;
- risk assessment;
- design of remediation;
- remediation project;
- remediation of the contaminated area,
- monitoring

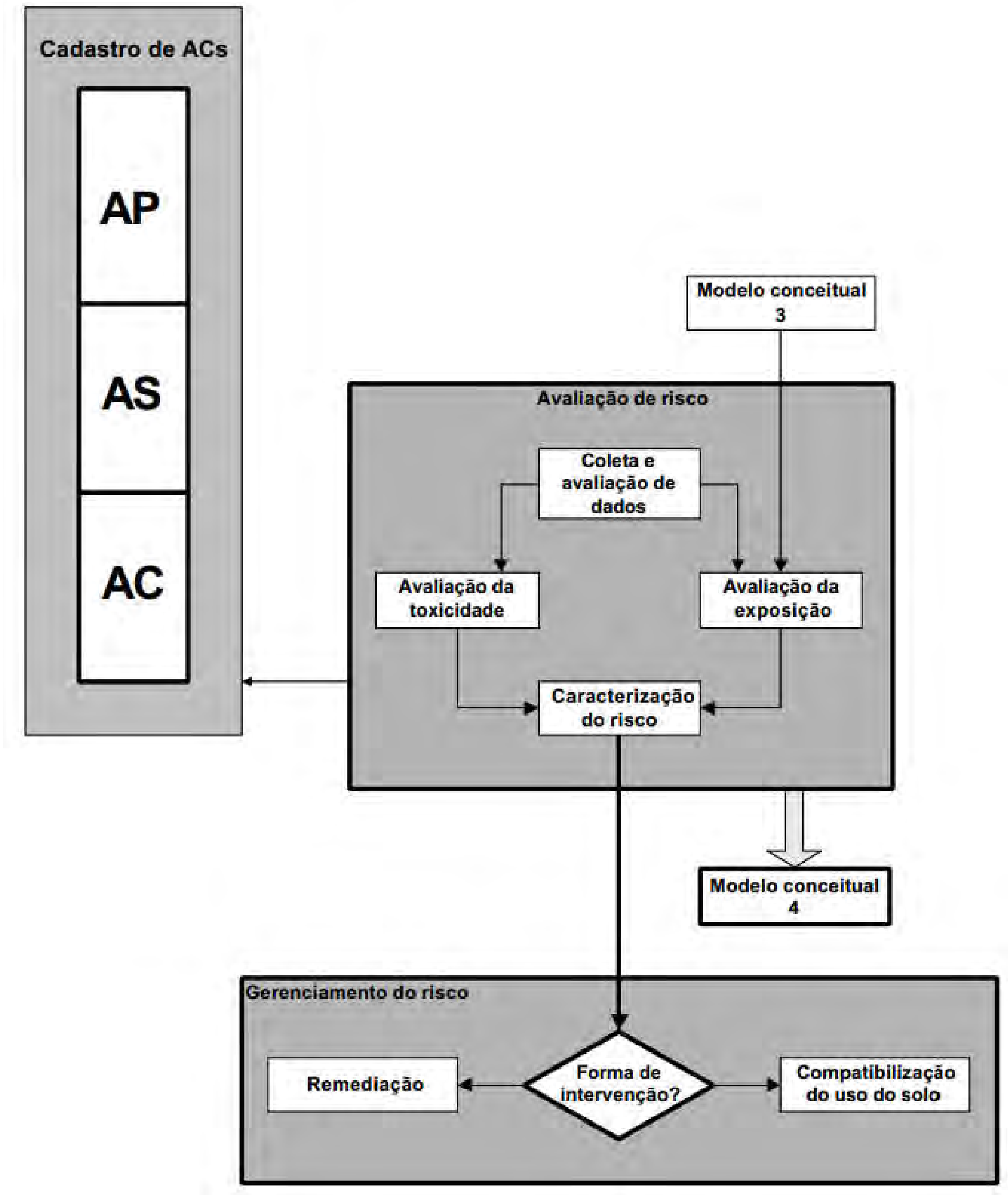
2.4.1 Detailed investigation

The purpose of this step is to measure the contamination (volume, extend, substance, concentration), the characteristics of the soil (geology, hydrogeology), the evolution of contamination, the exposure pathways and the receptors. The detailed investigation aims to collect information as an input for the risk assessment. The detailed investigation must follow this methodology:

- Research plan. It contains two aspects of research:
  - Infrastructure plan: this plan must contain the administrative authorizations, the schedule of the activities and the budget management as well as the measures to protect the worker's health and the security plans.
  - Plan for data collection in the contaminated area: this plan must provide the area to consider, the means to sample, the information to find, the number and location of sampling points, the number of sampling campaigns. Contrarily to the confirming investigation, in this step, the sampling is more exhaustive. Samples are taken in all area were contamination might be: soils, sediments, rocks, landfills, groundwater, surface water, waters of unsaturated zone (ground), the gas of the soil, waste, parts of buildings (walls, floors), dust, animals, plants and food. The aim of collecting data is to know the physical properties of the contamination, the process of transportation, the limits of the source(s), distribution of the contaminant in the different phases of the soil. Several strategies of sampling can be used. A grid can be used to sample the area. The space to consider between two sampling wells depends on the geological/hydrogeological characteristic of the soil. Sampling points have to be placed also by considering the information obtained during the previous phases. It is the direct strategy. A random disposition of the sampling wells can also be used. The sampling campaigns depends on the speed of propagation of the contaminant in the considered media.
- Data collection
  There are various types of technique to sample, depending on the type of information required. For example to evaluate the flow of the groundwater contamination various type of monitoring wells are used. To assess the concentration of the contaminant in the unsaturated zone, lysimeters can be used.
- Interpretation of the results
  The data collected are then entered in a mathematical model of flow and transportation of the contamination in the environment. The conceptual model has to be updated after the detailed investigation. The models widely used are Aquifem, 3DFEMFAT, Femwater, Flownet / Trans, GMS (Groundwater Modeling System), Micro-Fem, MOC, MOCDense, MODFLOW, MODPATH, MT3D, RT3D, Visual Moddflow.

2.4.2 Risk Assessment

The main objective of the risk assessment is to identify and quantify the health risks arising from the contaminant. The environment is also considered depending on the situation. The risk assessment follows the methodology set up by the US EPA. Next figure give the steps in the risk assessment process.



a. Data collection
The data collection is done taking into account the data already collected and the parameters needed for the mathematical model. The data must provide information about:
- the behavior of contaminant in the physical environment
- profile of contaminants
- concentration of contaminant
- characterization of the source (size, distribution)
- Information about the physical environment , that may affect the transport , the natural attenuation or the persistence of the contaminant.

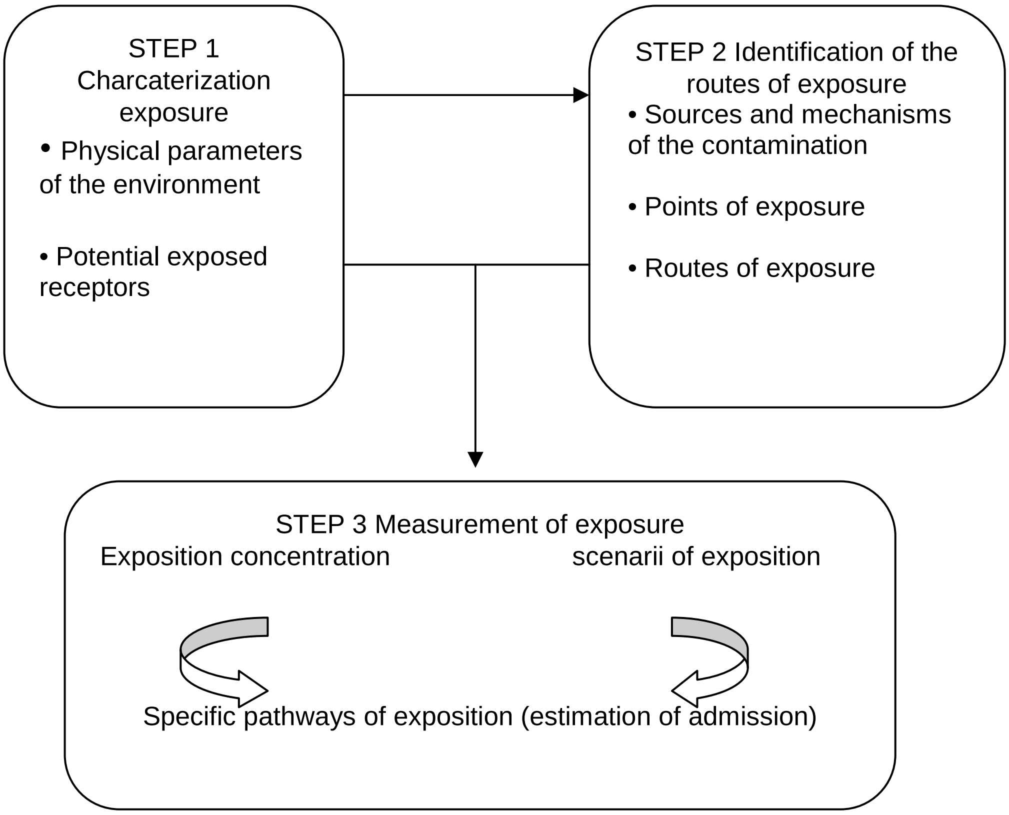
Some of these data can be found in reports from the previous steps. With these data, the conceptual model is updated.

b. Identification of human exposure
Supplement sampling can be necessary to determine the exposure and the conceptual model is determinant to guide the additional sampling campaigns. In fact, the areas of interests are:
- the limits of the contaminated area, near the sources of contamination

- the limits of the contaminated area between the sources and the receptors
- the points of exposure outside the boundaries of the contaminated area
- outside the contaminated area, between the source and the points of exposure.

The exposure pathways that are considered are:
- intra media: the contamination passes through one single medium before reaching the receptor.
- inter media: the contamination passes through several media before reaching the receptors (for example soil and air or soil and groundwater). For this last category, the concentration at the exposure point is estimated by mathematical models.

c. Exposure assessment
The purpose of the exposure assessment is to determine the type and the magnitude of the exposure. The quantification of exposure is divided in three steps:
- Characterization of exposure
- Identification of exposure pathways
- Quantification of exposure



Characterization of exposure

The aim of the characterization of the exposure is to analyze the collected data and to characterize the physical environment and the potentially exposed population inside and outside the area of contamination. To characterize the environment, a survey of the contaminated area is done (climate, vegetation, hydrogeology, geology), with an additional radius of 300m around the contaminated area and an additional radius of 1000m in case of the contaminant spreads in the air. The characterization of the population considers the use and occupation of the land, the position of the individual relative to the contamination, the frequency and the density of the population, and the presence of underground facilities like gas/water supply facilities. This information is essential to determine the exposure parameters: the period in which the population is exposed, if the exposure occurs inside or outside, the form and frequency of exposure.

Identification of exposure pathways

In this step, all pathways that could expose the population to contamination are described. The pathways depend on:

- the type of contamination: on which will depend the mechanism and the behavior in the soil
- environment where they are
- points of exhibition

The exposure routes linked to contaminated groundwater are: ingestion of groundwater or surface water used for consumption; ingestion of surface water during swimming / recreation; dermal contact with groundwater or surface water.

For the identification of the pathways, it is needed to know the source of contamination and also the transportation and natural attenuation. Transportations are modelized in order to have a better understanding. A series of physical and chemical parameters about the substances are therefore needed: partition coefficient between organic carbon and water, Water solubility of the contaminant(s), Henry's Law constant (H); Vapor Pressure (Pv), etc. It is also important ton determine the points of exposure as well as the points of entry to the organism. Three means of entry are considered: inhalation, ingestion, dermal contact.

Quantification of exposure

The quantification of exposure is made in two steps. First the calculation of the concentration to which the population is exposed, and then the calculation of the intake dose. The concentration of exposure is the concentration of the chemical that will be in contact with an organism during the exposure time. These data can be obtained by monitoring the environment or by mathematical modeling. The exposure rate can be expressed as an average of the exposure rate by time unit, but also by body mass unit. The intake dose is the concentration of the chemical which has potentially entered the body through different pathways. Each pathway is considered separately. It is expressed in terms of amount of the compound which is in contact with the human body per unit of time per kilogram of body weight (example: mg/(kg.day) of vinyl chloride). The calculation of the intake dose is based on the concept of Reasonable Maximal Exposure (*Exposição Máxima Razoável*), which can be defined as the maximal amount of a chemical accepted in a given area. The daily intake is given in this equation:

$$I = C \times \frac{IR \times EF \times ED}{BW \times AT}$$

I: daily intake through a pathway ($mg.kg^{-1}.day^{-1}$)
C: concentration of the contaminant in the area of interest ($mg.L^{-1}$ or $mg.kg^{-1}$).
IR: rate of penetration ($L.day^{-1}$ or $kg.day^{-1}$)
EF: frequency of exposure ($days.year^{-1}$)
ED: duration of exposure (years)
BW: body weight (kg)
AT: period of exposure (days)

The exposure parameters set by the CETESB or the EPA should be realistic parameters that represent the Brazilian conditions. Therefore, the CETESB conducted a literature review to quantify these variables. CETESB has consigned these values in 2001 in a report named “Report on the

Establishment of Guiding Values for Soils and Groundwater in the State of São Paulo" (*Relatório de Estabelecimento de Valores Orientadores para Solos e Águas Subterrâneas no Estado de São Paulo*).

For example the exposure parameters set by the CETESB for contaminated drinking water are: a child spends 5 days a year during 6 years in an industrial area whereas an adult spends 288 days a year during 25 years.

Parameter	source	Industrial area		Residential area		Agricultural area	
		Adult	Child	Adult	Child	Adult	child
IR	CETESB, 2001	1	0,5	1	1	2	1
EF	CETESB, 2001	288	5	365	365	365	365
ED	CETESB, 2001	25	6	24	6	58	6
BW	CETESB, 2001	60	15	60	15	60	15
ATN	US EPA, 1997	12775	12775				
ATC	US EPA, 1997						

Sources:

http://www.cetesb.sp.gov.br/

Contaminated Sites and Public Policies in São Paulo State, Brazil, Ana Luiza Silva Spínola and Arlindo Philippi Jr., School of Public Health, University of São Paulo,Brazil

CETESB presentation during Stockholm Convention for Latin America and the Caribbean Region, Eng Msc. Lady Virginia TraldiMeneses

Contaminated site management and brownfield redevelopment in Latin America, Project Rehabilitación de Áreas Contaminadas para el Desarrollo Sostenible Interno da la Ciudad – REDESC In the frame work of the Urb AL A Program of the European Union, GTZ, São Paulo , April 2007

Annex 2 Detailed reports international remediation approach

Australia

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1 Policy

1.1 Development of policy and legislation

The need for a consistent national approach to the assessment and management of contaminated sites was identified as a priority issue in Australia in September 1990. This was in response to the growing concern of the discovery of contaminated sites in Australia and their environmental and health implications. As part of a national strategy to handle this issue technical guidelines on contaminated sites and a consistent approach to addressing issues associated with financial liability for contaminated sites remediation were developed. In January 1992 the *Guidelines for the Assessment and Management of Contaminated Sites,* developed by the Australian and New Zealand Environment Conservation Council (ANZECC) and the National Health and Medical Research Council (NHMRC), were released. In April 1994 ANZECC released its *Position Paper on Financial Liability for Contaminated Sites Remediation*.

In 1999 the developed guidelines on contaminated sites were replaced by the *National Environment Protection* (*Assessment of Site Contamination) Measure 1999,* a National Environment Protection Measure (NEPM) prepared by the National Environment Protection Council (NEPC) in co-operation with environmental health agencies. NEPMs are formulated to ensure:

- That the people of Australia enjoy equivalent environmental protection; and
- That decisions by businesses are not distorted by variations between jurisdictions in relation to the adoption or implementation of major NEMPs.

The National *Environment Protection (Assessment of Site Contamination) Measure 1999* and *Position Paper on Financial Liability for Contaminated Sites Remediation* are discussed in the following paragraphs.

1.2 National Environment Protection (Assessment of Site Contamination) Measure 1999

1.2.1 Purpose and desired environmental outcome of the measure

The purpose of the Assessment of Site Contamination measure is to establish a nationally consistent approach to the assessment of site contamination to ensure sound environmental management practices by the community which includes regulators, site assessors, environmental auditors, land owners, developers and industry. The desired environmental outcome for this measure is to provide adequate protection of human health and the environment, where site contamination has occurred, through the development of an efficient and effective national approach to the assessment of site contamination.

1.2.2 Assessment of site contamination policy framework

In relation to the assessment of site contamination policy framework the measure outlines several principles that should be observed. It is outlined that the primary responsibility for ensuring the assessment of site contamination rests with the States and Territories, with the exception of sites that are owned by the Commonwealth. Each jurisdiction, which is generally the environmental protection authority of the individual State or Territory, may implement its own regulations and legislation concerning the assessment of site contamination as long as there is a consistent approach to this.

Other principles mentioned in the framework are:

- Prevention of contamination or further contamination;
- Regulatory control of site contamination in relation to use, storage, transport and ultimate disposal of contaminants;
- Planning authorities should ensure a site is suitable for its intended use;
- All relevant information on site contamination should be accessible, without detracting from any obligation of disclosure, to the community;
- The community should be consulted early on in the assessment of contamination if an impact on the community is expected;
- Regard should be given to sites with cultural or spiritual significance;
- Implementation of education programs on site contamination and the prevention hereof;

- Implementation of appropriate occupational health and safety measures during assessment of site contamination and community health assessment and monitoring where there is significant risk exposure to a contaminant;
- Management of on-site and off-site impacts of contamination during assessment of site contamination;
- Use of quality assurance and control procedures in data collection and chemical analyses. Approved standard methods should be performed by accredited laboratories;
- Preliminary assessment of human health risk and ecological risks may be undertaken by comparing levels of contaminants on the site with appropriate investigation levels or by undertaking a site specific risk assessment;
- Specialist areas requiring specialized forms of assessment include sites with unexploded ordnance, radioactive substances, biologically pathogenic materials and waste and contaminated sediments.
- Heritage values should, wherever possible, be assessed prior to any physical assessment of contamination of a site.

1.2.3 Assessing risks

The measure further mentions that the purpose of site assessment is to determine whether site contamination poses an actual or potential risk to human health and the environment, either on or off the site, of sufficient magnitude to warrant remediation appropriate to the current or proposed land use.

To assess the risk, a balance is to be achieved between:
- Optimizing the current or intended use of the site;
- The need to adequately protect human health and the environment.

The broader objective of assessment is to ensure:
- That the people of Australia enjoy the benefit of equivalent protection from air, water and soil pollution where they live;
- That the capacity of the soil is maintained for future generations; and
- That there is consistency of approach between jurisdictions to aid government and business decision making.

1.2.4 Management and cleanup preferences

With regard to the attainment of the desired environmental outcome, the measure mentions that the process of the assessment of site contamination be placed within the context of the broader site assessment and management process.

In assessing the contamination, the site assessor and others should take into account the preferred hierarchy of options for site clean-up and/or management which is outlined as follows:
- If practicable, on-site treatment of the contamination so that it is destroyed or the associated risk is reduced to an acceptable level; and
- Off-site treatment of excavated soil, so that the contamination is destroyed or the associated risk is reduced to an acceptable level, after which soil is returned to the site; or

If the above are not practicable,
- Consolidation and isolation of the soil on site by containment with a properly designed barrier; and
- Removal of contaminated material to an approved site or facility, followed, where necessary, by replacement with appropriate material;

Or,
- Where the assessment indicates remediation would have no net environmental benefit or would have a net adverse environmental effect, implementation of an appropriate management strategy.

The measure does mention that in cases where no readily available or economically feasible method is available for remediation, it may be possible to adopt appropriate regulatory controls or develop other forms of remediation.

1.2.5 Schedules with Guidelines

The measure contains two schedules to be used as guidelines by the individual State or Territory environmental protection authorities. These are:

1. Schedule A: Recommend General Process for Assessment of Site Contamination
2. Schedule B: General Guidelines for the Assessment of Site Contamination.

Schedule A (next figure) identifies the recommended general process for assessment of site contamination in Australia. As can be seen there are two types of investigations, a preliminary investigation and detailed site investigation. The purpose of a preliminary investigation is to identify whether contamination exits on the site. A detailed investigation is required when the results of a preliminary investigation are insufficient to enable site management strategies to be devised. If risk assessment is needed to determine action a risk assessment may need to be completed.

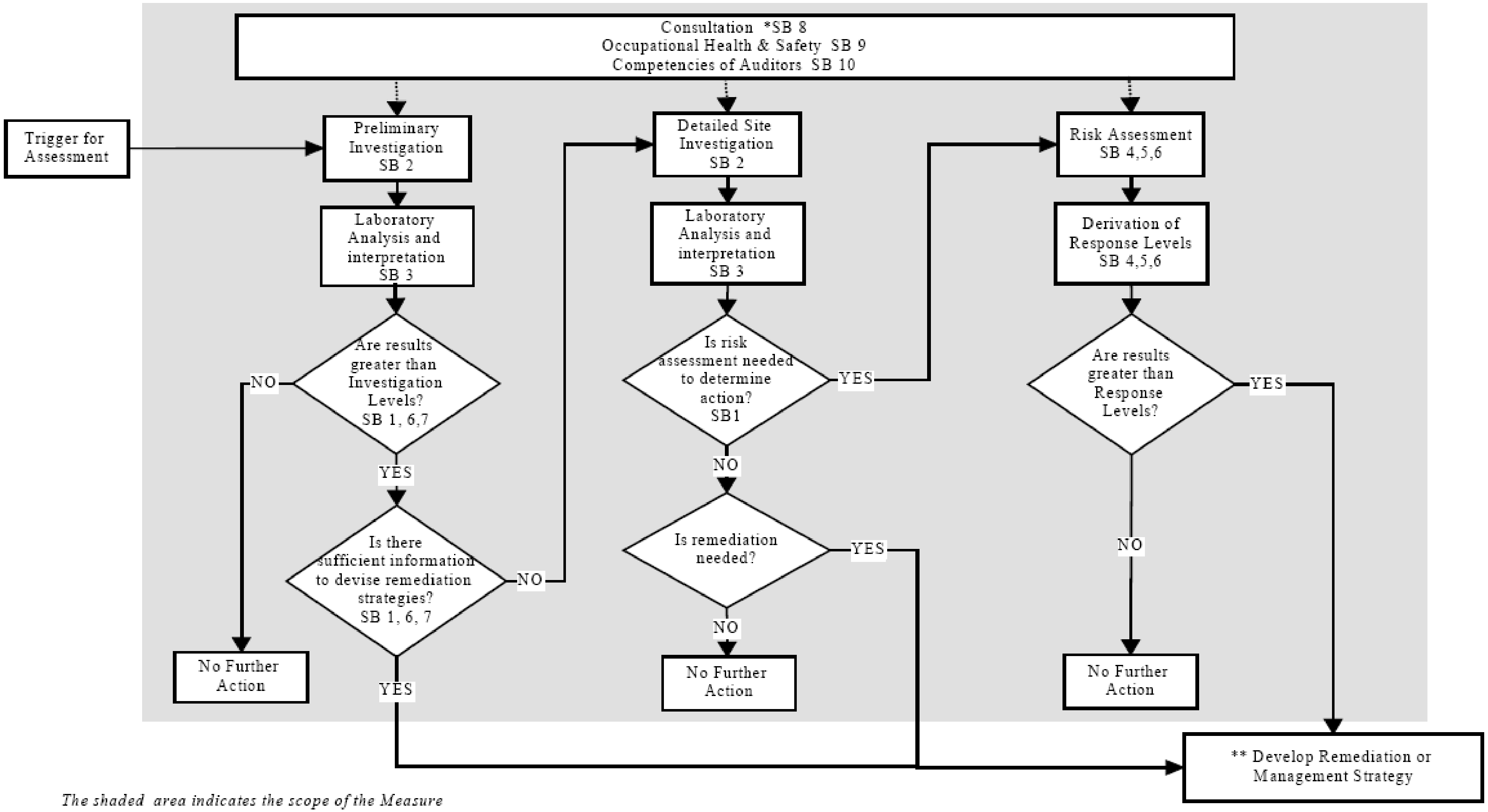
Guidelines have been written for the different stages shown on schedule A. These ten guidelines are included in Schedule B:

1) Guideline on investigation levels for soil and groundwater;
2) Guideline on data collection, sample design and reporting;
3) Guideline on laboratory analysis of potentially contaminated soils;
4) Guideline on health risk assessment methodology;
5) Guideline on ecological risk assessment;
6) Guideline on risk based assessment of groundwater contamination;
7) 7a) Guideline on health bases investigation levels and 7b) Guidelines on exposure scenarios and exposure settings;
8) Guideline on community consultation and risk communication;
9) Guideline on protection of health and the environment during the assessment of site contamination;
10) Guideline on competencies and acceptance of environmental auditors and related professionals.

Guidelines have not been written on what should trigger an assessment or how the remediation or management strategy should be developed.

The position paper presents a nationally consistent approach to the issue of financial liability for remediation of contaminated sites. The paper outlines the use of the “polluter pays principle”. In addition it recommends the use of market forces to achieve the objectives of any contaminated site liability scheme. It is suggested that these forces should be permitted to drive assessment and remediation of sites “without excessive government intervention or administration” (ANZECC 1994)

SCHEDULE A: RECOMMENDED GENERAL PROCESS FOR ASSESSMENT OF SITE CONTAMINATION



The shaded area indicates the scope of the Measure
** SB refers to Schedule B of the Measure*
** * These activities are outside the scope of the Measure*

1.2.6 Investigation levels

Schedule B(1) comprise guidelines on the Investigation Levels for Soil and Groundwater: Investigation levels are commonly Health-based or Ecologically-based (HILs and EILs). Because of Australia's ecological diversity it is proposed that EILs will be developed for regional land use (Regional Ecologically Investigation Levels (REILs)) as required by the relevant jurisdiction.

*An **Investigation Level** is the concentration of a contaminant above which further appropriate investigation and evaluation will be required (ANZECC/NHMRC Guidelines (1992)).*

***Response Level** is the concentration of a contaminant at a specific site based on a site assessment for which some form of response is required to provide an adequate margin of safety to protect public health and/or the environment.*

***HILs** – deriving HILs for soils is a particular example of deriving a guidance value for soil for each contaminant of concern. Guidance values are defined as: - 'values, such as concentrations in air or water, which are derived after appropriate allocation of the Tolerable Intake (TI) among the possible different media of exposure. Combined exposure from all media at the guidance values over a lifetime would be expected to be without appreciable health risk. The aim of a guidance value is to provide quantitative information from risk assessment for risk managers to enable them to make decisions concerning the protection of human health.' (WHO, 1994). Critical steps involved in deriving guidance values are an*

- *Evaluation of toxicity data in animals and humans, and*
- *Setting of tolerable intake (TI) levels based on the toxicity data, and allocation of the proportions of the TI to various exposure media.*

Investigation levels will be determined taking into account:

A. *The bioavailability of a substance. The bioavailability should be assumed to be 100% if specific information is not available;*
B. *The Provisional Tolerable Weekly Intake (PTWI) or Acceptable Daily Intake (ADI) as determined by the World Health Organisation/Food and Agricultural Organisation (1987, 1994), or Guideline Dose (GD) for cancer toxic effects as determined by national health advisory bodies;*
C. *Other potential sources of the substance that comprise a proportion of the PTWI or ADI, or GD (e.g. background levels of the substance in food, water, air; and the amount of exposure through these routes).*

HILs have been set for alternative exposure settings.

***EILs** – Ideally, ecologically-based guidelines will be developed at a regional level and related to land use. This will require the acquisition of data relevant to the regional flora, fauna, soils, climate, etc. It is recognised that the development of regional guidelines (RILs) is a resource intensive process and may not be developed for some time. In the interim, it is proposed that generic EILs are set for urban (comprising city, suburban and industrial areas) land use.*

In the interim, EILs for an urban setting are provided based on considerations of phytotoxicity (copper, chromium, lead) and soil survey data (barium, phosphorus, sulfur) from four Australian capital cities. It is acknowledged that the EILs for an urban setting have not been derived to protect nominated ecological values and are somewhat arbitary.

***GILs** – Groundwater Investigation Levels*
Based on ANZECC Australian Water Quality Guidelines (1992) (AWQG) and the NHMRC/ARMCANZ Australian Drinking Water Guidelines (1996) (ADWG). Guideline values provided define acceptable water quality for various contaminants at the point of use and apply the following settings identified in the framework for groundwater assessment: aquatic ecosystems (fresh and marine), drinking water and agricultural use (stock watering and irrigation).When assessing groundwater contamination the determined values are applied as investigation levels at point of extraction and as response levels at the point of use, or where there is the likelihood of an adverse environmental effect at the point of discharge.

Figure: Soil Investigation Levels (HILs), Schedule B1 - Guideline on investigation levels for soil and groundwater

Table 5-A - Soil Investigation Levels (mg/kg)

Substances	Health Investigation Levels (HILs)						Ecological Investigation Levels (EILs)		Background
	A[1]	B[2]	C[3]	D	E	F	KEIL[4]	Interim Urban	Ranges[5]
METALS/METALLOIDS									
Arsenic (total)	100			400	200	500		20	1 - 50
Barium								300	100 - 3000
Beryllium	20			80	40	100			
Cadmium	20			80	40	100		3	1
Chromium (III)	12%			48%	24%	60%		400	
Chromium (VI)	100			400	200	500		1	
Chromium (Total)									5 - 1000
Cobalt	100			400	200	500			1 - 40
Copper	1000			4000	2000	5000		100	2 - 100
Lead	300			1200	600	1500		600	2 - 200
Manganese	1500			6000	3000	7500		500	850
Methyl mercury	10			40	20	50			
Mercury (inorganic)	15			60	30	75		1	0.03
Nickel	600			2400	600	3000		60	5 - 500
Vanadium								50	20 - 500
Zinc	7000			28000	14000	35000		200	10 - 300
ORGANICS									
Aldrin + Dieldrin	10			40	20	50			
Chlordane	50			200	100	250			
DDT + DDD + DDE	200			800	400	1000			
Heptachlor	10			40	20	50			
Polycyclic aromatic hydrocarbons (PAHs)	20			80	40	100			
Benzo(a)pyrene	1			4	2	5			
Phenol	8500			34000	17000	42500			
PCBs (Total)	10			40	20	50			
Petroleum Hydrocarbon Components (constituents) • >C16 - C35 Aromatics	90			360	180	450			
• >C16 - C35 Aliphatics	5600			22400	11200	28000			
• >C35 Aliphatics	56000			224000	112000	280000			
OTHER									
Boron	3000			12000	6000	15000			
Cyanides (Complexed)	500			2000	1000	2500			
Cyanides (free)	250			1000	500	1250			
Phosphorus								2000	
Sulfur								600	
Sulfate								2000	

1 Human exposure settings based on land use have been established for HILs (see Taylor and Langley 1998). These are:
A. 'Standard' residential with garden/accessible soil (home-grown produce contributing less than 10% of vegetable and fruit intake; no poultry): this category includes children's day-care centres, kindergartens, preschools and primary schools.
B. Residential with substantial vegetable garden (contributing 10% or more of vegetable and fruit intake) and/or poultry providing any egg or poultry meat dietary intake.
C. Residential with substantial vegetable garden (contributing 10% or more of vegetable and fruit intake), poultry excluded.
D. Residential with minimal opportunities for soil access; includes dwellings with fully and permanently paved yard space such as high-rise apartments and flats.
E. Parks, recreational open space and playing fields: includes secondary schools.
F. Commercial/Industrial: includes premises such as shops and offices as well as factories and industrial sites.
(For details on derivation of HILs for human exposure settings based on land use see Schedule B(7a)).

2 Site and contaminant specific: on site sampling is the preferred approach for estimating poultry and plant uptake. Exposure estimates may then be compared to the relevant ADIs, PTWIs and GVs.

3 Site and contaminant specific: on site sampling is the preferred approach for estimating plant uptake. Exposure estimates may then be compared to the relevant ADIs, PTWIs and GVs.

2 Policy Instruments

2.1 Focus on Queensland

As mentioned in paragraph 1.1 regulations and legislation concerning the assessment, management and remediation of contaminated sites may be controlled by the individual State or Territory environmental protection authorities. Overall, as recommended in the *National Environment Protection* (*Assessment of Site Contamination) Measure 1999,* the controls implemented by these jurisdictions are similar to each other. The situation concerning assessment of site contamination in the state Queensland is discussed in this paragraph as an example.

2.2 Registration

In Queensland the Department of Environment and Heritage Protection (DEHP), Queensland Government, is the regulating body regarding contaminated land. The department reviews contaminated site investigations and approves site management plans in addition to providing advice to local government, industry and the community on legislative and technical requirements for contaminated land matters.

The department administers the *Environmental Protection Act 1994* (EP Act). This act emphasizes the management of Queensland's environment within the principles of ecologically sustainable development. The act provides a framework to identify contaminated land and land which has the potential to be contaminated because of past or present landuse. Furthermore, it outlines how contaminated land is managed in Queensland. The use of the act is to prevent health and environmental risks through environmental management of potentially contaminating activities. Listed in the EP Act is a list of activities, named notifiable activities, identified as being likely to cause contamination. Some of these include service stations, cattle dips, tanneries, wood treatment sites, landfills, fuel storage and refuse tips. Based on this list the DEHP maintains two public access registers under the EP Act, namely:

- the Environmental Management Register (EMR), and
- the Contaminated Land Register (CLR).

The EMR registers land that has been or is being used for a notifiable activity, which the department has been notified about. In addition it provides information on whether the land has been contaminated by a hazardous contaminant. Sites recorded on the EMR pose a low risk to human health and the environment under the current land use. Entry on the EMR does not mean the land must be cleaned up or that the current land use must stop. The register does, however, ensure that sites listed on the register are investigated and, where necessary, remediated before a change of use.

The CLR is a register of proven contaminated land that is causing or may cause serious environmental harm. Land is recorded on the CLR when a scientific investigation shows that the land is contaminated and action needs to be taken to remediate or manage it to prevent serious environmental harm or adverse public health risks. Actions might include technical measures to prevent migration, or full removal and off-site treatment.

Land is recorded on the registers via the local government who notify the DEPH of land in their local government area that has been used for a notifiable activity or is contaminated by a hazardous contaminant. The DEPH informs landowners of the notification before land is entered on the EMR and allows them to make a submission regarding the property's notification and any other information. Landowners and occupiers also have responsibilities to notify the department when they become aware their land has been or is being used for a notifiable activity or contaminated by a hazardous contaminant. Next figure outlines the process of entering land on the registers.

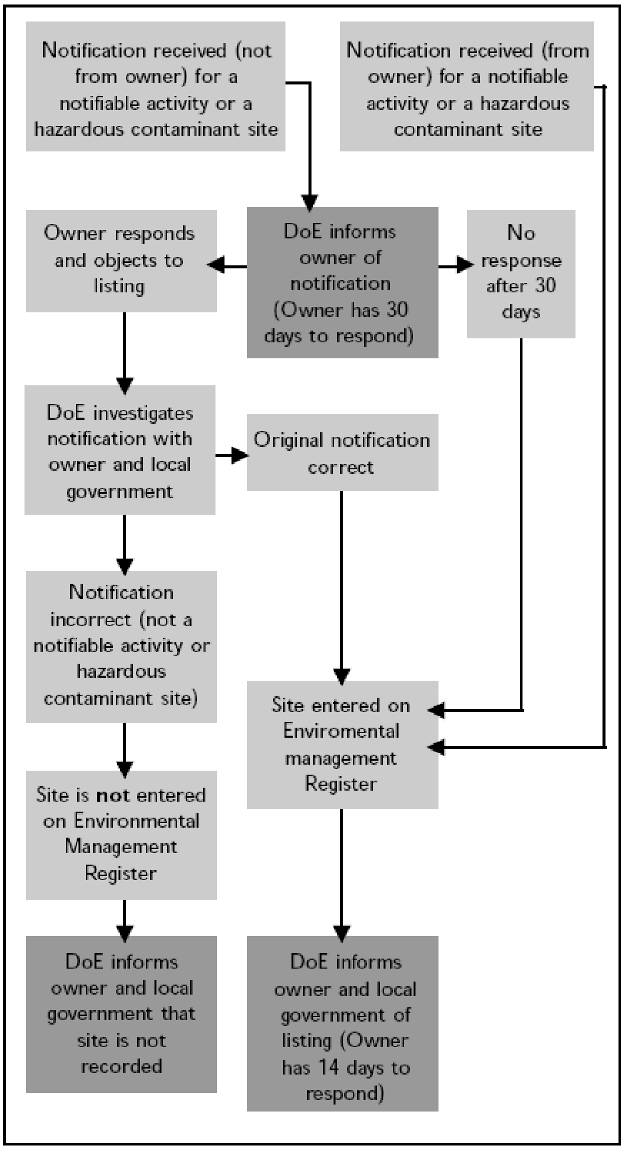


Figure 5.1. Notification and registration procedures for recording land on the EMR and CLR.

A search of the registers forms part of the process of transferring a legal title of property from one person to another. In addition a search of the registers may also be required if the land is to be developed or changed in use. When an application is made for a change in land use or reconfiguration of lot land recorded on either register the land may need to be investigated and assessed. Land not registered on the EMR or CLR may also need to be investigated if either of the above mentioned applications are made. This is usually the case if

- the existing use of the land, or if the land is vacant land with no existing use, the most recent use of the land was for a notifiable activity under the EP Act;
- the proposed use of the land is for residential, recreational, educational, childcare or similar purposes and the existing or immediately preceding use of the land is or was for industrial activity;
- the land is wholly or partly within an area for which an Area Management Advice for industrial activity or natural mineralization has been issued and the proposed use of the land is for residential, recreational, educational, childcare or similar purposes;
- the land is wholly or partly within an area for which an Area Management Advice for UXO (unexploded ordnance) has been issued.

In order to remove land from the EMR, information must be provided to the department that a notifiable activity has not occurred on the site, or the land has not been contaminated. To determine if the land has not been contaminated the land can be investigated by a consultant of a prescribed organization. The consultant prepares a site investigation report to be submitted and approved by the DEHP.

Regarding the removal of a site from the CLR, the land must be remediated and a site investigation report submitted to the department for approval that the land is no longer a risk to the environment or public health before it can be removed. Where a site management plan (SMP) exists for the land to manage the contamination so it no longer causes environmental harm or poses a risk to human health the land may be moved from the CLR to the EMR.

2.3 Staged assessment and remediation process

The Draft guidelines for the Assessment and Management of Contaminated Land for Queensland (1998) describe a following staged process, illustrated with next figure. This process is based on ANZECC/NHMRC Guidelines. The process emphasises the site-specific nature of contaminated land assessment and remediation.

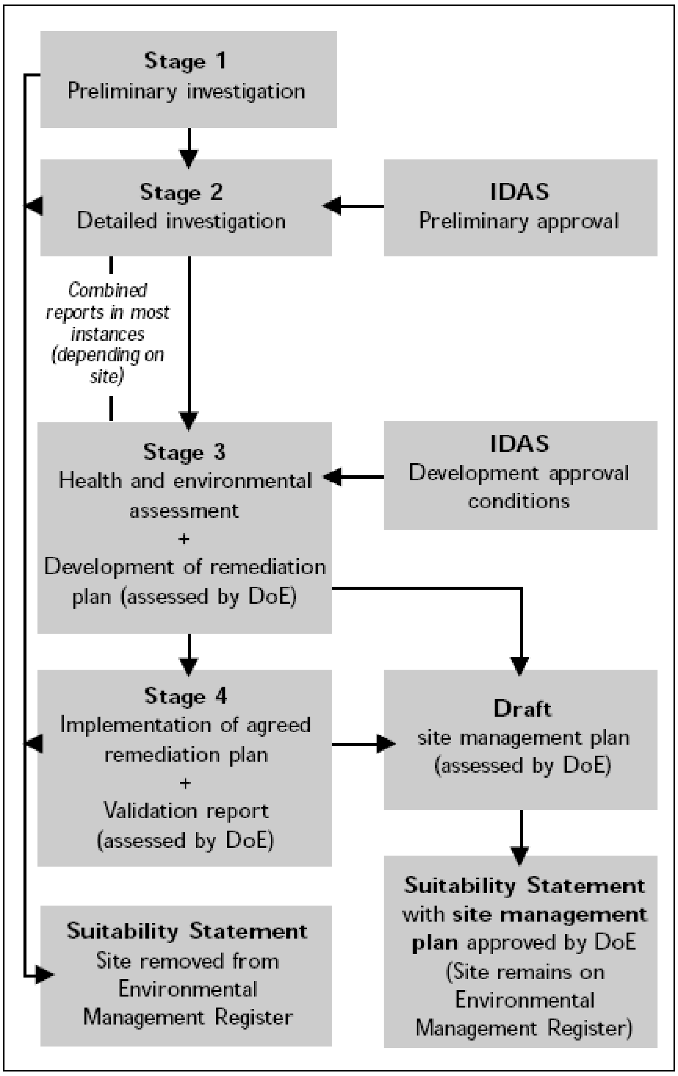


Figure 6.1. Staged assessment and site investigation process

2.3.1 Remediation program

A remediation plan must be prepared when the results of a contaminated site investigation indicate that some remediation is required before the land would be suitable for the current or proposed use.

The plan must include the following information:

- remediation goal;
- extent of remediation required, including areas off-site which have been affected;
- discussion of possible remedial options and how risk can be reduced;
- rationale for the selection of the recommended remedial strategy;
- extent (if any) of public consultation and local nuisance abatement required before and during remediation;
- plans to protect health and the environment during remediation, including health and safety considerations;
- proposed validation sampling plan;
- outline of a site management plan if a partial remediation is proposed; and
- timeframes for implementation (including submission of validation report).

A polluter is also held responsible for remediating any off-site impacts caused by his or her site. Therefore, the remediation plan should incorporate the strategy and timeframes for remediating off-site contamination and include discussions of the impact of the works on the neighbouring owners and operators.

An application for a disposal permit must be included in the remediation plan if off-site disposal of contaminated soil is proposed.

The DEPH must approve of the remediation plan before remediation of the site may start. After the remediation plan has been implemented a validation report, proving the site is no longer no longer a risk to the environment or public health, must be presented to the DEPH for approval.

The preferred options for site clean-up and management (according to ANZECC, *Australian and New Zealand Guidelines for Assessment and Management of Contaminated Sites)* are:

- on-site treatment of the soil so that the contaminant is destroyed or the associated hazard is reduced to an acceptable level, and
- off-site treatment of excavated soil' so that the contaminant is destroyed or the associated hazard is reduced to an acceptable level, after which the soil is returned to the site.

Other options may be considered if the above are not possible. The DEPH actively supports the national target of a 50% reduction in waste going to landfill, and disposal to landfill should be a last resort in the hierarchy for remediation options.

Another remediation option is the on-site containment of contaminated soil. For assessing a proposal for on-site containment of contaminated soil the ANZECC outlines four principles in the *Guidelines for the Assessment of On-site Containment of Contaminated Soil (ANZECC 1999)* that should be used. These include:

Principle 1: In considering whether to employ on-site containment as a means of managing contaminated soil the primary objective of the decision making process must be to protect the health and safety of human and environmental receptors.

Principle 2: Remedial options should minimize the need for on-going management and regulatory scrutiny of the site.

Principle 3: Remedial options should minimize constraints on reasonable and usual use of the land.

Principle 4: The preferred remedial strategy should support the best use of available waste treatment and disposal facilities (and other public resources) while providing an agreed, appropriate level of safety and environmental protection.

2.3.2 Remediation options

In the ‘Draft guidelines for the Assessment and Management of Contaminated Land’ of Queensland some examples of remediation strategies to be considered include:

- incorporating contaminated soil into the redevelopment design by placing it under buildings or paved areas etc. (this reduces exposure through the surface and reduces leaching from rain infiltration);
- leaving contaminated soil on site and building or capping over it;
- excavating contaminated soil and burying it at one location on site (this reduces the area which contains contaminated soil.);
- installing horizontal, vertical or reactive barriers;
- constructing an engineered landfill cell on site (for situations with shallow groundwater,
- permeable soils, leachable contaminants or very high results);
- changing proposed landuse to a less sensitive use (to accommodate on-site containment of contaminated soil);
- solidifying (locking contaminants in solidified matrix) or stabilising (converting contaminants to a less mobile and/or less toxic form, typically by chemical reaction) when contaminants are highly leachable, then incorporating with one of the above options;
- landfarming volatile contaminants and reusing soil on-site (if no sensitive receptors are nearby);
- landfarming volatile contaminants at an offsite location then returning the soil to site;
- on-site or off-site treatment e.g. thermal desorption; and
- in-situ biological (e.g. air stripping, sparging or venting) or chemical treatments. These may also be considered for permeable soils but are usually slow processes.

The choice of any of the above strategies will be dependent on:

- the goals of remediation;
- chemical and physical characteristics of the contaminants;
- geochemical properties of the soil;
- lateral and vertical distribution of contamination;
- volume of contaminated soil;
- proximity of contamination to structures;
- depth to water table;
- physical limitations of equipment;
- site-specific environmental considerations;
  and
- consideration of the proposed design and long-term management.

Some of these strategies will only be appropriate in certain situations. Where a site is contaminated and the costs associated with full clean-up are greater than the land value, then it may be more economical for the site to be partially remediated to allow for commercial or industrial use rather than completely remediated for residential use.

Sometimes the choice of remediation strategy will be governed by the development plans rather than by health and environmental considerations. For example, in situations where underground basements or carparks are proposed, clearly the soil in that area needs to be excavated for development purposes rather than because of the contaminant levels. However, consideration of contaminant concentrations is needed when determining a suitable disposal location for that soil. The option of building over contaminated soil is not recommended when soils are highly contaminated or highly leachable, groundwater is shallow and soils are highly permeable.

In other states, the regulation of remedial works effected for the purpose of managing contaminated sites is not dealt with by a formal assessment procedure. In many of the jurisdictions the review, assessment and approval of remedial works are carried out on an ad hoc, case-by-case basis. This is particularly the case in smaller scale site clean-ups. An exception is in Western Australian (WA) where a formal environmental impact assessment may be required for remedial works.

Sources:

Australian Master Environment Guide, CCH Australia Limited, 2010.

Safe on-site retention of contaminants, part 1: Regulatory approaches and issues – a legal perspective, CRC for Contamination Assessment and Remediation of the Environment, R. Fowler and D. Cole, 2010.

Guidelines for the Assessment of on-site containment of contaminated soil, ANZECC September 1999

http://www.derm.qld.gov.au/environmental_management/land/contaminated_land/index.html
http://www.derm.qld.gov.au/ecoaccess/contaminated_land/index.html
http://www.derm.qld.gov.au/environmental_management/land/contaminated_land/management_of_contaminated_land.html
http://www.legislation.qld.gov.au/legisltn/current/e/envprota94.pdf pg. 360 and 636

Annex 3 Examples of remediation projects

Content:

Example of chromium remediation: site Frontier Hard Chrome, Vancouver Washington, USA

Situation of the site

Location: The Frontier Hard Chrome Superfund site a 0,5-acre. The site is 1 mile from drinking water wells.

Activity: chrome plating industry from 1958 to 1970. Discharge of wastes to an on-site dry well

Date of listing in the National Priorities List: 1983

Contaminants: chromium VI (soil max. conc. Cr tot. = 7,500 mg/kg; groundwater max. conc. Cr tot = 300,000 µg/l).
Soil contaminated source: 28,000 square feet to depth of 20 to 31 feet, total volume: 21.000 cubic yards.
Groundwater plume extends 1,000 ft beyond property line to depth of 35 ft.

Risks: dispersion to drinking water wells

Climate: Marine Westcoast climate,
Av. max. temp.: 27ºC (August), av. min. temp.: 2ºC (January).
Av. Max. rainfall: 150mm (Dec), av. min. rainfall: 20mm (July).
(www.meteovista.co.uk for the city of Portland)

Remediation

Treat source area soil and treat migrating chromium from the source area

Technology:
-In Situ Redox Manipulation (ISRM) to treat soil and groundwater in the source area and downgradient
- Treatment of source area proceeded in two steps 1) sulphur-based reagent injection to reduce hexavalent chromium to trivalent chromium, followed by 2) cement-based grout injections to provide structural strength to treated soil
- The application used a 10-foot diameter auger to perform in situ vertical auger mixing; the auger size was reduced to a 6-foot diameter to reach depths below 25 feet
- An ISRM treatment wall (280 m. long and 33 ft. deep, active depth 13 ft.) was installed to treat migrating chromium from the source area
- The wall consisted of a series of eight pairs of injection wells (16 wells total)
- Each pair of injection wells had one deep well (screened 28 to 33 ft bgs) and one shallow well (screened 23 to 28 ft bgs)
- Approximately 5,700 gallons of sodium dithionite reagent was mixed with water and injected into each well pair (40,000 gallons total, about 700 m3)

Cleanup goals:
chromium VI: 19 mg/kg
Chromium III: 80,000 mg/kg
Groundwater: 50 µg/l total chromium

Results

Quantity of soil treated: 10,424 tons
Remediation goals:
In soil source area: concentration below 5 mg/kg
In groundwater: less than 800 µg/l, near treatment wall: 25 µg/l

Investments

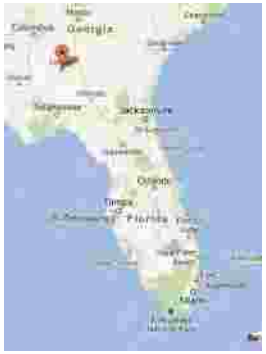
Time: May 2002: start pilot;
Jan.-Sept.2003: full scale cleanup

Costs: 1,030,000 $ including 350,300 $ for capital costs and 679,000 $ for O&M costs (Operation and Maintenance).
Unit cost: 330 $/square feet of the treatment wall

Sources

http://costperformance.org/profile.cfm?ID=381&CaseID=381

Example of pesticides remediation: site T.H. Agriculture and Nutrition Site, OU2, Albany, GA, USA



Situation of the site

Location: T.H.A Agriculture and Nutriction site OU2 is a 5-acre property named Jones Property which is an adjacent property of the original THAN site (THAN OU1). It is situated close to a boulevard and a forest (East) and other industries.

Activity: pesticide formulation and packaging from 1964 to 1970.

Date of listing in the National Priorities List: 1989

Contaminants: Organochlorine and organophosphorus pesticides including DDT, toxaphene, methyl parathion, and ethylene dibromide, as well as inorganics.

Cleanup Authority: CERCLA

Risks: a floating lens of NAPL located in the surficial aquifer can lead to a migration and human exposure

Climate: Humid Sub-tropical climate,
Av. max. temp.: 33.2ºC (August), av. min. temp.: 1ºC (January).
Av. Max. rainfall: 224mm (August), av. min. rainfall: 74.2mm (October).
(www.meteovista.co.uk for the city of Tallahessee (Georgia))

Remediation

Off site thermal desorption (LTTD Low Temperature Thermal Desorption) and activated carbon beds: 15 tons of soil/hr at 975°F.
Treated soil was combined with baghouse dust and water, discharged to a soil stacking area, and finally sent to a verification holding area for sampling.

Cleanup goals:
DDT - 94 mg/kg
Toxaphene - 29 mg/kg
Methyl Parathion - 17 mg/kg
Ethylene Dibromide - 0.006 mg/kg
Carbon beds removal efficiency >90%
Maximum stack gas total hydrocarbon (THC) levels limited to 118 ppmv.
Cleanup goals are based on a 10^{-4} risk level for carcinogenics and a hazard quotient of 1 for noncarcinogenics for the groundwater. For the surface soil the risk level for carcinogenics is 10^{-6} and a hazard quotient of 1 for non carcinogenics.

Results

Quantity of soil treated: 10,424 tons
Remediation goals have been met for 17/18 batches. The batch out of compliance met the goals after the second treatment.

Analysis of the activated carbon beds efficiency showed that changeout was not neccessary.

Treated soil was backfilled on site.

Investments

Time: October to November 1999

Costs: 1,058,230 $ including 566,184 $ for capital costs and 492,046 $ for O&M costs (Operation and Maintenance).
Unit cost: 102 $/ton

Sources:
http://costperformance.org/profile.cfm?ID=374&CaseID=374
http://www.epa.gov/superfund/sites/rods/fulltext/r0493136.pdf

Example of designed chromium remediation and site reconstruction: Shawfield Glasgow, UK

Situation of the site:

Activity: Former chromium processing industry (mid 19th centur untill 1968).
1.5M m3 of chromium ore processing residue (COPR) was produced in this period.

Location: several landfill sites in a commercial area. Location is part of the Clyde Gateway initiative, one of the largest regeneration projects in Scotland (2,095 acres)

Contaminants: chromium VI spreading with groundwaterflow. Soil concentration Cr VI upt to 10,000 mg/kg. Groundwater concentration Cr VI up to 3,425 mg/l. At some sites, mixture with other contaminants: PAH, fuels, heavy metals

Future use of the site: the area will be used for business purposes.

Climate: year average data in Scotland:
T°C av. min./-max.= +0/+20
Rainfall: 700 mm/year

Fig.2: Visible chromium contamination from COPR in the stands at a stadium in Shawfield.

Fig.1: Example of chromium ore processing residue

Solution:

Principle:
The remediation design has resulted in the following strategy:
•Capping of areas of exposed ground by upfill and the built development to provide containment of contamination (primarily COPR-associated) within the unsaturated zone;
•If required, capping or localised excavation with treatment or disposal represent the best practicable options for organic contamination within the unsaturated zone;
•Use of remedial criteria derived for soil and groundwater for hexavalent and total chromium;
•Receptor protection measures to isolate the surface waters from contaminated groundwater by engineering methods;
•Identification of treatment zones for elevated chromium based on derived threshold values, as advised by the Regulators;
•Based on earlier field validation trials, application of in situ direct injection chemical treatment for contamination within the soil saturated zone is proposed. Calcium polysulphide directly injected into the soil effects the conversion of hexavalent chromium to trivalent chromium;
•Monitoring natural attenuation, which is an integral part of the remediation process, will require to be included in all remedial works and to support the process of verification.

Sources:

Treatment of Chromium Contamination and Chromium Orde Processing Residue, CL:AIRE technical Bulletin 14, October 2007
Shawfield Infrastructure & Development Framework, Ground Contamination and Remediation Statement, URS, June 2012

Example of heavy metal remediation in large area: Active Soil Management in The Kempen, the Netherlands

Solutions have been drawn up in the ABdK project for each process (arrow) in order to halt the spread of heavy metals or to limit it as much as possible.

Situation of the site:

Activity: Former zinc smelting plants produced soil contamination by dispersion of smoke and by using zinc ashes as surfacing for roads, paths and grounds.

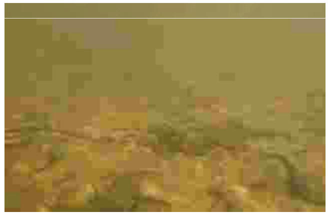
Location: soil contamination is present across an area of 2,600 km2 in the provinces of Noord-Brabant and Limburg, close to the border of Belgium.

Contaminants: excessive concentrations of heavy metals, cadmium and zinc have most negative effects on human health and ecology.

Future use of the site: the area is and will be used for residential and agricultural purposes.

Climate: year average data in Netherlands:
T°C average/year= +10.5
T°C av. min./-max.= +6/+25
Rainfall: 800 mm/year

Solution:



Principle:
- Remediation of industrial premises already was done in the past
- Removal of zinc ash in roads and lands
- Heavily contaminated soil and sediment is cleaned
- Removal or treatment of all contamination is not possible due to amount and costs. Effect oriented measures are taken: sustainable management of the contaminated soil

Works:
-removing and processing zinc ash (clinkers)
-partial digging out of contaminated sediment, using silt traps
-monitoring groundwater quality
- limits to growth of crops; liming soil for agricultural use
- adjusting designation, changing water table, liming or replacing soil in nature reserves .

Results:

	Remediated sites
number of private properties	800 (of 2,100 signed up)
area	70 ha. (175 acres)
remediated soil	650,000 m3

Investments:

Costs: the costs of the operation untill now have been 85 millioen € (funded by national, provincial, local government, the waterboard and private persons/companies)
Time: The project began in 2001 and the works will be ended in 2014

Sources:
http://www.abdk.nl/html/page290.asp

Example of VOCL remediation by reactive barrier: Katwijk, the Netherlands

red: source; yellow: plume with contaminated groundwater; blue line: perneabke reactive barrier

Situation of the site:

Activity: Former container storage facility

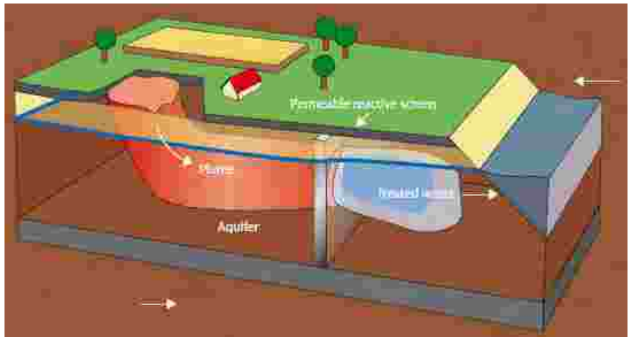
Location: groundwater contamination is present 100 m outside of source of pollution (severely polluted soil in 0.75 acre area) in Katwijk, near the sea.

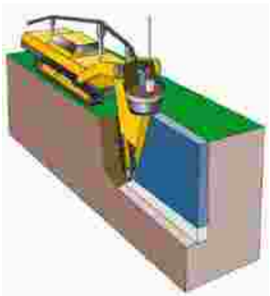
Contaminants: cis 1,2-dichloorethene and vinyl chloride spreading with groundwaterflow

Future use of the site: the area is and will be used for residential and agricultural purposes.

Climate: year average data in Netherlands:
T°C average/year= +10.5
T°C av. min./-max.= +6/+21
Rainfall: 850 mm/year

Solution:





Principle:
-The screen allows groundwater to pass through unhindered (=permeable), but forms a barrier for the contaminants. The contaminating substances can be degraded microbiologically or chemically or trapped in the screen, depending on the type of screen.

Works:
-a conceptual site model was used for designing the remedial measures
- placement of a deep wall (length 180 m, depth 5.5 m) by excavation and simultaneously filling the trench with iron granulate
-Monitoring groundwater

First results:

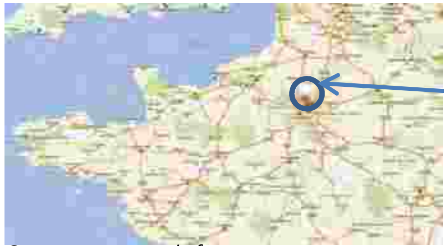
	Concentration in groundwater
before entering barrier	99 ug/l
within barrier	17 ug/l

Investments:

Costs: the costs of the operation untill are unknown, the costs were funded by provincial government. The estimation was that costs of this method would be 50% of traditional pump and treat methods
Time: The barrier was placed in 2006 and the active periode will be for about 15-20 years

Sources:
* http://www.soilpedia.nl/Bikiwiki%20documenten/SKB%20Projecten/PT5121-PT4121%20Demonstratieproject%20ijzerscherm%20Wassenaarseweg%20te%20Katwijk/PT4121%20eindrapport%20ijzerscherm%20fase%201%20compleet.pdf
* http://www.ntpgroep.nl/index.php/nl/projecten/milieu/item/21-anleg-ijzerscherm-wassenaarseweg-te-katwijk-incl-filmpje

Example of chromium (VI) in-situ remediation : Site Bois Colombes, France, 2003 (pilote plant)


Source: *maps.google.fr*


Source: *www.ademe.fr*

Situation of the site

Activity : mechanical building, ancient chroming workshop Hispano-Suiza

Location: Bois Colombes (92, Hauts-de-Seine, Ile-de-France) **urban area.** The site is situated between the river Val-d'Oise Hauts-de-Seine (West side) and the highway A86 (East side). At 200m South East of the site there is a stadion and sportive area. Next to it there is a residential area (South of the site). At the North East of the site there are other industries.

Contaminants: chromium (VI) [Cr(VI)]= 1000mg.kg^{-1} in an area of **250m²** with a depth of **15m**. 962 kg of Cr(VI) estimated.

Future use of the site: offices and residences. On the area polluted by chromium particulary the use will be leisure park.

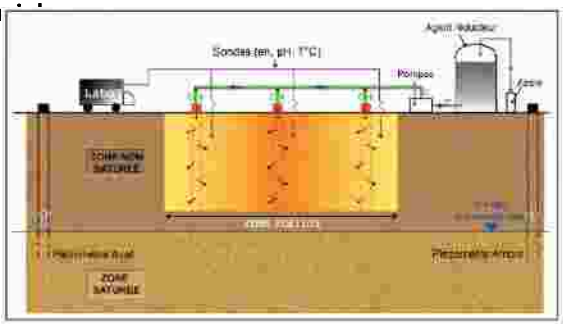
Climate: year average data:
Temp. Max. = 15,5 °C
Temp. Min. = 8,6 °C
Rainfall = 650 mm/year

Technique used for the remediation

Objective: removing contaminants from the soil without polluting the saturated zone (concentration must be <1000mg.kg^{-1})

Technique: CHROMSTAB®: in-situ chemical reduction

Prin



Reactive agent: sodium hydrosulfite $Na_2S_2O_4$

Control of the reaction:
-chain of 8 piezometers around the treated area
-lysimeters
-pH , redox potential, T°C, [Cr] (groundwater)

Results

Quantity of ground treated: 3700m^3

Residual concentration: 15mg.kg^{-1} of dry material. No by-product.

Yield: 88%

Monitoring :
-Groundwater: pH , redox potential, T°C, [Cr(VI)] , [SO_4^{2-}] each day during the tratment and each year during three years after the treatment.
-Ground: total chromium, chromium VI before and after treatment.

Investments

Time: 3 months

Costs: 780,000 € (funded by BRGM and ADEME)

Sources

- http://www.ingenieurspourdemain.fr/Journees_Environnement/14_BRGM_Sols%20pollu%C3%A9s.pdf
- http://www2.ademe.fr/servlet/KBaseShow?sort=-1&cid=96&m=3&catid=12836

Geomembrane

Example of HCH remediation: site PCUK in Wintzenheim, Haut-Rhin, Alsace, France

Situation of the site:

Activity: Factory PCUK producing HCH for agriculture.

Location: Wintzenheim (68), Haut-Rhin, Alsace. The site is situated in a residential area near the built-up area of Colmar. There is a water table which is used as drinking water.

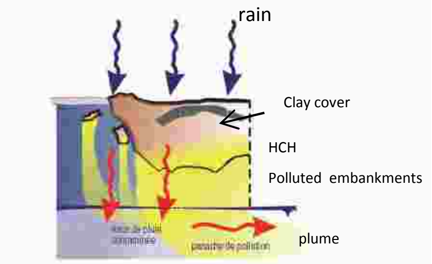
Contaminants: In 1966, 700 tons of lindane were stocked under a land of 3000m^2. In 1985, a watertight cover made in compacted clay was built but this cover is inadequate and the groundwater table is polluted by HCH.
In 2000 ADEME was asked to undertake this remediation.

Future use of the site: the access to the site will be forbidden for motorized engines. Herbs will be planted and the area will be protected by a fence.

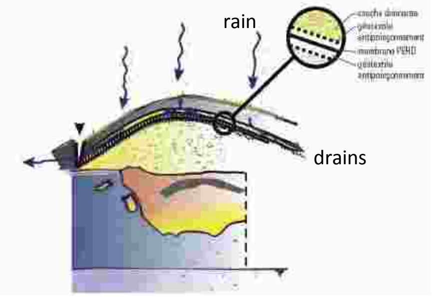
Climate: year average data in Colmar
T°C max.=15.3
T°C min.=5.8
Rainfall: 578 mm/year

Solution:

Before remediation made bu ADEME:



After remediation:



Principle:
Enlarge the existing cover and recovery of rain water with 8000m^2 of PEHD geomembrane.
In the meantime, restrictions to the use of the water.

Works:
-Use of 10 000m^3 of embankments
-The PEHD membrane (1,5 mm thickness)
-Drains are arranged either side of the structure
-Vegetalization of the cover
-Water is collected in a buried decanter

HCH waste mustn't be excavated or manipulated to protect the health of working people.

Results:

	HCH flow arriving to the groundwater (g/year)	Reduction of the plume (ha)
Before remediation	164	0
8000m2 PEHD	6 (-99%)	33 (46%)

Investments:

Costs: the costs of the operation ware estimated at 430,000 €
Time: The project began in 2000 and the works started in 2007-2008.

Sources:
http://www.ademe.fr/alsace/pdf/lettre_info_03_2.pdf
http://www.ademe.fr/alsace/pdf/lettre_info_02.pdf
http://www.industrie-environnement-alsace.fr/sites-et-sols-pollues/images/site-pcuk-a-wintzenheim.htm

Example of chromium sludge treatment: Tasman Sheepskin Tannery, near Brisbane, Australia

Situation of the site

Activity : Tannery in operation: storage of large volumes of chromium contaminated residues in open dams. Not only could the chromium potentially be leached into nearby soil and groundwater but the sludge in the dams had an objectionable odour and hosted large populations of microbes, including potential pathogens.

Location: The tannery was originally established in a rural area beyond the outer suburbs of Brisbane, but continuing urban growth has meant that residential areas are now close by and there is increasing pressure from both residents and regulatory authorities to resolve potential environmental and odour problems associated with the sludge dams.

Contaminants: Chromium (III)= 40,000-60,000 mg.kg^{-1} in about 3,900 m3 soil/sediment. Initial leaching chromium concentration about 40 mg/l.

Future use of the site: industry with residences nearby.

Climate: year average data:
Temp. Max. = 28 °C
Temp. Min. = 9 °C
Rainfall = 1,200 mm/year

Sludge Dam Prior to Treatment

Technique used for the remediation

Objective: immobilizing the chromium in the solid waste (leachate concentration must be <5mg.L^{-1} which is Queensland landfill acceptance limit)

Technique: excavation soil and thoroughly mixing with Virochrome™ reagent

ViroChrome™ reagent being delivered to site

Treatment was applied using an excavator

Results

Quantity of ground treated:
3,900m^3

Residual concentration leachate:
<5 mg.L^{-1}

For 1 year the leachate concentrations were monitored.

As required by Tasman Sheepskin Tannery operators, the treated solids were spread evenly over the existing clay-lined containment area and allowed to naturally revegetate.

Investments

Time: unknown for total project, mixing of soil took 5 days

Costs: unknown

Sources

•http://virotec.com/download/email/web_files/industrial-wastewater-remediation-viroflow/Case%20Study%20Tasman%20Solids.pdf: Brochure Virotech with case study description

Options and standards for remediation of polluted sites Key output Report Task 3

Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India

Ministry of Environment and Forests, Government of India, Delhi
The World Bank, Washington, D.C.

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Executive Summary

General

This report presents the key output of the activities carried out under Task 3 (Review of national and international approaches to remediation) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

In view of the formal definition being of 'contaminated sites' this report uses the term 'contaminated', except where citing the title of an existing report or where the term 'polluted' is part of a formal term, as is the case in the term 'NPRPS'.

Objective

The objective of Task 3 is to provide a generic approach for remediation of contaminated sites and a menu of prioritized options for remediation for all types of contaminated sites. The typology of Task 1 of this Assignment is used as a basis to reach this objective: it presents a site categorization designed for generating remediation solutions for all sites to be remediated in India.

The objective of this report is to present the above, but also to demonstrate its development, thereby providing the results with a sound basis. The results will be incorporated in the Guidance Document, aimed at the organisations responsible for the implementation of NPRPS. By contrast, this report is targeted primarily at those who need a deeper understanding of the technical backgrounds.

Results

This report presents the following results:

- An analysis of advantages and disadvantages of standard based and risk based approach, as well as an overview of principles and characteristics of remediation options. Besides a comprehensive overview of generic characteristics of the most important remediation technique groups, for each of these groups site specific characteristics, as well as a brief analysis of strengths, weaknesses, opportunities and threats is included, as well as hints as to the usefulness and restrictions of the remediation techniques under certain conditions (see Chapter 2);
- A first evaluation of hands-on experience with remediation practices in India, offering a preliminary selection of elements for a realistic technical approach to site characterisation and remediation (see Chapter 3);
- A Menu of remediation options, presenting an overview of technical choices and associated elements to consider in the process of remediation options appraisal and selection and remediation design (see Chapter 4);

- The application of the Menu of prioritized remediation options to the list of 100 sites from Assignment 1. Based on that, a discussion on the applicability of the Menu, which yields a provisional most likely remediation option at an early stage in the site investigation and remediation process. Also, a discussion on the implementation of site specific issues in the process of remediation options appraisal and selection to eventually achieve a selection of the preferred remediation option (see Chapter 5).

Conclusions
In this report we consider the information presented in the overviews to be central. Notwithstanding that, this report also presents the following conclusions, based on the results described above:

- Based on a profound analysis of risk based versus standard based approach in other countries, the risk based approach provides the best opportunities for India, while the standard based approach may still be useful in certain cases;
- The alignment of the remediation target for a site with the result of the site specific risk assessment forms an integral part of international best practice and offers major opportunities for cost effective remediation and integration of sites in their environment;
- Most of the successful remediation cases in India to date were the result of excavation and transfer of waste to secured landfills. However, considering the importance of the social aspects and other local conditions, chemical and biological remediation options can be expected to become more important in future. As some of these techniques are still in a laboratory phase of development, full scale use of these techniques may be considered only after thorough pilot testing and field trials;
- The Menu of remediation options offers a useful guide to the applicability of the most likely technical and in some cases also non-technical choices for remediation measures in a generic way. Particularly the technical, financial and social situation and the potential to implement sustainability aspects will show a great variability from site to site. This also applies to the potential land use post remediation and estimated cost benefits. Therefore, these factors cannot be included in the Menu of remediation options in a meaningful generic way: specific site conditions might result in the selection of a remediation option that in the Menu op remediation options is not linked to the type of site at hand. While the Menu of remediation options offers a good starting point for the selection of tailor-made site specific remediation options, the Guidance document, to be developed in Task 4, will literally guide the user through all the steps in the process of remediation options appraisal and selection.

Table of contents

1 Introduction

1.1 General

This report presents the key output of the activities carried out under Task 3 (Options and standards for remediation of polluted sites) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

The report presents the results of steps 3.1 to 3.4. Earlier versions of this report were presented to and discussed with the Technical Expert Panel (TEP), the World Bank and MoEF on13th August 2012, 14th May 2013 and 19th December 2014. The comments by the TEP, the World Bank, and MoEF referring to this Task have been implemented in this final version of the report.

In view of the formal definition being of 'contaminated sites' this report uses the term 'contaminated', except where citing the title of an existing report or where the term 'polluted' is part of a formal term, as is the case in the term 'NPRPS'.

1.2 Objectives Task 3

The objective of Task 3 is to provide a generic approach for remediation of contaminated sites and a menu of prioritized options for remediation for all types of contaminated sites. The typology of Task 1 of this Assignment is used as a basis to reach this objective: it presents a site categorization designed for generating remediation solutions for all sites to be remediated in India.

The key output is this report, presenting a generic approach for remediation of contaminated sites and a Menu of remediation options applicable to the typology that resulted from Task 1, i.e. each category of contaminated sites included in the database inventoried by Assignment 1.

1.3 Scope

The activities of Task 3 are based on the data provided or designated by the Client. To retain a clear distinction between the scope of Assignment 1 and this Assignment this report focuses not on site assessment, but rather on developing and selecting options for remediation. In view of the close links among the assignments, the project teams have retained close interaction on communal issues. One of the most important of these issues is the alignment on site assessment vs. site remediation. As a result this report does mention site assessment wherever needed. This is the case where Conceptual Site Model (CSM) is discussed and where additional data is needed (step wise data acquisition approach).

Remediation measures to assess contaminated soil, sediment or groundwater may have an immediate effect on surface water quality, as these systems may be linked to each other by exchange of components. This fact does not exclude these measures from the scope of this assignment. However, remediation measures addressed directly at contaminated surface water are beyond the scope of this assignment.

1.4 Relation with the Guidance document

The selection process of the most appropriate remediation option for any specific site is most likely to be carried out in a description of a set of applicable remediation options. Using such a study, a well defined selection of the most appropriate remediation options can be carried out in a transparent way.
The Guidance document, which forms the output of Task 4 of this Assignment, will guide end users through this selection process. This document will be based on the Menu of remediation options, presented in Section 4.2 in this report.

The objective of this report is to present a generic approach for remediation of contaminated sites and a menu of prioritized options for remediation for all types of contaminated sites, but also to demonstrate its development, thereby providing the results with a sound basis. The results will be incorporated in the Guidance Document, aimed at the organisations responsible for the implementation of NPRPS. By contrast, this report on Task 3 is targeted primarily at those who need a deeper understanding of the technical backgrounds.

1.5 Activities in Task 3 and reading guide

For the objectives in this task, as described in Section 1.2, we have carried out a detailed analysis of risk based versus standards based approach, from which we have derived recommendations for India. We have also analyzed international approaches in determining cleanup standards and selection of remediation options, from which we have derived principles and characteristics of remediation options. Combined with an assessment of experience with remediation action in India, we have determined the remediation approaches we deem most likely to be applicable in the Indian context. All this culminates in a Menu of remediation options (technology choices) for each category of site included in the typology developed in Task 1, which, based on the available database, may be deemed relevant for India at this time. We have also identified the potential land use post–remediation and indicated the cost benefits with each option.
This way, we have carried out the steps in Task 3 as described in the Contract for Consultants' Services (26/03/2012) and the report follows these steps:

- Step 3.1 Generic remediation approaches (Chapter 2);
- Step 3.2 Evaluation of present remediation practices in India (Chapter 3);
- Step 3.3 Menu of remediation options for each type of contaminated site (Chapter 4);
- Step 3.4 Integrated analysis remediation options (Chapter 5).

Chapter 2 describes generic remediation options for each type of site, included in the typology developed in Task 1. For each option characteristics are listed. This overview provides technical background information on the first step in the selection of remediation options to be evaluated in more detail. The remediation options described include both standard based and risk based options. In Sections 2.2, 2.3 and 2.4 we discuss issues associated with either approach, present them in a more generic frame and present the remediation options themselves. In Section 2.5 we present preliminary conclusions on their applicability in India.

In the end, the most appropriate remediation option is defined by legal and local conditions, as well as by conditions set by the financing party. This is where the evaluation of present remediation practices in India, described in Chapter 3, provides some background information. Chapter 4 of this report presents a synthesis of the information in Chapters 2 and 3, by presenting a comprehensive approach for remediation of polluted sites and a Menu of prioritized options for remediation for the types of contaminated sites included in the Typology developed in Task 1.

The applicability of the Menu of prioritized remediation options in India is tested by applying it to each of the sites entered in the list of 100 sites from Assignment 1. Chapter 5 discusses the results of this applicability test and a discussion on the applicability of the Menu, which yields a provisional most likely remediation option at an early stage in the site investigation and remediation process. Chapter 5 also includes a discussion on the implementation of site specific issues in the process of remediation options appraisal and selection to eventually achieve a selection of the preferred remediation option.

Note: Step 3.5 - Draft report options for remediation, consists of the present report.

2 Step 3.1 – Generic Remediation Approaches

2.1 Introduction

The first step of this task is to generate a draft generic series of remediation approaches for soil, including sediments, and groundwater fitting the typology developed in Task 1. This step includes a detailed analysis of risk based versus standards based approach. Based on this analysis step 3, described in Chapter 4, presents a Menu of remediation options (technology choices) and the level of cleanup that can be attained, for each category of site, which may, based on the available database, be deemed relevant for India at this time.

The next Section 2.2 presents technical background information to contaminated sites and to the most commonly applied generic remediation approaches. These approaches are evaluated in Section 2.3. Section 2.4 elaborates on the historic development of application of these approaches in three foreign countries. That Section provides an illustration of the advantages and disadvantages of risk based and standard based approach.

2.2 Technical background

2.2.1 General aspects

In developing effective targets for remediation it is important to discuss the policy goal on contaminated sites. This is related to the definition of contaminated sites, the inventory of sites and the technical, financial, legal and organisational possibilities to implement the NPRPS.

Contaminated sites are defined by situations which pose existing or imminent threats to human health and/or the environment. Remediation should be aimed at reducing these threats. The threats have been determined for the present or expected future land use. An important decision needed from the authorities is the form(s) of land use and the level of protection the remediation should take into account. A sensitive form of land use (e.g. residential area) requires more remediation effort than a less sensitive form of land use (e.g. industrial area). This with respect to human health as well as regarding the ecological value of an area.

To reduce the threats for an intended form of land use an intervention is required in the source-pathway-receptor- combination of a specific situation. This means that either the source needs to be reduced, the pathway between source and receptor needs to be cut off or the receptor needs to be protected or removed. Section 4.2 presents options for such remediation interventions.

The source-pathway-receptor combinations resulting in the most threatening exposure are:

- Contact of human with contamination through:
  - Direct contact with contaminated soil (ingestion of soil, inhalation of dust, dermal uptake of contaminants out of the soil);
  - Ingestion of crops grown on the contaminated site;
  - Ingestion of drinking water from contaminated ground water;
  - Inhalation of indoor air influenced by contaminated soil or ground water.
- For ecology:
  - Uptake of contaminants from the top layer of the soil;
  - The leaching of contaminants to surface water.

The key issue is to what level the threats should be reduced. In this regard, there are three approaches to consider.

Approach 1, Generic total threat reduction in soil, sediment or groundwater
Implementation of the approach of generic total threat reduction is aimed at reducing the identified threats to zero level, rendering the site fit for any use ('multifunctional'). Internationally, 'zero' is most commonly translated into 'as low as technically achievable'. To achieve this the source of the contamination needs to be removed or treated completely, as contaminant concentration levels need to be reduced to background levels.

Approach 2a, Generic fitness for use threat reduction in soil or sediments
Implementation of the approach of generic fitness for use threat reduction in soil or sediment is aimed at reducing threats to a generic acceptable level given the site's present and/or future use. To achieve this:

- The constituents in the source of the contamination need to be removed or treated to a generic level set for the present and/or intended future land use, or
- The pathway from contamination to receptor needs to be cut off, or
- The receptor needs to be protected or removed.

Approach 2b, Cost effective groundwater approach
Implementation of the cost effective groundwater approach is aimed at reducing threats to an acceptable level, while the remediation action is still cost effective. To achieve this contaminants are removed from the pathway to a degree where the costs of the removal is in balance with the amount of contaminants (mass) removed from the pathway. Contaminants in the source of the contamination are removed or treated to such a degree that this action benefits the actions in the pathway. Whenever the receptor is threatened it needs to be protected.

Approach 3a, Site specific fitness for use threat reduction in soil or sediments
Implementation of this approach is aimed at reducing threats to a site-specific acceptable level given the site's present and/or future use. To achieve this:

- The contamination needs to be removed to a predetermined site-specific level at which the contamination is considered to present no threat. This remediation level is based on site-specific risk assessment and is typically less strict than the generic (robust for all uses) level, or

- The pathway of the contamination to the receptor needs to be cut off exactly according to a specific use and spatial planning of the site, or
- The receptor needs to be protected or removed.

The required remediation efforts are most comprehensive in approach 1), less in approach 2a),most limited in approach 3a) and cost balanced in approach 2b). Conversely, the flexibility of the present and future land use and absence of restrictions and required efforts for monitoring and control increase from approach 3) to approach 1). Figure 2.1 below illustrates this for soil and sediments and figure 2.2 for groundwater.

Figure 2.1 Remediation effort and consequences for the different approaches to remediation of soil or sediment

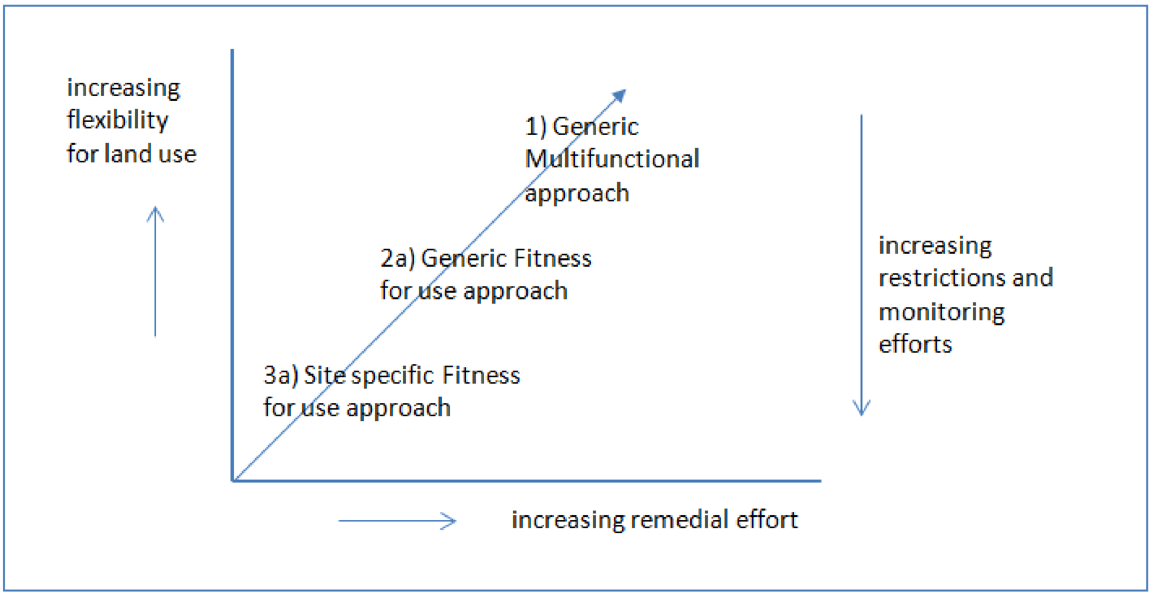
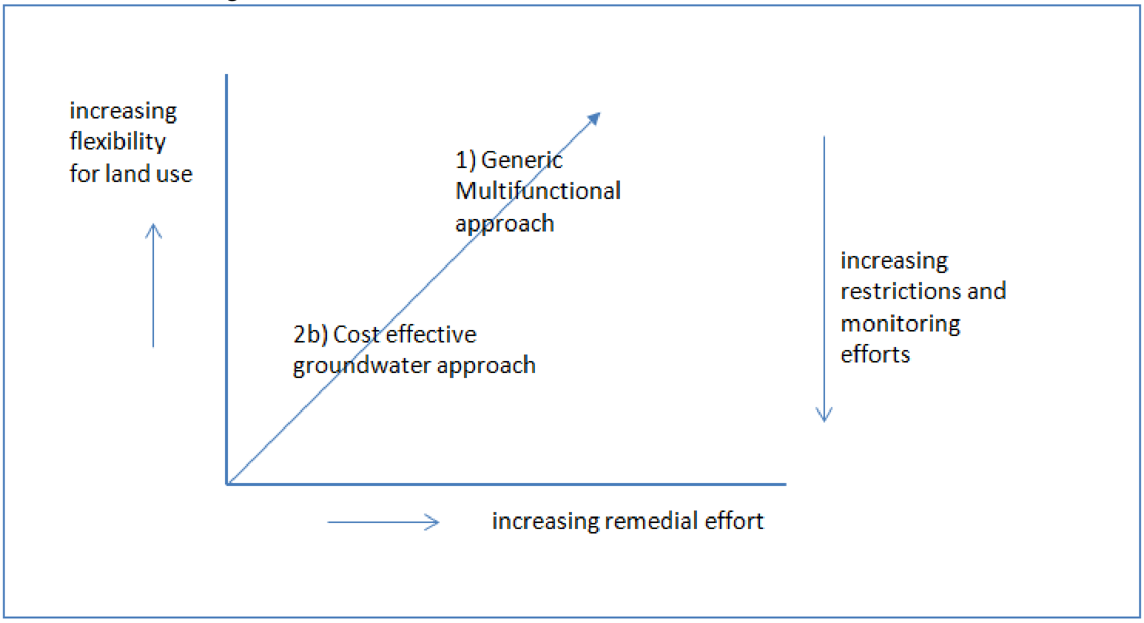


Figure 2.2 Remediation effort and consequences for the different approaches to groundwater remediation



The approaches introduced in this Section are discussed in more detail in Sections 2.2.2, 2.2.3 and 2.2.5 below.

2.2.2 Generic Multifunctional Approach

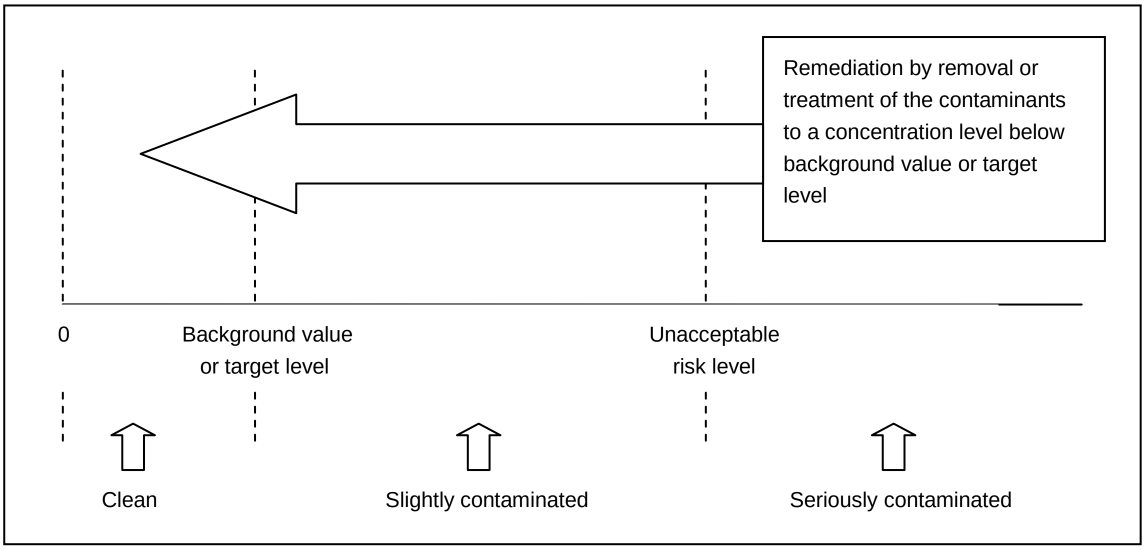
In most of the countries presently dealing with soil remediation the wheels have been set in motion by major incidents. Especially where these cases received widespread media attention governments were quick to respond. The clearest example of this is the United States where, barely a year after Love Canal became a household name, the federal Comprehensive Environmental Response and Liabilities Act (CERCLA) came into force (1980). Perhaps most remarkable was the fact that, aside from the development of regulation, the (sometimes huge) funds needed for concrete action also came swiftly. This was the case in the US, but also in the Netherlands, where, as in the US, a residential district built on top of a dangerous chemical waste dump (in Lekkerkerk) was the catalyst. The examples mentioned here had impact across national borders, as was the case with the Seveso explosion in northern Italy, which prompted other countries and the EU into action.

As the incidents were major, created clear danger to human health and to the environment in general, regulations in those early days tended to be strict. The front running countries, especially in Europe (e.g. Denmark and the Netherlands), generally adopted the principle of multifunctionality, meaning they aimed at remediating all contaminated land to pristine conditions. This would entail the restoration of soil quality from an intervention value back to a standard target level or natural background level regardless of site characteristics or site use. The objective of this approach was to reach a situation in which the remediated sites would be fit for all use after remediation. To reach this objective, all contaminated sites would need to be remediated back to pristine conditions.

This approach also meant a standard based approach, consisting of either complete removal or removal to a specific concentration, where criteria did not take into account the present or future use of the site. The obvious advantage of this approach is a simple, very clear decision-making system, easy to apply and hardly giving any space for discussion as the target levels are well defined and non negotiable.

If multifunctional soil remediation is impossible for site specific reasons containment of the contamination is a fall back option. As this containment needs to reach a situation comparable to complete removal it needs to be designed in such a way that its application results in the lowest possible emission and multiple site use options. Figure 2.3 demonstrates the multifunctional soil remediation approach.

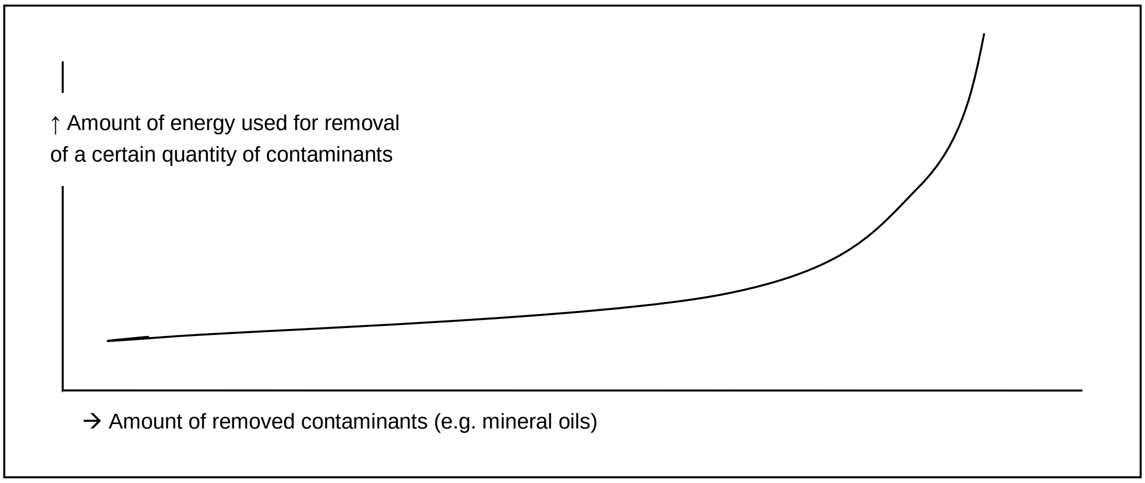
Figure 2.3 Multifunctional soil remediation approach



The notion that "multifunctionality should be the ultimate aim of contaminated land remediation, as being the only truly sustainable option" certainly seems a defendable one. Especially if we consider the direct link that was made almost one on one in those days between soil contamination and very serious threats to human health. Actually, the Netherlands has long defended the principle of multifunctionality in practice. Even after a study in the early 1990s had shown that pursuing this strategy would amount to an estimated cost of € 45 billion (equivalent to close to € 75 billion or U$ 100 billion of today). Or, as it was translated then, even with more than € half a billion per annum (to be borne by a population of around 17 million) it would take a full century for the operation to be completed. This example illustrates what became clear elsewhere as follows: "[multifunctionality] may not be technically feasible, nor economically viable in the short term."

An example, showing the costs and inefficiency of a multifunctional remediation approach: the removal of the final 'drop' of mineral oil from a mineral oil contaminated soil is a technical challenge disproportionate to its achievement. The same goes for the costs, as well as for the energy needed: the extraction of the last drop is likely to demand much more energy than represented by the drop itself. Figure 2.4 demonstrates this principle, which helps to determine a site based optimum in the remediation target to be established.

Figure 2.4 Principle of soil remediation efficiency



Note. Scales in this figure are arbitrary

During the first half of the 1990s the idea also gained ground that (re)development was actually slowed down considerably ('stagnation' was the word used) by the soil contamination on many urban, and otherwise prime, sites. This raised the question whether the policies in place influenced this stagnation in any way. Looking back, this certainly seems to be the case: the more stringent the policy leaned towards a standard based multifunctional approach, the higher the cost of remediation would be, leading to a significantly reduced interest in (potentially) contaminated sites by developers. Even in the densely populated areas of north-western Europe the economically best option often was to develop a Greenfield.

While some countries, notably Finland, the Netherlands and Switzerland, have retained, at least in theory, the ultimate goal of multifunctionality, risk based criteria tied to land use are presently in use in most countries.

With the drawbacks of the multifunctional approach apparent, that does not mean this approach has been phased out completely: it is still used in specific circumstances. For instance, in case the contaminated area is small, the costs of a multifunctional approach are relatively low. And a standard based approach may well be the most appropriate option for the liable party when his policy is to avoid any future liability issues.

2.2.3 Generic and Site specific Fitness for use Approach

From the previous Section we can digest that the multifunctional soil remediation approach is generally speaking not necessary from a health and environmental point of view, economically not feasible and not sustainable. The general response has been the introduction of a risk based approach. This approach focuses on the removal or treatment of contaminants as far as needed to reach a quality fit for one or more specific functional site uses, assessing all unacceptable risks prior to remediation. The result is an approach with "less stringent generic criteria tied to risk and future land use, and more flexible site-specific risk assessment and clean up procedures".

This approach can be based on either generic target levels for different types of land use or on site specific target levels. In either case, within this fitness for use approach the remediation measures can provide a generic protection level for a form of land use or can be directed to a very specific spatial design of the intended land use. An example to illustrate this: for a residential area the remediation measures can be designed with maximum flexibilty of the exact use of land within the boundaries of the site. In this way everywhere houses can be built and gardens with crops can be situated everywhere. However, remediation measures can also be designed for a very specific spatial plan for a residential area: this enables contamination levels below roads and buildings to be higher than the concentration levels in the gardens. While this way remediation efforts can be limited this approach also results in more restrictions for future use of the site, and this specific spatial site plan needs to be maintained and monitored.

In this 'fitness for use' approach the risks the contamination poses to human health and the environment are decreased to a level acceptable for the present land use. In case land use is expected to change in the near future, present as well as projected land use can form the basis for this approach. A basic principle that has been retained in taking the step towards a risk based approach is called the 'stand still': for each site reuse or redevelopment the soil and groundwater quality should at least be fixed or improved.

Figures 2.5 and 2.6 show the principle of the 'fitness for use' (risk based) approach.

Figure 2.5 ‘Fitness for use’ approach of the source: reducing levels of contamination in soil

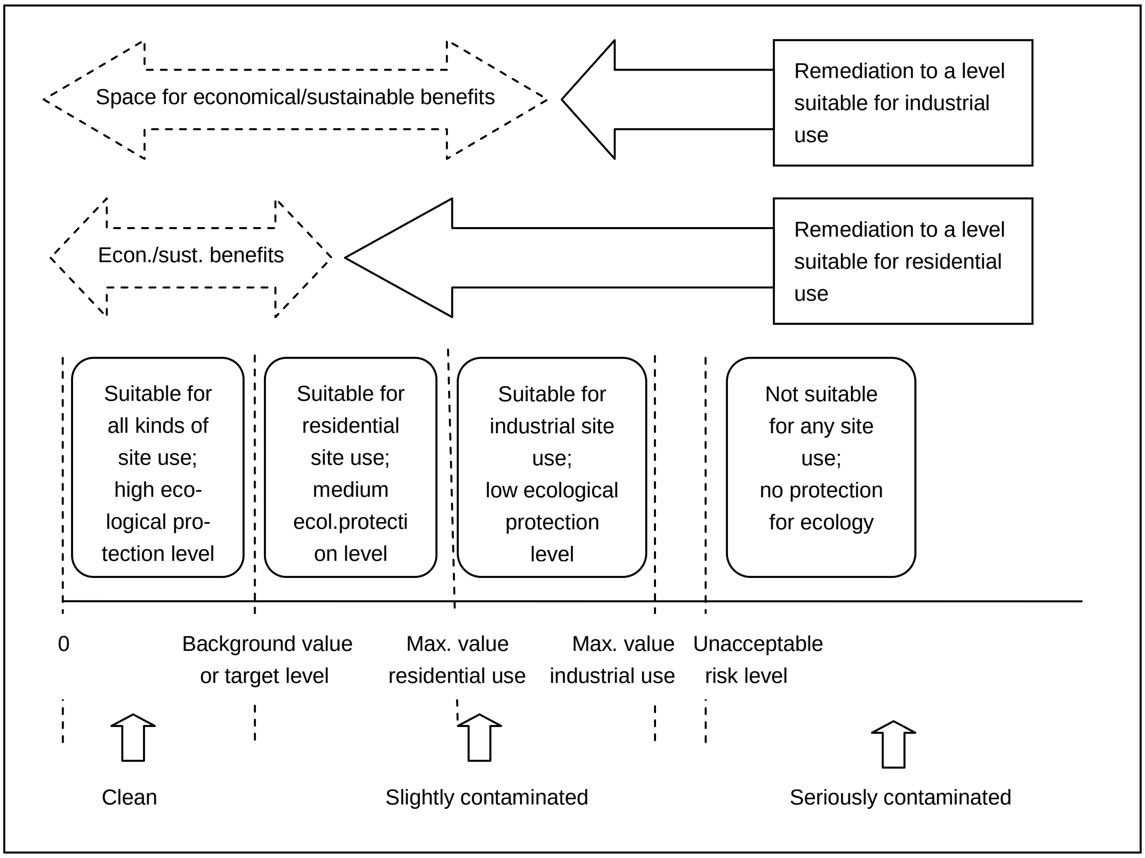
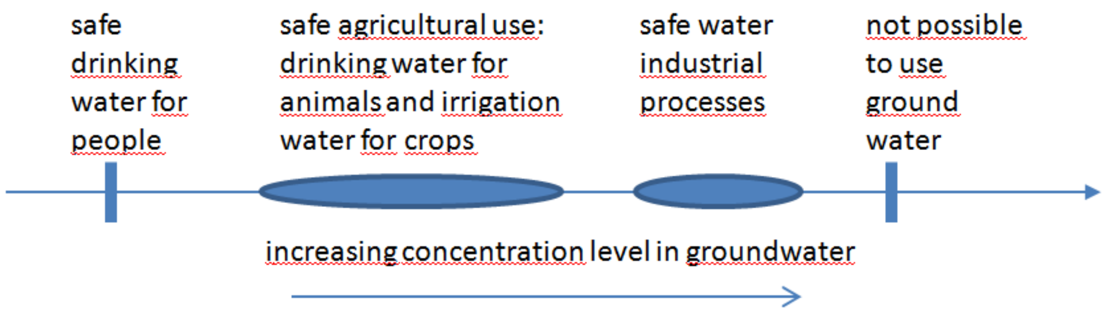


Figure 2.6 ‘Fitness for use’ approach of the source: reducing levels of contamination in groundwater



For each source-pathway-receptor-combination this approach can be used. In cases of immobile soil contamination, such as many heavy metals, this will result in assessing the quality of the top layer only, as the quality of this part of the soil is responsible for most human and environmental risks. The assessment of mobile contaminations is presented in Section 2.2.5.

In case only the top layer has to be assessed, much effort can be saved on the assessment of the contamination below the top layer. Using this approach, a risk based site management framework can be built, providing an opportunity to balance between a scientific underpinning of the assessments and pragmatism to deal with contaminated sites, anticipating site specific or region specific conditions. The maximum values for site use offer basic safety warranties.

A contamination without any receptors does not present any risks. In case it is decided to remediate such a contaminated site anyway, e.g. to improve the quality of an aquifer to meet drinking water standards, there may be time to consider alternative remediation options. At this point even more cost effective remediation approaches come into view.

A more recent development is to combine sustainability aspects (see also Chapter 4 in our Task 2 report) with the ‘fitness for use’ approach, offering a balance between human health and environmental protection versus the opportunity to reuse contaminated soil and to optimize economic aspects of site redevelopment. This approach offers a lot of space for economical and sustainable benefits without any public health or safety sacrifices. When assessing a national program for remediation of multiple contaminated sites, these benefits are crucial for the feasibility of the complete program.

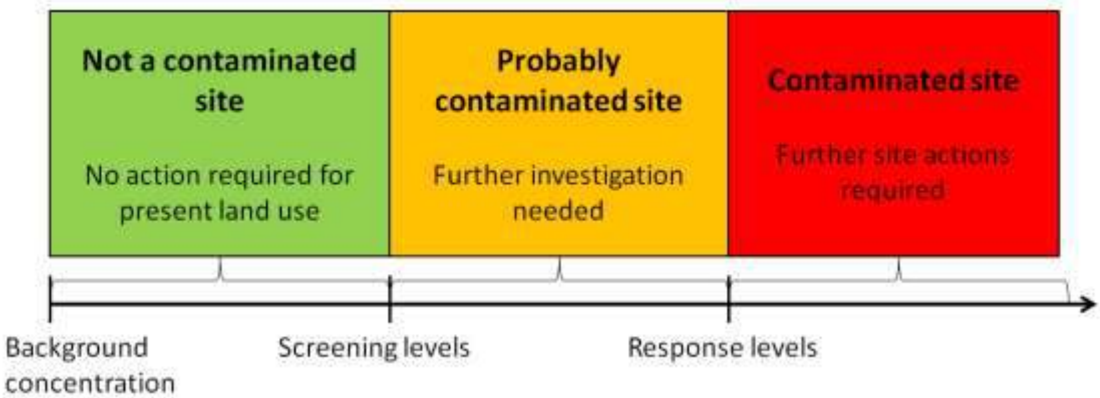
2.2.4 Target levels for remediation

General

When remediation measures on the source or part of the source of the contamination have to be taken it is necessary to define target levels.
At this point it again is important to stress the fact that complete removal or treatment of the source is not always required. In some situations there is no exposure to high concentration of parameters in contaminated material because the site is capped or a clean layer of soil is on top of the contaminated material. And in some situations there is no leaching because of capping or because of the fact that the contaminated material is lying above ground water level in a situation where evaporation exceeds precipitation.

We propose to connect these target levels with the levels already derived in the process of assessment of a contaminated sites. The determination of a site being recognized as a contaminated site will be based on the assessment of parameters in soil and groundwater against the screening and response levels. For more detail on this we refer to the report of Task-2 of Assignment 1-Inventory, while figure 2.7 below shows the approach of these levels schematically.

Figure 2.7 Schematic presentation of screening and response level approach



Soil
The Canadian soil quality guidelines have been proposed as screening levels. (Task 2 report – “Formulate approaches to identification and assessment of contaminated sites in India”, COWI, February 2013). In these soil quality guidelines concentration levels of several parameters in soil are presented for four categories of land use: agricultural, residential/parkland, commercial and industrial land use. Each of these forms of land use represents a different impact of (contaminated) soil to humans and environment. Annexure I provides an overview of these Canadian concentration levels, compared to soil quality target levels from the US and The Netherlands.
It should be noted that the levels as published in the Hazardous Waste Rules India (2008), Schedule II, are included in Annexure I. This has been done with the sole purpose of enabling comparison of the international levels with levels familiar to Indian professionals. However, it should be emphasised that there is a distinct difference between soil, water and sediment contaminations and hazardous waste. Soil quality standards define concentrations of contaminants that may pose risks to human health or to the environment. By contrast, hazardous waste definitions are internationally used to distinguish hazardous waste from non-hazardous waste. The international consensus is that hazardous waste definitions should not be applied in the assessment of soil contamination. This means the use of hazardous waste definitions is limited to procedures for the disposal of waste. It is conceded that this does include procedures for the disposal on landfills or the treatment of contaminated soil and sediment.

In case pollutant concentration levels are below the Canadian soil quality guideline levels the risks to human health and the environment are considered to be negligible. As described in a supporting document: “soil remediated to guideline levels will represent a healthy, functioning ecosystem capable of sustaining the current and likely future uses of the site by ecological receptors and humans, including uses of groundwater. When during site assessment it is these levels are not exceeded, no further investigation is required” (Guidance Document on the Management of Contaminated Sites in Canada, CCME, 1997).

The Canadian soil quality guideline levels have been developed on a sound scientific basis and are well suited as a standard for remediation target levels within a framework of a generic fitness for use threat reduction. Therefore, we propose to align generic remediation levels in NPRPS with these site screening levels.

Groundwater
For groundwater initially the intended use (at present or in future) of the groundwater needs to be established. Is it to be used for drinking water for humans, for drinking water for animals, for irrigation of crops, or for water in industrial processes? Depending on this, different standards are likely to apply. In cases where drinking water for humans is the intended use the Indian Drinking Water standards (reference IS 10500 : 2012 Drinking Water — Specification (Second Revision), Gr 6) can be regarded as target level for pollutants in groundwater within the framework of a generic fitness for use threat reduction.

Annexure II provides an overview of the concentration levels of the Drinking Water standards, compared to other international standards. Also included are suggestions for groundwater screening levels, derived from these standards.

In other situations, where groundwater is used for other purposes, e.g. drinking water for animals, for irrigation of crops or industrial processes, the groundwater remediation standards do not necessarily have to meet the Indian Drinking Water standards. In order to prevent excessive costs, economic and ecological factors may be taken into account. In such situations, the integrated assessment and appraisal of all remediation options, in which all criteria are balanced, may well lead to higher remediation target levels. Whenever that is the case, the application of additional measures at the point of use should be given careful consideration. Examples of these are a water treatment plant or an alternative water supply system.

Influence of elevated natural background levels
In some areas background concentrations of naturally occurring parameters in groundwater are elevated and can exceed the guideline levels. An example of this is constituted by heavy metal concentrations in groundwater in mineralised areas exceeding guideline levels. Whenever there is reason to believe that elevated concentrations in groundwater are due to naturally occurring contaminants the site assessment should include a specific assessment aimed at establishing whether or not this is the case. In case it has been established that the elevated concentrations are indeed caused by naturally occurring contaminants the use of the natural background levels for groundwater at that site as remediation target levels should be considered. In such cases the quality of the groundwater will not meet drinking water standards. Therefore, to secure the supply of the local community with drinking water, the installation of drinking water treatment plants should be given careful consideration.

Site specific remediation targets
Generic remediation targets are useful to gain a first indication, but sometimes the use of these generic targets results in disproportionate costs. Because site specific environmental conditions will vary generic target levels should not be regarded as absolute values. Results of a risk assessment study at a site will provide information on the level of threats for human health and environment and the necessity for quick response actions. Therefore, we propose to align the remediation target for a site with the result of the site specific risk assessment.

2.2.5 Cost effective groundwater approach
Contamination in groundwater can spread to huge volumes and contaminate large areas in the process. In areas where groundwater or downstream surface water is used as a drinking water source, groundwater contamination is likely to affect this strategic and fundamental asset.

As remediation of contaminated groundwater can be very cost intensive, as illustrated in figure 2.4, ‘Principle of soil remediation efficiency’, cost effective approaches are especially interesting. Such an approach is only possible if no actual human or environmental risks are at stake. This is because cost effective approaches of groundwater contaminations often lead to a long term remediation process such as natural attenuation or long term groundwater management using the stand still principle.

Basic principles of cost effective groundwater approaches are:
- maximum use of natural attenuation techniques;
- long term monitoring of potential hazards;
- assessing sources of spreading. As the remediation of the source of spreading is a relatively cost intensive operation, the remediation of the source can be balanced to the level of spreading which is acceptable;
- use of fall back scenarios only in case of unacceptable spreading (actual threatened receptor).

Cost effective remediation of groundwater offers opportunities for alternative solutions by combining different groundwater uses. For example, pump and treat remediation of a groundwater contamination can be combined with other parties using groundwater for industrial use or irrigation. After having treated the contaminated groundwater it can be offered for use by other parties or even for drinking water supply. If necessary a temporary drinking water piping system can be implemented as a safety measure before or during the remediation works.

2.3 Analysis of risk based versus standard based approaches

From the Sections 2.2.2 and 2.2.3 it can be derived that a standard based approach is, in comparison with a risk based approach, relatively simple and easy to understand, also for non professionals. This characteristic can help in drawing support, especially from residents, when proposing remediation solutions. On the other hand, a standard based approach is less flexible: once the standards have been set, a decision at policy level, the system in a way determines what decisions need to be taken in individual cases. Experience shows that this can lead to remediation approaches hardly taking into account the local situation. Moreover, the standard based approaches have shown a tendency to require, mostly considerably, more financial means.

By contrast, a risk based approach is aimed specifically at developing remediation options fitting the local situation. Furthermore, a risk based approach in assessing remediation options seamlessly fits on to the site assessment phase, which usually includes risk assessment to determine the need to remediate. Also, in a risk based approach, individual site specific targets for remediation sometimes can be derived from or combined with other target values, e.g. drinking water standards. A risk based approach, however, requires more data, in particular on the local situation. In most cases, the investment in acquiring these data yields larger returns later, by saving significantly on the costs of the remediation, which, after all, is aimed at the specific situation.

India is a cost sensitive market, meaning that any solution needs to use local components, hardware, engineering, skill level of operators, level of automation, etc. India is also very diverse, geographically, as well as socially, culturally and ethnically. This means the general approach should enable stakeholders to tailor remediation options to any local situation. This has implications at all levels of abstraction, from the regional cultural situation right down to the practical level, taking into account aspects like the availability of electric power.

Based on the above, the risk based approach seems, in general, to provide the best opportunities for India. While we propose therefore to focus on the risk based approach we will in this assignment continue to also discuss the standard based approach, as this may still be useful in certain cases.

2.4 International approaches to remediation

2.4.1 Generic objectives, methodologies and tools

The report on Task 2 contains a review of national and international approaches to remediation. Continuing on this review, we present the generic remediation objectives, as set by the three representative countries with a well developed policy on soil remediation: the United States, the United Kingdom and the Netherlands, in tables 2.1 and 2.2 below. Supporting methodologies and tools used in these three countries are presented in table 2.3. We refer to the Task 2 report for more detailed information.

Table 2.1 Generic objective of the national policy on soil remediation

NL	UK	US
The elimination of situations of unacceptable environmental risks in current or future land use. Promoting sustainable use of soil.	(a) To identify and remove unacceptable risks to human health and the environment. (b) To seek to ensure that contaminated land is made suitable for its current use. (c) To ensure that the burdens faced by individuals, companies and society as a whole are proportionate, manageable and compatible with the principles of sustainable development.	(Superfund program) Select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste.

Table 2.2 Generic remediation objectives for sites

NL	UK	US
• To remediate at least to a level suitable for the use of the land after remediation, where the risk to human, animal or plant as a result of exposure to contamination is minimized. • Additionally, the risk of the spread of contaminants are minimized.	The broad aim of remediation should be: (a) to remove identified significant contaminant linkages, or permanently to disrupt them to ensure they are no longer significant and that risks are reduced to below an unacceptable level; and/or (b) to take reasonable measures to remedy harm or con-	The CERCLA law authorizes two kinds of response actions. Short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response. Long-term remediation response actions, that permanently and significantly reduce the dangers associated with releases or threats of re-

NL	UK	US
• Finally, the need to take action and restrictions in the use of the soil (post remediation) are minimized. Explanation of 'minimized': the costs should be in proportion with the result of the remediation. <u>Immobile contamination</u>: Land use oriented rehabilitation (there are generic protection levels for different forms of land use. <u>Mobile contamination</u>: cost effective (= balance between burdens and benefits of remediation). There is no generic remediation objective case level. For mobile contaminants often a distinction between source and plume approach is used.	tamination that has been caused by a significant contaminant linkage. <u>Site specific remediation criteria are for example</u>: soil guideline values, drinking water standards, site specific assessment criteria (developed from detailed quantitative risk assessment), engineering based criteria (e.g. thickness of cover system).	leases of hazardous substances that are serious, but not immediately life threatening. Remedial action objectives provide a general description of what the cleanup will accomplish (e.g., restoration of groundwater). Preliminary remediation goals (PRGs) are the more specific statements of the desired endpoint concentrations or risk levels, for each exposure route, that are believed to provide adequate protection of human health and the environment based on preliminary site information.

Table 2.3 Supporting methodologies and tools (referring to Task-2 report for more information)

NL	UK	US
For deriving risks in the assessment process of site assessment the Sanscrit model is used as a general tool. For site specific situations detailed investigations on different exposure routes are recommended. Generic remediation levels for different land use have been developed in the national regulation: the Soil Quality Decree (for agricultural and ecological functions, for residential use and for industrial land use remediation levels.). For groundwater the target level in the Circular on soil reme-	The soil guideline values in UK are non-statutory SGV's and they are meant to provide technical guidance during site assessment. They are not derived explicitly to be used as remediation standards. For deriving SGV's a risk model is used. This risk model (CLEA software) estimates exposure to chemicals from soil sources by adults and children living or working on land affected by contamination over long periods of time, and compares this estimate to established health criteria values. The process for setting re-	In the process of site assessment several USEPA documents are supporting the site assessment and risk assessment. There are several supporting guidelines for selecting remediation measures in the Superfund program. In the phase of Remedial Investigation / Feasibility Study the Rules of thumb for Superfund remedy selection, 1997, is a supportive USEPA-document. For development of brownfields a road map with options for site investigation and cleanup and a supportive web-

NL	UK	US
diation. Supporting documents for setting remediation targets for mobile contaminants is 'ROSA, 2005'. There are no mandatory tools for remediation option appraisal. A model for assessment of remediation options that can be used is RMK. This model includes risk reduction, environmental aspects and costs.	mediation objectives and standards for remediation is outlined in CLR 11 (Defra and Environment Agency, 2004). To take into account various sustainability aspects Sustainable Remediation Forum-UK has developed a list of aspects.	site provide information on the approach of contaminated sites. To take into account various sustainability aspects under Sustainable Remediation Forum-US models have been developed.

Recommendations for India

Below, we present recommendations for the development of generic policies and objectives for India, based on the international approaches summarized above.

Objectives for national policy

A national policy on contaminated soil should be aimed at:

- The identification and removal of unacceptable risks to human health and the environment;
- Ensuring that contaminated land is made suitable for its current and if possible also for its intended future use;
- Ensuring that the burdens faced by individuals, companies and society as a whole are proportionate, manageable and compatible with the principles of sustainable development.

Generic remediation objectives

- Long term remediation objectives should assure that a situation is reached in which the use of the land without unacceptable risk to human health or the environment is secured against reasonable cost;
- Short term remediation objectives should assure that unacceptable risks requiring immediate action can be addressed, resulting in a situation where the risks have been reduced to an acceptable level.

Supporting methodologies and tools

- Remediation measures can be focussed on either source, pathway or receptor or on a combination of these;
- Remediation targets should be aimed at reaching a situation that assures long term use of the site ("fitness for use") against reasonable cost;
- A combination of generic and site specific target levels may be applied;
- Internationally, a considerable number of tools are available for the assessment of risks, for setting remediation objectives, for the appraisal of remediation options and for the appraisal of sustainability aspects. The Guidance

Document (Report on Task 4 in this Assignment) discusses the most widely applied of these tools;

- National screening and remediation target levels may be derived from international best practices. This report presents proposals for these levels.

2.4.2 Reduction of risk by intervention on source-pathway-receptor

To reduce the risk level an intervention has to be applied to either the source, the pathway or the receptor of the contamination:

- To source: the contaminants in the source have to be removed or treated. Risk based target levels of remediation are used which depend on the site use;
- To pathway: the pathway of the contamination to the receptor has to be cut off;
- To receptor: the receptor has to be protected or removed from the situation.

Remediation options to protect, modify or remove the receptor can be carried out with measures such as:

- remove the receptor (e.g., to rehouse affected residents)
- control an individual's exposure to contaminants by administrative means (e.g., imposing legal or contractual restrictions on their access to, or use of, a garden or play area).
- prohibiting access to a site by fencing the site;
- ending use of ground water for drinking water or other purposes by closing wells and providing water with a replacing option (piping system, tanks).

2.4.3 Principles and characteristics of remediation options

The remaining part of this Section provides more detail on remediation measures aimed at the source and the pathway. To begin with, remediation techniques can be grouped into four remediation principles:

- Extraction: extraction of the soil material, sediment or groundwater in which the contaminant is located;
- Transformation: destruction or alteration of the contaminant into harmless or less risky products;
- Immobilization: stopping of the migration of the contaminant in its pathway;
- Containment: capturing the contaminant within non penetrable physical limits.

Apart from these four remediation principles, it is also possible to implement temporary safety measures. Table 2.4 below presents an overview of best practices remediation techniques aimed at the source or the pathway, grouped according to the applicable remediation principle. These remediation techniques have provided good results internationally and seem to be applicable in India as well. For each of the techniques, table 2.4 provides information on the applicability in the remediation of specific substances.

Table 2.4 Overview of remediation techniques and their applicability

✓ Remediation option is potentially applicable to a specific media-contaminant combination
X Remediation option is not applicable to a specific media-contaminant combination
? A pre-treatment step or pilot may be necessary prior to the method being suitable or case study information is inconclusive regarding applicability
S Soils, made ground en sediments
W Groundwater and surface water

Principle	Technique	Section	Point of entry (SPR): Source	Pathway	Receptor	Applicable media	Applicability substances: VOC's	Halogenated Hydrocarbons	Non-halogenated Hydrocarbons	PAHs	PCBs	Dioxins and furans	Pesticides and herbicides	Heavy metals	Asbestos	Cyanides
Extraction	Excavation, followed by:	4.1	X	X	X	S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	- Biological treatment / biopile	4.1.1	X	X	X	S	✓	X	✓	✓	X	X	✓	X	X	X
	- Soil washing	4.1.2	X	X	X	S	X	✓	✓	✓	✓	X	✓	✓	X	✓
	- Thermal treatment	4.1.3	X	X	X	S	✓	✓	✓	✓	✓	✓	✓	X	X	✓
	- Physical separation	4.1.4	X	X	X	S	X	X	X	X	X	X	X	X	✓	X
	- Disposal in landfill	4.1.5	X	X	X	S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Groundwater abstraction (pump & treat)	4.2	X	X		W	✓	✓	✓	✓	✓	✓	✓	✓	X	X
	SVE – Soil vapor extraction	4.3	X	X	X	S	✓	✓	✓	X	X	X	X	X	X	X
	MPE – Multi phase extraction	4.4	X	(X)	X	S,W	✓	✓	✓	?	X	X	X	X	X	X
Transformation	Air-sparging	4.5	X	X		W	✓	✓	✓	?	X	X	X	X	X	X
	Soil Heating	4.6	X			W	✓	✓	✓	✓	?	X	X	X	X	?
	Elektrokinetics	4.7	X	(X)		S, W	✓	✓	✓	✓	?	?	?	✓	X	✓
	In-situ chemical oxidation (ISCO)	4.8	X	(X)		S, W	✓	✓	✓	✓	X	X	✓	X	X	?
	Permeable reactive barriers (PRB)	4.9		X		W	✓	✓	✓	✓	✓	✓	✓	✓	X	✓
	In-situ bioremediation	4.10	X	X		S, W	✓	✓	✓	✓	X	X	✓	X	X	X
	Phyto remediation	4.11	X	X		S, W	✓	✓	✓	✓	X	X	✓	✓	X	?
	Natural attenuation	4.12	X	X		W	✓	✓	✓	✓	X	X	✓	X	X	X
Immobilization	Vitrification	4.13	X			S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	In-situ grouting	4.14	X	X		S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Containment	Vertical wall	4.15		X		S, W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Capping layer	4.16		X		S, W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Geohydrological control	4.17		X		W	✓	✓	✓	✓	✓	✓	?	✓	✓	?
Temporary safety measures	Land use restrictions	4.18			X	S, W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Relocation and safety measures	4.19			X	S, W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Drinking water treatment	4.20			X	W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

The following internet sources provide generic information about remediation techniques and examples of cases where techniques have been applied:

- CLU-IN website of US-Environmental Protection Agency, providing information about innovative treatment and site characterization technologies: http://www.clu-in.org/
- Federal Remediation Technologies Roundtable website, providing information about technologies for assessment and remediation of contaminated sites: http://www.frtr.gov/
- A good overview on standings for in-situ treatments is provided in: http://www.frtr.gov/pdf/meetings/jun08/madalinski_presentation.pdf
- Soilection website, providing information and case descriptions of practical in-situ remediation experiences, mainly in The Netherlands and Belgium: http://www.soilection.eu
- Dutch directive on restoration and management of soil, groundwater and sediment, providing information on 130 techniques for investigation (an English translation is provided on this internet page): http://www.bodemrichtlijn.nl/Tools/bodemonderzoekstechnieken/applicatie-zoeken-naar-onderzoekstechnieken.

A detailed description of the techniques, including references to examples, is provided in the Guidance document.

Table 2.5 on the next pages presents a comprehensive description of characteristics of the most important remediation technique groups. For each group of remediation techniques the table summarizes the generic characteristics and the site specific characteristics, as well as a brief analysis of strengths, weaknesses, opportunities and threats. In addition, the table presents practical experience on both the applicability as well as the limitations of the remediation techniques under certain conditions.

Below the characteristics presented in table 2.5 are explained.

Generic characteristics

- Risk reduction potential: degree to which health and environmental risks are reduced beyond the target level of remediation, offering an extra surplus of risk reduction or protection. Applicable to both immobile and mobile contaminants.
- Technical success potential: technical complexity, implementability, robustness (intrinsic capacity of the technical measures to accommodate changes in circumstances or performance), and the availability of technical capacity.
- Cost and benefits. Included are:
    - Costs for activities like post remediation actions and measures needed due to failure of originally planned measures;
    - Benefits due increased value of the site and to combined implementation with site redevelopment.
- Sustainability: influence of the remediation on other environmental aspects, e.g. air quality, space, ecology, waste, energy.

Site specific characteristics

- Time: time needed to implement the remediation objective. Note: the time needed to implement post remediation actions is considered as a cost and/or social aspect.
- Post remediation site use: degree to which the site can be used for present, planned or not yet known site uses regarding its technical characteristics.
- Social criteria: social acceptance and impacts:
  - Physical Impacts to neighbourhood such as noise, dust, odour, traffic;
  - Changes in the way the local communities function;
  - Changes that could affect the site usage by communities.

Table 2.5 Remediation option principles and their characteristics

Remediation option principle: Extraction: extraction of the ground or the groundwater which the contaminant is located in.
Localisation: On site, soil treatment off-site
Remediation technique type: Physical, generic approach

Generic characteristics				Site specific characteristics			Strengths and opportunities	Weaknesses and threats
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
In general a high degree of removal of the contaminant is possible. For shallow contamination, removal of all contaminant is possible	The Conceptual Site Model and the delineation of the contamination must be well defined. Technical risks mainly related to the presence of buildings, foundations or other objects in the ground, that can obstruct the extraction. Technical risks increase with increasing depth of excavation, especially below groundwater level or near / under constructions Increased technical risk if remediation	Directly linked to: - The volume of soil to be excavated and treated - The treatment method and transportation of the excavated soil - The volume, transportation and quality of material needed to backfill Also linked to: - The excavation depth - Groundwater drainage during excavation - The groundwater extraction depth - The flow of extracted groundwater	- High energy consumption by diggers, trucks, pumps, treatment plants. - Transfer of contamination to other compartments than soil/groundwater depending on soil/groundwater treatment - Waste - Long term space consumption (sanitary landfill) - Air contamination: volatile contaminants can be released in the	Short duration of the operation (excavation) Long duration of the operation (pump & treat)	Limited to no use of site during excavation. Site can be restored for sensitive site use or even full multifunctional use.	May cause: -Noise, -Smell, -Traffic, -Dust, -Damage to adjacent buildings. Temporarily loss of function of the site Temporarily moving out of populations.	Strengths: - robust remediation - possible multifunctional restoration - possible short duration Opportunities: - Relatively small and shallow contaminations - Dynamic sites which require fast results - (partial) source removal, e.g. to prevent contact or spreading risks	Weaknesses: - loss of function of site during excavation - high energy consumption, transfer of contaminant to other compartments than soil/groundwater, waste - costs strongly related to volume of soil to be excavated, transported and treated Threats: - Causing of nuisance, particularly in urban areas - Lack of space, particularly in urban areas

	results for groundwater are to be attained mainly by pump & treat.	- The treatment method of the extracted groundwater	air during excavation.					

Remediation option principle: Extraction: extraction of the ground or the groundwater which the contaminant is located in. **Localisation:** On site, soil treatment on-site **Remediation technique type:** Physical, specific approach								
Generic characteristics				**Site specific characteristics**			**Strengths and opportunities**	**Weaknesses and threats**
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
In general a high degree of removal of the contaminant (source) is possible. For shallow contamination, removal of all source material is possible.	The Conceptual Site Model and the delineation of the contamination must be well defined. Technical risks mainly related to the presence of buildings, foundations or other objects in the ground, that can obstruct the extraction. Technical risks increase with increasing depth of excavation, especially below groundwater	Directly linked to: - The volume of soil to be excavated and treated - The treatment method of the excavated soil - The possibility to backfill with the treated soil Also linked to: - The excavation depth - Groundwater drainage during excavation - The groundwater extrac-	- Energy consumption by diggers, trucks, pumps, treatment plants. - Transfer of contamination to other compartments than soil/groundwater depending on soil/groundwater treatment - Waste - Space consuming, additional space for the on-site	Short duration of the operation (excavation) Longer duration of the operation depending on type of soil treatment process Long duration of the operation (pump & treat) if rebound processes should be dealt with	Limited to no use of site during excavation. Space required over longer time for on-site soil treatment Site can be restored for sensitive site use or even full multi-functional use.	May cause: -Noise, -Smell, -Traffic, -Dust, -Damage to adjacent buildings. Temporarily loss of function of the site Temporarily moving out of populations.	Strengths: - robust remediation - possible multi-functional restoration - efficiency on a larger scale Opportunities: - Large contaminations that allow for backfilling with the on-site treated soil - low control on process in case of highly changing weather conditions (monsoon) or extreme winter/summer conditions	Weaknesses: - not cost effective for relatively small contaminations - loss of function of site during excavation - high energy consumption, transfer of contaminant to other compartments, waste - costs strongly related to volume of soil to be excavated and treated Threats: - Causing of nuisance, particularly in urban areas - Lack of space, particularly in ur-

	level Increased technical risk if remediation results for groundwater are to be attained mainly by pump & treat.	tion depth - The flow of extracted groundwater - The treatment method of the extracted groundwater	soil treatment - Air contamination: volatile contaminants can be released in the air during excavation and soil treatment.					ban areas - Depending on length of the process long term supervision and fine tuning is needed

Remediation option principle: Transformation: Destruction or alteration of the contaminant into harmless or less risky products **Localisation:** In-situ **Remediation technique type:** Chemical, specific approach								
Generic characteristics				**Site specific characteristics**			**Strengths and opportunities**	**Weaknesses and threats**
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
Possibility to reduce risks of mobile organic contaminants in source or pathway beyond target level. Multi functional remediation not typical	Chemical agent has to be able to react with the contamination. Chemical reactions are usually non-specific (oxidation): any organic substance in soil (including valuable / natural organic matter) can be destroyed and will increase amount of agents	Related to: -Technical risks -Volume of soil to be treated - Depth of soil to be treated - Accessibility of the site - Chemical agent consumption by soil matrix and contaminant	-Relatively little waste generated -Some systems space consuming or energy consuming -Ecosystem of the soil can be affected or destroyed	Remediation objectives can be achieved relatively fast compared to other in-situ approaches	More intensive techniques prohibit or limit use of site during treatment. After treatment, typically a large load of contaminants has been removed and risks have been reduced.	Use of reactive chemical agents is a potential hazard to the neighbourhood During treatment phase (part of) site inaccessible due to chemical process equipment Underground piping can be required, limiting site use (digging)	Strengths: - treatment of source zones/pure product of mobile organic contaminants below groundwater - high load removal without excavation Opportunities: Alternative for high load removal when excavation of contaminants is not possible	Weaknesses: - while relatively fast, still takes time - not suitable for low permeable soil - multi phases of field activities may be necessary depending on progress of alteration - technical detail engineering is complex in case of high dynamic aquifers (monsoon depending)

	needed. Approach has to be expertly dimensioned and executed (dosage, injection area) to prevent insufficient contaminant breakdown. In case of building/foundations, technical risk increases Type of soil is key in technical risks. Chemical oxidation of organic contaminants in peat is inefficient.	- Safety measures				Low impact on residential area		Threats - relatively costly - requires hazardous chemicals - safety measures for the technicians and the neighbourhood must be planned when chemicals are used.

Remediation option principle: Transformation: Destruction or alteration of the contaminant into harmless or less risky products
Localisation: In-situ
Remediation technique type: Biological, specific approach

Generic characteristics				Site specific characteristics			Strengths and opportunities	Weaknesses and threats
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
Possibility to reduce risks of mobile organic contaminants beyond target level assessing the pathway Multi functional remediation not typical	Contaminants that are not biologically available will not be affected. Contaminants should be biochemical degradable.. The general soil biology (aerobic , anaerobic, nutrients) has to be (made) suitable for the desired biochemical reaction(s). In case of presence of pure product, technical risk increases. Type of soil determines technical risks as the nutrients may affect the soil or	Related to: - Type of deployment: passive / shockload / continuous - Volume of soil to be treated - Depth of soil to be treated - Accessibility of the site - Amount and type of nutrient(s) needed	- Green remediation: use of the soil's natural ability to remediate itself - Relatively little waste generated -Relatively low energy consumption	Relatively slow and time-consuming	After treatment, typically the mobile (biologically available) part of the contaminant load has been removed and risks have been reduced. However a degree of residual groundwater contamination will usually remain, just not spread anymore.	Very limited area occupation above ground Underground piping can be required, limiting site use (digging) Low impact on residential areas	Strengths: - green remediation - treatment of groundwater plumes of mobile organic contaminants. - relatively cheap - low impact on site activities - high temperature environments may speed up the process of degradation of contaminants Opportunities: Groundwater plumes that have the potential to spread, but have not yet reached the receptor	Weaknesses: - time consuming to reach remediation objectives - only applicable below groundwater level - typically not suitable for low permeable soil - typically not suitable for pure product - multi phases of field activities may be necessary depending on progress of alteration - technical detail engineering is complex in case of high dynamic aquifers (monsoon depending) Threats: - residual contamination after treatment - intermediate breakdown prod-

	are used to degrade organic compounds of the soil itself.							ucts can be more mobile and/or toxic than original contaminant - limited suitability as standalone approach

Remediation option principle: Immobilization: Stopping the spreading of the contaminant in its pathway (ground and/or groundwater) **Localisation:** In-situ **Remediation technique type:** Physical, specific approach								
Generic characteristics				**Site specific characteristics**			**Strengths and opportunities**	**Weaknesses and threats**
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
Reduction of risk of spreading of contaminants towards a receptor. Typically not focused on load removal. Only relevant for mobile contaminations	The CSM - in particular the mechanisms of spreading - and the delineation of the contamination must be well defined. Technical risks highly related to uncertainties in physical parameters like the permeability of the soil or the groundwater flow. Also related to the presence of	Related to: -Technical risks -The duration of the measures and monitoring (can be a very long) -The chemical and physical properties of the contamination and the point of operation are determinant for the design.	- Little waste and energy consumption compared to a full scale approach	Spreading can be quickly stopped (pathway As the source remains present in the soil, regular monitoring and other constraints are required. Those extra operations have to be maintained over longer time and can have an indefinite character.	Functional use of soil is limited. Therefore not obvious for dynamics sites Restrictions for underground use must be included in the future project of the site.	Can affect the surrounding populations due to maintenance and regular extra operations. Perception towards remediation that leaves the contamination untouched	Strengths: - quick solution to an immediate risk - cost effective compared to full scale remediation Opportunities: - temporary risk removal while awaiting a future further remediation	Weaknesses: - contamination remains - measures and monitoring can become indefinite in time - difficult to design for monsoon depending high groundwater table fluctuations Threats: - limited use of underground - perception issues by residents/users - Depending on length of the

	buildings, foundations or other objects in the ground. Technical risks can increase with depth.							process long term supervision and fine tuning is needed - illegal groundwater pumping activities

Remediation option principle: Containment: capturing the contaminant within non penetrable physical limits
Localisation: In-situ
Remediation technique type: Physical

Generic characteristics				**Site specific characteristics**			**Strengths and opportunities**	**Weaknesses and threats**
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
Reduction of risk of spreading (leaching from source) of contaminants towards a receptor. Reduction of risk of contact with contaminants by receptor No contaminant removal.	Surface capping: technical risks related to surface area. Vertical shielding: technical risks related to soil layering and required depth Subsurface horizontal shielding: technical risks related to accessibility, soil layering, required depth and required longevity	Surface capping: costs are linked to the surface area and the type of capping material. Vertical shielding: costs are related to shield dimensions (length x depth) and type of material. Subsurface horizontal shielding:	Little waste. Depending on method some to substantial energy consumption. Surface capping is space consuming and can change the landscape. Hard surface capping negates most previous ecological value of	The containment operation is quick. As the contamination itself remains present in the soil, regular monitoring and other constraints are required. Those extra operations have to be maintained over longer time and can have an indefinite character.	Use of the underground is limited. Therefore not obvious for dynamics sites Restrictions for underground use must be included in the future project of the site. Future use may not breach the containment, unless appropriate countermeasures are taken.	Limited to no use of site during capping Can affect the surrounding populations due to maintenance and regular extra operations. Perception towards remediation that leaves the contamination untouched. Subject to illegal use of commodities in and below	Strengths: - quick solution to an immediate risk - cost effective compared to full scale remediation Weaknesses: - contamination remains - measures and monitoring can become indefinite in time Opportunities: - temporary risk removal while awaiting a future further remedia-	

	of the shielding Surface capping is technical complex in a highly parcelled area. Robust design prevents post remediation repairs and maintenance.	costs are related to shield depth and surface area and method of placement.	the soil. Surface capping with suitable soil requires a sufficiently thick layer which has to be transported to the site.			capping layer ('Rag pickers problem')	tion Threats: - limits use of underground - perception issues by residents/users - subsurface shielding is difficult to control and maintain - When chancing site use a complete new remediation might need to be carried out (all earlier efforts are 'lost')	

2.4.4 Appraisal and selection of remediation options

All remediation options should meet the remediation objective: reducing the level of significant risk to the required level. In case this level is not reached by a remediation option, either additional measures are necessary or the remediation option is not appropriate for the case at hand. Intervention measures which may be effective to a certain degree but which cannot be seen as a final remediation option are not discussed in this Section. They may be used as a temporary safety measure, or in addition to other measures, but they are not applicable as the only remediation measure, as they cannot be relied upon to offer a solid and lasting risk reduction. Examples are well closure to prevent consumption of contaminated groundwater (a new well can be struck alongside the closed one), site access restriction by fencing or signs to prevent human contact (the fence can be breached) or moistening of dry soil surfaces to prevent wind induced contaminated and dust inhalation (the moisture can evaporate again). Another example is groundwater interception to prevent contaminated groundwater from discharging into surface water used for irrigation of crops. This should be temporary as the feeding of the surface water needs to be restored in time.

The applicability and expected success of remediation options can be assessed using the characteristics presented in the previous Section 2.4.3. In the remediation option appraisal and selection process these characteristics fulfil the role of the criteria, each containing several elements for consideration. The selection of remediation options is a balancing act: one option can be favourable regarding one criterion but can have a negative score on other criteria. Below, the elements for consideration in the appraisal and selection of remediation options are presented for each criterion.

Elements for consideration for the generic criteria

Criterion: risk reduction potential

- Level of risk reduction: the more the level of risk is reduced the more guarantees can be given the remediation will be adequate and more forms of land use can be practised without threats to health or environment;
- Phasing of remediation: stepwise improvement of a site's situation is preferable when final targets can be met in the future. Provided that most important actual risks are in sight and dealt with as needed. Stepwise improvement means a reduction in remediation efforts and provides more opportunity for natural breakdown of contaminants;
- Size of contamination source: total removal or treatment of the constituents at contaminated sites with a relatively small and well accessible source of contamination is preferable;
- Volume of contamination: the volume of contamination that could be left on site is often too small compared to the efforts required to remove all of it. The extra efforts include the design process of a ‘fitness for use’ approach, remediation actions that are likely to be required if the site will be redeveloped again after a period of time or post remediation actions for management of the contaminations remaining on site;
- Surrounding area: when in a larger area more than one site is contaminated it often makes sense to develop a management strategy for the approach of

the whole area rather than taking extensive remediation measures only at that specific site;

- Removal of load: the more kilograms of contamination is removed from the soil, the more the remediation will have a long term impact. Condition however is that the constituents have not been transformed into more toxic or mobile components;
- Liability: in certain cases third parties choose to avoid any risk of liability. In those cases, a remediation where all contamination is removed or treated is the best bet to not end up with post remediation obligations;
- Options for alignment with other developments: if remediation of a site is combined with the redevelopment of the site the redevelopment influences the selection of the remediation option. The alignment of the remediation design to the redevelopment plan (and vice versa). In some cases, land use planning may have to be adapted to the contamination situation, e.g. considering remediation of a former toxic waste dump for agricultural or housing purposes would require high costs, whereas the use as an industrial area may be very cost-effective.

Criterion: technical success potential

This criterion involves technical complexity, implementability, robustness (intrinsic capacity of the technical measures to accommodate changes in circumstances or performance), and the availability of technical capacity.

- Robustness: the remediation measures should remain effective, also under changing conditions or in case of poor maintenance. The measures should be ‘simple if possible, and complex only when necessary’;
- Stage of development of remediation technique: in case a remediation technique has only proven itself on a laboratory scale, no guarantees for reaching the remediation objective can be given. Proven remediation techniques should be preferred, innovative techniques may be considered after a well documented field trial shows potential success. Pilot tests may help to establish whether the technique is applicable under the specific situations at hand. This means a newly developed remediation technique needs to be tested, first in laboratory circumstances, but eventually also in the field, before it should be considered for application at any given site;
- Risk of failure: when risk of failure of the remediation strategy is considerable, additional costs to implement a fall back scenario should be taken into account.

Criterion: costs and benefits

- Costs for post remediation actions and extra measures needed due to failure;
- Benefits due to increased value of the site and to alignment of implementation with site redevelopment;
- Total budget of the redevelopment and, within that, means available for remediation measures.

Criterion: sustainability

- Influence of the remediation on other environmental aspects, e.g. air quality, space, ecology, waste, energy.

Elements for consideration for the site specific characteristics
Criterion: time
This criterion is about the time needed to reach the remediation objective. Note: the time needed to implement post remediation actions is considered as a cost and/or a social aspect.

- Time aspects: the longer a remediation takes the higher the risk of 'loss of control'. Especially in case long term post remediation measures should be taken, this is an important element.

Criterion: post remediation site use
This criterion is about the degree to which the site can be used for present, planned or not yet known site uses regarding its technical characteristics. Examples of this are 1) A complex and high-tech system (walls, interception system, ...) will be out of balance when changes on the site are made. A flexible system can easily accommodate those changes during its lifespan, 2) The more of the contaminants is removed during the remediation phase, the less risks will emerge in case of site use changes, and 3) Changes in site conditions can remobilize contaminants immobilized during the remediation phase.

- Disinvestments in case of site use changes: the more costs are spent on physical measures, the more costs are lost in case these measures need to be removed during future redevelopment. This can be avoided by later site use restrictions, but these will be difficult to maintain. A better solution is offered if this is considered as a design starting point;
- Time available for remediation: in case of a redevelopment plan a short and high cost remediation approach can be selected just to prepare the site within certain planning limits for the actual redevelopment. In cases where little time is left for remediation, a standard based high cost remediation approach taking only little time, might be selected.

Social criteria: social acceptance and impacts

- Physical Impacts to neighbourhood such as noise, dust, odour, traffic;
- Changes in the way the local communities function;
- Changes that could affect the site usage by communities;
- The degree to which a function fitted remediation may be aligned with redevelopment objectives.

At every site, different site specific circumstances will need to be evaluated, as they play a major role in this process. This Section presented the critical issues in the remediation options appraisal process. As this Section demonstrates, of these issues, particularly the technical, financial and social situation and the potential to implement sustainability aspects will show a great variability from site to site. This also applies to the potential land use post remediation and estimated costs and benefits. Therefore, these factors cannot be included in the Menu of remediation options in a meaningful generic way.

From this perspective, the Menu of remediation options in Chapter 4 should be seen as an overview of the most likely remediation options for every type of site, presenting the end user with an impression of potential and commonly applied options early on in the site investigation and remediation process. It must be stressed that the Menu of remediation options should therefore not be the only reference in the process of remediation options appraisal and selection. The Guidance document, developed in Task-4, describes in detail the process of remediation options appraisal and selection.

3 Step 3.2 – Evaluation of present practices in India

3.1 Introduction

The remediation of contaminated sites is a nascent sector in India. Therefore, the availability of reports on present practices in India is still limited. However, to date a series of remediation actions and experiments have been implemented and reports with site related remediation options have been published. Findings published in these reports, the first hands-on experience with remediation practices in India, are summarized in Annexure III.

In this Chapter an evaluation of these experiences is presented, with the aim assess which solutions may be promising, as well as which appear to have been less effective. It should be noted that, with the exception of the current pilot projects within the framework of CBIPMP the remediation actions implemented in India to date were not part of any programme to develop representative best practices for a national programme for remediation. Therefore, an evaluation of these remediation actions and experiments cannot be viewed within a theoretical context or policy evaluation. Because of this, the evaluation is limited to assess practical Indian experiences in key issues in site characterization and the selection of the remediation approach to be applied.

3.2 Data used and its constraints

The following data, provided or approved by the Client, is used for this Chapter:

- Report: 'Inventory and mapping of probably contaminated sites in India', Task-4: Site Inspections, COWI-consortium, January 2015;
- Report: 'Polluted Places – India', Blacksmith Institute, December 2007;
- Report: 'A compilation of polluted places India; Initial site assessment reports', Blacksmith Institute, June 2007;
- 'Need Assessment for Implementation of Hazardous Waste Management & Preparation of NPRPS', SENES, December 2008;
- Final Report: "Assessment and Remediation of Hazardous waste contaminated areas in and around M/s Tamil Nadu Chromates and Chemical Ltd, Ranipet";
- Chapters on remediation options as can be found in site assessment reports and remediation plans;
- Results of personal communication when visiting SPCB's during this project;
- Internet: only freely available data (if possible only for CBIPMP sites);
- Experience of Indian project team members.

A summary of the available data on remediation action and experiments in India is presented in Annexure III.

Further analysis of the Blacksmith report and further detailed data of the pilots or experiments are needed, as hardly any details nor backgrounds are given. The remediation actions were carried out on a pilot or experimental stage and not yet on a full scale. Expectations of these low cost options are high, referring to international experience with these techniques.

No data on the implementation of the Remediation Action Plans described in the SENES 2008 report is available. The proposed remediation measures can therefore not be used for the evaluation of present remediation practices.

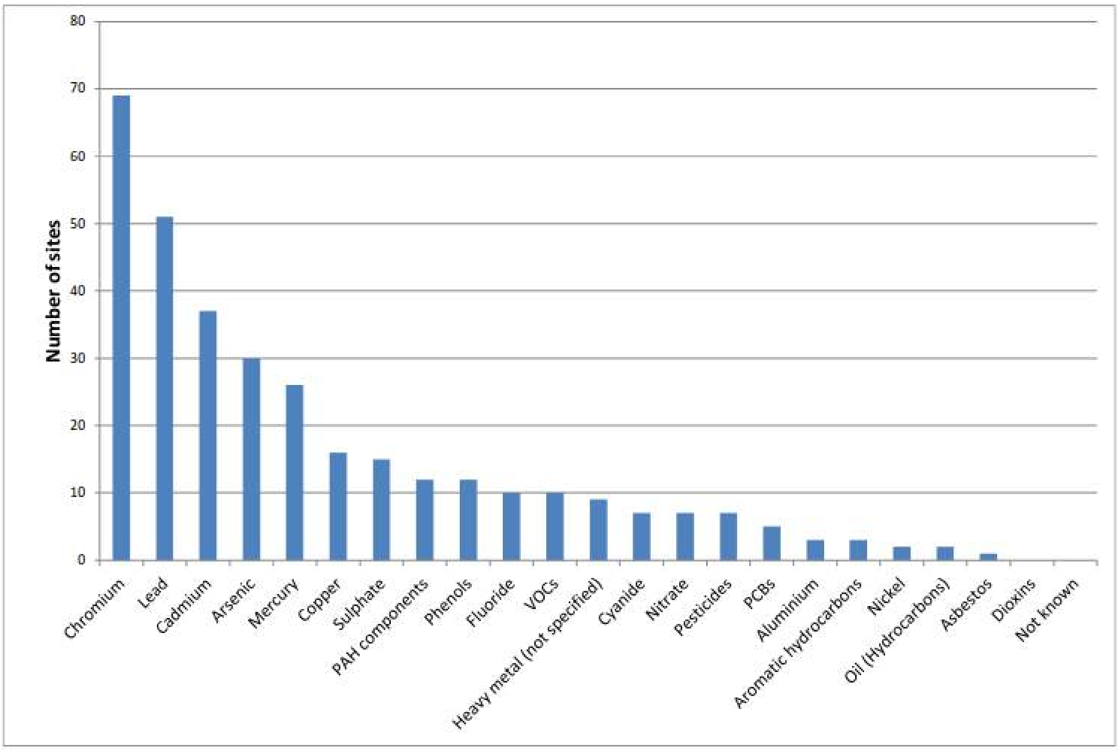
The reports on individual remediation actions are often incomplete, e.g. the technical aspects are discussed, but an evaluation of the assurance that remediation objectives will be reached using the proposed techniques is lacking.

3.3 Results

Key pollutants in India

Figure 3.1 below demonstrates the number of sites in India with a specific key pollutant. This figure is based on the report of the Assignment 1 consortium (January 2015) for 100 inspected sites. The relative distribution of the chemicals of concern of the inspected 100 sites is similar to the one linked to the total list of 320 probably contaminated sites identified as part of NPRPS.

Figure 3.1 Number of sites in India with specific key pollutants



From this graph it can be concluded that heavy metals (in soil, groundwater or surface water) are the most common type of contaminant identified to date in

India. Combined with detailed information from the sites it can be concluded that most sites are not contaminated with just a single key pollutant, but rather with a mix including other pollutants.

Technical issues

The Blacksmith Institute report of 2007 presents a brief evaluation of a number of pilot remediation cases, applying low-cost 'intervention' techniques expected to be effective at a local level. These techniques include tests with an electron donor, bioremediation techniques and basic water treatment.

The Remediation Action Plans described in the SENES 2008 report contain six remediation strategies in which more than one remediation technique is combined, e.g. excavation of contaminated soil with natural attenuation of groundwater contamination.

From reports on individual remediation actions it transpires that at several sites throughout India pilot projects are carried out. In these pilots, some within but others outside the CBIPMP framework, different remediation techniques are applied, including low-cost bio-remediation methods.

Local conditions

For every site, specific local conditions are likely to be relevant for the development of remediation options. One important issue is the availability to transport excavated material to a secured landfill (TSDF) and the capacity to store the material there. In cases where the contaminated site is situated a long distance from a secured landfill the transportation costs and environmental impact of transport may disqualify excavation and storage in landfill as a relevant remediation option.

Annexure 4 shows that of the 100 sites only some 20 are situated less than 50 kilometres from a TSDF. For those sites, this distance may not be a disqualifier for the remediation option of removal of excavated material to a secured landfill. On the other hand, over 30 sites, among which all sites in Madhya Pradesh, Tamil Nadu and West Bengal, and most sites in Punjab, are located more than 100 kilometres from a TSDF, meaning that removal of excavated material to a secured landfill is not likely to be the best applicable remediation option for those sites. From almost 40 other sites, among which all sites in Orissa, Assam, Jharkand, Bihar, Chattisgarh, Haryana, and in the National Capital Territory, a TSDF is not even accessible.
These data underscore that the number of secured landfills is limited throughout the country. In combination with the fact that development of new landfills is a complicated matter, this issue in general will favour in-situ remediation options.

Abundant rainfall on the one hand and evaporation on the other may have an important influence on the situation of a contaminated site. Groundwater levels may vary due to the influence of rainfall or flooding, causing replenishment of the shallow groundwater level. There can be an influence from surface water level changes on the groundwater level near water bodies. Groundwater level varying over the season in this way may cause periodical increasing and decreasing contamination concentration levels. Rising surface water in monsoon periods will cause an increase of sediment transport, which may have stopped almost completely during the dry season. These seasonal influences need to be taken into account when developing remediation options and implementing the techniques.

Social issues

Apart from the impact of living near a contaminated site and the effects on human health there are the following anticipated social impacts due to remediation of contaminated sites:

- During remediation works, the impact of air and noise contamination on the local communities depends on the duration of the project activities. If the transportation distance for waste from the site to say a landfill site is short the air contamination impact will be less. Higher air contamination impact can be anticipated if a lot of loading and unloading is required for site development. Noise contamination may be due to excavation activity, loading and unloading of waste and transport vehicle movement. Spillage of wastes during transportation may cause negative impacts on the community. However, if proper measures to stabilise the waste are taken this impact will get reduced;
- There is always an element of potential road accidents during transportation. This potential increases with increasing distances;
- Impact on business activity and livelihood at and around a contaminated site will have to be considered during the remediation period and will depend upon both short term and long term activity of remediation;
- For land users value of properties is dominant over health issues. As remediation is dealing with health issues, in discussions with land users different issues are getting mixed up and give a bias on the focus of remediation options. If coal pickers are deprived from their income due to a clean capping layer, this will negatively impact the support for such a remediation option. Only if a complete solution is given, which in the example would have to include the securing of a livelihood for the coal pickers, a remediation option is likely to be executed;
- The larger the remediation activity the more positive the impact on employment opportunities is likely to be. The site development for storage and disposal of waste will also generate additional employment opportunities.

The public has a legitimate right to understand and to be involved in decisions that may affect them. It follows that high levels of involvement and communication are important to prevent undue concerns about the risks during remediation or site testing work. Community involvement and consultation should begin at an early stage of any project.

The impact assessments on social issues are an integrated part of a remediation process and solicit views of the stakeholders including the community for designing the project. The consultation process helps in making the project responsive to social development concerns, including options that enhance benefits for poor and vulnerable people while mitigating risk and adverse impacts.

3.4 Conclusions

Technical issues

Conclusions of the Blacksmith report are that low cost interventions can be successful, provided that the effects are ‘focused on real health issues’ but that ‘problems cannot be completely solved’. ‘Full remediation of the groundwater is likely to cost millions of dollars’. The Lake Noor pilot project has yielded useful learning points, mainly for implementation in the process itself. An example of these is that an inventory of the historic land use and a site visit at an early stage in the site is very important, as it saves money in the end. Another is that there always will be surprises and unexpected issues to pop up.

Local conditions

When remediation options include the disposal of excavated material in a secure landfill, the distance of the site to the nearby landfill should be taken into account during the selection process.
In the development of remediation options and assessment of applicability of techniques the climatological situation has to be taken into account.

Social issues

The nature of social impacts may be direct, indirect and cumulative, based on the characteristics of impacts. The following activities are primarily required to establish the level of significance for each identified impact on the community:

- Socio-economic details of the nearby areas including type of settlements;
- Determination of the severity of the effect. For example, an impact is of low, medium, or high significance. Emphasis should be given on the slum population in the nearby areas as they are more exposed to hazardous wastes.

The following activities are recommended during the remediation process:

- Cover community awareness, participation, and education with respect to implementation and management of facilities, and educate communities about the issues related to improvement of the health and environment;
- Inform the project beneficiaries including stakeholders at different levels on implications to the community in terms of benefits and responsibilities;
- A plan for the site specific mitigation measures is to be formulated in consultation with the stakeholders for sustainable remediation techniques and to reduce hazardous impact on the community of the nearby areas;
- The following aspects have to be considered: cost of land; geographic advantages, i.e. nearness to urban area; land acquisition may be required during implementation; compensation and relocation may be necessary before implementation;
- Government policy is required to regulate the land use pattern and infrastructure, which have an impact on use of contaminated sites;
- The objective of the project can be conveyed to the local people near the contaminated site with the help of local administration and other institutions;
- Impacts on the environment and livelihood should be minimized during construction;
- Several public consultations with the stakeholders are required for smooth implementation.

3.5 Provisional conclusion on applicability of remediation options in India

From the available data on remediation cases it can be derived that most of the successful remediation cases in India to date were the result of excavation and transfer of waste to secured landfills. We have found no documented evidence of experience with full scale chemical and biological remediation actions. However, considering the importance of the social aspects and local conditions, as described above, we expect chemical and biological in-situ remediation options will become more important in future.

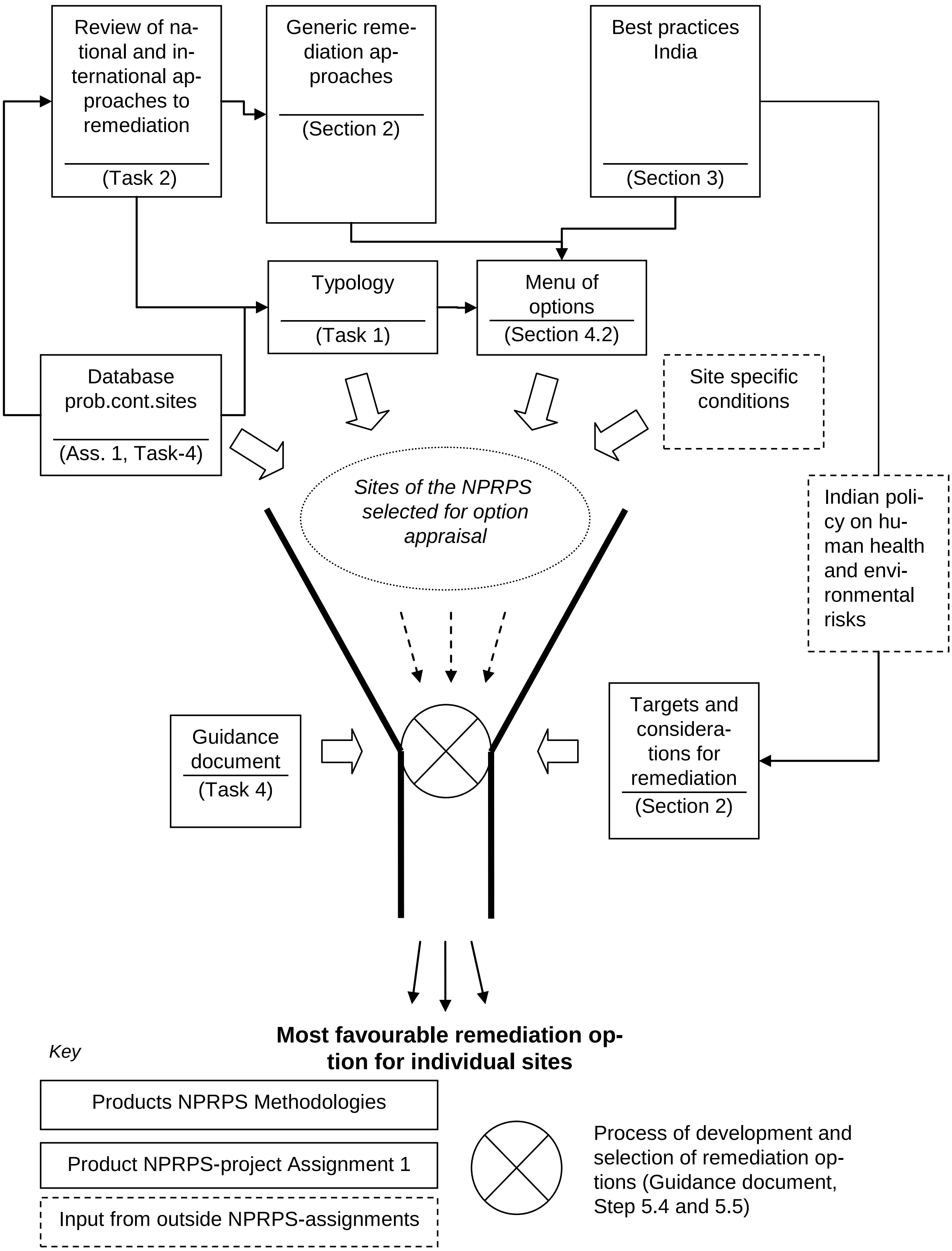
4 Step 3.3 – Menu of remediation options for each type of site

4.1 Introduction

Elements for the Menu of remediation options
In Task 1 of this Assignment all imaginable types of contaminated sites have been defined and presented in what we have named the Typology. Section 4.2 presents a Menu of remediation options for every type and subtype of contaminated site included in that Typology, which may, based on the available database of contaminated sites in India, deemed relevant for India at this time. Where the Typology distinguishes subtypes the Menu presents remediation options per subtype. The Menu also presents remediation options for combinations of types or subtypes. The Menu has been developed using, apart from the Typology itself, best practices of remediation in India (described in Chapter 3 of this report), evaluation of the Standard based and Risk Based remediation approaches (described in Chapter 2 of this report), and the review of national and international approaches to remediation (developed in Task 2).

Figure 4.1 illustrates how the different products of the NPRPS-Assignments 1, 2 and 3, including the Menu of options presented in Section 4.2 of this report, all contribute to the process of remediation option appraisal. The figure contains references for easy access to the products mentioned. Below, some general comments are offered regarding this process.

Figure 4.1 Contribution of NPRPS-assignment products to process of remediation option appraisal



Types of contaminated sites included in the Menu of remediation options
The box below summarizes which types and subtypes of contaminated sites are distinguished in the Typology. As indicated in the Task 1 report, the Typology has been developed to be robust. Therefore, it is expected that all types of contaminated sites in India, including those not identified (and therefore not represented in the database) to date, can be included in the Typology. In principle, all types and subtypes are included in the Menu, unless one or more of the following applies:

- Differences between subtypes are too small to make a distinction in the Menu of options;
- Differences between subtypes are based on assessment strategies rather than remediation options;
- A specific type is not recognized in the database or there are too few sites in the database to validate the potential best practices. This issue applies to type P1, NAPL contaminants in soil (Non Aqueous Phase Liquids), and its subtypes P1-a and P1-b.

Certain subtypes do not have a remediation option of their own, as these can be dealt with using remediation options aimed at the type they form part of.

Types and subtypes of contaminated sites distinguished in the Typology. The Menu presents remediation options for all types and subtypes not between brackets.

Source related

- Type S1 - Land bound solid phase contamination. Subtypes:
  - S1-a – Soil mixed with non- agricultural contaminated material
  - S1-b – Well defined body with contaminated material
  - S1-c – Contaminated solid material from industrial process
  - S1-d – Soil mixed with agricultural contaminated material
  - S1-e – Contamination through atmospheric deposition
  - S1-f – Contamination through deposition by flooding
- Type S2 – Water bound sediments solid phase contamination, i.e. contaminated open water sediments
- Type L – Land bound liquid phase contamination. Subtypes:
  - L1-a – Soil contaminated with liquids from industrial process
  - L1-b – Soil contaminated with liquids from leaking storage
  - L1-c – Soil contaminated with liquids from leaking pipe or drain
  - L1-d – Soil contaminated with liquids from spill from pipe or drain

Pathway related

- (Type P1 – NAPL contaminants in soil (Non Aqueous Phase Liquids) Subtypes:
  - P1-a – Permeable soil contaminated with DNAPL (Dense Non Aqueous Phase Liquids)
  - P1-b – Permeable soil contaminated with LNAPL (Light Non Aqueous Phase Liquids)
- Type P2 – Groundwater contaminations

Combining remediation options with each other and with redevelopment
Theoretically, an endless number of remediation options can be devised. In order to keep the Menu manageable it contains remediation options for the situa-

tions most commonly encountered in India, as per the current version of the database. Other remediation options can be developed by combining options included in the Menu. This is often done in situations where local conditions vary over the site. For example: removal by digging is carried out around buildings. Inside or under these buildings no digging is possible, due to risk of collapse of the building. Therefore, under the buildings another option is applied, e.g. by making the ground level floor of the building suitable to prevent direct contact with the contamination which is left under the building.

Remediation of a contaminated site may be executed as an integrated part of a redevelopment plan for the area. This approach provides multiple opportunities to combine activities and to save on costs for both the remediation and redevelopment activities. Examples of combined activities are: [i] the excavation of contaminated soil can present an opportunity to utilise the resulting void as a basement or parking lot or [ii] the construction of new roads, pavements and building floor slabs can provide effective cover layers as an alternative to the construction of a cover system on top of contaminated soil.

When combining site remediation with site redevelopment it is advisable to develop the remediation options as an integrated part of the redevelopment plans. The consultant charged with the remediation investigation should cooperate with the site owner or site redeveloper and the engineers responsible for the design of the redevelopment. This cooperation should start at an early stage of the preparation phase, providing maximum opportunities to combine both remediation and redevelopment activities. Often it is economically sensible to e.g. plan a parking lot instead of a playground or school garden on a former gasoline station site. If cooperation is started at an early stage the land use plan can often easily be adapted to the contamination situation.

Menu is for quick start of option appraisal, after which fine tuning is in order

Anticipating the toolbox setup of the Guidance document (Task 4), the remediation options should be generic, meeting all different conditions. Therefore, not a single one, but a set of applicable options is presented per type, meeting different site settings. Depending on local and site specific circumstances and specific conditions the user can then proceed by defining the most appropriate conditions and preferences for further detailed engineering in a site specific remediation action plan. Examples of site specific circumstances and specific conditions are the size of the contamination, local costs of commodities such as covering material, local field conditions like access roads, climate and terrain conditions, and availability of equipment.

In the Guidance document all steps in the process of site assessment and remediation will be discussed in detail. One of these steps is the development of potential remediation options for any given site by combining remediation techniques. Whilst there is no established process that should be followed when developing the remediation options, often an iterative procedure is followed. The Menu of remediation options provides a first indication of potential remediation options that may be suitable for the situation at hand. Therefore, the use of this Menu enables an efficient start of the iterative procedure. For the best results, the user of the Menu should select an option suitable for the situation at hand and then describe all elements on which the option will be evaluated in later steps. Later in the iterative procedure, the user needs to fine tune by adjusting the description of the selected options for site-specific objectives, requirements and constraints to achieve a tailor made solution.

4.2 Elements for approach in India: a Menu of remediation options

This Section presents a blueprint or Menu of options for remediation of the types and subtypes of contaminated sites most common in India, as per the current version of the database of contaminated sites.

Table 4.1 presents a summary of the most common situations in India, as identified in the available database, and links each of these situations to a remediation option eligible for application in that particular situation. The user can then refer to the relevant remediation option in figure 4.2 for more detailed information. For each type of contaminated site figure 4.2 provides insight in the most likely ('prioritized') remediation objectives and most likely technical and non technical choices for remediation measures, as well as specific conditions or alternative approaches in a variety of settings and their applicability to the different types and subtypes of contaminated sites. It should be noted that specific site conditions can lead to the selection of another remediation option than the one indicated in table 4.1.

Cluster types of contaminated sources and plumes had not been included in the Typology. This was because from a technical point of view these types of sites are similar to the same type of contamination on an isolated site (non-clustered type). However, when looking at best practices, as is done in this report, these clustered sites are of interest, as the technical assessment of sites in these categories can be done on a larger aerial scale, offering an advantage in efficiency when applying remediation options. Therefore, in addition to the regular types and subtypes remediation options for so called 'cluster types' are described as separate options (options 12 and 13) in the Menu of remediation options.

The structure of the Menu of remediation options provides the opportunity to include more types and subtypes in the Menu whenever more information becomes available.

Table 4.1 Most likely remediation options and their applicability to types of sites

Type of contaminated site	Land use or setting	Nature of contaminants	Example situation	Example of option that could be applied (see figure 4.2)
S1 + P2: Land bound solid phase contamination including groundwater contamination	Urban area	heavy metals	Urban area built on a former dumpsite or on a local depression, filled in with contaminated material and with contaminants leach-	Option 1

Type of contaminated site	Land use or setting	Nature of contaminants	Example situation	Example of option that could be applied (see figure 4.2)
			ing into groundwater	
Type S1-d + P2: Land bound solid phase contamination including groundwater contamination	Agricultural or other rural area	heavy metals, pesticides. Solid phase contaminants are found up to a depth to which the soil is treated by ploughs and other agricultural tools	Pesticides used on agricultural lands leaching into groundwater	Option 2
S1 + P2: Land bound solid phase contamination including groundwater contamination	Industrial area	heavy metals	Ore sludge stored on industrial site, leaching into groundwater	Option 3
S2: Solid phase contamination (water bound site) (open water sediments)	Urban, nature or industrial area	heavy metals (effluent related)	Effluent discharging into open water system	Option 4
S1-d-e-f : Land bound solid phase contamination	Agricultural area, open water shores	heavy metals, pesticides found over relatively large areas due to large scale agricultural activities, atmospheric deposition or flooding	River basin flooding area or agricultural areas with excessive pesticide usage	Option 5
S1 : Land bound solid phase contamination	Nature	heavy metals	Dumpsite in an otherwise natural setting	Option 6
S1: Land bound solid phase contamination	Urban area	heavy metals, PAH	Urban area built on a former dumpsite or on a local depression, filled in with contaminated material, but without contaminants leaching into groundwater	Option 7
S1 : Land bound solid phase contamination	Industrial area	heavy metals, PAH	Leakage of storage tanks on industrial site, spreading into groundwater aquifer	Option 8
L : Liquid phase contamination	All site uses	industrial effluents	Oil spill, oil tanker leakage, contamination of groundwater due to well injection	Option 9
P1-a: DNAPL contaminants in soil	Industrial area	Dense Non-Aqueous Phase Liquid (DNAPL) in permeable soil (bulk density > water)	Leakage of storage tanks on industrial site, spreading into the groundwater aquifer	Option 10
P1-b: LNAPL contaminants in soil	Industrial area	Light Non-Aqueous Phase Liquid (LNAPL) in per-meable soil (bulk density < water)	Leakage of storage tanks on industrial site, spreading at the water table or toplayer of groundwater aquifer	Option 11
S1-a/b: Cluster of land bound solid phase con-	Multiple sites and site usag-	heavy metals, PAH, pesticides in well defined (non) soil mixed	Filling of settling soft river delta sedi-	Option 12

Type of contaminated site	Land use or setting	Nature of contaminants	Example situation	Example of option that could be applied (see figure 4.2)
tamination	es	bodies	ments with contaminated material in a large scale expanding urban area	
L1: Cluster of liquid phase contamination	multiple sites and site usages, urban area	mobile organic compounds	City centre or old industrial area with a large and concentrated number of small industrial sites leaching contaminants into the groundwater	Option 13

In figure 4.2 below each of the thirteen remediation options mentioned in table 4.1 is discussed in more detail. Each option is presented in the same format, one option to a page, each divided into four headings:

- Site and setting summary
  This heading presents a brief summary of the main site characteristics, i.e. type of contamination, setting and land use, most prolific risks and most common contaminants, always illustrated by a schematic cross-section.

- Most likely remediation objectives
  This heading presents recommendations for cleanup levels. Where applicable, examples are given of sensitive land use that may require additional evaluation as to whether remediation to the generic level for the corresponding land use will provide sufficient level of protection. In general, fitness for use levels based on the corresponding type of land use are recommended. Setting generic levels as remediation objective may not always result in an economically or technically feasible remediation. In such cases remediation to a concentration level meeting a site specific level based on site specific risk assessment can be considered.

- Most likely remediation measures
  This heading lists the most likely remediation measures according to the targeted point of operation (source, pathway or receptor). It must be stressed that this heading should not be used as the only reference in the design process of remediation option. We refer to Chapter 5 for more information.

- Specific conditions or alternative approaches
  This heading describes specific conditions that may prove pivotal for cost efficient remediation design. Also listed are some alternative remediation options that may come into perspective in case the costs of full scale remediation to generic levels are not in balance with the required level of risk reduction. In specific cases alternative remediation options can be acceptable and viable, e.g. in case the costs render a full scale remediation not feasible, or in case these options are used as a temporary safety measure, or in case the

Indian soil remediation policy offers opportunities for a decreased (site-specific) level of risk reduction.

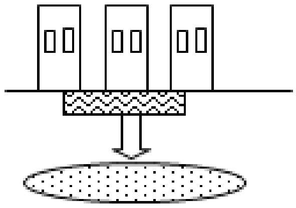
How to use the Menu of options is illustrated below by an example of how to read figure 4.2, for which we use the factsheet for remediation option 1.
Under the heading ‘Site and setting summary’ the situation for the type of contaminated site is described in general terms. Remediation option 1 is aimed at a site in an urban setting with both land bound solid phase contamination as well as and groundwater contamination. In the Typology, this site is classified as a site of both S1 and P2 type. The most likely remediation objectives are described, again in general terms, under their own heading, as are the corresponding measures which could be applied to the source, pathway and receptor. When designing remediation options either one or a combination of more of these most likely technical and non technical choices for remediation measures can be used. Specific conditions or alternate approaches that may be applicable to the situation at hand are described under the fourth heading of the factsheet. These can be referred to to render a remediation option fit for a specific site.

Figure 4.2 Menu of options: most likely remediation measures per type of contaminated site in India

Option 1: Remediation of land bound solid phase contamination including groundwater contamination in urban areas

Site and setting summary

Type S1 + P2: Land bound solid phase contamination including groundwater contamination
Landuse/setting: Urban area
Risks: Direct contact, exposure to polluted drinking water
Most common contaminant: heavy metals



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for residential areas
- Groundwater: fit for use based on generic levels for residential areas

Examples of sensitive uses that may require site-specific remediation goals:
- Use of soil as kitchen garden or playground
- Use of groundwater as drinking water

Most likely remediation measures

Source
- Excavation of soil to a concentration level meeting the remediation objective
- Cover with pavement or layer of clean soil
- Reduction of leaching by partial source excavation, sealing or drainage

Pathway (plume):
- Removal to a concentration level meeting the remediation objective by pump & treat
- Geohydraulical containment
- Natural or stimulated precipitation/sorption

Receptor:
- Treatment of well water to meet drinking water standards or alternative water source
- Imposed limits to site use (e.g. no unauthorized digging, no wells)

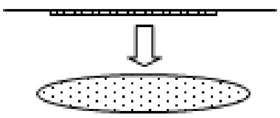
Specific conditions or alternative approaches

- Excavation is more efficient as part of a redevelopment project that involves excavating anyway
- Removal of contamination in pathway (plume) by pump & treat is more efficient if the leaching process has been reduced
- Soil surface elevation can be considered to avoid large volumes of excavated soil
- An alternative option to reduce contact risk and/or leaching may be chemical immobilisation or physical immobilisation (grouting)
- In-situ strategies towards hexavalent chromium are mostly based on reduction to the less toxic and less mobile trivalent chromium by chemical or microbiological means. These techniques are mostly in a laboratory or pilot phase of development

Option 2: Remediation of land bound solid phase contamination including groundwater contamination in agricultural and other rural areas

Site and setting summary

Type S1-d + P2: Land bound solid phase contamination including groundwater contamination
Landuse/setting: Agricultural / rural area
Risks: Direct human contact, exposure to polluted drinking water, ingestion of contaminated crops
Most common contaminants: heavy metals, pesticides



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for agricultural or other rural areas
- Groundwater: fit for use based on generic levels for agricultural or other rural areas

Examples of sensitive uses that may require site-specific remediation goals:
- Specific toxicity of copper to sheep
- Specific uptake of contaminants by crops
- Use of groundwater for irrigation purposes

Most likely remediation measures

Source
- Phytoremediation
- Excavation of soil to a concentration level meeting the remediation objective, on-site treatment (landfarming) and optional backfilling with soil of suitable quality

Pathway (plume):
- Removal to a concentration level meeting the remediation objective by pump & treat
- Geohydraulical containment

Receptor:
- Treatment of well water to meet drinking water standards or alternative water source
- Alternative crops with less uptake of contaminants in edible parts
- Imposed limits to site use (e.g. no unauthorized digging, no wells)

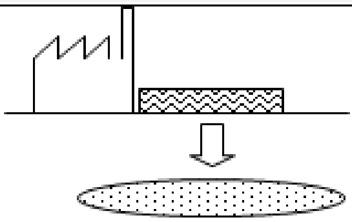
Specific conditions or alternative approaches

- Profile reversion can be considered as alternative approach
- Aggressive treatments like chemical treatments deteriorate the biology of the ground
- The cultivation method and climatic circumstances should also be taken into consideration when evaluating potential risk, cleanup levels and remediation, e.g.:
    - Erosion by wind and/or precipitation
    - Intensified contact with soil due to cultivation by manpower
    - Increased biodegradation rate due to tropical conditions
    - Promotion of anaerobic processes due to submerged cultivation methods
    - Cyclical changes in soil physical, macrochemical and biological properties due to slash and burn agricultural methods

Option 3: Remediation of land bound solid phase contamination including groundwater contamination in industrial areas

Site and setting summary

Type S1 + P2: Land bound solid phase contamination including groundwater contamination
Landuse/setting: Industrial area
Risks: Direct human contact, exposure to polluted drinking water
Most common contaminant: heavy metals



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for industrial areas
- Groundwater: fit for use based on generic levels for industrial areas

Examples of sensitive uses that may require site-specific remediation goals:
- Use of groundwater as drinking water
- Use of groundwater as process water

Most likely remediation measures

Source
- Excavation of soil to a concentration level meeting the remediation objective
- Capping with pavement
- Combined with redevelopment: isolation under new buildings or constructions

Pathway (plume):
- Removal to a concentration level meeting the remediation objective by pump & treat
- Geohydraulical containment
- Natural or stimulated recipitation/sorption

Receptor:
- Treatment of well water to meet drinking water standards or alternative water source
- Imposed limits to site use (e.g. no digging, no wells)

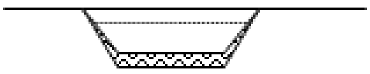
Specific conditions or alternative approaches

- Removal of contamination in pathway (plume) by pump & treat is more efficient if the leaching process has been reduced
- Removal of contamination in pathway (plume) by pump & treat is more efficient if the treated water can be used as process water by the industry or when performed in combination with storage of thermal energy in soil
- Chemical or biological barriers can be considered on sites neighbouring more sensitive (e.g. urban) areas as alternative to full plume treatment
- Treatment of the actual cause of the pollution (industrial activity), if still present, should be performed before starting remedial action

Option 4: Remediation of solid phase contamination in a water bound site (contaminated open water sediments)

Site and setting summary

Type S2: Solid phase contamination (water bound site) (open water sediments)
Landuse/setting: Urban, nature or industrial area
Risks: Direct human contact, ecological risks
Most common contaminant: heavy metals (effluent related)



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
• Sediment: fit for use based on generic level corresponding with type of site use

Examples of sensitive uses that may require site-specific remediation goals:
• Use of open water for swimming or bathing
• Use of surface water for consumption or agricultural purposes

Most likely remediation measures

Source
• Dredging
• Excavation (in times of drought)
• Capping layer with clean sediment

Pathway (plume): n.a.

Receptor:
• Government imposed limits to site use (e.g. fencing, no bathing or swimming)

Specific conditions or alternative approaches

• Capping is only technically feasible for relatively static water systems (lake, pond)
• Dredging or excavation typically involves large volumes for which adequate (temporary) storage has to be provided, also depending on method of treatment (on-site treatment/off-site treatment/sanitary landfill)

Option 5: Remediation of land bound solid phase contamination in agricultural areas or open water shores

Site and setting summary

Type S1-d-e-f: Land bound solid phase contamination
Landuse/setting: Agricultural area, open water shores
Risks: Direct human contact, ingestion of crops, risk of spreading
Most common contaminant: heavy metals, pesticides

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for agricultural areas

Examples of sensitive uses that may require site-specific remediation goals:
- Specific toxicity of copper to sheep
- Specific uptake of contaminants by crops

Most likely remediation measures

Source
- Phytoremediation
- Excavation and reuse in levees (open water shore settings) or big bags (fitted into the landscape)

Pathway (plume): n.a.

Receptor:
- Alternative crops with less uptake of contaminants in edible parts

Specific conditions or alternative approaches

- Profile reversion can be considered as alternative approach
- Aggressive treatments like chemical treatments deteriorate the biology of the ground
- Specific excavation of hotspots can be considered as alternative approach, but requires detailed site assessment
- The cultivation method and climatic circumstances should also be taken into consideration when evaluating possible risk, cleanup levels and remediation, e.g.:
  - Erosion by wind and/or precipitation
  - Intensified contact with soil due to cultivation by manpower
  - Increased biodegradation rate due to tropical conditions
  - Promotion of anaerobic processes due to submerged cultivation methods
  - Cyclical changes in soil physical, macrochemical and biological properties due to slash and burn agricultural methods

Option 6: Remediation of land bound solid phase contamination in nature areas

Site and setting summary

Type S1: Land bound solid phase contamination
Landuse/setting: Nature
Risks: Ecological risks, direct human contact
Most common contaminant: heavy metals

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for nature areas

Examples of sensitive uses that may require site-specific remediation goals:
- Intensive recreational use

Most likely remediation measures

Source
- Capping to reduce exposure by direct contact and vegetation consumption
- Phytoremediation to reduce concentration levels
- Excavation of hotspots

Pathway (plume): n.a.

Receptor:
- Goverment imposed limits to site use (e.g. fencing, no unauthorized access)

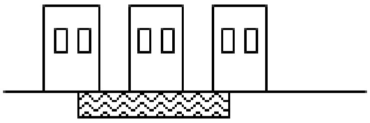
Specific conditions or alternative approaches

- Specific excavation of hotspots requires detailed site assessment
- To reduce the quantity of soil in excavation of hotspots, site-specific remediation levels higher than the generic levels for nature areas can be developed to obtain acceptable risk levels for a particular site under particular circumstances
- Capping can be combined with nature development (landscaping) to both increase environmental quality and biodiversity

Option 7: Remediation of land bound solid phase contamination in urban areas

Site and setting summary

Type S1: Land bound solid phase contamination
Landuse/setting: Urban area
Risks: Direct contact
Most common contaminant: heavy metals, PAH



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
• Top soil: fit for use based on generic levels for residential areas

Examples of sensitive uses that may require site-specific remediation goals:
• Use of soil as kitchen garden
• Use of soil as playground, potential exposure of children to lead

Most likely remediation measures

Source
• Excavation of soil to a concentration level meeting the remediation objective
• Covering by pavement or layer of clean soil

Pathway (plume): n.a.

Receptor:
• Imposed limits to site use (e.g. no unauthorized digging)

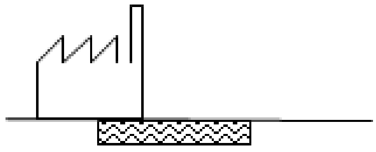
Specific conditions or alternative approaches

• Excavation is more efficient as part of a redevelopment project that involves excavating anyway
• While redeveloping, soil surface elevation can be considered to avoid large volumes of excavated soil
• An alternative option to reduce contact risk may be chemical immobilisation or physical immobilisation (grouting)
• In-situ strategies towards hexavalent chromium are mostly based on reduction to the less toxic and less mobile trivalent chromium by chemical or microbiological means. These techniques are mostly in a laboratory or pilot phase of development

Option 8: Remediation of land bound solid phase contamination in industrial areas

Site and setting summary

Type S1: Land bound solid phase contamination
Landuse/setting: Industrial area
Risks: Direct human contact
Most common contaminant: heavy metals, PAH



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for industrial areas

Examples of sensitive uses that may require site-specific remediation goals:
- Unpaved sites sensitive to spreading by dust

Most likely remediation measures

Source
- Excavation of soil to a concentration level meeting the remediation objective
- Capping with pavement
- Combined with redevelopment: isolation under new building

Pathway (plume): n.a.

Receptor:
- Imposed limits to site use (e.g. no unauthorized digging)

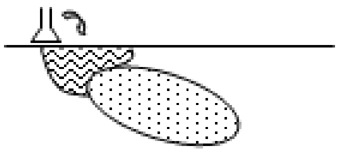
Specific conditions or alternative approaches

- Specific excavation of hotspots can be considered as alternative approach, but requires detailed site assessment
- An alternative option to reduce contact risk may be chemical immobilisation or physical immobilisation (grouting)
- In-situ strategies towards hexavalent chromium are mostly based on reduction to the less toxic and less mobile trivalent chromium by chemical or microbiological means. These techniques are mostly in a laboratory or pilot phase of development
- Treatment of the actual cause of the pollution (industrial activity), if still present, should be performed before starting remedial action

Option 9: Remediation of liquid phase contamination

Site and setting summary

Type L: Liquid phase contamination
Landuse/setting: all site uses
Risks: Direct human contact
Most common contaminant: industrial effluents



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
• Top soil: fit for use based on generic levels corresponding with site use
• Subsoil and groundwater: steady end state and removal of risks

Examples of sensitive uses that may require site-specific remediation goals:
• Habitation (soil vapour intrusion)

Most likely remediation measures

Source
• Excavation (above groundwater)
• Soil vapour extraction

Pathway (plume):
• Pump & Treat (combined with excavation)
• Multi Phase Extraction (combined with excavation)
• Bioremediation (combined with excavation)
• ISCO (combined with excavation)

Receptor:
• Forced ventilation of basement/crawl space, sealing of floors (soil vapour intrusion)
• Imposed limits to site use (e.g. no unauthorized digging)

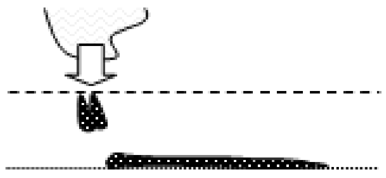
Specific conditions or alternative approaches

• Remediation of source and plume are often combined to obtain the most (cost) efficient remediation
• Several combinations of techniques for source and path remediation are possible, depending on site circumstances and project boundary conditions (timeframe, setting)
• Steady state is a situation, not a concentration level, therefore target concentration levels are not applicable. Proof of steady state is gathered by periodic sampling, condition for steady state is sufficient source load removal (e.g. 80% load removal)
• Typically, steady state does not require complete removal, but only removal of the mobile fraction of the contamination
• Inner air sampling is required to determine actual soil vapour risks, models will overestimate

Option 10: Dense Non-Aqueous Phase Liquid (DNAPL)

Site and setting summary

Type P1-a: Dense Non-Aqueous Phase Liquid in permeable soil (often found in combination with a P2 type)
Setting: Industrial site
Risks: inhalation (if no ground water present), spreading to groundwater
Most common contaminant: VOC, tar/heavy oil related contaminants, PCB



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:

- inhalation risk reduction (soil vapour)
- spreading risk reduction by:
    - mass removal as far as needed to reach a steady state plume
    - mass control (containment)

Most likely remediation measures

Exposure risk removal

- Soil vapour extraction and air sparging
- Vapour proof sealing in building floor

Spreading risk removal by mass removal

- Excavation
- Multi phase extraction
- Shock load bioremediation

Spreading risk reduction by mass control

- Physical/Hydraulic barriers
- Permeable reactive barriers

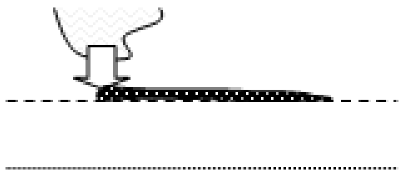
Specific conditions or alternative approaches

- DNAPL characterisation difficult due to irregular spreading pathways and specialistical soil investigation techniques.
- Risk of unintentional DNAPL vertical transport by faulty monitoring wells or drillings.
- Specialized (and thus expensive) in-situ techniques may be worth considering if a high degree of source removal in needed a very short time frame. Example techniques are: chemical oxidation, surfactant-enhanced subsurface remediation, cosolvent flushing, steam/hot air injection and three/six-phase electrical resistance heating.
- Pump and treat is generally not recommended for DNAPL removal due to long lasting rebound of contaminations to groundwater.

Option 11: Light Non-Aqueous Phase Liquid (LNAPL)

Site and setting summary

Type P1-b: Light Non-Aqueous Phase Liquid (LNAPL) in permeable soil (often found in combination with a P2 type)
Setting: Industrial site
Risks: explosion, exposure, spreading to groundwater/surface water
Most common contaminant: VOC and light/medium fraction mineral oil



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Exposure/Explosion risk reduction
- Spreading risk reduction:
    - Mass removal as far as technique is cost effective. If
    - Mass control (containment)

Most likely remediation measures

In case of acute risks requiring immediate action
- Excavation
- Vapour proof sealing in building floor

In absence of acute risks
- Mass recovery: excavation, skimming, dual pump extraction
- Mass recovery by phase change: soil vapor extraction, air sparging, bioslurping
- Mass control: subsurface barrier, trench, wells

In case of low risk profile
- Long-term stewardship
- Natural source zone depletion

Specific conditions or alternative approaches

- The assessment of LNAPL spreading potential and the fitting remediation objectives requires specialist soil characterisation expertise.
- If chosen the right technique, the implementation of this technique to a point it is effective will typically lead to an acceptable risk reduction.
- Specialized (and thus expensive) in-situ techniques may be worth considering if a high degree of source removal in needed a very short time frame. Example techniques are: in-situ chemical oxidation, surfactant-enhanced subsurface remediation, co solvent flushing, steam/hot air injection, radio-frequency heating and three/six-phase electrical resistance heating.
- Pump and treat is generally not recommended for LNAPL removal due to long lasting rebound of contaminations to groundwater.

Option 12: Remediation of cluster of land bound solid phase contamination

Site and setting summary

Type S1-a/b: Cluster of land bound solid phase contamination
Setting: Multiple sites and site usages
Risks: Direct human contact, ecological risks (depending on site use)
Most common contaminant: heavy metals, PAH, pesticides

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic level corresponding with site use
- Gradual improvement of soil quality over time towards a acceptable risk level and a minimal of site use restrictions

Most likely remediation measures

Technical aspects of the remediation can be found in the description of options for the non-clustered sites of the same type. The cluster approach differs from this sitewise approach regarding the management and coordination of the remediation of all the sites in the cluster area. Examples of aspects in dealing with cluster sites are:
- Remediation strategy and target levels established for the whole area
- Logistical solution for subsequent remediation of individual sites, such as a single sanitary landfill or central mobile soil treatment plant
- A single tender procedure
- A single generic remediation plan to be fine-tuned for individual sites, taking into account site specific conditions and site use
- A single organization dealing with post-remediation procedures
- A single generic plan for soil management (use, reuse and interchange between individual contaminated sites)

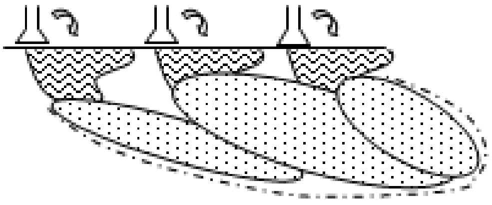
Specific conditions or alternative approaches

- Awareness of local aberrations in contamination situation required
- Generic remediation plans need updating every couple of years to remain aligned with developments in policy, state of the art in remediation approaches and changes in site use

Option 13: Remediation of cluster of liquid phase contamination

Site and setting summary

Type L1: Cluster of liquid phase contamination
Setting: multiple sites and site usages, urban area
Risks: Direct human contact, exposure to polluted drinking water, spreading
Most common contaminant: mobile organic compounds



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:

- Top soil: site-specific levels for risk removal or risk reduction
- Subsoil and groundwater: steady end state and removal or reduction of risks over entire system area to be reached over longer timeframe (typically 30 to 40 years)
- Target levels for load removal for individual plumes, based on their contribution to the total plume volume and spreading
- Custom signal and action levels to evaluate spreading (towards receptors).

Most likely remediation measures

Principle: area oriented approach of groundwater remediation

Technical aspects:

- The approaches as listed under the description of the option for P2
- MNA – monitored natural attenuation
- Stimulation of biodegradation of the contaminants
- Monitoring of the groundwater quality to protect receptors

Strategic instruments:

- Remediation strategy and warning or action levels to be developed for the entire area
- Generic remediation plan for the entire area and underlying site specific remediation plans to assess hot spots (leaching) and establish load removal
- A single organization dealing with post-remediation procedures

Specific conditions or alternative approaches

- The area oriented approach is only used in cases where assessment of individual plumes is not technically feasible because remedial action applied to one plume will affect other plumes
- Active, immediate remediation (topsoil, source, plume, receptor) is only applied in case of actual risks
- Signal level: level of contamination at which additional attention is required, e.g. more intense sampling over time or space
- Action level: level of contamination at which additional active measures are required
- Low intensity remediation techniques (vertical biological or chemical barrier) can be considered if active prevention of spreading out of the area towards receptors is required

5 Step 3.4 – Integrated analysis remediation options

Section 4.2 presents an overview of the most likely remediation options for different types of sites. It cannot be emphasized enough that these example options are for illustration purposes only and are not meant to be used as the only reference in the process of remediation options appraisal and selection and remediation design.
Various site specific circumstances are likely to play a major role in this process. We refer to Section 2.4 for a description of the critical issues in the remediation options appraisal process. Of these issues, particularly the technical, financial and social situation and the potential to implement sustainability aspects will show a great variability from site to site. This also applies to the potential land use post remediation and estimated cost benefits. Therefore, these factors cannot be included in the Menu of remediation options in a meaningful generic way.

Regarding this background, the Menu of remediation options in figure 4.2 offers a good starting point for tailor-made site specific remediation options that may be composed of a single or of a combination of different generic options. Not only type specific remediation options are given, the figure also offers context on how to tailor these options into a most favourable option for a specific site. The Menu of remediation options presents the end user with an impression of potential and commonly applied options early on in the site investigation and remediation process.

The Assignment 1 consortium has performed a preliminary inspection at 100 probably contaminated sites throughout India. This means that each of these sites is at an early stage in the site investigation and remediation process. Because of that, it is likely that a lot of detailed information is not yet available. The Assignment 1 consortium has presented the relatively limited information available at this stage in a database. Subsequently, the Menu of options has been applied to each of the sites included in the database. The result of this application is presented in Annexure IV to this report.

For each of the sites in the database provided by Assignment 1 (version of February 2015) the data in the various columns have been analysed in order to identify which remediation options and remediation techniques may be applicable to the specific sites. The following generic comments can be made:

- The present data provide information on important elements to describe the situation of these probably contaminated sites. However, this information is not very detailed, due to the fact that only a preliminary site inspection has been carried out at this stage. This is particularly relevant for cases where remediation of groundwater contamination would be appropriate. Only after completion of the preliminary site investigation and detailed site assessment the information is likely to be detailed enough for the development of remediation options. Subsequently, after selection of one option, the remediation can be prepared and implemented;

- For most of the sites, remediation activities seem to be required. However, a final conclusion on this can only be drawn once more information is available, based on a completed *preliminary site investigation;
- The table in Annexure IV provides the following columns:
    - From the database by Assignment 1: State; Site number; Site ID; Site name; Current land use at the site; Approximate area of site; Type of contamination according to MoEF definition; Primary contaminants; Typology summary (combination of three columns in the original database);
    - For this report the following columns have been developed: TSDF (nearest to site); Distance from contaminated site to nearest TSDF in km; Remediation options code; Remediation options; Remediation techniques;
- The column 'remediation techniques' provides a sequential order of remediation activities which may be carried out;
- The database includes the typology of a contaminated site. This typology is connected to the Menu of remediation options (refer to table 4.2 in the main text of this report). In this way it has proven to be possible to connect remediation options to all types of contamination represented in the database;
- At various sites activities which have caused contamination were still ongoing at the time of the preliminary site inspection. This may involve discharge of effluents on water bodies, atmospheric deposition from substances or continued dumping of solid waste or leaking of fluid waste. Before remediation of a contaminated site can be effective these activities need to be terminated;
- At many sites there is a clear indication of waste material at the site. The risks caused by this material need to be reduced by remediation. In case the amount of contaminated material is relatively small this can be done most effectively by excavating the material and storing it. In cases where the distance between the site and a TSDF is long this can be done instead in a controlled storage facility at the site or near to the site. This facility may be temporary in order to find a permanent solution. In case the amount of contamination is large containment of the material may provide the most cost-effective solution. After treatment of the waste the soil material, groundwater and sediments may be remediated using other remediation techniques;
- The application of in-situ remediation techniques is very much depending on local conditions, such as hydrogeology, geo-chemistry and climate. The exact information on the distribution of contaminating substances and the possible existence of multiple contaminants is important as well. The present information is not very detailed, for instance on the groundwater level and direction of groundwater flow, so the applicability of in-situ remediation techniques can only be assessed tentatively at this stage. When in-situ options are applied it is suggested to perform pilot studies to analyse the results and to develop knowledge about technical and organisational aspects. The in-

situ techniques may sometimes take many years before the remediation objectives will be met. This requires effective management of the installed equipment;
- The indicated remediation options and remediation techniques can be taken into account during the development of the investigation strategy of the detailed site assessment. The elements which are key for successful implementation of techniques can be investigated before implementing the decision on the remediation.

From the results of the testing of the applicability of the Menu of remediation options to the Indian sites in the database, it can be concluded that the Menu of options does indeed yield a most likely remediation option for each site. For a considerable number of the sites more than one remediation option is mentioned. This is done where the contamination situation is complex or where more than one option may be applicable in the specific situation at the site.

It should be stressed that specific site conditions, which will often be disclosed later on in the process, e.g. during the detailed site investigation, can modify this result and can even lead to the eventual selection of a remediation option that table 4.1 does not link to that particular type of site. Also, it should be noted that remediation is not a fixed process from beginning to end. It is essential to monitor the process, not only on the technical aspects, but also on economic and environmental aspects other than soil and groundwater. If necessary the (combination) of remediation techniques can be optimized or even changed. While a change in the applied option during remediation is rare it can be beneficial in specific situations, e.g. if a newly developed technique becomes available or if use of the site changes.

An integrated analysis of the remediation options described in the Menu in figure 4.2 requires taking into account factors that vary considerably from site to site. The Guidance document, developed in Task 4, literally guides the user through all the steps in the process of remediation options appraisal and selection.

Annexure I International soil quality standards

This Annexure presents a comparison of soil quality standards from the Netherlands, Canada and the US for the contaminants most commonly identified in India.
Please note that the levels for hazardous waste, as published in the HWR 2008, Schedule II, are also included in the table. This has been done to enable comparison of the international values to values familiar to Indian professionals. It is important to take note of the comments on the applicability of hazardous waste levels in Section 2.2.4.

Countries and target values (mg/kg) / Contaminant[1]	Netherlands[2]				Canada				US		India
	Background value	Residential value	Industrial value	Intervention value	Agricultural value	Residential value	Commercial value	Industrial value	Residential value	Industrial value	HW Rules 2008 schedule II
Chromium (total)	55	62	180	180	64	64	87	87	-	-	5000
Chromium (Hex)	-	-	-	78	0,4	0,4	1,4	1,4	0,29	5,6	50
Lead and lead compounds	50	210	530	530	70	140	260	600	400	800	5000
Cadmium	0,6	1,2	4,3	13	1,4	10	22	22	70	800	50
Mercury-organic	-	-	-	-	-	-	-	-	10	43	-
Mercury and mercury compounds	0,15	0,83	4,8	36	6,6	6,6	24	50	-	-	50
Copper (compounds)	40	54	190	190	63	63	91	91	3,1E+03	4,1E+04	5000
Arsenic	20	27	76	76	12	12	12	12	0,39	1,6	50

Countries and target values (mg/kg) / Contaminant[1]	Netherlands[2]				Canada				US		India
	Background value	Residential value	Industrial value	Intervention value	Agricultural value	Residential value	Commercial value	Industrial value	Residential value	Industrial value	HW Rules 2008 schedule II
PCBs (PolyChlorinated Biphenyls)	0,02	0,02	0,5	1	0,5	1,3	33	33	3,9[3]	21[3]	50
Dioxins	5,5E-5	5,5E-5	5,5E-5	1,8E-4	-	-	-	-	9,4E-5	3,9E-4	-
Cyanide	5,5	5,5	50	50	0,9	0,9	8	8	-	-	50
Pesticides											
Aldrin	-	-	-	0,32	-	-	-	-	0,029	0,1	50
Dieldrin	-	-	-	-	-	-	-	-	0,03	0,11	50
Chlorinated benzene (HCB)	0,009	0,027	1,4	2	0,05	2	10	10	0,3	1,1	50
DDT	0,2	0,2	1	1,7	-	-	-	-	1,7	7,0	50
HCH	-	-	-	-	0,01	-	-	-	0,27	0,96	50
Fluorides	-	-	-	-	200	400	2000	2000	3100	4,1E+04	-
Asbestos	-	-	-	100	-	-	-	-	-	-	5000
Poly Aromatic Hydro-carbons (PAHs)[4]	1,5	6,8	40	40							
Anthracene					#	#	#	#	1,7E+04	1,7E+05	50
Benzo[a]pyrene					#	#	#	#	0,015	0,021	50
Fluoranthene					#	#	#	#	2300	2,2 E+04	50
Naphthalene					#	#	#	#	3,6	18	50
Phenanthrene					#	#	#	#	-	-	50
Benz[a]anthracene					#	#	#	#	0,15	2,1	50
Benzo[b]fluoranthene					#	#	#	#	0,15	2,1	-
Benzo[k]fluoranthene					#	#	#	#	1,5	21	50
Ben-					#	#	#	#	0,38	1,3	-

Countries and target values (mg/kg) / Contaminant[1]	Netherlands[2]				Canada				US		India
	Background value	Residential value	Industrial value	Intervention value	Agricultural value	Residential value	Commercial value	Industrial value	Residential value	Industrial value	HW Rules 2008 schedule II
zo[b+j+k]fluoranthene											
Dibenz[a,h]anthracene					#	#	#	#	0,015	0,21	-
Indeno[1,2,3-c,d]pyrene					#	#	#	#	0,15	2,1	50
Pyrene					#	#	#	#	1700	1,7E+04	-

1 Most common contaminants in India as determined in the report CBIPMP_Methodologies_Task1_vs_final
2 In the Netherlands soil quality standards take into regard the organic matter and clay content of the soil. This "soil properties correction" provides an indicative correction for bioavailability. The values presented in this table are related to a so-called standard soil (10% organic matter and 25% clay content)
3 Chosen is for the PCB Aroclor 1016, because Aroclor is the most common PCB in the US.
4 List of PAHs is outlined in table between thick black lines
\# Site specific values in Canadian soil quality guidelines
\- No value available

The Netherlands
The Dutch standards and protocols explanation of soil quality standard: focus primarily on the investigations of potential risk and secondly on imminent threats to human health and/or the environment. The background value, the residential value and the industrial value refer to the maximum concentration allowed for residential and industrial use up to which the specific land use is acceptable, the intervention value is the concentration level from where remediation should be considered. Risk analyses is required to assess if there is an urgent need for remediation. When the value passes the intervention value, remediation is necessary. If the value lays between the intervention value and the background value, the ground can be used through sustainable land management.

Canada
Generic soil quality guidelines are available for four land uses: Agricultural, Residential/Parkland, Commercial, and Industrial. The guidelines take into account the effects of contaminated soil exposure on human and ecological receptors for given land uses. Soil guidelines must ensure that total exposure to a contaminant will present negligible risk.

US

Soil screening levels (SSLs) for contaminants in soil are not used in the process of indentifying contaminated sites but in the process of determining the need for response on contaminated sites (sites on the NPL list) by define “unacceptable” levels of contaminants in the soil. Generally, at sites or at defined areas within a site where contaminant concentrations equal or exceed SSLs, further study of investigation, but not necessarily cleanup, is warranted under CERCLA.

SSLs are risk-based concentrations derived from equations combining exposure information assumptions with EPA toxicity data.

UK

The UK focuses on a site specific approach and only very few generic levels and criteria are available.

Annexure II Drinking Water Standards and Groundwater Screening Values

This Annexure presents Drinking Water standards from Canada, USA, WHO, EU and India and target values for groundwater remediation from The Netherlands. In addition, the right hand column of the table presents suggested screening values for contaminant concentrations in groundwater. Most of the suggested screening values considered are as per IS 10500:2012. For contaminants not listed in that document suggested screening values are taken from Canadian Standards. Where Canadian values were also unavailable those were taken from WHO.

References for the standards are as below:

Canadian Standards : Federal-Provincial-Territorial Committee on Drinking Water. (2008). *Guidelines for Canadian Drinking Water Quality Summary Table.* Health Canada. Retrieved from http://hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/water-eau/sum_guide-res_recom/summary-sommaire-eng.pdf

USA Standards : Edstrom Industries. (2003). Drinking Water Quality Standards. Retrieved from http://www.edstrom.com/Resources.cfm?doc_id=167

WHO Standards : World Health Organization. (2008). Drinking Water Quality: Third Edition incorporating the First and Second Addenda, Volume 1: Recommendations. Geneva. Retrieved from http://www.who.int/water_sanitation_health/dwq/fulltext.pdf

Netherlands: Soil Remediation Circular, 2012, annex 1, target values for groundwater below 10 m b.s.l. These values refer to background values for heavy metals and to negligible risk level for other substances.

http://www.rwsleefomgeving.nl/onderwerpen/bodem-ondergrond/bodemsanering/wet-regelgeving/wet-bodembescherming/circulaire/

EU Standards : Council of the European Union. (1998). Council Directive 98/83/EC on the Quality of Water Intended for Human Consumption. Retrieved from
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:330:0032:0054:EN:PDF

Indian Standard Specifications for Drinking Water : IS:10500:2012 (2012, 2nd Revision).

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water		WHO Guidelines for Drinking	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water	**Proposed Screening Value**
			Regulations, USA		Water Quality			IS:10500:2012	**Ref. Indian/Canadian/WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
Acrylamide									
Adipate			0.4						**0.4**
Alachor			0.002		0.02			0.02	**0.02**
Aldicarb	0.009		0.007		0.01				**0.009**
Aldrin	0.0007				0.00003		9E-06	0.00003	**0.00003**
Deildrin	0.0007				0.00003		0.0001	0.00003	**0.00003**
Alkalinity, Total								200 as $CaCO_3$	**200 as CaCO3**
Aluminum		[0.1/0.2]		0.05-0.2		0.2		0.03	**0.03**
Ammonium						0.5		0.5	**0.5**
Anionic Detergent as MBAS								0.2	**0.2**
Antimony	0.006		0.006		0.02	0.005			**0.006**
Arsenic	0.01		0.05		0.01	0.01	7.2	0.01	**0.01**
Atrazine	0.005		0.003		0.002			0.002	**0.002**
Azinphos-methyl	0.02								**0.02**
Barium	1		2		0.7		200	0.7	**0.7**
Bendiocarb	0.04								**0.04**

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water		WHO Guidelines for Drinking	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water	**Proposed Screening Value**
			Regulations, USA		Water Quality			IS:10500:2012	**Ref. Indian/Canadian/WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
Benzene	0.005		0.005		0.01	0.001	0.2		**0.005**
Benzo[a]pyrene	0.00001		0.0002		0.0007	0.00001	0.0004		**0.00001**
Beryllium			0.004						
Boron	5				0.5	1		0.5	**0.5**
Bromate	0.01				0.01	0.01			**0.01**
Bromodichloromethane {BDCM)	0.016				0.06			0.06	**0.06**
Bromoform					0.1			0.1	**0.1**
Bromoxynil	0.005								**0.005**
Butachlor								0.125	**0.125**
Cadmium	0.005		0.005		0.003	0.005	0.06	0.003	**0.003**
Calcium								75 as Ca	**75 as Ca**
Carbaryl	0.09								**0.09**
Carbofuran	0.09		0.04		0.007				**0.09**
Carbon tetrachloride	0.005		0.005		0.004				**0.005**
Chloramines-total	3							4.0	**4**
Chlorate	1				0.7				**1**
Chlordane			0.002		0.0002		0.00002		**0.0002**

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water Regulations, USA		WHO Guidelines for Drinking Water Quality	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water IS:10500:2012	**Proposed Screening Value Ref. Indian/Canadian/WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
Chloride		≤250		250		250		250	**250**
Chlorite	1				0.7				**1**
Chlorine, Free Residual								0.2	**0.2**
Chloriforms, total	None detectable per 100ml		Less than 1 per 100 mL						**None detectable per 100ml**
Chloroform					0.3		0.01	0.2	**0.2**
Chlorotoluron					0.03				**0.03**
Chlorpyrifos	0.09				0.03			0.03	**0.03**
Chromium	0.05		0.1		0.05	0.05	2.5	0.05	**0.05**
Colour		≤15 TCU						5 Hazen Units	**5 Hazen Units**
Copper		≤1.0	1.3	1	2	2	1.3	0.05	**0.05**
Cyanazine	0.01				0.0006				**0.01**
Cyanide	0.2		0.2		0.07	0.05	10	0.05	**0.05**
Cyanobacterial toxins	0.0015								**0.0015**
Diazinon	0.02								**0.02**
Dibromochloromethane								0.1	**0.1**
Dicamba	0.12								**0.12**

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water Regulations, USA		WHO Guidelines for Drinking Water Quality	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water IS:10500:2012	**Proposed Screening Value Ref. Indian/Canadian/ WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
1,2-Dichlorobenzene	0.2	≤0.003	0.6		1				**0.2**
1,4- Dichloro benzene	0.005	≤0.001	0.075		0.3				**0.005**
1,2-Dichloroethane	0.005		0.005		0.03	0.003	7	0.003	**0.003**
1,1-Dichloroethylene	0.014		0.007						**0.014**
Dichloromethane	0.05				0.02		0.01		**0.05**
2,4-Dichlorophenol	0.9	≤0.0003							**0.9**
2,4-Dichlorophenoxyacetic acid	0.1		0.07		0.03			0.03	**0.03**
DDT and metabolites					0.001		4E-06	0.001	**0.001**
Di(2-ethylhexyl)phthalate			0.006		0.008				**0.008**
1,2-Dichloroethylene			0.07		0.05				**0.05**
1,2-Dichloropropane			0.005		0.04				**0.04**
Dicl of op-methyl	0.009								**0.009**
Dimethoate	0.02				0.006				**0.02**
Dinoseb	0.01		0.007						**0.01**
1,4-Dioxane					0.05				**0.05**
Diquat	0.07		0.02						**0.07**

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water		WHO Guidelines for Drinking	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water	**Proposed Screening Value**
			Regulations, USA		Water Quality			IS:10500:2012	**Ref. Indian/Canadian/ WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
Diuron	0.15								**0.15**
Edetic acid (EDTA)					0.6				**0.6**
Endosulfan (a,b and sulphate)							0.00002	0.0004	**0.0004**
Endothall			0.1						
Endrin			0.002		0.0006		0.00004		**0.0006**
Epichlorohydrin					0.0004	0.0001			**0.0004**
Ethion								0.003	**0.003**
Ethylbenzene		≤0.0024	0.7		0.3		4		**0.3**
Fenoprop					0.009				**0.009**
Fluoride	1.5		4	2	1.5	1.5		1.0	**1**
Glyphosate	0.28		0.7						**0.28**
Haloacetic Acids-Total (HAAs)	0.08								**0.08**
Hardness								200 as $CaCO_3$	**200 as CaCO3**
Heptachlor			0.0004				0.000005		
Heptachlor epoxide			0.0002				0.000005		
Hexachlorobenzene			0.001				0.0001		

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water Regulations, USA		WHO Guidelines for Drinking Water Quality	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water IS:10500:2012	**Proposed Screening Value Ref. Indian/Canadian/ WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
Hexachlorobutadiene					0.0006				**0.0006**
Hexachlorocyclopentadiene			0.05						
Hydrogen ion concentration						≥6.5 and ≤9.5			
Iron		≤0.3		0.3				0.3	**0.3**
Isoproturon					0.009			0.009	**0.009**
Lead	0.01		0.015		0.01	0.01	1.7	0.01	**0.01**
Lindane			0.0002		0.002			0.002	**0.002**
Magnesium as Mg								30	**30**
Malathion	0.19							0.19	**0.19**
Manganese		≤0.05		0.05	0.4	0.05		0.1	**0.1**
Mercury	0.001		0.002		0.006	0.001	0.01	0.001	**0.001**
Methyl Parathion								0.0003	**0.0003**
Methoxychlo	0.9		0.04		0.02				**0.9**
Methyl tertiary-butyl ether		0.015							
Metolachlor	0.05				0.01				**0.05**
Metribuzin	0.08								**0.08**

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water Regulations, USA		WHO Guidelines for Drinking Water Quality	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water IS:10500:2012	**Proposed Screening Value Ref. Indian/Canadian/ WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
Mineral Oil							50	0.5	**0.5**
Microcystin-LR					0.001				**0.001**
Molinate					0.006				**0.006**
Molybdenum					0.07		3.6	0.07	**0.07**
Monochloroacetate					0.02				**0.02**
Monochlorobenzene	0.08	≤0.03	0.1				7		**0.08**
Monocrotophos								0.001	**0.001**
N-Nitrosodimethylamine					0.0001				**0.0001**
Nickel			0.1		0.07	0.02	2.1	0.02	**0.02**
Nitrate	45		10		50	50		45	**45**
Nitrilotriaceticacid (NTA)	0.4				0.2				**0.4**
Nitrite			1		3	0.5			**3**
Odour		Inoffensive				Inoffensive		Agreeable	**Agreeable**
Oxamyl (Vydate)			0.2						
Paraquat (as dichloride)	0.01								**0.01**
Parathion	0.05								**0.05**

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water Regulations, USA		WHO Guidelines for Drinking Water Quality	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water IS:10500:2012	**Proposed Screening Value Ref. Indian/Canadian/ WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
Pendimethalin					0.02				**0.02**
Pentachlorophenol	0.06	≤0.030	0.001		0.009		0.05		**0.06**
Permethrin					0.3				**0.3**
Pesticides						0.0001		Individual Pesticide Limit	**Individual Pesticide Limit**
pH		6.5-8.5		6.5-8.5				6.5-8.5	**6.5-8.5**
Phenolic Compounds as C_6H_5OH								0.001	**0.001**
Phorate	0.002							0.002	**0.002**
Picloram	0.19		0.5						**0.19**
Polychlorinated biphenyls (PCBs)			0.0005				0.01	0.0005	**0.0005**
Polycyclic aromatic hydrocarbons						0.0001		0.0001	**0.0001**
Pyriproxyfen					0.3				**0.3**
Radioactive Materials a emitters, Bq/L								0.1	**0.1**
Radioactive Materials b emitters, Pci/L								1	**1**

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water		WHO Guidelines for Drinking	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water	**Proposed Screening Value**
			Regulations, USA		Water Quality			IS:10500:2012	**Ref. Indian/Canadian/ WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
Selenium	0.01		0.05		0.01	0.01		0.01	**0.01**
Silver				0.1				0.1	**0.1**
Simazine	0.01		0.004		0.002				**0.01**
Sodium		≤200				200			
Styrene			0.1		0.02		6		**0.02**
Sulphate		≤500		250		250		200	**200**
Sulphide (as H_2S)		≤0.05						0.05	**0.05**
Taste		Inoffensive				Inoffensive		Agreeable	**Agreeable**
Temperature		≤15°C							
Terbufos	0.001								**0.001**
Terbuthylazine					0.007				**0.007**
Tetrachloroethylene	0.03		0.005		0.04	0.01			**0.03**
2,3,4,6-Tetrachlorophenoi	0.1	≤0.001							**0.1**
Thallium			0.002	500					
Toluene		<0.024	1		0.7		7		**0.7**
Total dissolved solids (TDS)		≤500		500				500	**500**

All values are in units of mg/L unless stated otherwise	Guidelines for Canadian Drinking Water Quality		National Primary Drinking Water Regulations, USA		WHO Guidelines for Drinking Water Quality	Drinking Water Directives, EU	Target levels groundwater Netherlands, Soil Remediation Circular, 2012	Indian Standard for Drinking Water IS:10500:2012	**Proposed Screening Value Ref. Indian/Canadian/ WHO**
Parameter	Maximum Acceptable Concentration	Aesthetic Objective or Operational Guidance Value	Primary Maximum Concentration Level 1	Secondary Maximum Concentration Level 2	Guideline Value	Parametric Value		Maximum Acceptable Concentration	**Maximum Acceptable Concentration**
Toxaphene			0.003						
Trichloroacetate					0.2				**0.2**
Trichloroethylene	0.005		0.005		0.02	0.01			**0.005**
2,4,6-Trichlorophenol	0.005	≤0.002			0.2				**0.005**
1,2,4-Trichlorobenzene			0.002						
Trifluralin	0.045				0.02				**0.045**
Trihalomethanes-total	0.1		0.1			0.1			**0.1**
Trutuim	7000 Bq/L				10000 Bq/L	100 Bq/L			**7000 Bq/L**
Turbidity	0.1-1.0 NTU		0.5-1.0 NTU			Inoffensive		1 NTU	**1 NTU**
Uranium	0.0s				0.015				**0.0s**
Vinyl chloride	0.002				0.0003	0.0005	0.01		**0.002**
Xylenes-total		≤0.3	10		0.5		0.2		**0.5**
Zinc		≤5.0		5			24	5	**5**
E Coli or Thermotolerant coliform bacteria								Must not be detectable in any 100mL sample	**Must not be detectable in any 100mL sample**

Annexure III Experiences with remediation action in India to date

Introduction
This Annexure presents an overview of remediation actions in India to date and reports on them. For the social aspects of remediation actions an expert analysis is made, based on experience with related programs. An evaluation of foreign practices was presented in the Task 2 report.

Data used
The following data, provided or approved by the Client, is used in this Annexure:
- Report: 'Polluted Places – India', Blacksmith Institute, December 2007;
- Report: 'A compilation of polluted places India; Initial site assessment reports', Blacksmith Institute, June 2007;
- 'Need Assessment for Implementation of Hazardous Waste Management & Preparation of NPRPS', SENES, December 2008;
- Final Report: "Assessment and Remediation of Hazardous waste contaminated areas in and around M/s Tamil Nadu Chromates and Chemical Ltd, Ranipet";
- Chapters on remediation options as can be found in site assessment reports and remediation plans;
- Results of personal communication when visiting SPCB's during this project;
- Internet: only freely available data (if possible only for CBIPMP sites);
- Experience of Indian project team members.

Remediation actions and experiments
The Blacksmith report
The Blacksmith report presents a brief evaluation of a number of pilot remediations, applying low-cost 'intervention' techniques expected to be effective at a local level. The pilot projects and the techniques discussed are listed below.

Kanpur Groundwater Contaminated with Hexavalent Chromium (Uttar Pradesh)
Injecting an electron donor to the groundwater system to stimulate the transformation of hexavalent chromium into a nontoxic and more stable trivalent form. The trial was successful, with levels of hexavalent chromium in some of the test wells dropping to non detectable levels.

Muthia Hazardous Waste Dumps (Gujarat)
Treatment of the site with vermiculture – using worms – which concentrate heavy metals in their bodies, and reduce contamination in the soil and plantation of medicinal plants for bioaccumulation of the contaminants.

Chinhat land Decontamination from Lindane Pesticide (Uttar Pradesh)
Bioremediation degradation of Lindane to be used is the scaling up of successful laboratory work on the same type of wastes in which the degradation of persistent b-HCH has to be assessed.

Panki Land Rehabilitation (Uttar Pradesh)
Experiments on metal bioremediation fly-ash waste by the application of organic matter and symbiotic fungi, making it suitable for floriculture, phytoplantation and mushroom culture.

Basic water treatment (being trialled in Rajasthan)
Basic water treatment using low cost material is likely the most effective technique for the trial site. No more details are accessible. As the project is not finished yet, no further conclusions are drawn.

The SENES 2008 report
The Remediation Action Plans described in this report contain six remediation strategies of which the following two are given as an example:

- West Bengal: excavating of the waste material and contaminated sediments, treatment of surface water and a natural attenuation (NA) groundwater approach;
- Andhra Pradesh: a phased area based contamination management approach of a multi use 178 hectares water catchment area. This area based plan focuses on the near term remediation of readily apparent environmental risks (excavation of contaminated soil and sediments and fencing the area, well shut down or water treatment when using contaminated wells), followed by long-term impact assessment, remediation measure implementation, and natural attenuation opportunity and prolonged monitoring plan. Long term measures including a monitoring program focused on the effects of the near term measures and an awareness (prevention) program.

No data on the implementation of the Remediation Action Plans is available. The proposed remediation measures can therefore not be used for the evaluation of present remediation practices.

Ranipet-site (Tamil Nadu)
Collection of information
- Discussions with the TNPCB officials;
- Study of manufacturing process;
- Study of Waste generation and disposal;
- Plant and Machinery;
- Waste dumps on the premises;

- Discussions with officials of adjacent Tannery Common Effluent Treatment Plant (CETP).

Site Investigation Technique

- The site was physically visited and identified by a team of experts;
- Background Information on Products and processes, raw materials used, waste generated and disposed during the plant operation was gathered;
- Survey of existing dump in the backyard of site, area surrounding the site dugwell, borewell, handpumps;
- Representative samples of the dump material and the groundwater in and around the site were collected.

Density of sampling / measurement

- Collection of samples of dump material from 7 different locations and measurement of heavy metal concentration;
- Collection of leachates at 2 locations and measurement of heavy metal concentration;
- Collection of groundwater samples from 38 locations and measurement of heavy metal concentration;
- Collection of Surface water samples from 4 locations, Puniyanthangal Lake, overflow from Puniyanthangal Lake, Effluent drain from Tannery CETP, Effluent Drain from Thirumalai Chemicals and measurement of heavy metal concentration.

Other data used

- Review of secondary data / information of Geological Survey of India on geology and hydrogeology of the area.

Subsequent steps

- Hydrogeological investigation by National Geographical Research Institute, which included:
    - Detailed investigation of Geology and Hydrogeology;
    - Geophysical characteristics upstream, downstream of dumpsite and downstream of Ranipet Site;
    - Drilling of Boreholes;
    - Magnetic profile over Dyke Structure;
    - Monitoring of groundwater quality;
    - Groundwater modelling.
- Qualification
    - Combining all the data collected it can be said that the site assessment was carried out in a very scientific and systematic manner;
    - Due consideration is given to dismantling and decontamination of plant and machinery;
    - Site and surrounding observations has revealed leachate as an active source of groundwater contamination;

- Review of secondary data indicated a high potential of soil and groundwater contamination;
- Sampling of measurement of dump and leachate generated from dump showed high concentration of Total and Hexavalent Chromium indicating active nature of dumpsite and high potential for contamination of subsurface and groundwater;
- Monitoring of groundwater sources indicated contamination while the measurement of surface water concentration indicated non contamination;
- Geophysical investigation indicated non contamination upstream of dumpsite while there is contamination below dumpsite;
- The geophysical investigation also revealed a dyke passing through the dumpsite;
- The groundwater modelling study predicted the contamination plume to reach Puliankanu lake in 30 years and this matched with the measurements carried out;
- It has been possible to estimate the total volume of contamination in the area.

De-selection of remediation options is not documented and is likely to be based on not site specific verified a priori information. Selection process is technique driven as it only takes the effectiveness of techniques into account. No evaluation is made of the assurance that remediation objectives will be reached using the proposed techniques. Long term stability effects of Cr^{3+} are not discussed, while this discussion is essential for the assurance of long term risk reduction.

Nauraiyakheda, Kanpur (Uttar Pradesh)
A first-of-its-kind Kanpur Pilot Remediation of Hexavalent Chromium-contaminated Groundwater was implemented by CPCP North Zone office and entrusted to Blacksmith Institute the details of which are as follows.

Nauraiyakheda, a settlement of 30,000 people within Kanpur, has developed right on top of a plume of Cr^{+6}, emitted by toxic sludge (about 15,000 tonnes) from an old chemical plant (Basic Chromate Sulphate industry) that had supported the tanneries. The sludge is a source of contamination and a danger to human health. Flammable methane trapped inside the sludge catches fire during the hot summer months, releasing harmful toxins into the air. Summer heat and winds also distribute dust particles from the sludge containing Cr^{+6} and other toxins that are harmful when inhaled. Chromium from the sludge leaks into the river, subsoil, and groundwater, the primary source of drinking water for the surrounding community. A 1997 study conducted by the CPCB on the groundwater quality in Kanpur revealed Cr^{+6} levels of 6.2 mg/L, while the Indian limit for Cr^{+6} is 0.05 mg/L.

Blacksmith's two-pronged approach aimed at both chemically neutralizing the chromium and also warning locals of the hazards. For the awareness-raising campaign, Blacksmith supported Ecofriends, a local environmental NGO in Kanpur. For chemical remediation of the chromium, Blacksmith worked with

Ecocycle/GZA (engineering consultants who could supply some of the needed materials) and the CPCB. Other collaborators included the Industrial Toxicology Research Center (ITRC), Indian Institute of Technology (IIT) - Kanpur, and the National Geophysical Research Institute (NGRI).

As part of the remediation, Blacksmith and its partners dug four new wells in a portion of the contaminated groundwater system. One of the wells was an injection well used to introduce the electron donor chemical, and the other three were water quality monitoring stations that would test for 16 health criteria, including metal concentrations. Once baseline samples had been taken, the chemical was added through the injection well and then the monitoring sites sampled the water quality in 5 later series.

Results

From a public awareness perspective, the intervention from Blacksmith and Ecofriends succeeded in installing two new submersible water pumps that would supply the Nauraiyakheda area with safe, potable drinking water. The chemical remediation was also successful, with levels of Cr^{+6} dropping at all the test sites, sometimes to levels as low as to be undetectable. It is claimed that the technology is suitable to Indian conditions and the successful outcome forms a sound basis for scaled-up Full Scale Remediation.

Remediation and Bioremediation of Heavy Metals, Kanpur (Uttar Pradesh)

In Kanpur city a large number of tanneries (around 350) and unauthorized glue production units. The site of the study are the three villages in Jajmau, Sheikhpur, Allaulapur and Kulgaon with a population of around 50,000 people. The tanneries discharge their toxic waste laden with Cr(VI) into the sewage system. This effluent is carried through the main drainage system to the centralized treatment plant located in Jajmau.

Suggested alternatives for mitigation of heavy metal contamination:

1) Chemical remediation-Zerolite and Charcoal;
2) Bio-remediation- Biomass-Trapa, Hibiscus, etc.;
3) Phyto remediation-Different Fungal species;
4) Flyash-Glomus (mycorrhizae) Bioremediation- biomass Phyto-remediation;
5) Chemical remediation through filters.

IIT Kanpur has designed filters with an aim to remove Cr(VI) and other metals and distributed the filters in the rural areas of Kanpur tannery for the immediate relief from heavy metal contamination. These filters have been designed for a small scale water purification system, which can clean 10 to 12 litres of water in a bucket in 30 minutes. Basic constituents required for the construction of filters are easily available in markets and cost effective.

Use of inactivated biomass. Bio- materials used by IIT Kanpur: Canna flower, Portulaca flower, Hibiscus flower and Trapa fruit skin (exocarp). Chromium concentration decreased after using this biomaterial, but no detailed report is found for reviewing.

Remediation at Muthia Village Dumpsite, Ahmedabad (Gujarat)
Muthia village lies on the eastern border of Ahmedabad City, adjacent to a major industrial estate operated by the Naroda Gujarat Industrial Development Corporation (GIDC). Approximately 60,000 tons of industrial waste has formed as a result of careless disposal from the effluent treatment plants over the last decade. These hazardous waste products had leaked into the groundwater, which turned a worrisome shade of red. Monsoon rains washed and spread the contaminated sludge over a very wide area.

Concept Biotech and the Society for Environmental Protection have been studying contamination in this village since 1996. Blacksmith Institute funded the implementation of a three phase clean up, the last phase of which is the treatment of the site with vermiculture-worms that concentrate heavy metals in their bodies, and reduce the contamination in the soil around them.

Originally a site containing an estimated 150 tons of hazardous waste had been targeted for a pilot-scale intervention project. However, upon further examination, it was discovered that the contamination had permeated the soil deeper than initially been estimated, requiring excavation of the site. Heavy machinery and other equipment were brought in, and eventually removed 3,000 tons of hazardous wastes, which was later sent to a disposal facility operated by Naroda Environmental Projects Ltd. (NEPL). The costs of this unforeseen contingency were covered by local industries, who also contributed their services and effort to the project.

The first plot affected by dumping has been remediated with approximately 60% reduction in select heavy metals, though another round of decontamination was recommended. The second round of decontamination involved the distribution of some 400 litres of EM solution, followed closely by the introduction of 8 tons of vermin-castings and another 40 kilograms of worms. The results at the end of the second year have proven to be encouraging, showing even further reductions in the presence of heavy metals.

The site has been monitored quarterly to further assess the efficacy of this methodology through soil testing and analysis of plants in the area to test for the presence of heavy metals. This low-cost pilot bio-remediation method has proven highly effective in managing and treating the waste dumps state wide. As complete details of the project could not be obtained it is not possible to comment on the viability of this pilot.

CBIPMP pilot projects
Known to us are four pilot projects within CBIPMP, regarding assessment and remediation. Information on these projects is necessary to evaluate the learning points for future projects. At the time of writing this report, we only possessed information on one of these projects, Lake Noor. We did not have access to detailed project report or documentation on evaluating remediation results.

Andra Pradesh: Noor Mohammed Kunta, Katedan Industrial Estate – KIE
This lake is contaminated by many industries in the nearby industrial estate. The water of the lake is used for agricultural and domestic purposes. The lake

has a pink colour and sediment and surface water are suspicious for containing contamination.

The assessment and remediation of this contaminated site is one of the pilot studies in the CBIPMP. Andra Pradesh PCB is carrying out the steps in the assessment and remediation process. Witteveen&Bos of The Netherlands is the consultant in this project. During the meeting of 29th November 2012 at Hyderabad, Dr. Ramani of APPCB and Mr. Marten van der Wijk of Witteveen&Bos presented the situation of the pilot project. Following steps and activities have been or will be carried out:

- Task 1: Preliminary site assessment
- Task 2: Investigation plan (Sampling protocol and H&S)
- Task 3: Detailed field investigation
- Task 4: Environmental Management Plan and Remediation Action plans
- Task 5: Procurement Planning

For each task the executed activities are described below.

<u>Task 1 Preliminary site assessment</u>

- site visit;
- interviews (APPCB, local authorities and other stakeholders);
- desk study – data collection: zones (I. KIE, II. NMK, III. plains); historical data on previous and Present industrial activities; environment (physical, biological, cultural and socio-economics);
- preliminary sampling.

The results of this assessment have lead to:

- Identification Components Of Potential Concern;
- Elaboration Conceptual Site Model;
- Input Task 2 Investigation plan, including health and safety.

Inventories carried out: total wells present; open drains in KIE; topographic survey of the lake and the KIE area; inventory of Open areas and characterization in KIE; site assessments of the industries in the KIE.

Site assessment

- A format has been developed for assessment of the industrial activities;
- Site assessment of around 320 industrial plots has been carried out using the format;
- The data has been digitized on GIS platform.

<u>Task 2 – Investigation plan (Sampling protocol and H&S)</u>

- field work plan: field work team ; sampling gear (augers, pontoon…); sampling maps; planning (pre and post monsoon);
- laboratory plan and choice of laboratories (having three analytical instruments: ICP-AIS; GC-MS; ED-XRF) and execution of analyses;
- health & safety.

<u>Task 3: Detailed field investigation</u>

Main objectives of the site inspections and investigations:

- inventory of: the open drains and existing wells; contaminating sources at the open areas of the KIE; contaminating activities industrial plots at KIE (+350 industries inspected);
- assessment of the contamination levels at: open areas of the KIE; industrial plots of the KIE; Lake NMK;
- risk evaluation and assessment , including biomonitoring;
- environmental and social base line investigation;
- Public consultation: Environmental Baseline Investigation; In current conditions contamination levels have a severe impact on the nature around the lake and in the plains.

Task 4: Environmental Management Plan and Remediation Action plans

- Management plan NMK site: Strategy (Zoning source- pathways- receptors; −Risk based mitigation measures); Management plan per zone (Goals and objectives zone specific; Conditions for remediation, zone specific; Management of contaminated soil); Action plan per zone (Detailed description of remediation activities; Direct risk short term; Remaining risk mid term; Monitoring and after care; Recommendation enforcement preventive measures);
- Selection criteria for options to assess: Planning implementation; Technical feasibility Cost/benefit; Land use; Environmental impact; Social impact; Monitoring aftercare/post remediation; Risk factors;
- Remediation action plan for central open area and sludge from the ditches and ponds
- Potential options:
    - Collection and off site disposal;
    - Collection and off site treatment (e.g. cement kilns, furnaces);
    - Collection and on-site treatment (bio, immobilization, washing);
    - Collection and on-site disposal in technical landfill cell;
    - Waste mining and partial re-use;
    - Top cover over entire area.
- Proposed final remediation approach;
- KIE: Construction of containment facility in central open area and safe storage of contaminated material; Dredging, dewatering and on site storage in Geotubes of sediments from drains, swamps and stagnant water ponds;
- NMK: Dredging, dewatering and on site storage of black sediments in Geotubes in green belt around the lake, parallel to beatification of the shore line; Capping of remaining contaminated clay layer with a sand cap (potential application of active carbon in sand layer); Plains downstream; Apart from monitoring, no actions required.

Task 5 Procurement Planning

- Currently focus on activities which limit impact on NMK;
- After that remediation of lake NMK;
- Phased procurement.

Learning points

Following learning points in the process of assessment and preparation of remediation can be derived from this presentation on 29th November 2012 meeting:

- Sedimentation causes reduction of holding capacity lake (extra driver for removing sediments);
- Simple sketches of situation (top view and cross section) are already enough to give good information and ground for discussion;
- During step inventory historic land use and site visit is very important, this saves money in the end;
- Health and safety procedures for working crew and residents are important;
- Screening levels: Dutch intervention values are used;
- Important learning point for AP: there are always surprises and things will pop up;
- Contaminants in sediment give indication what you could find on land;
- First step, before remediation, should always be: preventing new contaminated effluents;
- During fieldwork: cycled approach and adjustment where necessary;
- Differences in concentration levels in pre-monsoon and post-monsoon are not large;
- Atmospheric deposition surely has taken place causing contaminated soil;
- Way of presenting risk-evaluation in a table is simple and useful;
- The step-wise approach containing a management plan per zone is very important;
- Using a broad set of criteria for remediation option appraisal is important;
- Presence of enough open space for temporary storage or treatment is a real problem here and it sure will be at other sites;
- Regarding long term monitoring: the compliance culture on this should be taken into account;
- Close stakeholders closely involved (Industrial board; civil society organizations; NGO) has shown results.

Other sites and studies

Although no literature on other remediation cases is listed in this Annexure the project team is familiar with different published articles and seminar articles describing the best practices in India.
From these it transpires that most of the successful remediation cases in India were implemented using excavation and transfer of waste to secured landfills. Chemical and biological remediation actions are only known on a laboratory or small pilot scale.

Social aspects approaching contaminated sites

For an introduction to the social aspects in approaching contaminated sites, this Section describes an example from West Bengal.

When visiting contaminated sites at Nibra-Village and the Hoogly-area in July 2012, our project team had discussions with the West Bengal Pollution Control Board (WBPCB) on the social aspects related to remediation of the sites. Below, the situation of the contaminated sites is described first and after that some considerations for taking into account social aspects in all steps of a remediation process are presented. These points will be implemented in the Guidance document, to be developed in Task 4.

Situation of the contaminated sites
WBPCB has identified hazardous waste dumpsites in and around Nibra Village in Howrah District and also along the Kolkata-Delhi Road in Hoogly district. Due to lack of a proper hazardous waste management system in the past most of the waste earlier generated has been disposed of in low lying areas, contaminating water and soil. On some sites houses have been built. It is not known at present to what level people have knowledge of the soil contamination of their premises. Workers engaged in the industries and on the weighbridges are constantly exposed to the waste through skin contact, inhalation and possible ingestion. Vehicles using the weighbridge are spreading the contamination as the loose waste road fill is being carried over by the wheels and also causes suspension of the waste dust, leading to air contamination. During the rains, the waste gets carried to other areas, including nearby agricultural land and surface water bodies along with surface run-off.

There appears to be a clear preference for such industrial wastes for road construction and land filling in the said area. A large number of potentially contaminated spots have already been identified and recent instances of such land filling have also been detected by the WBPCB. The general ignorance of people and organizations is an important social aspect. Such widespread use of industrial waste will eventually raise social costs and influence the selection of remediation technology in case serious health impacts are predicted through detailed assessments.

Use of industrial waste to build access roads over public land and obstruction of drainage canals is also a matter of public concern. It is fairly clear that the number of industries in the area is increasing fast and there is a clear tendency in the region to conversion of farm land into industrial land. Industrial infrastructure development, drainage and sewerage issues, access and service road development are allied social and environmental needs.

General aspects for integrating social aspects in the remediation process
Apart from the impact of living near a contaminated site and the effects on human health there are the following anticipated social impacts due to remediation of contaminated sites:

- During remediation works, the impact of air and noise contamination on the local communities depends on the duration of the project activities. If the transportation distance for waste from the site to say a landfill site is short the air contamination impact will be less. Higher air contamination impact can be anticipated if a lot of loading and unloading is required for site development. Noise contamination may be due to excavation activity, loading and unloading of waste and transport vehicle movement. Spillage of wastes during transportation may cause negative impacts on the community. However, if proper measures to stabilise the waste are taken this impact will get reduced;

- There is always an element of potential road accidents during transportation. This potential increases with increasing distances;
- Impact on business activity and livelihood at and around a contaminated site will have to be considered during the remediation period and will depend upon both short term and long term activity of remediation;
- For land users value of properties is dominant over health issues. As remediation is dealing with health issues, in discussions with land users different issues are getting mixed up and give a bias on the focus of remediation options. If coal pickers are deprived from their income due to a clean capping layer, this will negatively impact the support for such a remediation option. Only if a complete solution is given, which in the example would have to include the securing of a livelihood for the coal pickers, a remediation option is likely to be executed;
- The larger the remediation activity the more positive the impact on employment opportunities is likely to be. The site development for storage and disposal of waste will also generate additional employment opportunities.

The public has a legitimate right to understand and to be involved in decisions that may affect them. It follows that high levels of involvement and communication are important to prevent undue concerns about the risks during remediation or site testing work. Community involvement and consultation should begin at an early stage of any project.

The impact assessments on social issues are an integrated part of a remediation process and solicit views of the stakeholders including the community for designing the project. The consultation process helps in making the project responsive to social development concerns, including options that enhance benefits for poor and vulnerable people while mitigating risk and adverse impacts.

The nature of social impacts may be direct, indirect and cumulative, based on the characteristics of impacts. The following activities are primarily required to establish the level of significance for each identified impact on the community:

- Socio-economic details of the nearby areas including type of settlements;
- Determination of the severity of the effect. For example, an impact is of low, medium, or high significance. Emphasis should be given on the slum population in the nearby areas as they are more exposed to hazardous wastes.

The following activities are recommended during the remediation process:

- Cover community awareness, participation, and education with respect to implementation and management of facilities, and educate communities about the issues related to improvement of the health and environment;
- Inform the project beneficiaries including stakeholders at different levels on implications to the community in terms of benefits and responsibilities;
- A plan for the site specific mitigation measures is to be formulated in consultation with the stakeholders for sustainable remediation techniques and to reduce hazardous impact on the community of the nearby areas;
- The following aspects have to be considered: cost of land; geographic advantages, i.e. nearness to urban area; land acquisition may be required dur-

ing implementation; compensation and relocation may be necessary before implementation;

- Government policy is required to regulate the land use pattern and infrastructure, which have an impact on use of contaminated sites;
- The objective of the project can be conveyed to the local people near the contaminated site with the help of local administration and other institutions;
- Impacts on the environment and livelihood should be minimized during construction;
- Several public consultations with the stakeholders are required for smooth implementation.

Annexure IV Remediation options 100 sites

State	Site no	ID number	Site Name	Current land use	Approximate area of site *(Sqm)*	Type of contamination according to definition from MoEF	Primary Contaminant(s) (chemical name(s))	Typology, summary	TSDF	distance from contaminated site to TSDF in km	remediation options code	remediation options	remediation technologies
Andhra Pradesh	3	AP-502-1	Patancheru, Medak District , Andhra Pradesh	Mixed (Water Bodies& Waste Land)	6200 Sqm	Hazardous Waste, Effluent;	Chromium, lead, Cadmium, Arsenic , Mercury , Copper, Zinc, Nickel	S1-c; L1-d	M/s Hyderabad Waste Management Project (Ramky Enviro Engineers Ltd) Survey no. 684/1, Dundigal village, Qutbullapur Mandal, R.R. Dist- 500 043 (A.P.)	40	3, 8, 13	Removal of waste, and excavation of underlying contaminated soil. In-situ remediation in selected areas / contamination types. Abstraction of contaminated groundwater.	1-Excavation followed by disposal in landfill. 2-In-situ technologies (fixation, immobilsation). 3-Groundwater abstraction.
Assam	12	AS-781-3	Rangia, District-Kamrup, Assam	Agricultural Land	62,000 Sqm	Effluent	Chromium, Nickel, Zinc	L1-d; P-2	None : Now proposed	Not Applicable	5, 13	Removal of contaminated soil and sludge, extraction of contaminated groundwater in selected areas. Also phyto remediation in selected zones or crop selection as option.	1-Collection of sludge from waterways in Geo tubes. 2-Deepwells for groundwater abstraction. 3-In-situ technologies Phyto remediation, fixatation / immobilisation. 4-crop selection.
Bihar	16	BR-800-1	Hathidah Khurd village, Mokama Block, Patna District, Bihar	Industrial	>60,000 Sqm	Effluent; Hazardous Waste	Arsenic, Cadmium, Lead, Mercury	L1-d; P-2	None	Not Applicable	3, 8, 13	Removal of contaminated soil and sludge in impacted agricultural areas. Installation of new wells in non contaminated aquifers. Prevention of spreading by groundwater. Crop selection as option.	1-Collection of contaminated sludge in Geo tubes. 2 collection of residu and storage in controlled conditions. 3-In-situ technologies fixatation / immobilisation), abstraction of polluted groundwater
Chhattisgarh	17	CG-491-1	Bhilai steel plant, Chhattisgarh	Waste land	1,000,000 Sqm	Hazardous Waste	PAH, PCB, Arsenic, Mercury, Sulphate, Chloride	S1-c?, S1-e	None	Not Applicable	8, 12	Removal of surfcae waste material and excavation of underlying contaminated soil in selected areas	1-removal of surface waste and collection in to central storage on the site. 2-covering of surface waste by paving (capping layer). 3-In-situ technologies fixatation / immobilisation), abstraction of polluted groundwater in selected areas
Chhattisgarh	21	CG-495-2	BALCO, Korba	Industrial	3,500 Sqm	Hazardous Waste	Lead, Cynide, Fluoride	S1-c; P-2?	None	Not Applicable	8	Redevelopement of storage facility on the site. Excavation of contaminated soil and storage in facility on the site.	1-redevelopment of controlled storage facility on the site. 2-relocation of waste to approved storage facility.
Goa	23	GA-403-2	M/s Sunrise Zinc Ltd , Plot No. L-2 & M/S Nicomet Industries Ltd Plot no, L-15 ,19 & 20, Cunicolum Industrial Estate, Punjim, Goa	Mixed (Industrial & TSDF)	52,234 Sqm	Hazardous Waste	Chromium, Copper, Cobalt, Cadmium, Arsenic , Zinc, Manganese	S1–b; P-2?	None Private dumpsite near manufacturing plant	1	3, 5, 8	Redevelopement of storage facility on the site. Relocation of waste material from current storage facility to approved storage facility on the site. Excavation of contaminated soil and storage in facility on the site. Prevention of off-site migration of contaminated groundwater.	1-redevelopment of stotage facility on the site. 2-releocation of waste to approved storage facility. 3-In-situ technologies hydrological control of polluted groundwater migrating from the site
Gujarat	24	GJ-360-1	Aji GIDC Industries Association Estate Rajkot	Industrial	830,000 Sqm	Hazardous Waste	Hexavalent Chromium, Lead, VOCs, Aromatic hydrocarbons (BTEX)	S1-c, S1-e, P-2	M/s Saurashtra Enviro Projects Pvt Ltd. Survey no. 415, 417 & 418, Vill Juna katariya, Tal- Bhachau, Dist-Kutch, Gujarat	160	3, 8, 9, 11	removal of waste. Capping of waste to prevent further leaching out and spreading. Removal of sludge and drainage systems. Removal of source areas of solvents	1- removal of waste. Capping of waste. 2- In-situ removal of any LNAPL. Biological remediation of solvents in groundwater. 3- excavation of sludge and soil in selected areas. Use of Geo tubes to dewater sludge
Gujarat	27	GJ-383-1	Larsen Chem, B/2, Ganeshpura, Opp Janta Petrol Pump, Modasa Sabarkantha district-Gujarat	Industrial	3500 Sqm	Effluent, Hazardous Waste	Lead, Arsenic, Cadmium, Chromium, Zinc, Mercury	S1-a?; P-2	M/s The Green Environment Services Co-op. Society Ltd. Survey no. 89-90-91, Vill Vinzol, Ahmedabad, Gujarat	110	3, 8, 9, 10, 11	prevention of further migration goundwater pollution. Removal of any source areas of pollution in groundwater and soil.	1- in-situ biological remediation of groundwater & groundwater abstraction. In-situ source removal LNAPL / DNAPL. 2- excavation of sludge and soil in selected areas.
Gujarat	28	GJ-383-2	Swastik Organic, survey no 93 paiki,Sabar Dairy Road,Piplodi	Industrial	3,000 Sqm	Effluent	Zinc, Lead , VOCs, Aromatic Hydrocarbons (BTEX)	S1-a?, P-2	M/s The Green Environment Services Co-op. Society Ltd. Survey no. 89-90-91, Vill Vinzol, Ahmedabad, Gujarat	85	3, 8, 9, 11	prevention of further migration goundwater pollution. Removal of any source areas of pollution in groundwater and soil.	1- in-situ biological remediation of groundwater & groundwater abstraction. In-situ source removal LNAPL / DNAPL. 2- excavation of sludge and soil in selected areas.
Gujarat	31	GJ-390-4	Effluent Channel Project Limited (ECPL) (Baroda Effluent Canal) Vadodara and Bharuch District	Other (effluent drain line)	55,300 Sqm	Effluent	Chromium, Lead, Arsenic, Cadmium, Mercury, Phenolic compounds	L1-d; P-2	M/s Nandesari Environment Control Ltd, 519-P, GIDC, Nandesari, Dist. Vadodara	10 to 100	3, 4, 5, 9, 10, 11	Stop leaking effluent pipeline and control of emmissions from Industry into pipeline. Remediation of adjacent areas of pipeline which have become impacted. May have sediments to be removed periodically.	1-Collection of sludge from open water in Geo tubes. Dewatering.
Gujarat	32	GJ-391-1	Hema Chemicals Unit II, Nandesari, Vadodara	Industrial	6400 Sqm	Hazardous Waste	Chromium, Hexavalent Chromium, Lead	S1 – c; P-2	M/s Nandesari Environment Control Ltd, 519-P, GIDC, Nandesari, Dist. Vadodara	15	3, 8	Remediation measures should focus on prevention on exposure to waste material. After achieving this, systemetical removal of waste in selected areas and permanent capping.	1-prevention of exposure to waste (fences, temporary capping) 2. removal of waste material and storage in control landfill. 3-permanent capping of waste. 4-groundwater abstraction in selected areas.
Gujarat	33	GJ-392-2	J Point,(Effluent Discharge Point) Jambusar, District-Bharuch,	Other (Effluent Drain Line)	3,000 Sqm	Effluent	Cadmium, Cyanide, Chromium, Heavy metals, VOCs, Phenolic Compound, BTEX	L1-d; P-2	M/s Nandesari Environment Control Ltd, 519-P, GIDC, Nandesari, Dist. Vadodara	100	3, 5, 8, 9, 10, 11	Inspection pipeline and control of emmissions from Industry into pipeline. Remediation of sediments at drain discharge point . May have sediments to be removed periodically.	1-Dredging of sludge from open water at drain disharge point. Collection in Geo tubes.
Gujarat	34	GJ-393-2	Ankleshwar Induatrial Estate ,GIDC Industrial Estate, Ankleshwar. Dist.Bharuch (Gujarat, India,Ankleshwar	Industrial	70000 Sqm	Hazardous Waste	Chromium, Cadmium, Arsenic, Zinc, Lead, Total Petroleum, VOCs, Aromatic Hydrocarbons (Benzene, Toluene), PAH components, Pesticide Residue, Phenolic Compounds, Copper, PCB	S1–a; P-2	M/s Bharuch Enviro Infrastructure Ltd. Plot no. 9701-9716, GIDC, Ankleshwar-393 002	5	3, 8, 9, 10, 11	Proper containment of remaing dumpsites and restriction of acess. In time removal of remaing dumpsites to TSDF. Excavation of underlying soil. Removal of sources in groundwater by groundwater abstraction supported by LNAPL / DNAPL removal and by in-situ biological remediation	1-control of remaing dumpsites. 2-removal of remaining dumpsites to TSDF. 3-removal of underlying contaminated soil, disposal in TDSF. 4-in-situ remediation groundwater (abstraction, biological)
Gujarat	40	GJ-396-4	TSDF site, GIDC-Vapi, District-Valsad	Other (TSDF site)	100,000 sqm	Hazardous Waste	Zinc, Copper, Chromium, Lead, Cadmium, Mercury, Arsenic, PCB, VOCs	S1–b; P-2	M/s Vapi Wate & Effluent Management Co. Ltd. Plot no. 4807, etc. Phase IV GIDC, Vapi, Dist: Valsad, Gujarat	0	9, 11, 12	Proper management TSDF. Removal spillage into TSDF.	1-removal of spillage into TSDF. 2-in-situ biological remediation of groundwater
Gujarat	44	GJ-391-4	Gorwa Pond, Vadodara Gujarat,Behind Hema Chemicals, Nr.Samta Colony, Subhanpura Road,Vadodara	Water bodies	27,740 Sqm	Effluent	Hexavalent Chromium, Chromium, Lead	S2; L1-d; P-2	M/s Nandesari Environment Control Ltd, 519-P, GIDC, Nandesari, Dist. Vadodara	15	4	Prevention of leaching out from remaining waste on the land. Dredging of sediments and collection into geotubes for dewatering	1- prevention of leaching out form remaing waste on the land. 2-dredging of sediments in the ponds and collection in geo tubes. Dewatering. 3-collection and storage of remaining material.

State	Site no	ID number	Site Name	Current land use	Approximate area of site *(Sqm)*	Type of contamination according to definition from MoEF	Primary Contaminant(s) (chemical name(s))	Typology, summary	TSDF	distance from contaminated site to TSDF in km	remediation options code	remediation options	remediation technologies
Haryana	53	HR-122-2	Pace City-II, Sector 37 Gurgaon Haryana	Water bodies	45,560Sqm	Effluent	Chromium, Mercury, PAH components, Hydrocarbons, VOCs, PCB	S2?; L1-d; P-2?	None	Not Applicable	4	Influent from discharge with chemichals to be stopped. Dredging of sediments and collection into geotubes for dewatering	1- stop discharge into the lake. 2-dredging of sediments in the pons and collection in geo tubes. Dewatering. 3-collection and storage of remaining material.
Haryana	59	HR-131-1	Prem Colony, Kundli Sonepat	Habitation settlement	885 Sqm	Hazardous Waste	Chromium, Lead, Arsenic, Fluoride	S1-c; P-2?	None	Not Applicable	1	most likely removal of waste material and excavation of underlying contaminated soil in selected areas. Prevention of infiltration of polluted water	1-removal of waste material. 2- excavation of underlying contaminated soil. 3-collection of contaminated soil in storage with capping. 4- in-situ technologies (fixation). 5-drainage system on the site to prevent infiltration of polluted water
Haryana	61	HR-133-2	Sectors 25 & 29, Dyeing Industry, Panipat, Haryana	Industrial	126,000 Sqm	Effluent, Hazardous waste	Chromium, Hexavalent Chromium, Lead , Mercury, Zinc, Ammonia, Phenolic Compounds	S1-c; L1-d	None	Not Applicable	3, 8, 9, 10, 11	Restructure of dumpsites on the location to proper storage facilities. Removal of shallow contaminated soil in selected source areas. Groundwater abstractions, in-situ remediation, supported by LNAPL/DNAPL removal	1-restructure of dumpsites. 2- excavation of contaminated soil and relocation to proper storage facility.4- in-situ technologies: bio remediation of contaminated groundwater, groundwater abstraction, removal of any LNAPL, DNAPL
Himachal Pradesh	65	HP-173-2	Effluent Drain , Housing Board Phase-III, Baddi, Himachal Pradesh	Water bodies	10,000 Sqm	Effluent	Zinc, Copper, Lead , Chromium, Hexavalent Chromium	L1-d; P-2?	M/s Shivalik Solid Waste Management Ltd. Vill Majra, P.O. Dabhota, Teh. Nalagarh, Distt Solan (H.P.)	80 Mountain Road	4	Influent from discharge with chemicals to be stopped. Dredging of sediments and collection into geotubes for dewatering	1- stop discharge into the lake. 2-dredging of sediments in the ponds and collection in geo tubes. Dewatering. 3-collection and storage of remaining material.
Jharkhand	79	JH-833-1	Roro hills Jharkhand	Industrial (Mining)	5250000 Sqm	Hazardous waste	Asbestos	S1-c, S1-e, S1-f; P-2	None	Not Applicable	8	Controlled access to most polluted areas. Most likely removal of waste material, reduce the possibilities of migration by dust and water. Collection of waste to a controlled facility	1-controlled access to the sites. 2- collection and removal of waste material and storage into a controlled facility. 3-covering of waste in selcted areas (capping, plants)
Jharkhand	81	JH-833-2	Manikui -Chandil Swarnarekha River Polluted Site, Seraikella- Kharswan, Jharkhand	Water body	>60,000 Sqm	Effluent	Lead, Cadmium, Zinc , Arsenic, Chromium, Copper, Molybdnum	L1-d	None	Not Applicable	4	Influent from discharge with chemicals to reduced. Dredging of sediments and collection into geotubes for dewatering	1- reduce discharge into river. 2-dredging of sediments in the ponds and collection in geo tubes. Dewatering. 3-collection and storage of remaining material.
Karnataka	88	KA-560-15	Mavallipura Dumpsite, Yelahanka , Banglore	Waste Land	60,700 Sqm	Municipal Solid Waste	Total Cr, Tin. Silver, Zinc, Molybdenum,Copper, Cadmium, Lead,Arsenic, Mercury, Hexavalent Chromium	S1-c; P-2	Dabaspet, Vadesamudra, Karnataka	160	12	Capping existing waste body to limit exposure and infiltration of water. Removal of waste and collection in proper storage facility. Groundwater abstraction to prevent further migration of leachate	1- capping of waste material to provent further leaching out. 2- construction of proper controlled storage facility for waste. 3- installation of groundwater abstraction / control to prevent further migration of leachate
Karnataka	92	KA-560-2	Goripalya near Mysore Road, Bangalore, Karnataka. E-waste recycling in Bangalore, Karnataka	Habitation settlement	50,000 Sqm	Any other (e-Waste)	Chromium, Hexavalent Chromium, Lead, Arsenic, Cadmium, Mercury, Zinc, Copper	S1-c; P-2?	Dabaspet, Vadesamudra, Karnataka	130	7	removal of waste material and excavation of underlying soil layer in selected areas.	1-removal of waste material. 2-collection of waste material in controlled storage.
Karnataka	98	KA-560-8	Mangamanapalya Road, Hosur Road, Bangalore, Karnataka	Habitation settlement. Commercial, Industrial	9,000,000 Sqm	Air	Hexavalent Chromium, Chromium and Lead	S1-e	Not Applicable	Not Applicable	1	Reduction of air emissions: filtering of polluting air emissions.	1- Control of air emissions to prevent spreading of pollutants
Karnataka	99	KA-560-9	Peenya Industrial area, Bangalore, Karnataka	Industrial	2,000,000 Sqm	Effluent	Zinc, Cromium, Lead	L1-d; P-2	Dabaspet, Vadesamudra, Karnataka	150	8	Emissions of chemicals and sewage to the discharge system should be controlled and reduced to acceptable levels.	1-reductions of emissions from the discherge system. 2-in-situ remediation of affected groundwater by bio remediation of groundwater abstraction
Karnataka	101	KA-571-1	Cauvery River, downstream Nanjangud, Mysore District, Karnataka	Water bodies	>60,000 Sqm	Effluent	Lead ,Cadmium, Hexavalent Chromium, Chromium, Zinc, Nickel	L1-d; P-2?	Dabaspet, Vadesamudra, Karnataka	70	4	Reduction of emissions of chemicals into the river. Dredging of polluted sediments.	1-reductions of emissions to the river. 2-dredinging of sediments and collection in geo tubes. Dewatering, collection of remaining material. 3-in-situ remediation of affected groundwater by bio remediation of groundwater abstraction
Kerala	108	KL-628-1	Kalamukke Lake, Kochi	Water bodies	10,000,000 Sqm	Effluent	Lead	S2; L1-d; P-2	M/s Keral Enviro Infrastructure Ltd., Common TSDF Project, Inside Fact-CD Campus, Ambalmedu, Kochi-682 303	25	4	Reduction of emissions into the water bodies (river and estuaries). Dredging of polluted sediments.	1-reductions of emissions to the water bodies. 2-dredinging of sediments and collection in geo tubes. Dewatering, collection of remaining material. 3-in-situ remediation of affected groundwater by bio remediation of groundwater abstraction
Kerala	110	KL-683-1	Kuzhikandom Thodu (Creek), Kerala	Water bodies	200,000 Sqm	Effluent	Pesticides Residues, Chromium, Lead, Cadmium, Mercury	S1-d; L1-d; P-2	M/s Keral Enviro Infrastructure Ltd., Common TSDF Project, Inside Fact-CD Campus, Ambalmedu, Kochi-682 303	20	4	Reduction of emssions into the creek. Dredging of sediments from the creek. Excavation in selected land areas. Phytoremediation for larger land areas.	1-reductions of emissions to the water bodies. 2-dredinging of sediments from the creek and collection in geo tubes. Dewatering, collection of remaining material. 3- excavation of selected areas. Phyto remediation of selected areas. 4-in situ remediation of affected groundwater (bio remediation of groundwater abstraction)
Kerala	111	KL-683-2	Ammanthuruthu-Karipadam	Agricultural Land	206,200 Sqm	Effluent, Hazardous Waste	Pesticide Residue, Chromium, Hexavalent Chromium, Lead, Arsenic, Cadmium, Mercury, pH	S1-d; L1-d; P-2	M/s Keral Enviro Infrastructure Ltd., Common TSDF Project, Inside Fact-CD Campus, Ambalmedu, Kochi-682 303	25	4	Removal of waste and excavation of underlying impacted soils in selected land areas. Remdiation of groundwater in selected areas	1-removal of waste material. 2-collection of waste material in controlled storage. 2-in-situ remediation (biological, abstraction) of groundwater
Kerala	116	KL-686-1	Vadavathoor , Kottayam	Other (MSW Dump site)	14,000 Sqm	Municipal Solid Waste	Chromium, Hexavalent Chromium, Lead, Arsenic, Cadmium, Mercury, pH, Chloride and Sulphate	S1-c; P-2?	M/s Keral Enviro Infrastructure Ltd., Common TSDF Project, Inside Fact-CD Campus, Ambalmedu, Kochi-682 303	70	12	Removal of waste. Excavation of underlying soil in selected areas. Groundwater abstraction to prevent further spreading	1-relocation of waste followed by disposal in proper landfill. 2-in-situ remediation: groundwater abstraction (hydrological control) to prevent further spreading
Madhya Pradesh	120	MP-454-1	Indo Zinc, Plot-79, Sector -3, Pithampur, Dist-Dhar, Madhya Pradesh	Industrial	15,000 Sqm	Hazardous Waste	Zinc, Cadmium , Mercury, Arsenic, Chromium, Lead, Fluoride	S1-a; P-2?	M/s Madhya Pradesh Waste Management Project,(Division of Ramky Enviro Engineers Ltd.) Plot No. 104, Industrial Area No.-II, Pithampur, Dist- Dhar 454 775 (M.P.)	5	8	Removal of waste and excavation of underlying soil in selected areas. Groundwater abstraction to prevent further spreading	1-removal of waste and excavation of contaminated soil. Followed by disposal in proper landfill. 2-in-situ remediation: groundwater abstraction (hydrological control) to prevent further spreading

State	Site no	ID number	Site Name	Current land use	Approximate area of site *(Sqm)*	Type of contamination according to definition from MoEF	Primary Contaminant(s) (chemical name(s))	Typology, summary	TSDF	distance from contaminated site to TSDF in km	remediation options code	remediation options	remediation technologies
Madhya Pradesh	121	MP-456-1	M/s Grasim Chemical, Grasim Nagar, Nagda, Madhya Pradesh	Mixed (Water Bodies & Industrial)	41,600 Sqm	Effluent	Mercury	L1-d; P-2?	M/s Madhya Pradesh Waste Management Project,(Division of Ramky Enviro Engineers Ltd.) Plot No. 104, Industrial Area No.-II, Pithampur, Dist- Dhar 454 775 (M.P.)	120	8	Removal of waste and excavation of underlying soil in selected areas. Groundwater abstraction to prevent further spreading	1-removal of waste and excavation of contaminated soil. 2-capping in selected areas. Disposal of waste in proper landfill. 2-in-situ remediation: groundwater abstraction (hydrological control) to prevent further spreading.
Madhya Pradesh	122	MP-457-1	Sajjan Chemicals -Plot No ; 54 E dosigoan Industrial area, Ratlam, Madhya Pradeh	Industrial	4550 Sqm	Hazardous Waste	Arsenic, Cadmium, Chromium, Lead, and other heavy metals, Sulphate, Chloride, Aluminium, Phenolic compounds, PAH	S1-a; P-2?	M/s Madhya Pradesh Waste Management Project,(Division of Ramky Enviro Engineers Ltd.) Plot No. 104, Industrial Area No.-II, Pithampur, Dist- Dhar 454 775 (M.P.)	120	8	Removal of waste and excavation of underlying soil in selected areas. Groundwater abstraction to prevent further spreading	1-removal of waste and excavation of contaminated soil. 2-capping in selected areas. Disposal of waste in proper landfill. 2-in-situ remediation: groundwater abstraction (hydrological control) to prevent further spreading.
Madhya Pradesh	123	MP-457-2	Sajjan chemical Pvt Ltd (Plot No -61 B, Dosigaon Industrial Area, Ratlam)	Industrial	10,000 Sqm	Hazardous Waste	Arsenic, Cadmium, Chromium, Lead, and other heavy metals, Sulphate, Chloride, Aluminium, Phenolic compounds, PAH	S1-c; P-2	M/s Madhya Pradesh Waste Management Project,(Division of Ramky Enviro Engineers Ltd.) Plot No. 104, Industrial Area No.-II, Pithampur, Dist- Dhar 454 775 (M.P.)	120	8	Removal of waste and excavation of underlying soil in selected areas. Groundwater abstraction to prevent further spreading	1-removal of waste and excavation of contaminated soil. 2-capping in selected areas. Disposal of waste in proper landfill. 2-in-situ remediation: groundwater abstraction (hydrological control) to prevent further spreading.
Madhya Pradesh	124	MP-457-3	Sajjan chemical Pvt Ltd (Khandarwesa Mines, Near Nimali Village)	Other (Mining - Abandoned mine)	326,400 Sqm	Hazardous Waste	Arsenic, Cadmium, Chromium, Lead, and other heavy metals, Sulphate, Chloride, Aluminium, Phenolic compounds, PAH	S1-b; P-2?	M/s Madhya Pradesh Waste Management Project,(Division of Ramky Enviro Engineers Ltd.) Plot No. 104, Industrial Area No.-II, Pithampur, Dist- Dhar 454 775 (M.P.)	140	8, 12	Removal of waste and excavation of underlying soil in selected areas. Groundwater abstraction to prevent further spreading	1-removal of waste and excavation of contaminated soil. 2-capping in selected areas. Disposal of waste in proper landfill. 2-in-situ remediation: groundwater abstraction (hydrological control) to prevent further spreading.
Maharashtra	140	MH-400-5	Mithi River, Mumbai, Maharashtra	Water body	270,000 Sqm	Effluent	Nitrate, Lead,Sulphates	L1-d; P-2	M/s. Trans Thane Waste Management Association, Mahape, Navi-Mumbai	30	4	Further reduction of emssions into the river basin. Continuing of dredging of sediments from the river.	1-further reductions of emissions to the river. 2-continuing of dredinging of sediments from the river
Maharashtra	141	MH-400-6	Dahisar,Mumbai Suburban, Maharashtra	Habitation settlement	105,000Sqm	Hazardous Waste	Chromium, Hexavalent Chromium	S1-a?; P-2?	M/s. Trans Thane Waste Management Association, Mahape, Navi-Mumbai	60	7	Removal of waste and excavation of underlying impacted soils in selected land areas. Remediation of groundwater in selected areas	1-removal of waste material. 2-collection of waste material in controlled storage. 2-in-situ remediation (biological, abstraction) of groundwater
Maharashtra	142	MH-431-1	Naregaon dumping site, Aurangabad city	Other (MSW Landfill)	1,39,000Sqm	Municipal Solid Waste	Cadmium, Hexavalent Chromium, Chromium, Zinc, Lead, Copper	S1-c; P-2	M/s. Maharashtra Enviro Power Ltd. Plot No. 56, MIDC Ranjangaon, Taluka- Shirur, Dist – Pune.	200	5, 12	removal of waste, excavation of underlyng soil in selected areas. Controlled access to sites	1-stop dumping of waste. 2-removal of waste and relocation to controlled site
National Capital Territory	146	ND-110-14	Okhla industrial area, New Delhi	Mixed (Industrial, Habitation settlement &Commercial)	450,000 Sqm	Hazardous Waste, Effluent	Hexavalent Chromium, Chromium	S1-a?; P-2?	None	Not Applicable	8	Remedial action as part of the process of modernizing the landfills. This process should include reuse / recycling of waste material	
National Capital Territory	148	ND-110-16	Gazipur landfill-site, Gazipur, Delhi	Other (MSW Landfill)	300,000 Sqm	Municipal Solid Waste, Effluent (leachate)	Nitrate, Silica, Chromium, Nickel, Copper, Heavy Metals, Potassium, Ammonia, Chloride, Fluoride, Nitrate	S1-b; L1-d; P-2	None	Not Applicable	12	Remedial action as part of the process of modernizing the landfills. This process should include reuse / recycling of waste material	
National Capital Territory	149	ND-110-17	Jhilmil Industrial Area , New Delhi	Industrial	700 Sqm	Hazardous Waste	Metals, PAH, Oil/fuel Hydrocarbons (TPH), VOC's, PCB	S1-c; P1-a	None	Not Applicable	3, 8, 9, 10, 11	Stop dumping of waste. Removal of waste, excavation of underlyng soil in selected areas. Controlled access to sites	1-stop dumping of waste. 2-removal of waste and relocation to controlled site
National Capital Territory	154	ND-110-20	Road side & in front of C-58/1, Essco Sanitations, National Capital Territory (Delhi) Wajirpur Industrial Area	Industrial	480,000 Sqm	Effluent	Chromium, Lead, Zinc, Nickel, VOCs	P-2	None	Not Applicable	3, 8	Stop dumping of waste. Removal of waste, excavation of underlyng soil in selected areas. Controlled access to sites	1-stop dumping of waste. 2-removal of waste and relocation to controlled site
National Capital Territory	155	ND-110-21	Badli Industrial Area, Delhi	Industrial	310,000 Sqm	Effluent	Arsenic, Chromium, Lead, Cadmium	L1-d	None	Not Applicable	3, 8	Reduction of emissions of chemicals into drainage. Removal of contaminated sludge	1- reduction of emissions into drainage.2-removal of contaminated sludge
National Capital Territory	163	ND-110-29	Mandoli&Seelampur E-Waste site East Delhi	Habitation settlement	640,000 Sqm	Hazardous Waste, Effluent	Copper, Zinc, Selenium, Arsenic, Lead, Cadmium	S1-c; L1-d; P-2	None	Not Applicable	7	Removal of dumped waste. Reduction of emissions of chemicals into drainage. Removal of contaminated sludge	1- removal of dumped waste to controlled facility. 2- reduction of emissions into drainage. 3-removal of contaminated sludge
Orissa	172	OR-769-3	RKL-III , (In a low lying area in kalunga industrial estate near Kalinga Sponge industry, around 500 m away from M/s Konark Chemicals and M/s Siddharth Chemicals)	Industrial	11,100 Sqm	Hazardous Waste	Hexavalent Chromium, Chromium	S1-c; P-2	None	Not Applicable	3, 8	Removal of waste material, excavation of soil in selected areas. Groundwater abstractions	1- removal and collection of waste into controlled facility. 2-excavation of underlying soil. 3-in-situ remdiation: groundwater abstraction
Orissa	173	OR-754-1	Gypsum Pond -Paradip Phosphate & IFFCO, Paradip,Orissa	Industrial	60000 Sqm	Hazardous Waste	Fluoride, Phosphate, Chloride	S1-c; P-2	None	Not Applicable	8	storage of all waste sludge in proper containments and look for maximum reuse of material	1- creating proper containment facilities for sludge, storage of sludge in this facility

State	Site no	ID number	Site Name	Current land use	Approximate area of site *(Sqm)*	Type of contamination according to definition from MoEF	Primary Contaminant(s) (chemical name(s))	Typology, summary	TSDF	distance from contaminated site to TSDF in km	remediation options code	remediation options	remediation technologies
Orissa	175	OR-757-1	Site KCL-I, , Inside the premises of M/s KCL near H2SO4 Tank	Industrial	4,800 Sqm	Hazardous Waste	Chromium, Hexavalent Chromium	S1-c; P-2	None	Not Applicable	8	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-excavation of underlying contaminated soil
Orissa	176	OR-757-2	Site KCL II, Inside the premises of M/s KCL near Gate, Mayurbhanj Orissa	Industrial	4,800 Sqm	Hazardous Waste	Chromium, Hexavalent Chromium	S1-c; P-2	None	Not Applicable	8	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-excavation of underlying contaminated soil
Orissa	177	OR-757-3	Site KCL III, ,Inside the premises of M/s KCL inside drier room, Mayurbhanj Orissa	Industrial	1,900 Sqm	Hazardous Waste	Chromium, Hexavalent Chromium	S1-c; P-2	None	Not Applicable	8	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-excavation of underlying contaminated soil
Orissa	178	OR-757-4	Site KCL IV, outside the premises of M/s KCL near Northern Boundary-Mayurbhanj Orissa	Waste land	136,500 Sqm	Hazardous Waste	Chromium, Hexavalent Chromium	S1-c; P-2	None	Not Applicable	12	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-excavation of underlying contaminated soil
Orissa	179	OR-757-5	Site KCL V, outside the premises of M/s KCL near main Gate; Mayurbhanj Orissa	Industrial	15,000 Sqm	Hazardous Waste	Chromium, Hexavalent Chromium	S1-c; P-2	None	Not Applicable	8	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-excavation of underlying contaminated soil
Orissa	180	OR-757-6	Site ECFC-I (Backside of the unit.) Mayurbhanj, Orissa	Industrial	5,000 Sqm	Hazardous Waste	Vanadium, Fluoride, Hexavalent Chromium, Chromium, Phosphate , Sulphate	S1-c; P-2	None	Not Applicable	8	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility. Groundwater remediation	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-excavation of underlying contaminated soil. 4-in-situ remediation. Groundwater abstraction or bio remediation
Orissa	181	OR-757-7	Site ECFC-II (Outside the Premises along the boundary wall)), Mayurbhanj, Orissa	Industrial	10,054 Sqm	Hazardous Waste	Vanadium, Fluoride, Hexavalant Chromium, Chromium, Phosphate , Sulphate	S1-c; P-2	None	Not Applicable	8	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility. Groundwater remediation	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-excavation of underlying contaminated soil. 4-in-situ remediation. Groundwater abstraction or bio remediation
Orissa	182	OR-759-1	Site NALCO-I, M/sNational Aluminum Co. Products, Angul	Industrial	11,200 Sqm	Hazardous Waste	Flouride, Cyanide	S1-c; P-2	None	Not Applicable	8	control of landfill quality (monitoring of surrounding grondwater quality)	1-monitoring groundwater quality to assess if leachate is spreading to the groundwater
Orissa	183	OR-759-2	Site OCL-I, ORICHEM abandoned site (inside the premises of M/s Orichem Ltd and also outside the boundary of wall), Talcher, Orissa	Industrial	32,000 Sqm	Hazardous Waste	Hexavalent Chromium, Chromium	S1-c; P-2	None	Not Applicable	8	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility. Groundwater remediation	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-excavation of underlying contaminated soil. 4-in-situ remediation. Groundwater abstraction or bio remediation
Orissa	184	OR-759-3	Site NALCO-II,M/sNational Aluminum Co. Products, Angul	Wasteland	900 Sqm	Hazardous Waste	Flouride, Cyanide	S1-b; P-2?	None	Not Applicable	12	repair of top cover of the storage facility (liner). Monitoring of groundwater naer the facility.	1-repair of cover (liner). 2-monitoring of groundwater quality to assess spreading of leachate to the groundwater
Orissa	186	OR-759-4	Site NALCO-III,M/sNational Aluminum Co. Products, Angul	Industrial	1,000 Sqm	Hazardous Waste	Flouride, Cyanide	S1-b; P-2?	None	Not Applicable	8	control of landfill quality (monitoring of surrounding grondwater quality)	1-monitoring groundwater quality to assess if spreading of leachate to the groundwater in spreading
Orissa	192	OR-761-1	Dumpsite JCL-I (Outside the Premises Of M/S Jayshree Chemicals Ltd Near Rushikulya River) Jayashree Chemicals, Ganjam	Industrial	3,500 Sqm	Hazardous Waste	Mercury	S1-c; P-2	None	Not Applicable	8	Removal of waste and excavation of underlying impacted soils in selected land areas. Remediation of groundwater in selected areas	1-removal of waste material. 2-collection of waste material in controlled storage. 2-in-situ remediation (biological, abstraction) of groundwater
Orissa	193	OR-761-2	Dumpsite JCL-II (Inside the Premises Of M/S Jayshree Chemicals Ltd) Jayashree Chemicals, Ganjam	Industrial	12,000 Sqm	Hazardous Waste	Mercury	S1-c; P-2	None	Not Applicable	8	Removal of waste and excavation of underlying impacted soils in selected land areas. Remdiation of groundwater in selected areas	1-removal of waste material. 2-collection of waste material in controlled storage. 2-in-situ remediation (biological, abstraction) of groundwater
Orissa	194	OR-761-3	Dumpsite JCL-III ((Outside the Premises Of M/S Jayshree Chemicals Ltd Near Rushikulya River)) Jayashree Chemicals, Ganjam	Industrial	8,000 Sqm	Hazardous Waste	Mercury	S1-c; P-2	None	Not Applicable	8	Removal of waste and excavation of underlying impacted soils in selected land areas. Remdiation of groundwater in selected areas	1-removal of waste material. 2-collection of waste material in controlled storage. 2-in-situ remediation (biological, abstraction) of groundwater
Orissa	196	OR-768-1	Site INDAL-I (Located inside the unit premises of M/s Indian Aluminium Company Limited), Hirakud,Sambalpur	Industrial	15,000 Sqm	Hazardous Waste	Fluoride, Cyanide	S1-a?; P-2?	None	Not Applicable	8	most likely excavation of underlyng soil in selected areas.	1- excavation of contaminated soil followed by disposal in landfill.

State	Site no	ID number	Site Name	Current land use	Approximate area of site *(Sqm)*	Type of contamination according to definition from MoEF	Primary Contaminant(s) (chemical name(s))	Typology, summary	TSDF	distance from contaminated site to TSDF in km	remediation options code	remediation options	remediation technologies
Orissa	197	OR-768-2	Site INDAL-II (Located inside the unit premises of M/s Indian Aluminium Company Limited), Hirakud, Sambalpur	Industrial	880 Sqm	Hazardous Waste	Fluoride, Cyanide	S1-a?; P-2?	None	Not Applicable	8	remval of any waste material. Excavation of underlyng soil in selected areas.	1-remoavl of waste material to controlled storage 2- excavation of contaminated soil followed by disposal in landfill.
Orissa	198	OR-768-3	Site INDAL-III (Located outside the unit premises of M/s Indian Aluminium Company Limited), Hirakud, Sambalpur	Industrial	800Sqm	Hazardous Waste	Fluoride, Cyanide	S1-b; p-2?	None	Not Applicable	8	remval of any waste material. Excavation of underlyng soil in selected areas.	1-remoavl of waste material to controlled storage 2- excavation of contaminated soil followed by disposal in landfill.
Orissa	200	OR-769-1	RKL-I (Inside The Premises Of M/S Lotus Chrome Chemicals)	Industrial	1,000 Sqm	Hazardous Waste	Hexavalent Chromium, Chromium	S1-c; P-2	None	Not Applicable	8	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility. Groundwater remediation	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-excavation of underlying contaminated soil. 4-in-situ remediation. Groundwater abstraction or bio remediation
Orissa	201	OR-769-2	RKL-II (In Beldihi village along the play ground between Govt primary school & St. Georgia school)	Habitation settlement	10,000 Sqm	Hazardous Waste	Hexavalent Chromium, Chromium	S1-c; P-2	None	Not Applicable	7	removal of waste material and relocation to controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility. Relocation of water well for school	1-collection of waste material and transport to controlled storage. 2-excavation of underlying contaminated soil. 3-relocation of water well
Orissa	202	OR-769-4	RKL-IV, inside the premises of M/S Siddharth Chemicals	Industrial	4,500 Sqm	Hazardous Waste	Hexavalent Chromium, Chromium	S1-c; P-2	None	Not Applicable	8	Removal of waste and excavation of underlying impacted soils in selected land areas. Remdiation of groundwater in selected areas	1-removal of waste material. 2-collection of waste material in controlled storage. 2-in-situ remediation (biological, abstraction) of groundwater
Punjab	203	PB-141-1	Buddha Nullah, Ludhiana, Punjab	Water bodies	200,000 Sqm	Effluent, MSW dumping	Nickel, Cadmium, Lead, Pesticides	S1-c; L1-d; P-2	Nimbua, Derabassi	120	4	remediation effort in progress	
Punjab	204	PB-141-5	Tajpur road MSW Sumpsite, Ludhiana	Waste land	102,000 Sqm	Municipal Solid Waste	Nickel, Heavy Metals, Oil/fuel Hydrocarbons (TPH), Pesticide residue, PAH, Phenolic compounds, Nitrate, Sulphate, Phosphate, Ammonia, Chloride, Potassium	S1-c; P-2	Nimbua, Derabassi	70	7, 8, 12	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste to facility. Groundwater remediation	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-in-situ remediation. Groundwater abstraction or bio remediation
Punjab	205	PB-141-6	Hambran Road Msw DumpSite, Ludhiana	Mixed (Agricultural, Landfill)	40,500 Sqm	Municipal Solid Waste	Nickel, Heavy Metals, Pesticide residue, PAH components, Phenolic compounds, Nitrate, Sulphate, Phosphate, Ammonia, Chloride, Potassium	S1-c; P-2	Nimbua, Derabassi	200	7, 12	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste to facility. Groundwater control to prevent spreading of leachate	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-in-situ remediation. Groundwater abstraction or bio remediation
Punjab	207	PB-144-2	PSIEC Leather Complex, Jalandhar, Punjab	Industrial	1,280,000 Sqm	Hazardous Waste, Effluent	Hexavalent Chromium, Chromium	S1-c; L1-d; P-2	Nimbua, Derabassi	180	3, 8	Emissions of chemicals and sewage to the discharge system should be permamantly controlled. Cleaning of impacted areas surroundig the drainage	1-control of emissions from the discherge system. 2-collection of waste material surrounding the discharge system (collection of waste)
Punjab	208	PB-144-4	Basti Sheikh, Jalandhar	Mixed (Habitation settlement, Commercial, Landfill)	63,000 Sqm	Municipal Solid Waste	Arsenic, Cadmium, Chromium, Lead, Mercury, Nick, Zinc, VOC, TPH, Pesticide residue, PAH, el, Phenolic compounds, pH, nitrate, sulphate, phosphate,	S1-c; P-2	Nimbua, Derabassi	180	7, 12	preventing of leaching out: restore capping of waste material. Removal of waste to facility. Groundwater control to prevent spreading of leachate	1-capping of waste material. 2-collection of any waste material outside the controlled storage.
Punjab	211	PB-148-1	Mahaluxmi OrgoChemical Industries, Nabha Road, Bhawanigarh, Sangrur	Agricultural land	17,000 Sqm	Hazardous Waste, Effluent	Phenolic compounds, PAH, Lead, Chromium VI, Total Chromium, Sulphate, Chloride	S1-a; L1-b	Nimbua, Derabassi	110	5, 9	Removal of any remaining waste material. Excavation or capping of underlying contaminated soil. Groundwater remediation	1-removal of any remaing waste material. 2-excavation or capping of underlying contaminated soil. 3-in-situ remediation, groundwater abstraction
Rajasthan	216	RJ-302-1	Amanishah nalla, Sanganer Indutrial Area, Jaipur	Water Bodies	101,680 Sqm	Effluent	BTEX, VOC, Total Chromium, Lead, Zinc, Copper, Phenolic compounds	L1-d; P-2	M/s Rajasthan Waste Management Project (M/s Ramky Enviro Engineers Ltd) Survey no. 1018/13, Vill-Gudli,Tehsil-Mavli, Zinc Choraha to Debari Railway Station Road, Dist-Udaipur (Rajasthan)	380	4	Reduction of emssions into the drainafge system. Dredging of sediments from impacted agricultural fields / phyto remediation crop rotation.	1-reductions of emissions to from the drainade system. 2-removal of contaminanted sediments from the fields. 3-Phytoremediation or crop rotation in selected areas.
Rajasthan	219	RJ-313-1	Village Bichhadi, Block Girva, Rajasthan	Industrial	442,200 Sqm	Hazardous Waste	Arsenic, Cadmium, Chromium, Hexavalent Chromium, Lead, Mercury, zinc, copper	S1-c; P-2	M/s Rajasthan Waste Management Project (M/s Ramky Enviro Engineers Ltd) Survey no. 1018/13, Vill-Gudli,Tehsil-Mavli, Zinc Choraha to Debari Railway Station Road, Dist-Udaipur (Rajasthan)	40	8	Removal of remaining wastematerial to controlled facilites (on-site, of site). Excavation of underlying soil in selected areas. Groundwater remediation (abstraction, biological)	1- removal and collection of remaing waste into controlled facility (on-site, of-site). 2-excavation of underlying soil and storage in controlled facility (on-site, of-site). 3-in-situ remdiation: groundwater abstraction and bio remediation of groundwater

State	Site no	ID number	Site Name	Current land use	Approximate area of site *(Sqm)*	Type of contamination according to definition from MoEF	Primary Contaminant(s) (chemical name(s))	Typology, summary	TSDF	distance from contaminated site to TSDF in km	remediation options code	remediation options	remediation technologies
Tamil Nadu	226	TN-607-1	Eachangadu, Cuddalore, Tamil Nadu,	Mixed(Industrial& Habitation Settlement)	1,620,000 Sqm	Air, Hazardous Waste,Effluent	Lead, Chromium, Cadmium, Arsenic, Barium,	S1-b; L1-d; P-2	M/s. Tamilnadu Waste Menagement Ltd (M/s Ramky Agencies, Hyderabad) Gummidpoondi in Thiruvallur District	110	12	Removal of wastematerial to controlled facilites (on-site, of site). Excavation of underlying soil in selected areas. Groundwater remediation (abstraction, biological). Removal of contaminated sludge, groundwater remediation	1- removal waste in the surrounding area and storage into controlled facility. 2-excavation of contaminated underlying soil and storage in controlled facility. 3. Removal of contaminated sludge and storage in geo tubes for dewatering. 4-in-situ remdiation: groundwater abstraction and bio remediation of groundwater
Tamil Nadu	227	TN-624-1	Kodaikanal ,Tamil Nadu	Industrial	60,000 Sqm	Hazardous Waste	Mercury	S1-c; P-2?	M/s. Tamilnadu Waste Menagement Ltd (M/s Ramky Agencies, Hyderabad) Gummidpoondi in Thiruvallur District	600	8	removal of remaining contaminated soil and storage in controlled facility	1- excavation of remaining contaminated soil and storage into controlled facility.
Tamil Nadu	231	TN-632-1	TCCL, Ranipet , Tamilnadu	Industrial	75,000 Sqm	Hazardous Waste	Chromium, Hexavalent Chromium	S1-c; P-2	M/s. Tamilnadu Waste Menagement Ltd (M/s Ramky Agencies, Hyderabad) Gummidpoondi in Thiruvallur District	150	8	preventing of leaching out: temporary capping of waste material. Construction of controlled disposal facility for waste. Removal of waste to facility. Groundwater remdiation and control	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-in-situ remediation. Groundwater abstraction or bio remediation
Tamil Nadu	233	TN-632-3	Vanitec Limited (inside the premises of CETP) Vallayambattu, Vadiumbadi, Vellore, Tamilnadu	Other (CETP and Sludge Dump Site)	54,000 Sqm	Hazardous Waste	Chromium, Hexavalent Chromium	S1-c; P-2	M/s. Tamilnadu Waste Menagement Ltd (M/s Ramky Agencies, Hyderabad) Gummidpoondi in Thiruvallur District	170	12	preventing of leaching out: temporary capping of waste material in uncontrolled dump site. Construction of controlled disposal facility for waste. Removal of waste to facility. Groundwater remdiation and control	1-temporary capping of waste material. 2-collection of waste material in controlled storage. 3-in-situ remediation. Groundwater abstraction or bio remediation
Tamil Nadu	235	TN-640-1	Noyyal river ,Tirupur, Tamil Nadu	Water Bodies	>60,000 Sqm	Effluent	Chlorine, Sulphate, Manganese	L1-d; P-2	M/s. Tamilnadu Waste Menagement Ltd (M/s Ramky Agencies, Hyderabad) Gummidpoondi in Thiruvallur District	500	8	Emissions of chemicals and sewage to the discharge system should be controlled and reduced to acceptable levels. After this is achieved, remediation of impacted areas	1-reductions of emissions from the discherge system. 2-remediation of affected sediments an dgroundwater
Uttar Pradesh	236	UP- 201-1	Sahibabad Industrial Area	Industrial	36,300 Sqm	Effluent, Hazardous Waste	Hexavalent Chromium, Chromium, Lead, Arsenic	S1-c; L1-d	M/s Uttar Pradesh Waste Management Project (M/s Ramky Enviro Engineers Ltd.,) Plot No. 672, Village – Kumbhi, Tehsil: Akbarpur, on Sikandara Road-NH –2, Dist – Kanpur Dehat (U.P.)	400	8	Reduction of emissions of chemicals to the discharge system. Removal of waste to a controlled facility.	1-reductions of emissions to the discherge system. 2-removal of waste material to controlled storage facility
Uttar Pradesh	239	UP-201-9	Lohia Nagar C Block, Ghaziabad	Mixed (Industrial, Habitation settlement)	22,44,000 Sqm	Hazardous Waste	Hexavalent Chromium, Chromium	S1-a; P-2?	M/s Uttar Pradesh Waste Management Project (M/s Ramky Enviro Engineers Ltd.,) Plot No. 672, Village – Kumbhi, Tehsil: Akbarpur, on Sikandara Road-NH –2, Dist – Kanpur Dehat (U.P.)	400	7, 12	remediation options are developed	
Uttar Pradesh	242	UP-204-1	Shakti Nagar, Aligarh	Habitation settlement	8,500 Sqm	Effluent	Chromium, Lead, Cadmium, Arsenic	L1-d	M/s Uttar Pradesh Waste Management Project (M/s Ramky Enviro Engineers Ltd.,) Plot No. 672, Village – Kumbhi, Tehsil: Akbarpur, on Sikandara Road-NH –2, Dist – Kanpur Dehat (U.P.)	300	1	Reduction of emissions of chemicals to soil and the discharge system. Removal of waste to a controlled facility. Groundwater remediation	1-reductions of emissions to the soil and discherge system. 2-removal of any surface waste material to controlled storage facility. 3-in-situ remediation of groundwater (abstraction, biological)
Uttar Pradesh	244	UP-208-12	Tejab Mill Campus, Anwarganj, Kanpur	Habitation settlement	3,400 Sqm	Hazardous Waste	Hexavalent Chromium, Chromium, Sulphide	S1-a; P-2	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	25	1	Providing of alternative drinking water resource for habitants. Groundwater remediation	1-construction of alternative drinking water resource for inhabitants. 2-groundwater remediation: in-situ methods (bio remediation, abstraction)
Uttar Pradesh	247	UP-208-15	Khanchandrapuri, Rania Kanpur Dehat	Wate Land	3,000,000 Sqm	Hazardous Waste	Hexavalent Chromium, Chromium, Cadmium	S1-c; P-2	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	60	5	preventing of leaching out from waste material and sludge. Hydrological control. Construction of controlled disposal facility for waste. Removal of waste and underlying contaminated soil to facility. Groundwater remediation	1-temporary capping of waste material. 2- hydrological control to prevent further spreading of leachate. 3-collection of waste material in controlled storage. 4-excavation of underlying contaminated soil.
Uttar Pradesh	249	UP-208-3	Nauriaya Kheda Kanpur	Mixed (Industrial, Habitation settlement)	6,000 Sqm	Hazardous Waste	Hexavalent Chromium, Chromium, Zinc, Sulfate,Lead	S1-c,S2; P-2?	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	30	7, 8	remediation options are developed, pilots in progress	
Uttar Pradesh	250	UP-208-4	Juhi Baburaiya (Rakhi Mandi), Kanpur	Mixed (Industrial, Habitation settlement)	250,000 Sqm	Hazardous Waste	Arsenic, Chromium, Hexavalent Chromium, Lead, Mercury, Zinc, Cadmium, Copper, Nitrate, Sulphate	S1-c; P-2	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	30	7, 8	preventing of leaching out from waste material. Hydrological control. Capping of waste to prevent further leaching out.	1-temporary capping of waste material. 2- hydrological control to prevent further spreading of leachate.
Uttar Pradesh	251	UP-208-5	Panki Industrial Area, Kanpur	Waste land	40,400 Sqm	Hazardous Waste	Chromium, Lead Arsenic, Zinc, Nitrate, Flouride,Sulphate	S1-c; P-2?	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	30	12	Removal of wastematerial to controlled facilites (on-site, of site). Excavation of underlying soil in selected areas. Groundwater remediation (abstraction, biological).	1- removal waste and storage into controlled facility. 2-excavation of contaminated underlying soil and storage in controlled facility. 3-in-situ remdiation: groundwater abstraction and bio remediation of groundwater
Uttar Pradesh	252	UP-208-6	Shivnathpura, Rania , (Kanpur Dehat) Ramabai Ngar, Kanpur, Uttar Pradesh	Agricultural land	20,000 Sqm	Hazardous Waste	Chromium, Cadmium, Heavy metals	S1-c; P-2	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	45	5	Removal of wastematerial to controlled facilites. Excavation of underlying soil in selected areas.	1- removal of remaining waste/sludge and storage into controlled facility. 2-excavation of contaminated underlying soil and storage in controlled facility.

State	Site no	ID number	Site Name	Current land use	Approximate area of site *(Sqm)*	Type of contamination according to definition from MoEF	Primary Contaminant(s) (chemical name(s))	Typology, summary	TSDF	distance from contaminated site to TSDF in km	remediation options code	remediation options	remediation technologies
Uttar Pradesh	261	UP-226-1	Chakar Village Chinhat, Lucknow	Mixed(Commercial, Industrial)	10,000 Sqm	Hazardous Waste	Pesticides (isomers of HCH)	S1-c; P-2?	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	80	5	Removal of wastematerial to controlled facilites (on-site, of site). Excavation of underlying soil in selected areas. Groundwater remediation (abstraction, biological).	1- removal waste and storage into controlled facility. 2-excavation of contaminated underlying soil and storage in controlled facility. 3-in-situ remdiation: groundwater abstraction and bio remediation of groundwater
Uttar Pradesh	263	UP-226-3	Uttardhauna, Chinhat Block, Lucknow	Agricultural land	12,000 Sqm	Hazardous Waste	Pesticides (isomers of HCH)	S1-c; P-2?	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	80	5	Removal of wastematerial to controlled facilites (on-site, of site). Excavation of underlying soil in selected areas. Groundwater remediation (abstraction, biological).	1- removal waste and storage into controlled facility. 2-excavation of contaminated underlying soil and storage in controlled facility. 3-in-situ remdiation: groundwater abstraction and bio remediation of groundwater
Uttar Pradesh	264	UP-226-6	Dewa Road, Lucknow (Palhauri Village, Deva Road, Chinhat, Lucknow)	Commercial	10,000 Sqm	Hazardous Waste	Pesticides (isomers of HCH)	S1-c; P-2?	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	80	5	Removal of wastematerial to controlled facilites (on-site, of site). Excavation of underlying soil in selected areas. Groundwater remediation (abstraction, biological).	1- removal waste and storage into controlled facility. 2-excavation of contaminated underlying soil and storage in controlled facility. 3-in-situ remdiation: groundwater abstraction and bio remediation of groundwater
Uttar Pradesh	265	UP-231-1	Kanoria Chemical Renukoot ,Renukoot, Sonebhadra, Uttar Pradesh	Water Bodies	60,000 Sqm	Effluent	Mercury, Pesticides (HCH Isomers)	S1-c; L1-d	M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.	500	4	Reduction of emissions to drainage system. Control of existing storage site on leachate. Excavation of underlying soil in selected areas. Groundwater remediation (abstraction, biological). Removal of contaminated sludge	1- reduction of emissions to drainage system. 2-control of leachate from storage facilities. 3. Removal of contaminated sludge and storage in geo tubes for dewatering. 4-in-situ remdiation: groundwater abstraction and bio remediation of groundwater
Uttar Pradesh	271	UP-250-1	Barnawa Village, Baghpat, District Meerut (Confluence point of Kali River & Hindon River)	Mixed (Waste land,Water bodies)	320,000 Sqm	Effluent, Hazardous waste	Chromium, Lead, Cadmium, Pesticides	S1-c; L1-d	M/s Uttar Pradesh Waste Management Project (M/s Ramky Enviro Engineers Ltd.,) Plot No. 672, Village – Kumbhi, Tehsil: Akbarpur, on Sikandara Road-NH –2, Dist – Kanpur Dehat (U.P.)	400	4, 12	Reduction of emissions to drainage system. Removal of contaminated sludge	1- reduction of emissions to drainage system. 2. Removal of contaminated sludge and storage in geo tubes for dewatering.
Uttar Pradesh	272	UP-250-2	Jaibheem Nagar, Ward No. 5, Meerut	Mixed (Waste land,Water bodies)	174900 Sqm	Effluent, Bio-medical Waste	Lead, Mercury, Chromium, Cadmium.	S1-c; L1-d	M/s Uttar Pradesh Waste Management Project (M/s Ramky Enviro Engineers Ltd.,) Plot No. 672, Village – Kumbhi, Tehsil: Akbarpur, on Sikandara Road-NH –2, Dist – Kanpur Dehat (U.P.)	350	4, 12	Removal of wastematerial to controlled facilites (on-site, of site). Excavation of underlying soil in selected areas. Groundwater remediation (abstraction, biological).	1- removal waste and storage into controlled facility. 2-excavation of contaminated underlying soil and storage in controlled facility. 3-in-situ remdiation: groundwater abstraction and bio remediation of groundwater
Uttar Pradesh	275	UP-283-1	Firozabad	Mixed (Industrial, Habitation settlement)	60,000 Sqm	Effluent, Hazardous waste	Arsenic, Cadmium, Lead , Chromium, Other heavy metals	S1-c, S1-e	M/s Uttar Pradesh Waste Management Project (M/s Ramky Enviro Engineers Ltd.,) Plot No. 672, Village – Kumbhi, Tehsil: Akbarpur, on Sikandara Road-NH –2, Dist – Kanpur Dehat (U.P.)	260	7, 8	Removal of wastematerial to controlled facilites (on-site, of site). Excavation of underlying soil in selected areas.	1- removal waste and storage into controlled facility. 2-excavation of contaminated underlying soil and storage in controlled facility.
Uttarakhand	283	UK-249-2	Ibrahimpur Village, Bhadarabad, Haridwar District, Uttarakhand	Water Bodies	4,000 Sqm	Effluent	Copper, Chromium, Lead, Cadmium,	L1-d	M/s Bharat Oil & Waste Management Ltd. Mauza Mukimpur, Roorkee-Laskar Road, Roorkee, Haridwar	40	4	Dredging of sediments, dewatering.	1-dredinging of sediments from the river, storage in geo tubes. Dewatering
West Bengal	287	WB-701-2	Tiljala, Picnic Gardens, Kolkata	Industrial	10,000 Sqm	Hazardous Waste	Lead, Cadmium, Arsenic, Tin, Zinc, Copper	S1-c; P-2?	M/s West Bengal Waste Management Ltd. J.L. no. -103, Mouza- Shrikrishnapor, P. S. - Sutahata Dist- Purba Midnapore, Haldia- 721 635 (W.B.)	120	8	reduction of airborne emissions. Removal of waste material to controlled facilites (on-site, of site). Excavation of underlying soil in selected areas. Groundwater remediation (abstraction, biological).	1-reduction of airborne emissions. 2- removal waste and storage into controlled facility. 3-excavation of contaminated underlying soil and storage in controlled facility. 4-in-situ remdiation: groundwater abstraction and bio remediation of groundwater
West Bengal	288	WB-711-1	Nibra Indusrial Area,Howrah, West Bengal	Industrial	41,600 Sqm	Hazardous Waste	Mercury, Zinc Lead, Chromium, Nickel, Cadmium, Copper, PAH, TPH, BTEX	S1-c; P1-a; P-2?	M/s West Bengal Waste Management Ltd. J.L. no. -103, Mouza- Shrikrishnapor, P. S. - Sutahata Dist- Purba Midnapore, Haldia- 721 635 (W.B.)	110	8, 9, 11	Remediation measures difficult due to immovable settlement. When posible most likely removal of waste, excavation of soil in selected areas. BTEX and PAH contamination not present as far as known. Groundwater abstraction depends on actual groundwater quality data.	1- removal waste and storage into controlled facility. 2-excavation of contaminated underlying soil and storage in controlled facility. 3-in-situ remdiation: groundwater abstraction and bio remediation of groundwater (if required)
West Bengal	301	WB-712-2	Delhi Road, Near Shivang Trexium Pvt. Ltd. & Shree Balaji Veneers Pvt. Ltd. Netaji More, Dist. Hooghli (HW site 3 in NPC report from 2006)	Other (Dump site)	2,000 Sqm	Hazardous Waste	Lead Arsenic, Mercury, Cadmium, Zinc, Hexavalent Chromium, Chromium	S2, S1-c; P-2	M/s West Bengal Waste Management Ltd. J.L. no. -103, Mouza- Shrikrishnapor, P. S. - Sutahata Dist- Purba Midnapore, Haldia- 721 635 (W.B.)	150	12	Removal of waste material to controlled facilites. Groundwater remediation (abstraction, biological).	1- removal waste and storage into controlled facility. 2 In-situ remdiation: groundwater abstraction and bio remediation of groundwater
West Bengal	310	WB-712-3	Near minu weigh bridge, Delhi Road (100 mt from Netaji More) Near Dhaba, Dist. Hooghli	Other (Dump site)	1,700 Sqm	Hazardous Waste	Lead Arsenic, Mercury, Cadmium, Zinc, Hexavalent Chromium, Chromium	S2, S1-c; P-2	M/s West Bengal Waste Management Ltd. J.L. no. -103, Mouza- Shrikrishnapor, P. S. - Sutahata Dist- Purba Midnapore, Haldia- 721 635 (W.B.)	120	12	preventing of leaching out from waste material.	1-capping and immobilisation of waste material.2-hydroligical monitoring on leachate behaviour

Annexure V References and literature

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National Program for Rehabilitation of Polluted Sites in India

Guidance document for assessment and remediation of contaminated sites in India

1st Edition, December 2015

Ministry of Environment, Forest and Climate Change
Government of India

Overview Guidance document for assessment and remediation of contaminated sites in India

Overview Guidance document for assessment and remediation of contaminated sites in India

1st edition, December 2015

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National Program for Rehabilitation of Polluted Sites in India

Guidance document for assessment and remediation of contaminated sites in India

Volume I - Methodologies and Guidance

1st Edition, December 2015

Ministry of Environment, Forest and Climate Change
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Volume I

0 Introduction

0 Introduction

0.1 Objectives and scope of this Guidance document

Key objective
The key objective of this Guidance document is to provide different agencies, both Government and non-government, involved in the assessment and remediation of contaminated sites in India with methodologies. These methodologies mainly cover [i] the process for selecting and implementing preferred remediation options and [ii] the technical guidelines and standards that can be applied.
The Guidance document has been developed so that the agencies involved in the assessment, investigation and remediation of contaminated sites on a day to day basis will find it to be a practical manual for years to come.

Scope

This Guidance document is arranged in three Volumes as follows:

- Volume I: Methodologies and Guidance;
- Volume II: Standards and Checklists;
- Volume III: Tools and Manuals.

Volume I guides the user through every step of the assessment and remediation process by providing relevant information, flowcharts, practical guidance and considerations. For standards and checklists the user is referred to Volume II, and for more detailed technical manuals to Volume III. The Guidance document is designed as a standalone reference manual and can therefore be considered to either include or refer to all information relevant for dealing effectively with contaminated sites.

It should be noted that the contaminated site remediation industry in Europe, USA and similar countries has accumulated its knowledge and experience over a period of more than 35 years. It is therefore not intended to capture all that in this Guidance document. By contrast, the Guidance document aims to provide a judicious mix of general overviews and detailed specifications to encapsulate the global practical knowledge and theoretical basis, international industry practices and above all, the great wealth of practical experience around the world for an experienced and trained technical manager in India to take up the next steps of the National Program for Remediation of Polluted Sites (NPRPS).

The document was developed while keeping in mind factors such as [i] the nascent phase the site remediation industry in India is in, [ii] the wide ranging variety and complexity of individual sites and their particular characteristics, [iii] the capacity gaps at different levels, and [iv] the particular interrelation between technical and non technical (legislative, legal, financial) factors typical for India.

Content

The Guidance document covers the entire gamut of technical aspects stakeholders need to address while dealing with a contaminated site in India. Each aspect is dealt with the appropriate degree of general descriptions and specific details. The document presents the complete process of dealing with a contaminated site, from identification through assessment and remediation to delisting, in a sequence of fourteen steps, explains their interrelations, and provides detailed presentation of each of the steps. While the focus is on practical, technical, aspects, wherever relevant reference is made to institutional, legal and financial aspects.

Targeted users: technical and non-technical

The aim of the Guidance document is to provide practical guidance to various types of users by providing references to technical issues they face on a day to day basis. While all professionally involved stakeholders may find the information useful, the Guidance document is mainly aimed at the competent authorities and/or agencies assigned to implement any part of site remediation works.

The Guidance document can be used by a non-industry professional, policymaker or manager, or as a technical manual by those more directly involved in site remediation in India. While the general reader does not need to know anything about site remediation, a degree of familiarity with basic remediation issues is expected from the technical user wishing to explore the details.

The level and complexity of technical details included assumes that the user is trained as an engineer or manager, is dealing with contaminated sites on a day to day basis, and has a background in the fields of one or more of: [i] civil engineering, [ii] chemical engineering, [iii] geology, [iv] hydrology or [v] environmental (waste) management. However, the document is set up in such a way that it is also useful for decision makers and those persons supporting the engineers.

For providing technical guidance and supervision

With the help of the Guidance document a trained engineer should be able to give technical direction to the approach of the assessment and the remediation of a contaminated site. The document will guide such a reader through every step of the assessment and remediation process by providing, among other information, flowcharts, data, checklists, and considerations. Detailed information is included, e.g. in the form of data overviews, checklists and technical manuals. For additional detailed information, e.g. on methods, equipment and models, the Guidance document refers to websites and other documents.

For dealing with contamination, not its prevention

Experience in many countries has led to international consensus that dealing with existing contamination on a site is very different from preventing such contamination in the first place. It is well accepted that the key in prevention is a thorough environmental awareness. For example, at sites where potentially contaminating activities take place, technical measures to prevent hazardous substances from penetrating into soil, groundwater or surface water are necessary. One of the better known of these measures is providing the site with an impermeable floor.

This Guidance document primarily deals with issues concerning assessment and remediation of already contaminated sites. Any technical measures for the protection of soil, groundwater and surface water or for the prevention of further contamination are covered only in passing, where appropriate.

For training and technical capacity building
An equally important intended use of the Guidance document is for initial training and technical capacity building among various stakeholders and agencies involved in the Indian site decontamination industry. While it is impractical to capture in one document many hundreds of man years of global site decontamination experience, the emphasis in the Guidance document is on providing practical knowledge and, quite literally, guidance, to a person involved in the Indian site decontamination Industry.

A non-technical person, for example a policy decision maker, a finance professional or a project manager, may use relevant sections of this document to familiarise him- or herself with the process of identification, assessment and remediation of contaminated sites and how it affects the non-technical decision parameters.

For a technical professional involved in a specific aspect of carrying out, supervising or regulating site decontamination, both organised overviews, adequately contextualised, and sufficient details on those aspects are provided. It is intended that after digesting the specific information provided in the Guidance document, the technical professional may seek further details in the wide ranging references the Guidance document provides.

Terms and definitions – the Glossary
For terms and definitions please refer to the Glossary, presented at the end of Volume I.

0.2 Introduction to contaminated sites

Generally, around the world, it is an accepted practice to describe contaminated sites as areas in which toxic and hazardous substances exist at levels and in conditions which pose existing or imminent threats to human health or the near and surrounding environment (see Glossary for the formal definition of a contaminated site).

Such sites often pose multi-faceted health and environmental problems to society. They can adversely impact any or all parts of the surrounding environment, particularly surface waters, soils, and groundwater and can result in people being knowingly or unknowingly exposed to toxic substances. Contaminated sites may include production areas, landfills, dumps, waste storage and treatment sites, mine tailings sites, spill sites, chemical waste handler and storage sites. These sites may be located in residential, commercial, agricultural, recreational, industrial, rural, urban, or wilderness areas. This situation is also applicable in India. This document is aimed at dealing with a broad range of types of contaminated sites occurring in India.

However under NPRPS bio-medical wastes, mining wastes and radioactive wastes have not been considered as these are dealt separately under the relevant Acts and the rules made thereunder. Various elements of the process and content of assessment and remediation, as described in this Guidance Document, can be used for remediation of other types of waste as well.

While it is recognised that legal aspects of the origin of a contaminated site may or may not be clear, the technical issues concerning disposal or dumping remain the same for legal or illegal contamination.

More specifically, the types of sites addressed in this Guidance document are:

- “Point” sites, such as dumps of waste or individual contaminated facilities (an example is shown in figure I-0.1 below);
- “Area” sites, a site within a broader area of ongoing and legacy contamination where the site of concern needs to be addressed in this wider context. An example of this is an individual dump within an industrial area, where there are also other sources of pollution (an example is shown in figure I-0.2 below);
- Municipal dumps, often with an unclear history, which may contain hazardous substances dumped before the municipality gained effective control (an example is shown in figure I-0.3 below);
- Brownfields, which may, or may not, have clear ownership and which have development potential if the contamination problems can be successfully resolved.

Figure I-0.1 Waste material at Ranipet site, typical “point” site

Figure I-0.2 Contaminated land near Eloor, typical “area” site

Waste versus soil contamination
A by product of almost every human activity anywhere is waste, which can manifest itself in countless different forms. Not all waste automatically leads to soil contamination. In fact, when waste is effectively reused, it can actually avert soil contamination. Waste does lead to soil contamination when it negatively affects soil or groundwater or other environmental features. Most often, this is due to uncontrolled dumping or lack of timely suitable remediation measures.

The soil comprises three phases
"Soil" is one of the most universally used every day terms in all societies and often means the same to all users, except maybe in very specific contexts. In this document, soil is considered to comprise three phases, including the organisms living in these phases:

- Solid phase, consisting of the sand, loam, and clay particles, but also including the organic solid elements, like decomposing leaves;
- Liquid phase, consisting of the groundwater;
- Gaseous phase, consisting of the air trapped among the soil particles.

Underwater soil is usually referred to as 'sediment', and also comprises three phases, albeit that the gaseous phase is very small.

Soil contamination can occur in any of these three phases or in any combination thereof. Contamination of the solid phase may be visible, e.g. when hazardous waste has been dumped on top of the soil, or not visible, e.g. when dumped waste was covered. However, contamination of the liquid and gaseous phase is often not clearly visible, and almost always entails specific, sometimes far greater, risks. This is because local soil contamination often spreads relatively easily, thereby contaminating ever larger volumes of soil, groundwater or air.

Figure I-0.3 Municipal Waste dump site of Dhapa

0.3 General description of contaminated sites in India

At the time of writing this edition of the Guidance document the availability of formal data on contaminated sites in India was still relatively limited. An analysis of available data at the time showed that in the sites already formally identified, only a relatively small number of contaminants were present, i.e. mainly heavy metals, pesticides and fluoride. However, it is felt by experts and generally agreed in India that when a comprehensive inventory of contaminated sites is carried out over longer periods of time, the extent of the contaminated sites, the range of contaminants and types of sites can increase substantially. This is the conclusion when considering the size of the country, the extent and diversity of its economy and industry, the industrial and non-industrial processes adopted (which are usually comparable to international processes) and the current practices of handling contamination in different sectors.

Keeping this in mind and taking cues from global practices, a system has been developed for the generic classification of types of contaminated sites in India. All sites identified in India at the time of writing this document could be assigned to a type within this classification system, except in cases where contamination is limited to surface water.

Contaminated site classification system
The proposed classification system distinguishes the following main types of contaminated sites:

- Source related:
  - Type S1: Land bound solid phase contamination
  - Type S2: Water bound sediments solid phase contamination
  - Type L: Land bound liquid phase contamination
- Pathway related:
  - Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids)
  - Type P2: Groundwater contaminations

Depending on the specific situation, a site may fit into more than one of these types. Subtypes are defined where necessary to enable the system to absorb additional specific site characteristics.

This system is, in our view, fully suitable to typify and classify the large number of contaminated sites that may be added to the current inventory in future. The complete classification system is outlined in the explanation of the typology in the Glossary.

0.4 Introduction to the concept of Risks and Intervention

When contaminated sites require intervention: the concept of risks
Contaminated sites can cause risks to human health and to the environment. The extent of risk and the impact of contamination depends on many factors, but key is the probability of contact between the contamination and the surroundings. In case there is no contact between the contamination and humans or the environment the

contamination carries no risk. This is, in all its simplicity, a conceptually important point to keep in mind.

International experience shows that not all soil contamination requires intervention. In the Netherlands, for example, the soil decontamination industry has evolved over the last 35 years and the expertise developed indicates that an optimum exists between the two extremes of decontaminating all contamination at all sites, so as to eliminate all potential risks, or decontaminating only to a certain acceptable level of risk at selected sites. Such an optimum is specific to a country or region and is influenced by many factors, such as the site inventory, characteristics of sites, geography, hydrology, as well as social, cultural, financial and political factors. For India too such an optimum needs to be found. This will involve taking into account considerations specific for India. Experience from other countries is a useful guide in reaching such an optimum balance.

The perception of a “risk” associated with an event or situation depends on a multitude of complex factors. Among these are the context, the observer, environmental factors, time factors, the historical record, the human factor. In view of this, the international site remediation efforts over the years have developed tools and approaches for quantitative assessment of risks associated with a particular contaminated site. These tools and approaches are applicable in India and it is recommended they should be applied.

Risk assessment: the Source-Pathway-Receptor approach
In this context, it is internationally agreed that it is vital to determine the chance that either humans or the environment will get in contact with the contamination. The widely accepted approach for this risk assessment is the ‘Source – Pathway – Receptor’ (SPR) approach. Within this approach, the source is the contamination, e.g. a leaking oil tank or a layer of pure oil in the topsoil. The pathway is the route between the source and the receptor, and the receptor is a human, animal, plant, ecosystem, property or a controlled water that may be affected by the contamination. An example of the three is shown in figure I-0.4 below. The generally accepted principle is that adverse effects of contamination are only considered to occur when contamination actually threatens humans or resources, i.e. puts them at some substantial risk. This happens only when all of the three elements (source, pathway and receptor) are present.

Figure I-0.4 Source - Pathway - Receptor

Risk from contamination?
An amount of waste is stored on an industrial site (source). Water containing hazardous elements leaches into the soil and into the groundwater, which takes it further downstream (pathway). The contaminated groundwater reaches a well that is used for drinking water by the local community (receptor) *→ YES, in this situation there is a risk that the contamination causes adverse effects on human health.* Assessment should be aimed at establishing whether that risk may be substantial, in which case there may be a need for intervention.

In the situation described above the waste is stored in an enclosed space and the water that leaches out is captured and removed in a controlled way to be treated elsewhere (there is no pathway, so the hazardous elements cannot reach any receptor *→ NO, in this situation there is no substantial risk that the contamination causes adverse effects on human health.*

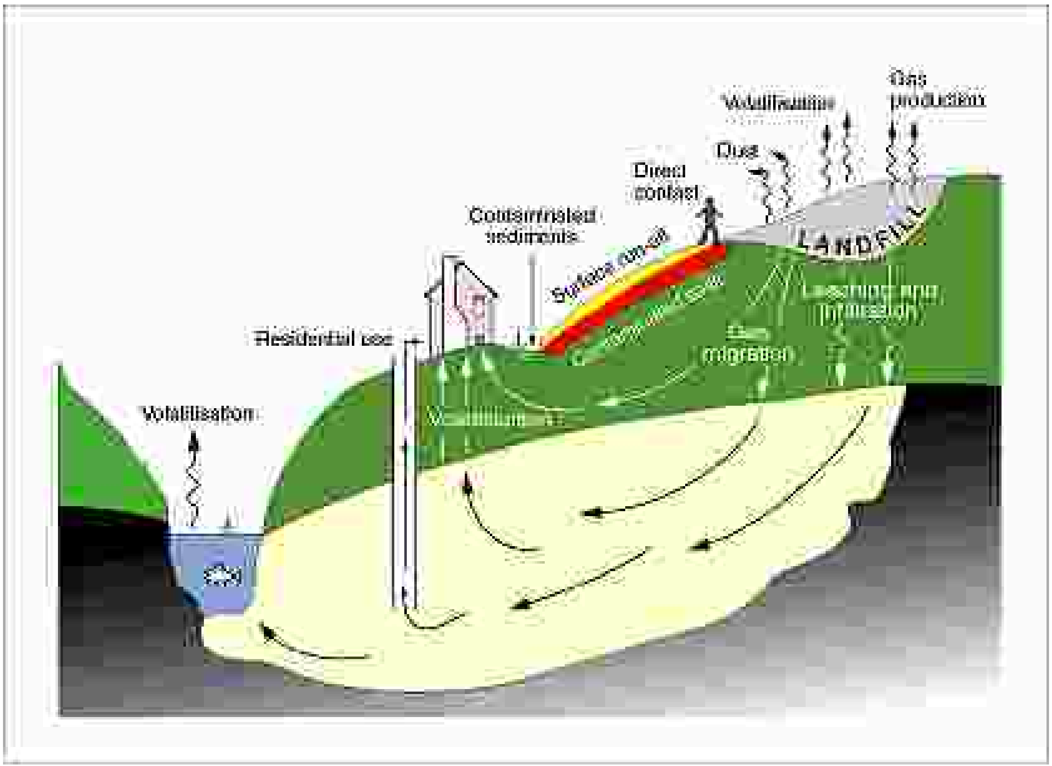
At any given site the exact situation with respect to each of these three elements and their interconnectivities determine [i] the need to intervene, [ii] the points of intervention (start and end), as well as [iii] the focus and the potential types of remediation options. Site assessment should show whether contamination puts human health or the environment at substantial risk. Only in case these risks are deemed unacceptable by the prevailing law or by the stakeholders the need for intervention arises. Only then a process of selection of intervention (remediation) measures needs to be initiated, eventually leading to remediation action.

In various risk assessment methodologies, the contamination (source) is clearly identified, as well as what that source may affect (receptor) and through what route the source may reach the receptor (pathway). It is important to note that receptors may be located on-site as well as off-site, and also that while in a current situation there may be no pathway, this can still develop over time (sometimes long periods), by diffusion through groundwater, surface water, sediment or air.

Most of the available risk assessment methodologies use a tiered approach, which starts with a relatively quick qualitative assessment. If needed this may be followed by a more elaborate semi-quantitative assessment, based on model calculations, and, again if needed, a comprehensive quantitative assessment. A quantitative approach involves actual measurements in contact media, such as indoor air, vegetables or drinking water.

Information for risk assessment: the Conceptual Site Model
No matter what approach is used, input of site data will be needed. Conceptual Site Models (CSM) are commonly used to implement a structured and efficient investigation for risk assessment. Such a model is developed by integrating as much relevant information on the contaminant situation as possible. This helps to understand the mechanics at the site, and may result in an image like the one in Figure I.0.5 below. Volume III-2.2-i presents guidance on how to develop a CSM and its role in the assessment and remediation of sites.

Figure I.0.5 Conceptual model of landfill exposure sources and environmental pathways



Source: Petts, J. and G. Edulgee. Environmental Impact Assessment for Waste Treatment and Disposal Facilities, p. 229. John Wiley and Sons, Chichester, 1994

Socio-economic issues
In addition to the adverse effects to human health and the environment, a contaminated site and its remediation process can cause lesser or greater social and economic disturbance in local and regional surroundings. International experience gives some pointers, which are also applicable to India.

Pollution during remediation
During remediation works, impacts of air and noise pollution on the local communities depend on the duration of the project activities. For example, if the transportation distance for waste from the site to say a landfill site is short the air pollution impact will be less. Higher air pollution impact can be anticipated if a lot of loading and unloading is required for site development. Noise pollution may be due to excavation activity, loading and unloading of waste, transport vehicle movement. Spillage of wastes during transportation may cause negative impacts on the community. However, if proper measures to stabilise the waste are taken this impact will get reduced.

Potential accidents
Transportation by road may cause accidents. This risk increases with increasing transportation frequency and distance.

Land value
Research has found that the public perception of the value of contaminated land is often not in line with reality. The general public usually perceives contaminated land to have hardly any value. In many cases, this perception has created a significant obstacle for redevelopment plans involving contaminated sites. In reality, when redevelopment and remediation plans are integrated from the start, costs for remediation often turn out to be much lower than the value of the land, even prior to remediation. Communication and awareness building may help to reverse this perception.

Business activity, income and employment
Remediating a site may have both positive and negative effects on income and employment of individuals or a group. The larger the remediation action the more positive the long term impact on employment opportunities is likely to be. Development of a site for storage and disposal of waste also generates employment opportunities. In extreme cases of contamination remediation may induce positive health effects. The reduction of the (unpaid) sick leave days may in turn lead to increased income for the local community.

Remediation action may also negatively impact business activity and endanger the livelihood of the local community or part thereof at and near a contaminated site. As a general rule, the impact of long term remediation action is usually significantly higher than the impact of short term remediation action. An example of negative impact of remediation is a clean capping layer, applied as a remediation measure, that renders impossible existing use of a landfill by the local community. In this situation support for the remediation option is likely to be impacted negatively by of the effect on the existing situation. In such a case a proposed solution should include a livelihood for the affected part of the local community.

Socio-economic impact may be direct, indirect and cumulative, depending on the site and remediation characteristics.

Assessment of the socio-economic issues
In each specific case, these and other potential social-economic issues should be assessed through a formal and structured effort. The aim of this effort should be to determine the level of significance of any given issue and a quantification, as far as possible, of the socio-economic costs and benefits. This process entails
[i] identification of the socio-economic issues of the nearby areas, including the type of settlements, and [ii] assessment of the significance of the impact of each issue, either quantified or in qualitative terms like low, medium, or high.

The need for community involvement
It is generally accepted that the community affected by any economic activity, including remediation of a site, has a legitimate right to understand and to be involved in decisions that may affect them. Therefore, close interaction with the affected community, e.g. by public consultation meetings like the one in figure I-0.6 below, is recommended and may also prevent undue concerns about the risks during

remediation or site testing work. Community involvement and consultation is most effective when initiated at an early stage of any remediation project.

Assessment of the impact of socio-economic issues is an integrated part of any site assessment and remediation process. Views of the stakeholders, including the local community, are needed for designing any successful remediation project. The consultation process helps in making the project responsive to social development concerns, and increases the chances of reaching options that enhance benefits for the community while mitigating risk and adverse impacts.

Figure I-0.6 Public Consultation Meeting
(picture by Andra Pradesh Pollution Control Board)

0.5 Guiding principles for decision making

Programme level
A number of guiding principles serve as reference points for international policymakers and programme managers when developing site assessment and remediation programmes. These principles are commonly applied, regardless of geographic, social, cultural and economic contexts. Therefore, these principles can be, with proper review and adaptation to Indian conditions, considered for use as a reference framework for India, at Central as well as State level.

Strategic principles at programme level
Pollution by itself does not usually incite action, it is when risks become apparent that wheels are set in motion. The main guiding principle is always the elimination of or minimizing the risks for human health caused by pollution, with the prevention of risks for the environment following closely. With drinking water being the strategic asset that it is, a guiding principle is the protection of the groundwater quality in aquifers for drinking water storage or with drinking water storage potential.

Typically, the capacity required to assess and remediate the listed sites exceeds the available capacity. In that case, the guiding principle of site prioritisation is applied. A guiding principle of a different nature is the one that states that the notification of sites should be a solid procedure. The reason for this is that notification of a site usually incites stakeholders, including operators, owners, the local community, developers, NGO's and local authorities, to expect that remediation may be implemented in the near future.

Typical strategic principles for a remediation programme

- Elimination of or minimizing the risks to human health and to the environment caused by contaminated sites;
- Protection of groundwater quality in aquifers for drinking water storage or with drinking water storage potential;
- Prioritisation of sites for remediation action, in case the capacity required to assess and remediate the listed sites exceeds the available capacity;
- Development and implementation of a solid procedure for the notification of contaminated sites.

Typical operational principles for a remediation programme

The operational principles for a remediation programme are largely based on the strategic principles. Because the prevention of risks is key, any site assessment and remediation programme will be based on the assessment of risks. The information such assessment yields is needed to establish the risks, to prioritise the sites and to direct remediation action towards the reduction of those risks.

- Assessment of risks and potential risks caused by contaminated sites and by probably contaminated sites;
- Application of the Source-Pathway-Receptor approach, including standard target values for remediation, coupled with risk-based action;
- Implementation of capacity building, e.g. by offering a structure for the systematic acquisition of knowledge and hands on experience;
- Reconnaissance and notification of newly discovered probably contaminated sites.

Individual Site level

Guiding principles are also available for those dealing with an individual contaminated site.

Typical strategic principles for a site specific approach

- Appraisal of remediation objectives, including prevention of further contamination, using generic and site specific criteria (environmental results, technical feasibility/risks, costs, impact of works, available time, spatial planning, social aspects);
- Application of simple, robust and validated site assessment and remediation solutions. Innovative technologies might be considered if these have been successfully applied in well-documented field trials;
- Prioritisation of the reduction of human health risks, as opposed to ecological risks, unless highly valued ecosystems are under threat.

Figure I-0.7 Prevention of actual contaminating activities is important before starting remediation activities

Typical operational principles for a site specific approach

- Whenever possible, application of an integrated approach, i.e. a combination of remediation with reconstruction or redevelopment of the site and/or its surrounding area. In practice, this will usually mean that the remediation design is integrated in the redevelopment plan. In some cases it can be the other way around, when land use planning needs to be adapted to the contamination situation.

> An example of a situation that may call for adapting intended land use to the contamination situation is intended redevelopment of a former dumpsite for toxic waste. Remediation towards a situation that renders the site fit for agricultural or residential use would require high costs, whereas it may be more cost effective to aim the remediation at use of the site as an industrial area.

- Whenever final remediation objectives can be reached in the longer run but not at once, application of a stepwise approach for improvement of the site situation. This under the condition that the most important risks can be brought under control (figure I-0.7) and temporary safety measures are in place where necessary;
- Design and implementation of an iterative sequence of activities for the assessment of contamination and the selection of the most appropriate remediation option. Review of and discussion on intermediate data, results and designs at several stages often leads to the most effective and efficient remediation solutions;
- Focus on assessment activities that provide useful information for the selection of a remediation option and re-use of the site.

0.6 Legal, institutional and financial aspects

At the time of writing of this edition of the Guidance document the key assumption is that the **Ministry of Environment, Forest and Climate Change** will delegate the central management of NPRPS to a central **Remediation of Polluted Sites (RPS) Authority**. In the current plans, outlined in the Task 4 report of Assignment 3 (December 2015), this authority is to be involved in Programme management as well as in Site related programme implementation. This authority is to be supported by the **Central Pollution Control Board (CPCB)**, where the latter will be responsible for the information management, including the management of the polluted site registry and the coordination of the SPCB's. The **State Pollution Control Boards (SPCB's)**, in turn, will provide CPCB with data on the identified polluted sites, each within their own jurisdiction. On state or union territory level the remediation of sites and their reuse is facilitated by the **State or Union Territory Government.**

The performance of site assessment is usually commissioned to an independent third party **site investigator**, while site remediation is usually performed by a third party **remediation contractor**. Post remediation monitoring can be performed by either a site investigator or a remediation contractor. All are likely to engage an independent accredited **laboratory**, either third party or part of CPCB or SPCB, for the analysis and testing of soil, sediment, groundwater and surface water samples, collected during site assessment or remediation.

This Guidance document could serve as a knowledge base for the technical aspects that are important for all stakeholders mentioned above. The legal, institutional and financial aspects are set out in more detail in the Task-4 report of Assignment 3, 'National Program for Remediation of Polluted Sites'.

0.7 Steps in the site assessment and remediation process

In this Guidance document the entire process of intervention in a contaminated site, from its earliest identification to post remediation measures, is described in a sequence of fourteen distinct Steps. This set of Steps covers all activities that are performed in dealing with such a site. Wherever applicable, this Guidance document refers to these fourteen Steps. The same Steps, with identical descriptions, are also used in correlation with the non technical aspects, i.e. legal, financial and institutional, of dealing with polluted sites.

The fourteen Steps are outlined in table I.0.1 below.

Table I.0.1 The fourteen Steps in the site assessment and remediation process

Step	Title	Concise description
Identification		
1	Identification of probably contaminated sites	A structured procedure for the identification of polluted sites, the collection and systematic computerised storage of data serving that purpose.
2	Preliminary investigation	A preliminary site assessment is performed in a desk study and a site inspection, to confirm types of contaminants present. In case the results of the preliminary site assessment warrant this, a preliminary site investigation is performed. This involves investigation to assess if the site may pose threat to human health and environment.
3	Notification of polluted site	Notification of a contaminated site as 'polluted site' to restrict activities pending final remediation, trace liable parties.
4	Priority list addition	The programme managing activities to rank sites based on the threat to human health and environment.
Planning		
5	Remediation investigation	Detailed site assessment, including risk assessment, is commissioned to provide information for inventorying and designing multiple options for rehabilitation. For each option the (post) remediation target and the recommended approach are described. The potential options will be assessed using a set of criteria, and as a result of this assessment the optimum option will be selected.
6	Remediation design, Detailed Project Report	The selected remediation option is designed in greater detail, detailed costing and planning is carried out and responsibilities are analysed in a Detailed Project Report (DPR).
7	DPR approval and funding	The competent authority would approve the DPR. Furthermore, the process of raising funds, maintaining funds and disbursing funds for remediation activities.
Implementation		
8	Implementation of remediation	Preparation, commissioning and implementation of remediation works. Supervision and validation investigation during implementation.
9	Approval of remediation completion	Evaluation of the remediation works and approval of the results by the competent authority.

Step	Title	Concise description
Post remediation		
10	Post Remediation Plan	In case residual contamination remains at the site, post remediation measures are designed to ensure end goals of remediation will be reached. The measures are described in a plan including long term review.
11	Post Remediation Action	The site is monitored periodically to ensure pollution limits are within the values as determined by the end goals of final clean up report and that the land is being used for the purpose as permitted by the end results. If necessary active maintenance measures are taking place.
12	Cost recovery	Any costs, fees and penalty that have not been paid in advance or recovered from responsible person would be recovered either by enforcing financial security or through the recovery process of arrears of land revenue or public demand.
13	Priority list deletion	Upon completion of remediation activities, the site is marked in the database as 'remediated'. If necessary monitoring activities may continue.
14	Site reuse	Reuse of the site after approval of remediation results.

0.8 How to use this Guidance document

Document structure
This Guidance document is organised as a set of documents, arranged in three Volumes:

Volume I	Methodologies and guidance
Volume II	Standards and checklists
Volume III	Tools and manuals

This **Volume I** is the core of the Guidance document set. It presents guidance and instructions as to how to perform each of the fourteen Steps in the site assessment and remediation process. The correlation among the Steps is shown, to enable the user to see what happened before the Step he is involved in and what should happen after completion of that Step. Centred around a concise description of actions to perform the Step the user is involved in, the guidance details aspects for an effective performance, like data needed and where these may be found, and control mechanisms. Wherever relevant, the guidance includes references to Volume II and III and to websites and documents. Volume I is set up in such a way that it may be used in capacity building. It also includes an introduction for aimed at decision makers.

Volume II contains reference data in various forms. Engineers dealing with contaminated sites may use Volume II on a day to day basis to refer to data, standards, criteria and checklists. Every one of these is linked by a reference to one or more descriptions of Steps in Volume I. Therefore this Volume I document should be used in conjunction with the other two Volumes.

Volume III contains more extensive data like technical manuals. Examples of manuals presented in Volume III include a Site Inspection Protocol, points of attention for fieldwork and laboratory testing, an overview of available remediation techniques, and methods for the evaluation of remediation options. Like Volume II, Volume III is intended for day to day reference by engineers dealing with contaminated sites.

Effective use of this document
In Volume I the user will find guidance on the performance of every one of the fourteen Steps in the site assessment and remediation process. The structure of the document seeks to aid the user to quickly familiarise himself with the essence of every Step, after which he may refer to the guidance on the activities to be performed.

Each of the next Chapters presents guidance to a single Step. For quick and easy reference the numbering of the Steps corresponds with the Chapter numbering. For example, Step 5, Remediation investigation, is presented in Section 5. More complex Steps have been subdivided in Tasks, presented in Subsections. For example, Step 5 consists of five Tasks, presented in Subsections 5.1 through 5.5. This means the user may find guidance on the performance of Task 5.3, Setting remediation objectives, in Subsection 5.3, and so on.

The user who wishes to quickly grasp the sequence of steps may refer to the Overview of the Guidance document, on the fold out page at the end of this Volume. Should he wish some more detail on the different steps he may combine this with the introduction to every Step, invariably presented in the first part of every Section. For example: the introduction to Task 5.3 may be found in Subsection 5.3.1, the introduction to Task 5.4 in Subsection 5.4.1, and so on.

The user who wishes to be guided in the performance of a particular Step may refer to the Section describing that Step. Every Section is invariably structured as shown below.

Presentation of description of Steps and Tasks in Volume I of Guidance document

- Section 1: Introduction to and scope of Step
    - Brief summary of the Step;
    - Flowchart showing the position of the step in the process;
    - List of the activities to be performed within the scope of the Step;
    - Brief reference to the parties responsible for performance of the activities.
- Section 2: Guidance for performing the activities of Step
    - Description of the activities to be performed;
    - References to Volume II for standards and checklists, to Volume III for manuals and tools, and to external sources for more detailed information supporting performance of the activities;
- Section 3: Step output
    - brief summary of the output the Step should result in.

For guidance on a particular Task the user may refer to the outline above, while reading ‘Subsection’ for ‘Section’.

Volume I

Step 1 Identification of probably contaminated sites

Step 1: Identification of probably contaminated sites

1.1 Introduction to and scope of Step 1

General description and connection to other Steps

Step 1 concerns the identification of probably contaminated sites as defined in Box I-1.1. In this Step 1 a decision can be made whether or not a site may be regarded as a probably contaminated site requiring further investigation.
This is the first step in the process of assessment and possible remediation of a contaminated site. The figure below shows how this step is connected to the preceding and subsequent steps within the sequence of site assessment and remediation.

Activities

Within this step the following activities are to be performed:

1) The collection of information on probably contaminated sites (for example any existing site investigation reports, regulatory records, petitions, or complaints);
2) The verification and evaluation of the information obtained. This may also require a site visit.

> **Box I-1.1 Definition of a probably contaminated site**
>
> A probably contaminated site is an area (whether or not delineated) where the presence of contaminants is suspected but not conclusively determined or where contaminants exceed specified standards but the threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity is not conclusively established.
> A probably contaminated site may require further investigation to establish whether it is a contaminated site that requires remediation.
> The area may consist of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources.

Responsible Parties

The activities in this step are typically carried out by technical specialists within the competent authority for the assessment and remediation process. If a specialized agency/consultant is appointed to review the information this should be supervised by the competent authority.

The team involved should demonstrate in-depth knowledge and experience of hazardous waste production associated with industrial processes, and of the environmental fate, transport and degradation characteristics of contaminants (e.g. mobility, biodegradability).

1.2 Guidance for performing the activities of Step 1

This section presents concise guidance for the performance of the activities within Step 1. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Data Collection

Information regarding probably contaminated sites may be derived from reactive or proactive processes.

In a reactive process of Data Collection the competent authority may receive petitions, reports, complaints etc. from local or state level agencies, government agencies, the general public and NGOs. Some examples to illustrate which information may be received:

- Reports on the production, treatment, transport and disposal of hazardous waste, by private parties, including operators and land owners, members of the public or government agencies.
- Petitions or complaints on the suspicion of presence of hazardous materials or substances at a site, by the public or local government agencies. This may include reports on nuisance caused by odour or dust, or visual evidence of the presence of waste material.
- Complaints, through various governmental organisations. These complaints should be forwarded to the competent authority.

Figure I-1.1: coloured tap water, indication of contaminated ground water

The use of a standardised petition format will improve the completeness and quality of the information necessary for submission of a well-founded petition (refer *Example Petition format for identification of probably contaminated sites, Volume II-1-a*).

In a proactive process of Data Collection the data are gathered through a structured process for systematic information collection by the competent authority. This kind of information may be obtained following reviews of:

- hazardous waste registers regarding generation, transport, treatment and disposal of hazardous waste;
- the locations of municipal solid waste dumps;
- records of government agencies that own or control land;
- regional plans and development plans regarding spatial planning;
- industries regarding change of land use.

Activity 2 – Data verification and evaluation

The data obtained during the Data Collection should be verified and evaluated. The initial step is to establish whether the data contains sufficient information to warrant any further investigation of the site or not. The data needed to make this decision is described in the *Checklist relevant data for identification of probably contaminated sites, Volume II-1-b*. In the event there is insufficient data, or data of insufficient quality, to make the decision, then more data should be collected.

Verification of data can be done by collecting information independently from the person or organisation responsible for submitting the original petition, report or complaint. Often, a brief site visit may be beneficial to enable a visual verification of the situation by the reviewing team. Interviewing relevant stakeholders usually yields information that will at the very least provide colouring to the previously collected data. In addition, information by stakeholders will prove useful in the verification of these data. At this stage, interviews can generally be limited to local stakeholders, whom may be interviewed during the site visit.

Stakeholder	Interview objective	Level
Site owner	collect information, verify data	site
Site operator	collect information, verify data	site
Local businesses and residents	collect information, verify data	site and direct vicinity

Figure I-1.2: Site visit

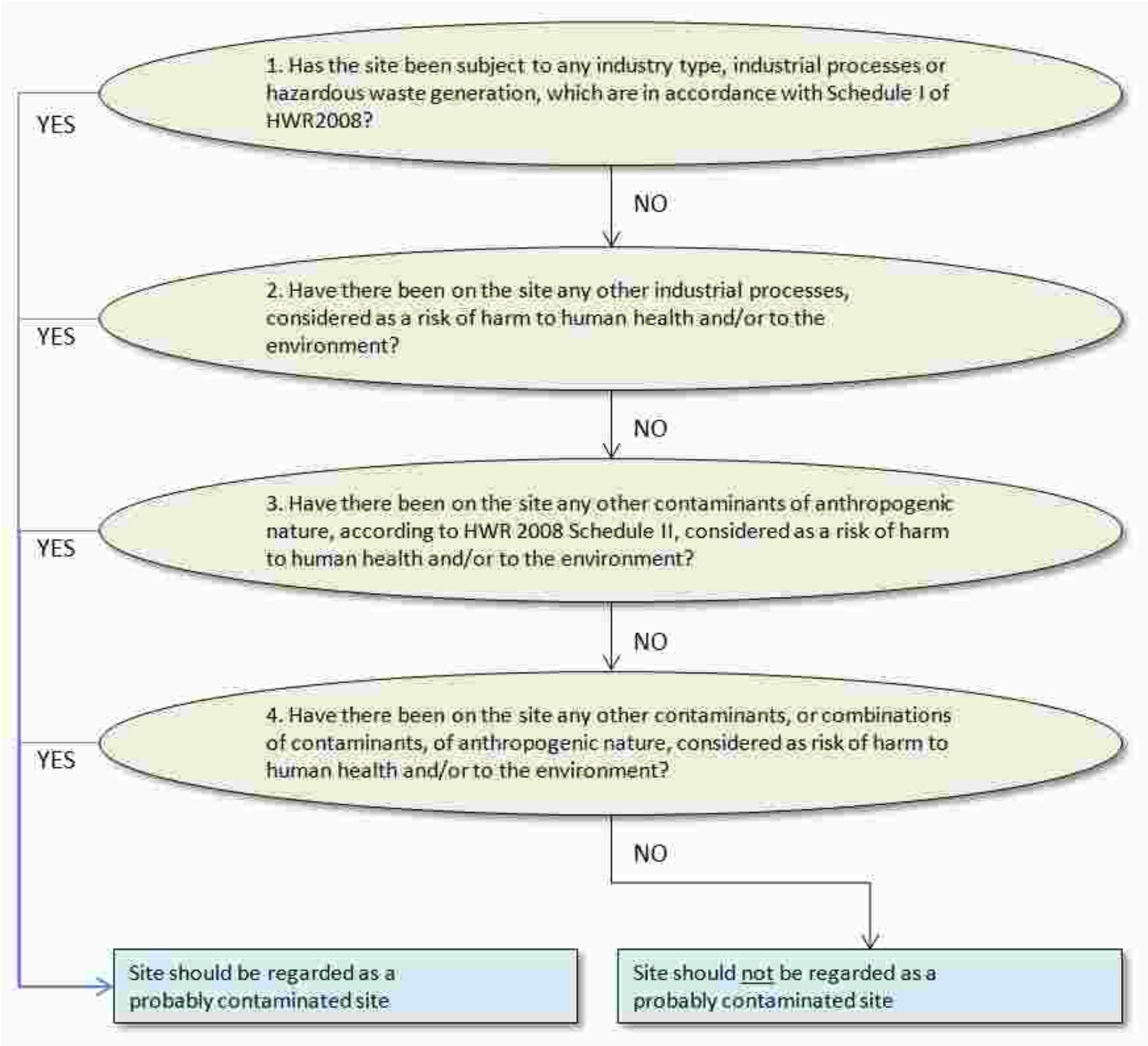
Once the appropriate data has been obtained and verified an evaluation assessment of whether or not the site qualifies as a ‘probably contaminated site’ may be undertaken. This evaluation comprises answering the following questions:

1. Has the site been subject to any industry type (number 1.12 of *Checklist relevant data for identification of probably contaminated sites, Volume II-1-b*), industrial processes (Checklist, number 2.3) or hazardous waste generation (Checklist, number 2.4), which are in accordance with Schedule I of Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008?
2. Have there been on the site any other industrial processes (Checklist, number 2.3), considered as a risk of harm to human health and/or to the environment?
3. Have there been on the site any other contaminants of anthropogenic nature (Checklist, numbers 2.2 and 2.6), according to Schedule II of Hazardous Waste Rules 2008, considered as a risk of harm to human health and/or to the environment?
4. Have there been on the site any other contaminants, or combinations of contaminants, of anthropogenic nature (Checklist, number 2.6), considered as risk of harm to human health and/or to the environment?

If either one or more than one of these four questions is answered by ‘yes’ the site should be regarded as a ‘probably contaminated site’. If all of these four questions are answered by ‘no’, and there is no actual indication of significant contamination at the site, the site should not be regarded as a ‘probably contaminated site’.

The evaluation is visualised in the flowchart below.

Figure I-1.3: Flowchart for evaluation of probably contaminated site in Step 1



1.3 Step 1 output

The output of this Step is the decision record for the conclusion as to whether or not the site is regarded as a probably contaminated site. If yes, further assessment may be undertaken. This assessment is described in the following Section, on Step 2, Preliminary investigation. The data on the site and the decision record should be included in the database of contaminated sites.

If the site does not qualify as a probably contaminated site it is not necessary to continue the assessment process in Step 2. The data on the site and the decision record can be submitted into the archives.

Volume I

Step 2 Preliminary investigation

Task 2.1 Preliminary site assessment

Step 2: Preliminary investigation

Task 2.1: Preliminary site assessment

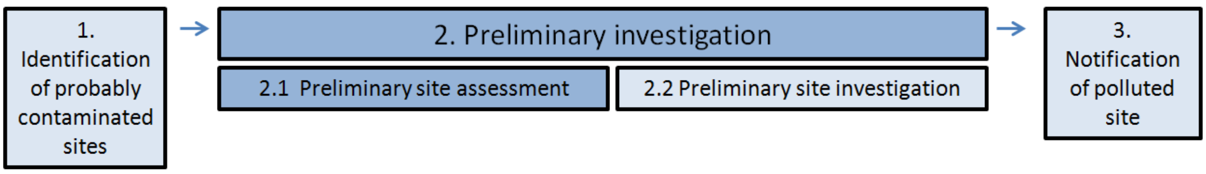
2.1.1 Introduction to and scope of Task 2.1

General description and connection to other Steps
Step 2 concerns the preliminary investigation of individual sites which have been recognised as probably contaminated sites during the previous Step 1. The purpose of the preliminary investigation is to establish whether or not a site should be regarded as a contaminated site as defined in Box I-2.1.1.

> **Box I-2.1.1 Definition of a contaminated site**
>
> A contaminated site is a delineated area consisting of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources.
>
> If on the basis of preliminary site assessment or preliminary site investigation or detailed site investigation, the constituents and characteristics of contaminants discharged or otherwise come to be located at the site, exist at or above Response levels and in conditions including possible combination of contaminants and interaction between contaminants and/or environmental constituents which pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity, in such case the site may be determined as contaminated site.

This is the second step in the process of assessment and (possible) remediation of a site that could be a contaminated site. Step 2 is divided into two tasks: preliminary site assessment (Task 2.1) and preliminary site investigation (Task 2.2).
The objective of Task 2.1 preliminary site assessment is to focus as quickly as possible on imminent threats to human health and/or the environment to verify if the site is a contaminated site.

The figure below shows how this Task 2.1 is connected to the preceding and subsequent steps and tasks within the sequence of site assessment and remediation.



Activities
Within this task the following activities are to be performed:

1) A desk study is carried out on the available information of the site. Information in reports and petitions is assessed and new information is inventoried.

2) A site inspection is carried out to verify the information of the desk study and to prepare a plan for sampling and testing.
3) At the locations where main sources of contamination and relevant pathways to possible affected receptors are expected limited sampling and testing is carried out.
4) The results are compared with the Screening and Response levels and a conclusion is drawn as to whether or not the site should be regarded as a contaminated site. Recommendations on the necessity to carry out preliminary site investigation (Task 2.2) and specific aims of that investigation are presented.
5) Reporting of results of the preliminary site assessment and review of the report.

Responsible Parties
This activity is typically carried out by technical specialists of the specialized agency/consultant appointed to carry out the preliminary investigation. The work should be supervised by a senior colleague, and close cooperation with the competent authority is necessary to collect important information during the desk study and to prepare the site inspection and sampling.

The team involved should demonstrate in-depth knowledge and experience in the assessment of contaminated sites, including interpretation of topographic and geological maps and reports. The field work team should have relevant expertise, experience and skills for the site inspection and sampling. The laboratory work has to be carried out by an accredited lab.

2.1.2 Guidance for performing the activities of Task 2.1

This section presents concise guidance for the performance of the activities within Task 2.1. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

The detailed information on the execution of the preliminary site assessment can be found in section Volume III-2.1-i of this Guidance Document. This section comprises the Site Inspection Protocol (SIP) which contains several elements:
- General introduction on the use of the SIP;
- Checklists and manuals for execution of the individual activities;
- Recommendations for proper health and safety measures during the site visit and for reporting the results.

The SIP is related to the information inventoried and summarized in the database of contaminated sites. The information in this database enables the prioritization of sites in a program for remediation of polluted sites.

Activity 1 – Desk study

A review of the site information within reports, petitions and complaints obtained at Step 1 is performed (refer Box I-2.1.2 below). It is necessary to have as much information as possible concerning the history and land use both on site and off site (representing the surrounding area). This information indicates the possibility of the presence of contamination at the site.

Box I-2.1.2 Practical tip: Importance of desk study

It is very important to focus attention on the desk study at this stage of the process of assessment and remediation. If sources of contamination are not recognised it can lead to under-estimation of the extent of potential contamination and potential risks to receptors may not be recognized.
Furthermore, this can lead to unexpected problems during future site activities e.g. when reconstruction or reuse of the site will necessitate digging in subsoil or extraction of groundwater.

In addition an incomplete inventory of contamination sources and exposure pathways can lead to ineffective remediation plans. There are many examples of projects where, unfortunately, remediation activities had to be re-designed, causing exceedance of budgets and in some instances the remediation objectives previously agreed were not achieved.

The points below should be considered when assessing existing primary data:
- determine what data are available;
- evaluate purpose and scope of previous investigations;
- review sampling locations, dates, depths and sample descriptions;
- evaluate the sampling results and hazardous substance concentrations;
- review field preparation and collection techniques for previous samples;
- review available laboratory documentation;
- assess usability of previous primary data.

The data review may identify gaps in the available data. Additional information can be obtained from maps, data bases or governmental information.

The available reviewed information and the newly collected information can be summarised in a table and information gaps should be indicated before the site inspection is carried out (refer *Volume III-2.1-i SIP, Appendix E, table 1 Existing and general information and table 2 Overall assessment of data and data gaps*).

Based on all the compiled information a work plan should be devised prior to the site inspection. This work plan should include all reconnaissance activities and identify the specific information to be collected e.g. sampling from drinking water wells, noting the local hydrogeology, estimating the population at risk, interviews with specific stakeholders (such as occupants, current or former owners, neighbours, manager, employees and government officials) etc.

On completion of the desk study a review should be carried out to confirm whether there is any indication of contaminating activities at the site. If it is established that there is no such indication it should be concluded that the information from step 1 is incorrect. The site should be classified as ‘not a probably contaminated site’ and the database should be revised accordingly. Further investigation activities should not be regarded necessary for the site.

<u>Activity 2 – Site inspection</u>

The site inspection is a field visit to observe the site and the potential sources of contamination (on-site reconnaissance) and to undertake a perimeter survey of the facility as well as a survey of the local site environs (off-site reconnaissance). During this site inspection information is obtained to fill the gaps and the existing available information is verified. If possible photographs should also be taken.

The site inspection needs to be prepared by arranging access to the site and in consultation with important stakeholders. Furthermore, equipment, e.g. for sampling, needs to be prepared. Interviewing relevant stakeholders is an integrated part of the preliminary site assessment. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may only be applicable to large scale sites.

Stakeholder	**Interview objective**	**Level**
Site owner	collect information, verify data	site
Site operator’s health facility director	collect information, verify data	site
Local businesses, residents and NGO’s	collect information, verify data	site and direct vicinity
Municipal authorities, including Water Supply and Sanitation	collect information	local
District administrator	collect information, e.g. on land ownership	district
State authorities, including SPCB and Groundwater Authority	collect information	state

During the site inspection health and safety guidelines have to be taken into account (refer *Volume III-2.1-i SIP, section 3*).

The information gathered during the site inspection should be summarized in tables (refer *Volume III-2.1-i SIP, section 5 –on-site- and 6 –off-site-*) and a sketch map should be drawn showing the principal recorded occurrences and expected sources of contamination the main exposure and migration pathways of pollutants and the locations of receptors.

<u>Activity 3 – Limited sampling and testing</u>

An initial assessment of the contamination present at the site may be ascertained from samples taken during the site inspection. These samples should be obtained from locations where the main sources of pollution are expected, and at locations within migration pathways. Because only a limited number of samples are obtained, the sample locations should be well chosen, and guidance is provided in Box I-2.1.3 below.

The sampling should be carried out according to the Sample Protocol (refer *Volume III-2.1-i SIP, Appendix A*).

The samples should be tested in a laboratory to assess the levels of contamination present. Laboratories should operate in accordance with specific accreditation criteria (refer *Checklist prequalification for site investigation including ToR, Volume II-2.1-a*).

Box I-2.1.3 Practical tip: Possible locations for sampling

Possible locations for sampling of sources and pathways:

- visual indication of cause of pollution such as the presence of (former) industrial process equipment, storage tanks, broken pipelines, etc;
- visual evidence of hazardous material by means of colour or odour or the composition of material, or uneven ground surface;
- reported location with confirmed high concentration levels in previous sampling results;
- where an incident (spill / uncontrolled release) has occurred identified by a former employee of a company;
- areas which can easily be accessed by humans and areas of sensitive use (residential, playground, agriculture);
- drinking water wells downstream of the site (to collect groundwater samples to assess if this pathway is contaminated);
- surface water at or near the site if expected to be contaminated by hazardous waste material;
- at discharge points with noticeable contamination an effluent sample should be taken;
- in cases of sites with effluent discharges a ‘source sample’ should also include a sample of the sediment.

The parameters for determination within each sample scheduled for analysis will depend on the hazardous waste material potentially present (refer *Volume III-2.1-i SIP, Appendix C*). For the various activities representative tracer components have been described. The tracer components can be seen as components of concern. If there is existing information about contaminants from previous investigations, this information should be used to select tracers. It has to be stated that not all the listed tracers necessarily have to be analysed at a site, but the list can be used as a starting point for the assessing analysis program at a specific site.

Figure I-2.1.1a: Sampling of groundwater (picture by COWI, Kadam)

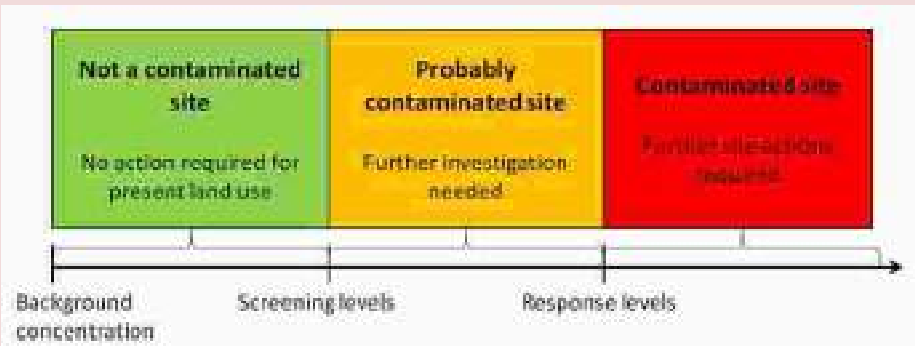
Activity 4 – Comparing testing results with standards

The laboratory testing will result in a list of concentration levels for various parameters / substances. These concentration levels have to be compared with the Screening levels and the Response levels (refer *Volume II-2.1-b*). A brief explanation on these levels is provided in Box I-2.1.4.

Box I-2.1.4 Explanation: Screening levels and Response levels

Screening levels are generic concentrations of hazardous substances in soil and sediments, groundwater and surface water at or below which potential risks to human health or the environment are not likely to occur and where no further investigation and assessment is needed. These Screening levels are distinguished for land use.

Response levels are generic concentrations of hazardous substances in soil and sediments at or above which it is very likely there is threat to human health or the environment, that may be imminent. At or above this level some form of response is required to provide an adequate level of safety to protect public health and/or the environment.



Note that that for certain contaminants such as Persistent Organic Pollutants, no background concentrations should be used, as there is no natural background for these substances.

The outcome of the comparison will determine whether or not the site should be regarded as a contaminated site (refer to definition in Box I-2.1.1). The following situations can occur:

- If the concentration level of one or multiple contaminants exist at or below Screening levels the site cannot directly be regarded as 'not a probably contaminated site'. This because of the fact that only a limited number of samples were taken. Further investigation is necessary to assess if there are any further sources of contamination at the site which may cause a risk to present or future land use. This can be done by a preliminary site investigation.
- If one or multiple contaminants exceed Screening levels but at or below Response levels the site may be determined as probably contaminated site. Then preliminary site investigation should be carried out as well. This is because of the fact that only a limited number of samples were taken and there may be other locations at the site where higher concentration of contaminants occur;
- If one or multiple contaminants exceed Response levels the site can be classified as a contaminated site. Often it is not clear if all sources and pathways have been identified and samples may not have been taken. In that case a preliminary site investigation is necessary. If it is clear that all sources and relevant pathways have been identified and samples were taken at these points, no preliminary site investigation is necessary. In that case the site may be notified directly as a contaminated site and prioritisation can take place (Step 3 and Step 4 of the assessment and remediation process).

All these situations are illustrated in the below result flowchart Figure I-2.1.3 for the comparison of concentration levels with Screening and Response levels.

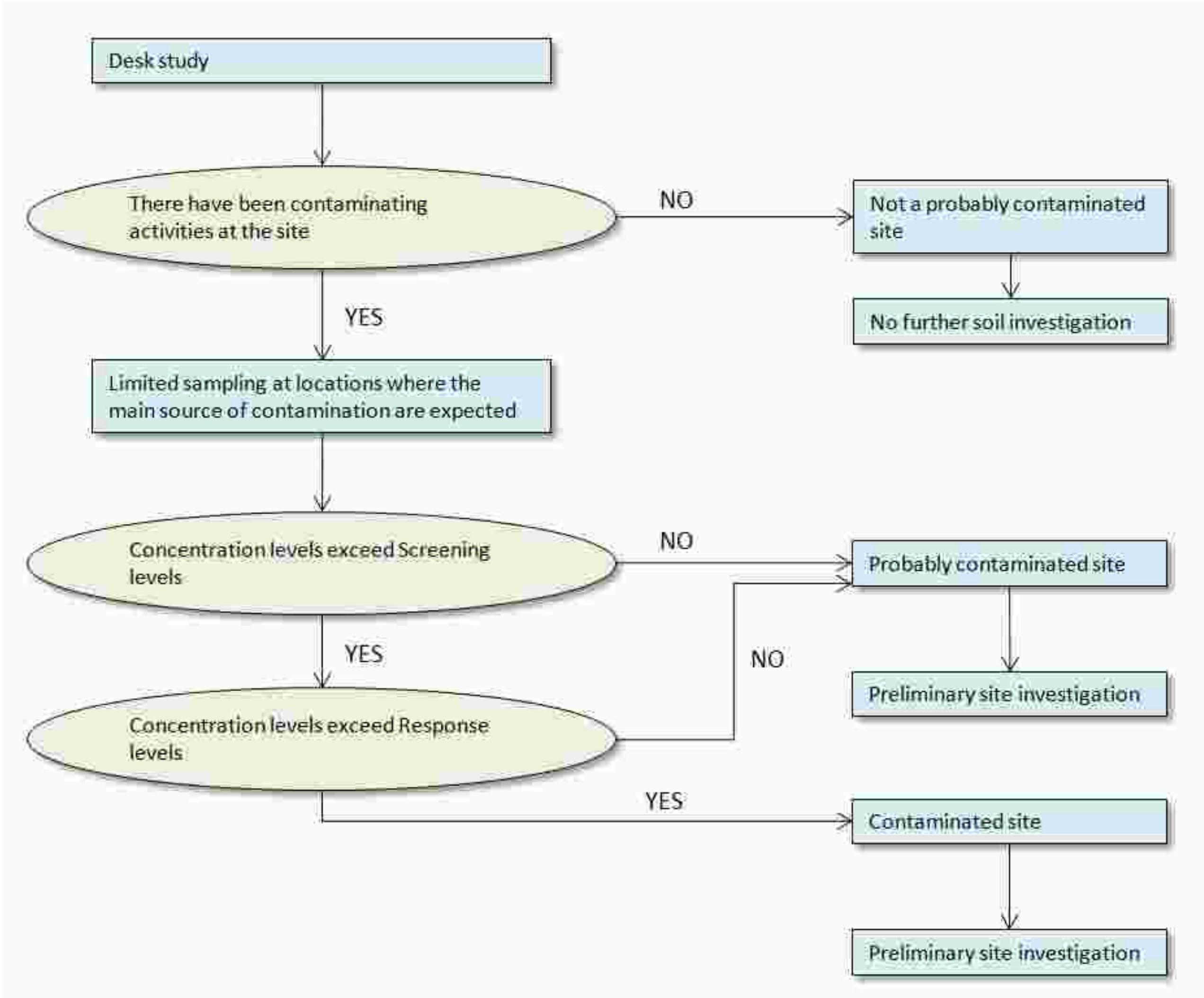
<u>Activity 5 – Reporting and review</u>

The activities carried out, the methods used and the results of the preliminary site assessment should be described in the report. The chapters of the report are structured in accordance with the stages of the investigation itself (refer *Checklist for preliminary site assessment report, Volume II-2.1-c*).

Finally, a conclusion should be drawn as to whether or not the site meets the definition of contaminated site. Recommendations should also be provided for the next step in the assessment and remediation process. If there is not enough information to draw a conclusion a recommendation for further investigation should be provided.

It is important that this document contains copies of the original sources of information in databases, previous reports and other sources. This is because at later stages of the assessment and remediation process, it is often necessary to revert to the original information when interpreting newly collected data.

Figure I-2.1.3: Preliminary site assessment result flowchart in Task 2.1



2.1.3 Task 2.1 output

The output of this task 2.1 is the conclusion whether the site should be regarded as a contaminated site. If so, or if there is not enough information, further investigation is necessary to obtain more information.

If the site is not regarded as a contaminated site, it is not necessary to continue the process of assessment and remediation of the site. The site information and the decision should be registered on the database.

Volume I

Step 2 Preliminary investigation

Task 2.2 Preliminary site investigation

Step 2: Preliminary investigation

Task 2.2: Preliminary site investigation

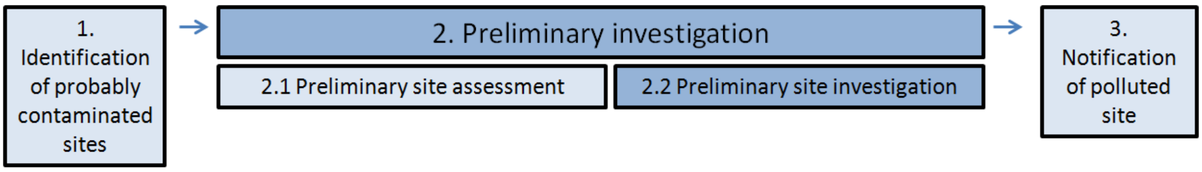
2.2.1 Introduction to and scope of Task 2.2

General description and connection to other Steps
Step 2 concerns the preliminary investigation of individual sites which have been recognised as probably contaminated sites during the previous step 1. The purpose of the preliminary investigation is to establish whether or not a site should be regarded as a contaminated site as defined in Box I-2.2.1.

> **Box I-2.2.1 Definition of a contaminated site**
>
> A contaminated site is a delineated area consisting of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources.
>
> If on the basis of preliminary site assessment or preliminary site investigation or detailed site investigation, the constituents and characteristics of contaminants discharged or otherwise come to be located at the site, exist at or above Response levels and in conditions including possible combination of contaminants and interaction between contaminants and/or environmental constituents which pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity, in such case the site may be determined as contaminated site.

This is the second step in the process of assessment and (possible) remediation of a site that could be a contaminated site. Step 2 is divided into two tasks: preliminary site assessment (Task 2.1) and preliminary site investigation (Task 2.2). The objective of the preliminary site investigation is to identify all sources of contamination and the relevant pathways linking them to the receptors of concern.

The figure below shows how this Task 2.2 is connected to the preceding and subsequent steps and tasks within the sequence of site assessment and remediation.



Activities
Within this task the following activities are performed:
1) Design of the investigation and testing strategy
2) Fieldwork and laboratory testing
3) Comparison of the test results with standards
4) Reporting of the preliminary site investigation and review of the report.

Responsible parties
This activity is typically carried out by technical specialists of the specialized agency/consultant appointed to carry out the preliminary investigation. The work should be supervised by a senior colleague. Cooperation with the site owner and competent authority is necessary to prepare the field work and to grant access to the site.
The team involved should demonstrate in-depth knowledge and experience in the assessment of contaminated sites and interpretation of information obtained from reports and maps on the topography and geology of a site. The field work team should have relevant expertise, experience and skills for the site inspection and sampling. The laboratory work has to be carried out by an accredited lab.

2.2.2 Guidance for performing the activities of Task 2.2

This section presents concise guidance for the performance of the activities within Task 2.2. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Because the preliminary site investigation is a follow up of the preliminary site assessment a lot of information on the execution of the preliminary site investigation can be found in the Site Inspection Protocol (SIP) (ref. *Volume III-2.1-i*). This SIP comprises:

- General introduction on the use of the SIP;
- Checklists and manuals for preparation and execution of the individual activities;
- Recommendations for proper health and safety measures during the site visit and for reporting the results.

The SIP is related to the information inventoried for a database on probably contaminated sites. The information held in this database enables the prioritisation of sites in a program for remediation of polluted sites.

Activity 1 – Investigation strategy

The starting point of the preliminary site investigation is a review of the output from the preliminary site assessment. The desk study information within the preliminary site assessment should already provide a detailed history of the site use.

The potential sources, pathways and receptors of concern should be established based on previous reports or petitions, maps, records, aerial photographs and interviews with owners or other informed parties. If there is doubt on the results of the desk study during the preliminary site assessment or if the report cannot be regarded as valid anymore, parts of the desk study should be carried out again. Depending on the land use and changes in land use, a period of 5 years can be used as a rule of thumb as the period for carrying out a new desk study.

During the preliminary site assessment the activities of the fieldwork have been focussed on locations where the highest contaminant concentrations were expected and the locations of the most sensitive land use. For the preliminary site investigation it is necessary to verify all potential sources, pathways and receptors at the site.

The investigation strategy to achieve this objective efficiently starts with the typology of the contaminated site (see Box I-2.2.2 for a short explanation of typology of contaminated sites. For a more detailed explanation we refer to the Glossary in the Annex of this Volume I). For each type of contamination a different investigation strategy is provided and from that points of attention for the fieldwork and laboratory work are specified in the *Protocol investigation strategy preliminary site investigation (*ref. *Volume III-2.2-ii).*
Note: at any contaminated site more than one type of contamination can occur. For each type of contamination and for each source a separate investigation strategy can be developed.

Box I-2.2.2 Explanation: Typology of contaminated sites

Contaminated sites are delineated areas in which toxic and hazardous substances exist at levels and in conditions which pose existing or imminent threats to human health or the environment. These sites often pose multi-faceted health and environmental problems. They can impact all components of the environment, particularly surface waters, soils, and groundwater and can result in people being knowingly or unknowingly exposed to toxic substances. Contaminated sites may include production areas, landfills, dumps, waste storage and treatment sites, mine tailings sites, spill sites, chemical waste handler and storage sites. These sites may be located in residential, commercial, industrial, rural, urban, or wilderness areas. All these elements are combined in a typology of contaminated sites. This typology is of importance for the assessment and design process of remediation.

The following main types of contaminated sites are distinguished based on the causing activity and pathway of spreading of contamination:

Source related:
- Type S1: Land bound solid phase contamination
- Type S2: Water bound sediments solid phase contamination
- Type L: Land bound liquid phase contamination

Pathway related:
- Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids)
- Type P2: Groundwater contaminations

Note: depending on a specific situation, a combination of these types may be possible. Example: a land bound storage of chromium containing hazardous waste (type S1), causing leachate of chromium to groundwater and leading to a contaminated groundwater plume (type P2).

Further explanation on the typology is provided in the Glossary.

If additional site specific information is available the general type can be made more site-specific by developing a Conceptual Site Model (CSM). The CSM supports the investigator to visualize the possible sources, pathways and receptors relevant at the site. See Box I-2.2.3 for a short explanation of the Conceptual Site Model. For more detailed information how to apply the CSM refer to *Manual Conceptual Site Model an identifying the Source-Pathway-Receptor, Volume III-2.2-i*.

> **Box I-2.2.3 Explanation: Conceptual Site model**
>
> The Conceptual Site Model is a representation of the characteristics of the site in diagrammatic or written form that shows the possible relationships between contaminants, pathways and receptors. It crystallises understanding of what needs to be done to achieve the investigation of contaminated sites, the assessment of risks and from this point appropriate remediation techniques to achieve remediation objectives.
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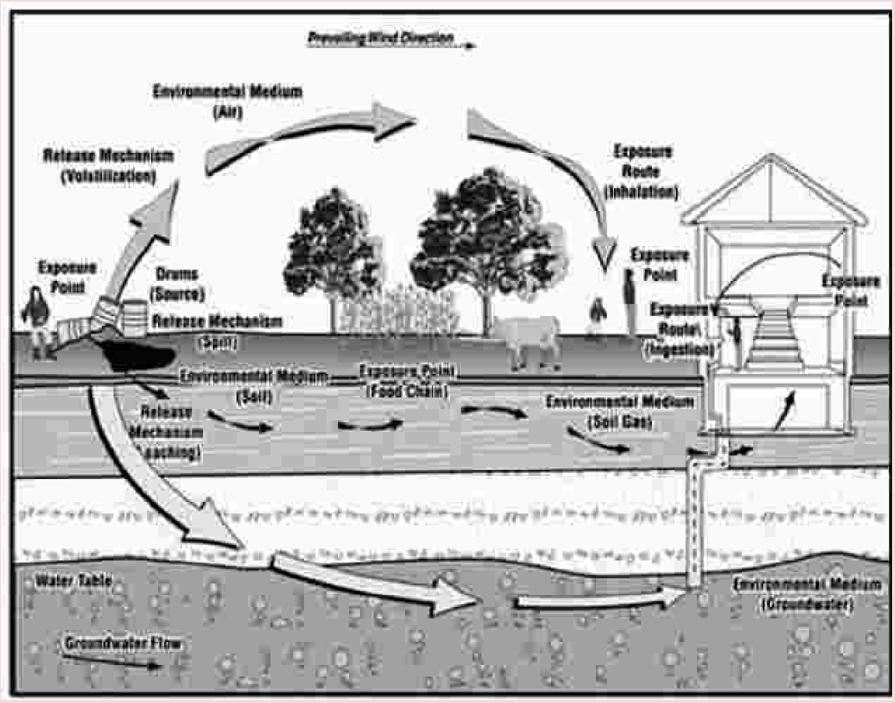
> 
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>
> *Figure I-2.2.1: Example of a schematic exposure pathway in a Conceptual Site Model (source: Public Health Assessment Guidance Manual, Agency for Toxic Substances and Disease Registry, 2005)*

Based on the investigation strategy an investigation protocol is prepared, regarding assessment of the contamination levels of the source and identification of the major pathways and receptors of concern. This protocol should pay attention to the following elements:

- Screening and sampling technical equipment;
- Sampling pattern and depth of samples, number of samples, use of composite samples;
- Analytical test parameters / determinants required;
- QA/QC procedures such as use of field blanks/trips blanks, procedures to avoid cross contamination by sampling equipment etc.

Technical equipment for site assessment
Generally two ways of carrying out field investigation are distinguished: screening methods which provide an area-wide information and sampling methods at specific locations.

There are several screening methods that provide qualitative information from which the possible presence of contamination can be concluded. Some examples are illustrated in Box I-2.2.4 below. An overview of screening techniques is provided in the *Overview of techniques for site investigation, Volume III-2.2-iii.* This approach can help to provide a first rough indication of the source of contamination and delineation of a contaminated site.

Box I-2.2.4 Example Site screening methods

For recognition of the presence of heavy metals in soil or waste material an XRF device can be used. This equipment detects increased levels of heavy metals in samples.

For volatile organic components the use of a soil vapour survey technique can be helpful. A portable Photo-ionization Detector can detect these components in a soil or water sample.

For hydrocarbon site investigations a Cone Penetration Test (CPT) mounted UV fluorescence screening tool can be used for a quick reconnaissance of a site for hydro carbon contaminations.

Note.
Screening methods are often sensitive to side-effects caused by naturally occurring substances, the indirect type of measurement or the calibration shifting during the use of the screening tool. For instance i- the fluorescence sensor may deliver false positives in cases of high proportions of peat and other naturally occurring organic carbon or ii- a clay layer or saline groundwater body may be mistaken for a contaminated plume by a electromagnetic mapping (EM).
Verification and calibration procedures are tool or supplier specific.
It is especially necessary to align screening values with other data such as laboratory analyses and typically cannot be used as the only tool for data acquisition.

Based on the outcome of such screening methods additional sampling and testing is always necessary to provide quantitative results of the concentration levels of components in the soil, sediment, groundwater or surface water.

For groundwater sampling existing groundwater wells can be used, but sometimes it is not clear how the installations have been designed, and which stratum the groundwater is derived from. To obtain accurate information for a specific level new dedicated monitoring wells should be installed.
An overview of possible technical equipment for collection of samples (soil, sediment, surface water, groundwater) is provided in the *Overview of techniques for site investigation, Volume III-2.2-iii*.

Sampling pattern, number of samples and depth of samples
Knowledge of the possible location of contamination sources is important for defining the sampling pattern. Small areas where contaminated material is concentrated in one place (point source contamination) can be investigated during the preliminary site investigation by a few representative samples collected from one or two exploratory excavations. In case contaminated material is spread over a large area it is necessary to use a pattern of samples to collect representative information of the contaminated site. The *Protocol investigation strategy preliminary site investigation*

Volume III-2.2-ii provides a first indication of the sampling pattern and number of samples.

There are some additional aspects that should be taken into account when developing a sampling strategy for a specific site:

- Restrictions for investigation such as buildings, subsurface infrastructure and site boundaries;
- If possible some samples should be obtained for identification of background quality of soil, groundwater, sediment or surface water which has not been influenced by this particular contamination;
- Samples of groundwater may be obtained from selected existing observation wells in the aquifer beneath the surface of the site, for monitoring water level elevation and water quality at appropriate locations. The depth of the well and the filter (if any) should be known. If there is data from previous sampling or level measurements it is important to know the frequency and period relating to the hydrological environs (influence of monsoon).

Parameters for laboratory testing:
The parameters important for the investigation can be selected based on:

- Previous industrial operation processes or waste generation, discharges or disposal activities. The type of industry determines the parameters involved (ref. *Volume III-2.1-i SIP, Appendix C*).
- Specific observations during site inspection and field work of signs which indicate contamination not related to the above mentioned activities.
- Characteristics of the components regarding mobility or retardation. For assessment of groundwater quality the most mobile tracers are interesting to focus on. For sediments, components with high binding capacity are important to focus on when investigating a surface water body near to a former point of discharge.
- It is always recommended to test some samples for a broad spectrum of parameters. This because it is possible that there may have been polluting activities at the site that are either unknown or not documented in databases. These activities may possibly have caused contamination with different characteristics compared to the known activities.

<u>Activity 2 – Fieldwork and laboratory testing</u>

The fieldwork needs to be prepared by arranging access to the site and in consultation with important stakeholders. Furthermore, sampling equipment needs to be prepared.

The stakeholder consultation is needed, both to inform them on the fieldwork plan and to secure their support for the plan. The consultation may also yield information that can be useful in the final design of the fieldwork plan. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may only be applicable to large scale sites.

Stakeholder	Interview objective	Level
Site owner	provide information, secure support	site
Site operator’s health facility director	provide information, secure support	site
Local businesses, residents and NGO’s	provide information, secure support	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	provide information, secure support	local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	provide information, secure support	state
For large scale site: national authorities, including Surveyor of India and Central Ground Water Board	collect information	national

During the site inspection health and safety guidelines have to be taken into account by the field team (ref. *Volume III-2.1-i SIP, section 3*).

The activities in the field should be described in a logbook of the field investigator. Detailed descriptions of each source and of relevant pathways and receptors should include:

- Regarding source: type, location, dimensions, sensory perceptions/observations of possible pollution (form or colour or smell or stressed vegetation);
- Samples should be taken of the soil, sediment, groundwater and/or surface water assumed to be most contaminated based on visual / olfactory evidence of contamination;
- Regarding pathway: depth of groundwater, presence of surface water and possible overland flow route from source to the nearest surface water body;
- Regarding receptors: dwellings, schools/playgrounds, use of groundwater wells, crops or cattle, other sensitive environments, land use in the vicinity.

Furthermore, the activities carried should be accurately described for inclusion in the report.
The descriptions should be accompanied by sketches of the site (location of sources, dimensions, distances to receptors, significant site features, with marking of north and scale. The locations of exploratory holes should preferably be indicated by XYZ-coordinates, using GPS.

Note: Always be flexible on fieldwork activities to maintain efficiency. Based on the initial field work results additional samples and testing may be appropriate in case of unexpected indications of pollution.

The sampling should be carried out according to the Sample Protocol (ref*. Volume III-2.1-i SIP, Appendix A*).
The samples should be tested in a laboratory to assess the levels of contamination in the sample. Laboratories should operate in accordance with specific accreditation criteria (ref. *Volume II-2.1-a*).

The parameters for determination within each sample scheduled for analysis will depend on the hazardous waste material potentially present (refer *Volume III-2.1-i SIP, Appendix C*). For the various activities representative tracer components have been described. The tracer components can be seen as components of concern. If there is existing information about contaminants from previous investigations, this information should be used to select tracers. It has to be stated that not all the listed tracers necessarily have to be analysed at a site, but the list can be used as a starting point for the assessing analysis program at a specific site.

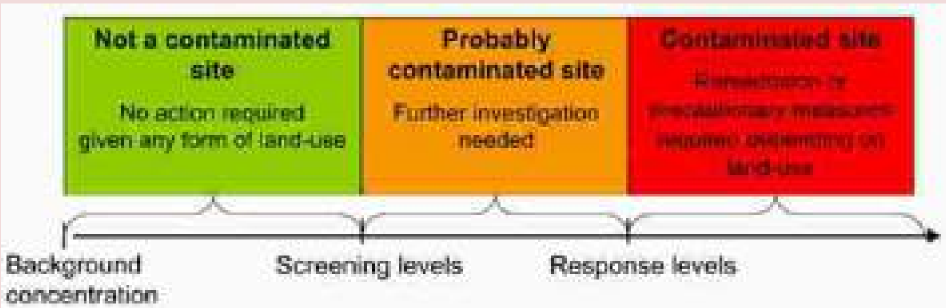
<u>Activity 3 – Comparison of testing results with standards</u>

The laboratory test results should be tabulated and recorded in terms of concentration levels for each parameter / substance per sample. These concentration levels are compared with the Screening levels and the Response levels (ref. *Volume II -2.1-b*). A short explanation on these levels is provided in Box I-2.2.5 below.

Box I-2.1.4 Explanation: Screening levels and Response levels

Screening levels are generic concentrations of hazardous substances in soil and sediments, groundwater and surface water at or below which potential risks to human health or the environment are not likely to occur and where no further investigation and assessment is needed. These Screening levels are distinguished for land use.

Response levels are generic concentrations of hazardous substances in soil and sediments at or above which it is very likely there is threat to human health or the environment, that may be imminent. At or above this level some form of response is required to provide an adequate level of safety to protect public health and/or the environment.



Note that that for certain contaminants such as Persistent Organic Pollutants, no background concentrations should be used, as there is no natural background for these substances.

The outcome of the comparison will define if the site should be regarded as a contaminated site (refer to definition in Box I-2.2.1). The following situations can occur:

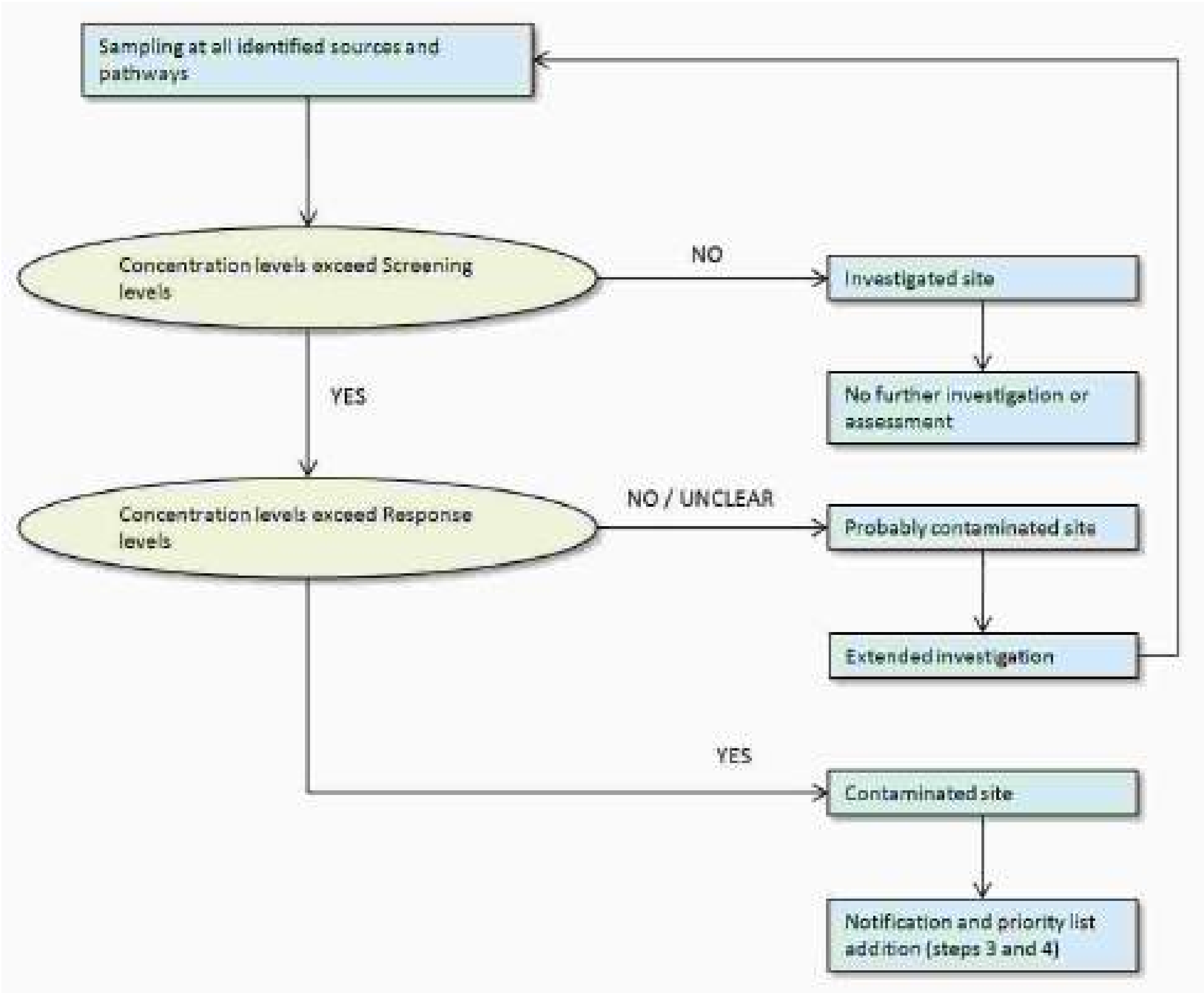
- If concentration levels of contaminants in all samples do not exceed Screening levels it can be concluded that there is no imminent threat to human health and/or the environment and the site can directly be regarded as 'investigated site' which has not proven to be contaminated. There has been sufficient investigation undertaken and further investigation or assessment of the site is not necessary.

- If concentration levels exceed the Screening levels but are lower than Response levels it is not directly possible to determine the site as a 'contaminated site' or as 'not a contaminated site'. If the outcome of the preliminary site investigation is not clear further investigation using elements of the detailed site investigation (Task 5.1) may be recommended.
- If concentration levels exceed Response levels it can be concluded that imminent threats to human health and/or the environment may occur and the site may be classified as a contaminated site. The site should be notified and prioritisation should be carried out (Step 3 and Step 4 of the assessment and remediation process).

All these situations are illustrated in the below result flowchart Figure I-2.2.3 for the comparison of concentration levels with Screening and Response levels.

In some areas the natural background levels may be higher compared to the Screening levels, e.g. the natural background levels of metals and other inorganic chemicals can vary widely and this should be taken into account when applying the Screening levels. Where it can be demonstrated that natural background concentrations are elevated (e.g. heavy metal concentrations in mineralised areas), it would be appropriate to develop less stringent assessment criteria. However care needs to be taken when establishing the level of the natural background and its natural variation as the local background may be influenced by historic mining and/or waste disposal activities.
For some contaminants such as Persistent Organic Pollutants, no background values should be used, as there is no natural background for these substances.

Figure I-2.2.3: Preliminary site investigation result flowchart in Task 2.2



Activity 4 – Reporting and review

Details of all activities carried out, the equipment and methods used and the results of the preliminary site investigation should be included in the site investigation report. The chapters of the report should be arranged in the same sequence of the investigation activities (ref. *Checklist for preliminary site investigation report, Volume II-2.2-a*). The topics in this checklist may be used as elements in Terms of Reference for the investigation of a specific site.

The relevant elements of the previous report of the preliminary site assessment can be incorporated in the report of the preliminary site investigation, if still valid.
In the preliminary site investigation report all major sources, pathways and receptors of concern should be identified. It is very important to recognize if there are indications of ongoing hazardous waste generation or fresh waste disposal or discharge on the site. If that is the case the first step must be to prevent these activities from occurring before proceeding with the remediation investigation.

Furthermore the initial Conceptual Site Model should be reviewed and probably adjusted based on the results of the preliminary site investigation.
If enough data is available groundwater level contour maps may be developed in order to indicate the groundwater flow direction.

When interpreting the results of groundwater quality the possible influence of seasons should be taken into account, see Box I-2.2.6.

Box I-2.2.6 Practical tip: Seasonal Influences

Groundwater levels may vary due to the influence of rainfall or flooding causing replenishment of the shallow groundwater level. There can be an influence from surface water level changes on the groundwater level near water bodies. Rising surface water in monsoon periods will cause an increase of the groundwater level. Changes in groundwater level can impact contamination distribution and concentration in soil and groundwater. Constituents bound to soil particles may be released and may be dissolved into groundwater causing increasing concentration levels. After a while equilibrium will be restored with a new balance between bound and dissolved particles so the concentration level remains the same until further changes in groundwater level occur. Groundwater level varying over the season in this way may cause periodical increasing and decreasing contamination concentration levels. They as well may have an effect on light non-aqueous phase liquids (LNAPL) on the groundwater surface which tend to reduce in thickness or disappear when water levels rise.

Although the primary purpose of a preliminary site investigation has not been to delineate the contamination it is often possible to provide a rough estimate of the extent of and boundaries of the contamination. When interpreting the data it may appear that several zones of distinct contamination may be present within the single contaminated sites. Each may be sufficiently distinguished to represent a contaminated site in it's own right. This is important for the legal notification of the contaminated site (step 3).

Finally a conclusion has to be drawn if the site has to be regarded as a contaminated site or not. Recommendations should be provided for the next step in the remediation process. If there is not enough information to draw a conclusion a recommendation for further investigation should be provided. The report has to contain as much as possible verifiable information meaning that copies of all original data from desk study, site inspection, field work and laboratory testing should be provided in annexes.

The investigating agency should ensure appropriate quality assurance protocols and systems have been adhered to including prescribed protocols, the calibration of field instruments, proper sampling and collection techniques and by providing records of responsibility, non-conformity events, corrective measures and data deficiencies.

The report is then reviewed by the competent authority regarding contaminated sites, ref. *Checklist review and approval preliminary site investigation report, Volume II-2.2-b*.

2.2.3 Task 2.2 output

The output of this task is the conclusion whether or not the site should be regarded as a contaminated site. If so, the next steps of the process of assessment and remediation, Step 3 notification and Step 4 prioritization should follow in succession. After that the remediation investigation (Step 5) can proceed.

If the site is not regarded as contaminated site it is not necessary to continue the process of assessment and remediation of the site. The site information and the decision should be registered by submitting it into the database.

Volume I

Step 3 Notification of polluted site

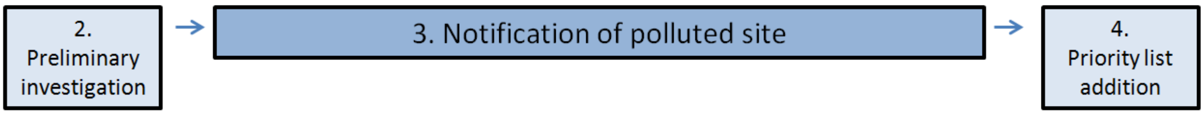
Step 3: Notification of polluted site

3.1 Introduction to and scope of Step 3

General description and connection to other Steps
Step 3 concerns the notification of a contaminated site by the competent authority as a ‘polluted site’ as defined in Box I-3.1 which requires remediation. Furthermore this notification has the effect of restricting further on-going activities at the site, depending upon the threats caused by the contamination.
Parallel to the above activities, parties responsible for contamination need to be identified and liability for the remediation and for paying the cost of remediation and rehabilitation of the affected environment and community needs to be assigned to them.

> **Box I-3.1 Definition of a polluted site**
>
> A polluted site means areas where hazardous substances exist at levels and in conditions which may pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living creatures, plants, micro-organisms, property, water quality or the environment in general, determined in the manner prescribed.

This is the third step in the process of assessment and remediation of a contaminated site.
The figure below shows how this Step is connected to the preceding and subsequent steps within the sequence of site assessment and remediation. Step 4 Priority list addition can be carried out parallel to this Step 3.



Activities
Within this step there are a number of activities to be performed. Most of these activities are on institutional, legal and financial aspects. For guidance on those activities we refer to the National Program for Remediation of Polluted Sites (Final Task 4 report, PWC Dec. 2015). Here, the guidance focuses on the technical aspects, and hence on the following activities:

1) Delineate the site;
2) Impose site use restrictions and temporary safety measures.

Responsible Parties
The activities in this step are typically carried out by technical, legal, financial and social specialists within the competent authority for the assessment and remediation process. The team involved should be able to interpret the technical information and recommendations of preliminary site investigation reports, and to link these properly to institutional, legal and financial consequences. Review is typically performed by senior staff members, to prepare the regulatory decision by the appropriate official.

3.2 Guidance for performing the activities of Step 3

This section presents concise guidance for the performance of the activities within Step 3. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Delineate the contaminated site

In order to notify a contaminated site as polluted site the boundaries of this site need to be established. Based on the preliminary site investigation report an overview of the contamination of a site is provided. All relevant sources, pathways and receptors of concern have been identified, described and preferably marked on a map. Although a preliminary site investigation is not intended for delineation of the contamination the collected information should provide a first indication of the contaminated area. This indicative information should be used to delineate the site. As these data will be used to notify a site, a decision with potentially far reaching consequences, proper care should be applied while performing this activity. When assessing the preliminary site investigation report it should be confirmed that the report contains at least the following elements:

- Sufficient data, both from historical sources as well as from the field, on the contamination situation in soil and sediment and, if applicable, in groundwater and surface water. These data should comprise at least the location of all samples and, if applicable, monitoring wells, a description of the stratigraphy and composition of the soil, the depth of the groundwater table, relevant observations from site inspection, and results of laboratory testing;
- Proper interpretation of all data and clear summary of the results;
- Conclusions, which can be related to the results.

Box I-3.2 provides some practical tips for the delineation of a contaminated site.

The data collected from official sources need to be verified through consultation of officials concerned with land matters.

Stakeholder	Interview objective	Level
Local authorities, including Patwari, Kotwal, Revenue Department	collect and verify information	local
District Collector	collect and verify information	district

When interpreting the data it may appear that the situation involves not one contaminated site, but several. In such a case, all identified contaminated sites need to be distinguished and assessed separately before notification can take place.

During the remediation investigation, Step 5 in the sequence of steps of assessment and remediation, further information will be developed so that more detailed delineation of the contaminated site from the surrounding area can be made.

Box I-3.2 Practical tip: How to delineate a contaminated site

The possibility for delineation of the contaminated site and the level of detail involved depends on the quality of the available information. It is always important to combine different pieces of information such as:

- The information collected during the desk study provides an indication of the situation of the presumed contamination at the site:
    - the industrial activities and the location of specific activities may indicate where typical waste material may be located and what will be the chemicals of concern;
    - the geological and hydrological characteristics may indicate the pathways of the contamination and where spreading of contamination is expected. Information about the time since polluting activities started and the permeability of the soil and the direction and speed of the groundwater flow may provide a first indication of the distance to where contamination might have spread. For contaminated sediment information of surface water flow is necessary to have an indication of the distance to where contamination might have spread;
    - the previous and current land use may indicate activities through which contaminated material can be moved or covered. This may have caused a totally different situation of the contaminated site than initially caused by the polluting activities.
- Maybe previous investigations already provide some information about the boundaries of the contamination.
- During site inspection sensory observation of contaminated material or information of effects of the contamination may indicate the presence of this material. If a presumed source of contamination is detected the surrounding area should be searched to find out where there is no indication of this material anymore. This can e.g. be the color of material lying at the surface, the shape and differences in height of the surface level or differences in vegetation. Combined with the results of the desk study a first rough conceptual site model (CSM) can be developed. In this CSM the area where contamination may be indicated.
- The preliminary site investigation report provides concentration levels of samples (soil, sediment, groundwater or surface water) which may indicate the locations where contaminated material is present and other locations where the levels do not exceed background concentration values. Possibly the sources of contamination presumed from the desk study can be confirmed.
- These results can support or contradict the conceptual site model, so this model can be updated incorporating the new information.

<u>Activity 2 – Impose site use restrictions and temporary safety measures</u>

Once a site has been notified this automatically sets in motion the next steps in the assessment and remediation process. It should be noted that often this sequence can take a lot of time, due to multiple reasons, e.g. the further investigation of the site and the preparation of the remediation may be technically complex or it may be necessary to carefully study remediation options before selecting the most effective and efficient option. Also, funding of the further assessment and remediation steps can take time. Furthermore, plans for redevelopment of the site or the surrounding area may define the moment when remediation works should start.

It may be that threats to human health or to the environment are assessed to be very severe, resulting in the need to rapidly respond to these threats. This can be the case if e.g. a clear relation can be made between the contamination of the site and current health problems of people living at or near the site (or in case this kind of threats is likely to occur in the very near future). If remediation works cannot start at short notice restrictions to the current site use and monitoring of the contamination should be considered.

By applying temporary safety measures the imminent risks caused by the contamination can be managed. An example of a temporary safety measure is to place fencing thereby implementing the site use restriction of prohibiting access.
If this leads to the necessity to make special arrangements for water and food supply the State Government may need to be involved.

A comprehensive overview of potential site use restrictions and temporary safety measures is presented in the *Checklist restrictions to site use and temporary safety measures, Volume II-3-a*.
Two examples of temporary safety measures are illustrated in the figures below.

Figure I-3.1: Example of fencing of a contaminated site

Figure I-3.2: Example of temporary safety measure to prevent new contamination from spill. The clamp is applied to stop a leak on a leaky pipe header running

3.3 Step 3 output

The output of this step is the site being notified based on the delineation and the conclusion whether there are site use restrictions which require the need of temporary safety measures. Further result of this step is information which relate to former contaminating activities and possible responsible parties.

Step 4 Priority list addition can be carried out parallel to this step 3. After that the remediation investigation (Step 5) can start.

If there is not enough information to delineate the site and as a result of that notification is found not be possible more detailed investigation should be considered.

Volume I

Step 4 Priority list addition

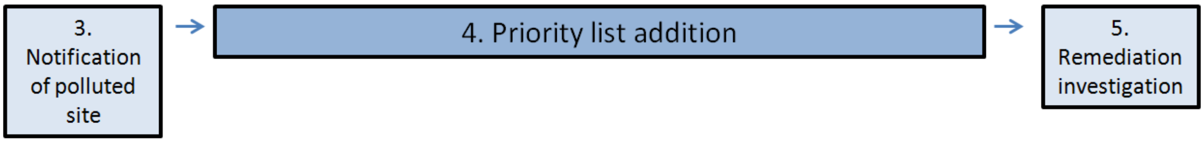
Step 4 Priority list addition

4.1 Introduction

General description and connection to other steps
Step 4 concerns the ranking of contaminated sites according to the priority their further investigation and remediation warrants, in comparison to other contaminated sites. This priority is related to the threat to human health and environment. A computerized database of priority sites with ranking features will be maintained and updated by the competent authority.

This section will discuss the technical aspects of this listing process, i.e. the application of prioritisation criteria to the parameters of a specific contaminated site. Step 4 commences with the assessment of relevant data on the site and ends with the presentation of a priority score for the site.

The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation. It should be noted that this Step may be performed in parallel with Step 3 Notification of polluted site.



Activities
A number of activities are performed in Step 4. In this document only the technical aspects to these are discussed:

1) Assess available data on the contaminated site;
2) Apply prioritisation algorithm to obtain priority score.

For detailed guidance on the prioritisation algorithm we refer to the Report of Prioritization of sites (part of NPRPS-Inventory and mapping of contaminated sites, COWI, Dec. 2015). The mentioned report includes explanation on two stages of prioritization. In this section we refer only to Stage II prioritization which is relevant for sites where a preliminary investigation has been carried out.

Responsible parties
The activities in this step are typically carried out by the competent authority for the assessment and remediation process. The team involved should demonstrate ability to interpret the information and recommendations of preliminary site investigation reports. This requires in-depth knowledge of and experience with the characteristics of contaminations (e.g. mobility, biodegradability) and its potential effects on humans and the environment.

4.2 Guidance for performing the activities of Step 4

This section presents concise guidance for the performance of the activities within Step 4. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

<u>Activity 1 – Assess available data on the site</u>

The first activity is to assess the available relevant data required for the prioritization system. Relevant parameters are listed in Table I.4.1 below. This table also indicates from which data sources these data may be retrieved.

Table I.4.1 Parameters relevant for prioritisation system

Parameter	Data source
On the source	
source concentration	site inspection or site investigation report
quantity of source	site inspection or desktop study
toxicity factor	Geoenviron Data Base
mobility factor	Geoenviron Data Base
On the pathway	
containment (access to contaminant)	technical judgement based on site access
attenuation reflecting directness of path to receptor	reflecting directness of path to receptor (including distance to receptor and groundwater vulnerability)
On the receptor	
land use	desktop study, site inspection
population at risk	desktop study, site inspection
sensitivity of receptor	site inspection
groundwater system at risk	Central Groundwater Boards, site inspection
surface water at risk	State Governments for Rivers, site inspection
sensitive ecosystems	scoring based on distance and type of sensitive ecosystems

The data collected from official sources need to be verified through consultation of officials concerned with land matters.

Stakeholder	Interview objective	Level
District Collector	collect and verify information	district

Activity 2 – Apply prioritisation algorithm to obtain priority score

In this activity the available data on the parameters listed in Table I.4.1 are processed in the prioritisation algorithm. To enable this, the data need to be converted into numerical values eligible to process the algorithm. Basic guidance for this is provided by table I.4.2 below.

Table I.4.2 Parameter values for prioritisation system

Code	Parameter	Scoring basis	Scoring range
On the source			
C	Source concentration	Marks as Low, Medium, High or ratio to Screening Level	0 – 10
Q	Quantity of source	Volume, or Low, Medium, High	0 – 5
T	Toxicity factor	A list of chemicals	0 – 5
M	Mobility factor	List of chemical characteristics	0 – 5
On the pathway			
F	Pathway Factor = containment * attenuation	 access to source directness to source	0.8 – 1 0.4 – 0.5 0.4 – 0.5
On the receptor			
L	Land use at the site	Low, Medium, High risk	0 – 10
P	Population at risk	log(pop) within 1 km radius or Low, Medium, High	0 – 10
S	Sensitivity of receptor	Low, Medium, High	0 – 30
G	Groundwater system at risk (use/importance of aquifer)	Low, Medium, High	0 – 10
SW	Surface Water at risk (use/importance of surface water)	Low, Medium, High	0 – 10
E	Sensitive ecosystems	Distance to designated reserves, etc.: Low, Medium, High	0 – 5

Once the data on the parameters have been converted into a score within the scoring range these scores can be applied into the following prioritisation algorithm:

Priority score = [C + Q + T + M](F) + [L + P + S + G + SW + E]

The *Checklist information for application prioritization system Volume II-4-a* provides additional guidance on the parameters needed to effectively use the prioritisation system.

Figure I-4.1: Example of contaminated material at the surface

Figure I-4.2: Example of possible receptors at contaminated site

4.3 Step 4 output

The output of this Step 4 is a priority score for the contaminated site at hand, which should be used to prioritize the site in relation to other contaminated sites and subsequently to include the site at the Priority list.

Volume I

Step 5 Remediation investigation

Task 5.1 Detailed site investigation

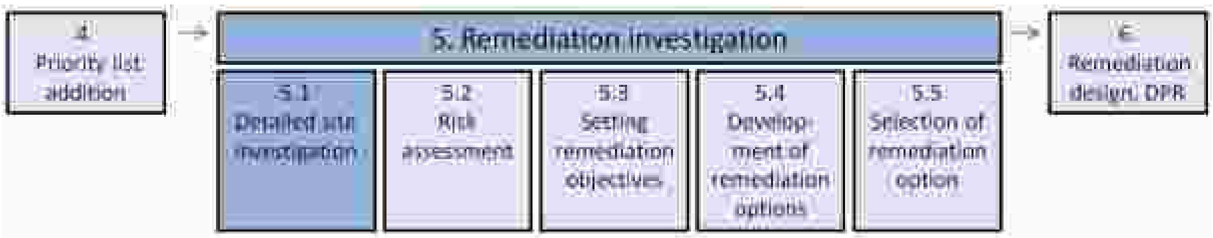
Step 5: Remediation investigation

Task 5.1: Detailed Site Investigation

5.1.1: Introduction to and scope of Task 5.1

General description and connection to other Steps and Tasks
Task 5.1, Detailed Site Investigation, concerns the identification of the nature, extent and concentrations of the substances at the contaminated site and of the site conditions. The results provide key information for risk assessment and the development of remediation options.

The figure below illustrates how this task 5.1 is connected to the preceding and following Steps and Tasks in the sequence of site assessment and remediation. The risk assessment may be developed sequential to the detailed site investigation and the results may be combined in one report.



Activities
The following activities are performed in Task 5.1:
1) Investigation strategy
2) Fieldwork and laboratory testing
3) Analysis and interpretation of exploratory data
4) Reporting detailed site investigation

Responsible Parties
This activity is typically carried out by technical specialists of the specialized agency/consultant appointed to carry out the site investigation. The work should be supervised by a senior colleague. Cooperation with the site owner and competent authorities is necessary to prepare the field work and to grant access to the site.
The team involved should demonstrate in-depth knowledge and experience in the investigation of contaminated sites and interpretation of exploratory results in relation to information obtained from reports and maps on the topography and geology of a site. It may be required to involve experts on modelling groundwater flow and subsurface transport of contamination.
The field work team should have relevant expertise, experience and skills for the site inspection and sampling. The laboratory work has to be carried out by an accredited lab.
For complex issues regarding the interpretation of exploratory results research institutes may be involved.

5.1.2 Guidance for performing the activities of Task 5.1

This section presents concise guidance for the performance of the activities within Task 5.1. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Investigation strategy

The starting point of the detailed site investigation is to define the scope for the investigation and to establish the required information. The detailed site investigation is generally aimed at:

- Providing comprehensive information on the nature, extent and concentrations of the substances at the contaminated site:
  - delineation of the area of the identified contaminating substances in soil, groundwater, sediment or surface water, related to the sources of contamination at the notified contaminated site (Step 3);
  - location and contours of concentration levels of the contamination;
  - assess contaminant dispersal in soil, groundwater, surface water, sediments, air and dust, direction and speed of spreading
- Providing information on the site conditions to identify and assess all contaminant pathways with respect to assess risks (refer to Task 5.2 for Risk assessment) such as a comprehensive geological and hydrogeological assessment;
- Providing information on site conditions to assess possible options for remediation (refer to Task 5.4 for Development of remediation options), e.g. permeability of stratigraphic subsurface layers, density of soil material, or concentration of general parameters in groundwater (iron, related to groundwater abstraction techniques).

Information of the contaminated site already has been obtained by a preliminary site investigation which provides a detailed history of the site use and an identification of all major sources, pathways and receptors of concern. Although the primary purpose of a preliminary site investigation has not been to delineate the contamination an indication of the extent of and boundaries to the contamination should be described.

The Conceptual Site Model is a key element during this detailed site assessment. The CSM enables the investigator to visualize the possible sources, pathways and receptors and focus on the areas for investigation relevant at the site, refer *Volume III-2.2-i, Manual Conceptual Site Model and identifying the Source-Pathway-Receptor*, on how to apply the CSM.
In the preliminary site investigation (Task 2.2) the CSM already has been developed.

If there is doubt on the results of the preliminary site investigation or if the report cannot be regarded as valid anymore, parts of the desk study or identification of sources, pathways and receptors should be carried out again in the detailed site investigation phase. Depending on the land use and changes and the contaminated substances involved, a period of 5 years can be used as a rule of thumb as the period for carrying out an update of the preliminary site investigation.

Detailed site assessment is always a site specific exercise for which a specific investigation protocol should be developed. An example of the development of an investigation strategy is included in *Example investigation strategy detailed site investigation, Volume III-5.1-i*.

Based on the investigation strategy a detailed investigation protocol is prepared, regarding assessment of the contamination levels of the source and identification of the major pathways and receptors of concern. This protocol should pay attention to the following elements:

- Required information and data gaps;
- Screening and sampling technical equipment (refer *Overview of techniques for site remediation (Volume III-2.2-iii*), an example is illustrated in figure I-5.1.1 below;
- Sampling rationale and design (media, locations, pattern and depth of samples) and the required level of detail of information), refer to Box I-5.1.1 below for an example;
- Number of samples;
- Screening of observations wells or necessity for drilling new wells;
- Necessity for multisampling events;
- Methods for establishing stratigraphy and characteristics of subsurface layers;
- Analytical test parameters for determination required. Based on the chemicals of concern as reported in the preliminary site investigation. In addition parameters referring to risk assessment or the applicability of remediation techniques may be tested (e.g. inorganic chemistry to describe redox conditions and potential for natural degradation, macro ions for assessing water treatment, bacterial analyzes, etc.).;
- Restrictions for investigation such as buildings, subsurface infrastructure and site boundaries;
- Quality assurance and quality control procedures such as use of field blanks/trips blanks, procedures to avoid cross contamination by sampling equipment etc.

Box I-5.1.1 Example for sampling design

The spacing and number of sampling points depends very much on the situation of the contaminated site. Based on experience the knowledge has gained that no generic sampling designs and no minimum protocol should be applied during the detailed site investigation phase.

To explain the differences in design for two totally different situations of contamination an indication on the number of sampling points are mentioned:

- Top layer of soil contaminated with heavy metals on a site of 1 ha: to achieve a representative impression of the actual situation about 10 boreholes may be drilled and for every distinct soil layer (at least every 50 centimetres) a sample will be taken;
- Volatile hydrogen chloride contamination has infiltrated the soil into the base of the aquifer: applying a CSM is of major importance to understand how the contamination may be located in soil and groundwater. The number of sampling points is not simply related to the surface of the above example of a contaminated top layer. Maybe tens or even hundreds of samples may be necessary to delineate the contamination. Apart from the primary contaminant parameters other parameters are required to obtain information of the macro chemical and biological situation of the aquifer.

Figure I-5.1.1: example of field work: tripod for drilling boreholes and placing water wells

Elements for Terms of Reference for the detailed investigation of a specific site may be selected from the topics in the *Checklist for detailed site investigation report, Volume II-5.1-a*.

<u>Activity 2 - Fieldwork and laboratory testing</u>

The field work may be assigned to experienced fieldwork teams of third parties. Samples should be tested in a laboratory to assess the levels of contamination in the sample. Laboratories should operate in accordance with required accreditation criteria.
For the selection of third parties the *Checklist prequalification for site investigation including ToR, Volume II-2.1-a* may be used.

The fieldwork needs to be prepared by arranging access to the site and in consultation with important stakeholders. Furthermore, sampling equipment needs to be prepared.

The stakeholder consultation is needed, both to inform them on the fieldwork plan and to secure their support for the plan. The consultation may also yield information that can be useful in the final design of the fieldwork plan. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may for the state and national levels only be applicable to large scale sites.

Stakeholder	Interview objective	Level
Site owner	exchange information, secure support	site
Site operator's health facility director	exchange information, secure support	site
Local businesses, residents and NGO's	exchange information, secure support	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	exchange information, secure support	local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	exchange information, secure support	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	exchange information, secure support	national

During the site investigation health and safety guidelines have to be taken into account by the field work team (refer *Volume III-2.1-i SIP, section 3*).
The sampling should be carried out by using the Sample Protocol (refer *Volume III-2.1-i SIP, Appendix A*).

The activities in the field should be described in a logbook of the field work team. The activities carried out should be accurately described for inclusion in the report.
The descriptions should be accompanied by sketches and pictures of the site (location of sources, dimensions, distances to receptors, significant site features, with marking of north arrow and scale. The locations of exploratory holes, wells or other observation points should preferably be indicated by XYZ-coordinates, using GPS. Possible deviations from the original investigation protocol should be described in detail (refer Box I-5.1.2 below).

Box I-5.1.2 Practical tip: flexibility during field work

During field work activities certain observations may lead to considerations for deviation of the original investigation protocol. Therefore it is required to maintain flexible on fieldwork activities to achieve good results in an efficient manner. Based on the initial field work results additional samples and testing may be appropriate in case of unexpected indications of pollution. Multiple sampling events have to be taken into account and an iterative approach of detailed site assessment may be considered for efficiency reasons.

Activity 3 - Analysis and interpretation of exploratory data

Interpretation laboratory testing results against Screening and Response levels
The laboratory test results should be tabulated and recorded in terms of concentration levels for each parameter / substance per sample. These concentration levels are compared with the appropriate *Screening levels and the Response levels, Volume II -2.1-b*.

In some areas the natural background levels may be higher compared to the Screening levels, e.g. the natural background levels of metals and other inorganic chemicals can vary widely and this should be taken into account when applying the screening levels. Where it can be demonstrated that natural background concentrations are elevated (e.g. heavy metal concentrations in mineralised areas), it would be appropriate to develop less stringent assessment criteria. However care needs to be taken when establishing the level of the natural background and its natural variation as the local background may be influenced by historic mining and/or waste disposal activities.

Analysis of groundwater flow and assessment of contaminant transport
Contaminants released into the soil can work their way down through the unsaturated zone into groundwater and can create a contaminant plume within an aquifer. Transport in the aquifer is mainly caused by movement of water (advective transport and dispersion). Within the aquifer the contaminant is spreading over a wider area, its advancing boundary often called a plume edge, which can then intersect with groundwater wells and springs, making the water supplies unsafe for humans and ecology.
Various mechanisms have influence on the transport of contaminants in the aquifer, e.g. diffusion (which is important in case groundwater flow is limited and in case of dissolving of substances in water), adsorption and decay. Analysis of groundwater systems is the basis for a good understanding of the transport of contaminants. Therefore a conceptual site model has to be developed which includes the understanding of transport in the groundwater.

Contaminating fluids are seeping into the soil in a vertical direction. Depending on the density of the fluid it will spread (float) on top of the groundwater level, e.g. for mineral oil, of seep through the groundwater to reach an impermeable layer.

The stratigraphy of the area plays an important role in the transport of these pollutants. An area can have layers of sandy soil, fractured bedrock, clay, or hard pan. Areas of karst topography on limestone bedrock are sometimes vulnerable to surface pollution from groundwater. Therefore information from hydrogeological data and site specific soil profile descriptions are important.

For analyzing and mapping of the hydrogeological systems and spreading of contaminants a variety of direct and indirect information is required. For describing the regional systems these data are usually available in various databases. But for the shallow and very local systems (characteristic surfaces be 100 to 2500 m2) should be obtained through additional information.

Three types of information are required for compiling a complete hypothesis for the distribution of a contamination in a particular area:

1. geological and hydrological information of the subsoil: this involves the information of the whole area, but also information from boreholes etc. and expert knowledge about the relationship between the composition of the soil and the pattern of the spreading of the of contamination (hydrology);

2. Information on soil contamination: This relates to information about pollution in the area. This is data from soil information databases and reports, combined with expert knowledge about the spreading of the contamination;
3. other information of interest for carrying out the assessment, in particular the location of (drinking) water extraction.

The items below indicate the required parameters for hydrogeological investigation and prediction of spreading of contamination.

Geographical information of the subsoil:

- Presence, thickness and resistance / composition of a top layer, including:
  - risk of occurring of local (natural) changes in continuity
  - risk of occurring of excavation / disruption of the top layers (large buildings, drawn construction piles, tunnels, hydraulic head of the top and bottom layers)
- Thickness of the upper aquifer, including:◦
  - variability in thickness and composition of the aquifer
  - information on the groundwater flow and recharge of the aquifer
- Information on the hydrology, including:
  - Patterns of hydraulic head (isohypse maps), based on data over a period of at least one year
  - Replenishment of groundwater
  - Information on the geochemical characteristics of the geological layers: organic matter, clay matter, ironhydroxide, cation exchange capacity, sulfides, porosity, grading.

Information on known contaminants:

- Contaminants present in groundwater
- Characteristics of the substances: density, solubility, adsorption level
- Levels of contamination
- Depth of aquifer in which the contaminants are found, related to soil structure.
- Whether or not passage of the top layer has occurred
- Length and shape of ground water plumes, taking into account the age of the contamination
- Direction of spreading of the groundwater plumes
- Volume of groundwater plumes, taking into account the age of the contamination
- Information on the activity which has caused the contamination (type of industry/activity and scale and volume of used substances during process)
- Presence of floating layers (LNAPL) and sinking layers (DNAPL)

Site-specific information on distribution and spreading of contaminants:

- The degree of disturbance of the spreading of the plumes by groundwater extraction (e.g. for construction purposes).
- Is spreading through sewage system applicable in the present area?
- Multiple sources upstream of the site?

Other information:
Location and types of receptors (i.e. drinking water wells, areas of drinking water catchments, valuable ecosystems).

The results of measuring groundwater levels in observation wells should be outlined in a contour map. This should be combined with interpretation of the geological, hydrological and hydrogeological features of the site to estimate groundwater flow direction and speed.

For complex situations it may be required to carry out modelling of groundwater flow and contaminant transport and information on general geochemical parameters should be collected during fieldwork (refer to *Tools for risk assessment, Volume III-5.2-i*).

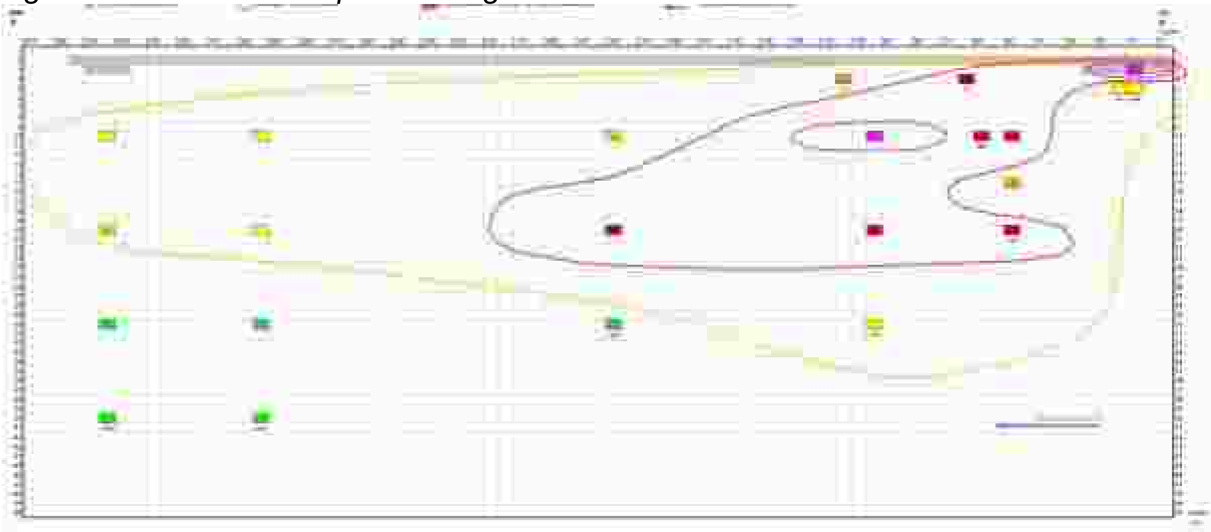
<u>Activity 4 – Reporting detailed site investigation</u>

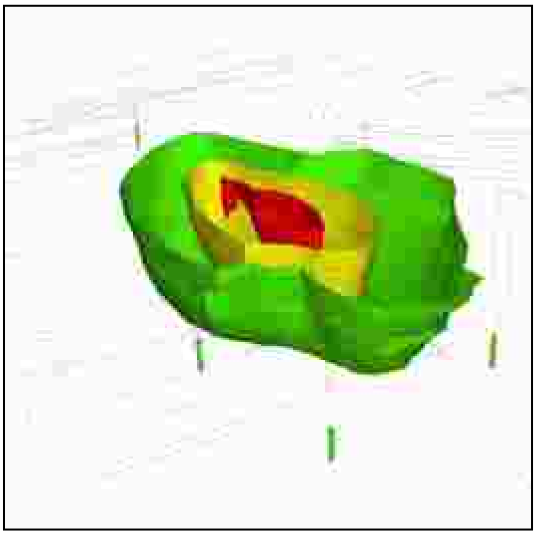
Details of all activities carried out, the equipment and methods used and the results of the detailed site investigation should be included in the site investigation report. The chapters of the report should be arranged in the same sequence of the investigation activities (refer *Checklist for detailed site investigation report, Volume II-5.1-a*).

The relevant elements of the previous report of the preliminary site investigation should be incorporated in the report of the preliminary site investigation.
The Conceptual Site Model should be reviewed and adjusted based on the results of the detailed site investigation.

The extent and amount of contaminated material and the manner it has been migrated should be described and outlined trough maps. Concentration levels and delineation of contaminated soil, groundwater and sediment can be explained clearly in this way. More than one map and use of colors for different categories of concentration levels may be required for optimal result. If there are uncertainties they should be indicated clearly. It may be not necessary to fill all data gaps because the decision on the remediation may not be depending on it.

Figure I-5.1.2.a-c: example drawings of contamination situation





When interpreting the data it may appear that several zones of distinct contamination can be present within the single contaminated sites. Each may be sufficiently distinguished to represent a contaminated site in it's own right. This is important regarding the confirmation of legal notification of the contaminated site which has taken place in Step 3.

Finally, a conclusion should be drawn regarding the predefined scope of the investigation. Recommendations should be provided for the next step in the remediation investigation process. If there is not enough information to draw a conclusion a recommendation for further investigation should be provided.

The report has to contain as much as possible verifiable information meaning that copies of all original data from desk study, site inspection, exploratory field work and laboratory testing and modelling should be provided in annexes.
The investigating organisation should ensure appropriate quality assurance protocols and systems have been adhered to including prescribed protocols, the calibration of

field instruments, proper sampling and collection techniques and by providing records of responsibility, non-conformity events, corrective measures and data deficiencies.

Before proceeding to the risk assessment and further steps in the preparation of remediation it is useful to discuss the results with the competent authority regarding contaminated sites.

5.1.3 Task 5.1 output

The output of this Task 5.1 provides clear information on the nature, extent and concentrations of the substances at the contaminated site and on the site conditions. A checklist of elements a detailed investigation report may contain is presented in *Volume II-5.1-a.*

The competent authority responsible for reviewing the risk assessment report may refer to the checklist mentioned above. First, it needs to be determined which of these elements are relevant for the situation at hand. The competent authority may then proceed by assessing whether the report contains all these relevant elements. Data in the report should be complete and presented clearly. Most importantly, the report should show that the data and other information underpin the conclusions and provide enough information for risk assessment and development of remediation options.

Volume I

Step 5 Remediation investigation

Task 5.2 Risk assessment

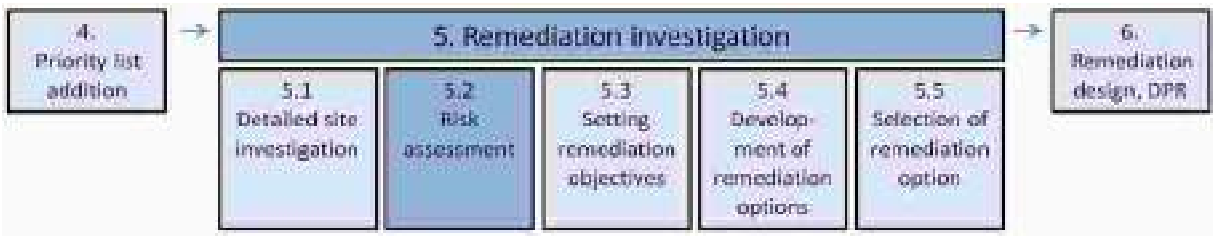
Step 5: Remediation investigation

Task 5.2: Risk Assessment

5.2.1 Introduction to and scope of task 5.2

General description and connection to other Steps and Tasks
Task 5.2, "Risk Assessment", concerns the assessment of the risks caused by the contamination as investigated during Task 5.1 Detailed site investigation. Risk assessment is the process of identifying, assessing and evaluating the risks that may be associated with a threat to human health and/or the environment at a contaminated site. The result of the risk assessment provides information to determine if remediation is warranted and if so, to provide input for the selection of remediation objectives and the development of remediation options. This way, the remediation objectives established in Task 5.3 and the remediation options developed in Task 5.4 are aligned with the identified risks.

The figure below illustrates how this Task 5.2 is connected to the preceding and following Steps and Tasks in the sequence of site assessment and remediation.



Activities
The following activities are performed in Task 5.2:

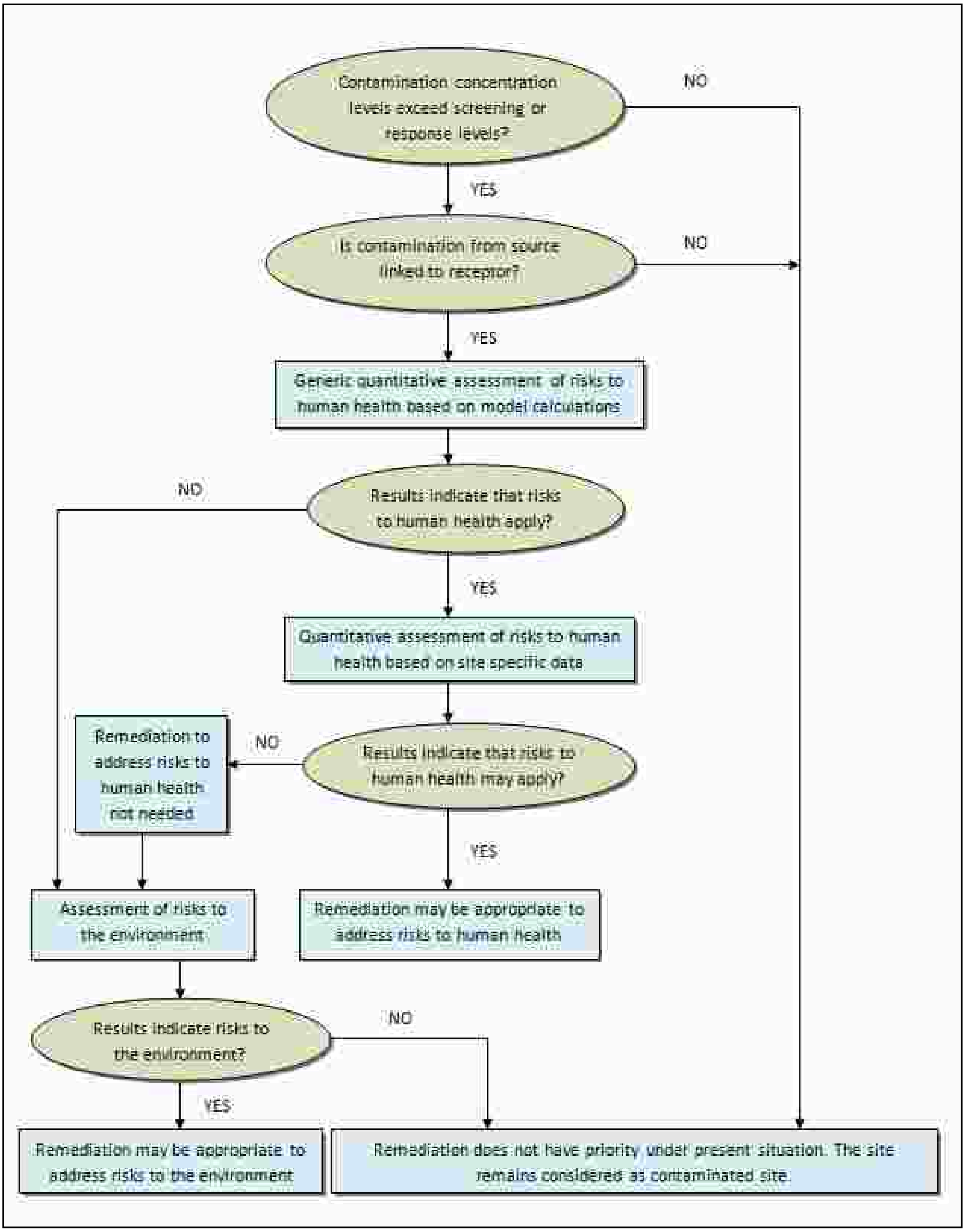
1. Assess contaminant concentration levels;
2. Identify applicable source-pathway-receptor-combinations for human health;
3. Perform a generic quantitative risk assessment for human health;
4. If necessary, perform a more detailed quantitative risk assessment for human health;
5. If necessary, perform a risk assessment for the environment.

This sequence of activities provides a tiered approach to achieve a sound and efficient decision on whether the contamination leads to risks for human health and/or the environment in the current situation at the site. This is visualised in figure I-5.2.1

Responsible Parties
The activities in this step are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant.

The team involved should demonstrate in-depth knowledge and experience in the risk assessment of contaminated sites. For complex risk assessment studies research institutes may be involved.

Figure I-5.2.1 Flowchart tiered approach for risk assessment



5.2.2 Guidance for performing the activities of Task 5.2

This section presents concise guidance for the performance of the activities within Task 5.2. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Assess contaminant concentration levels

The aim of this activity is to draw a preliminary conclusion on whether the pollution may cause risks. This is done by comparing the contaminant concentration levels described in previous investigation reports with general key values for soil, sediment and groundwater quality (refer *Screening and Response levels, Volume II-2.1-b*). This activity may have been performed during the preliminary or detailed site investigation. In that case the results of the activity should have been incorporated in the respective site investigation reports.

In cases where the contaminant concentration levels are below the Screening levels it can be concluded that there are no relevant risks to human health or the environment. Based on this the competent authority may decide to remove the site from the Priority list of contaminated sites and determine as investigated site.

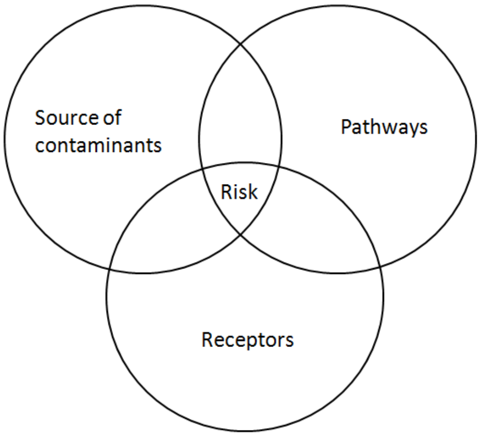
In case contaminant concentration levels exceed the Response levels there may be risks involved. This means further risk assessment is required, which would typically commence by proceeding to activity 2.

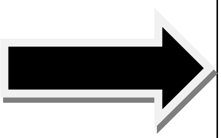
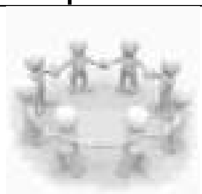
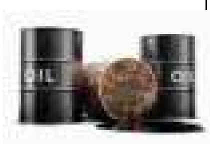
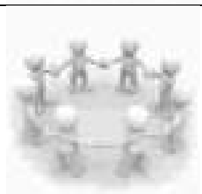
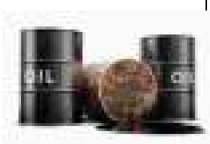
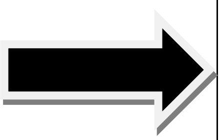
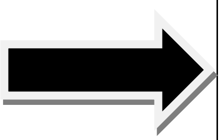
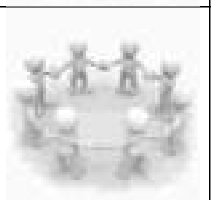
Activity 2 – Identify applicable source-pathway-receptor combinations for human health

The occurrence of risks depends on three components: source, pathway and receptor. It is important to note that all three of these components must be present for risks to occur. This is illustrated in figure I-5.2.2. In a situation where for example high concentrations of chemicals occur in a source but there are no receptors that can come into contact with these chemicals then risks cannot occur. It has to be emphasized that in future the situation of the site may change and contact with chemicals may become a possibility.

- Source: the location from which a contaminant(s) has entered or may enter a physical system. A primary source, such as a location at which drums have leaked onto surface soils, may produce a secondary source, such as contaminated soils;. Sources may hence be primary or secondary
- Pathway: the course through which contaminants in the environment may move away from the source(s) to potential environmental receptors.
- Receptor: humans and other living organisms potentially exposed to and adversely affected by contaminants because they are present at the source(s) or along contaminant migration pathways.

Figure I-5.2.2-a and b Risks occur only if source, pathway and receptor are all present (demonstrated in two different ways)



Source	Pathway	Receptor	Risks?
			Risk from this source may apply for this receptor
			
			No risk from this source for this receptor
			

Therefore, to assess whether the contamination may pose risks to human health and/or the environment it should first be established if all three components are present. This is typically done by identifying which combinations occur of the source from which contaminants are released, the transport medium that carries the contaminants to the receptors and the receptors that may come into contact with the contaminants. This is the qualitative phase of the risk assessment process. A diagram may be used to visualise the combinations that occur at the site. Such a diagram clearly shows the exposure routes (refer *Tools for risk assessment, Volume III-5.2-i* for an example). The resulting diagram serves as a basis for the quantification of risks, as in that phase attention should be paid only to the potential source-pathway-receptor-combinations.

The source-pathway-receptor-combinations applicable to assess human risks depend on the structure and use of the contaminated site and its vicinity. The source-pathway-receptor combinations resulting in the most threatening exposure are:

- Contact of human with contamination through:
  - Direct contact with contaminated soil or groundwater (ingestion of soil or groundwater, inhalation of dust, dermal uptake of contaminants from the soil or from the groundwater) (figure I.5.2.3 below);
  - Ingestion of cultivated crops grown on the contaminated site;
  - Ingestion of fish from contaminated water;
  - Ingestion of drinking water from contaminated groundwater;
  - Inhalation of indoor air influenced by contaminated soil or groundwater.
- For ecology:
  - Uptake of contaminants from the top layer of the soil;
  - The leaching of contaminants to surface water.

Figure I.5.2.3-a and b Examples of direct contact of human with contaminated soil and groundwater

<u>Activity 3 – Perform a generic quantitative risk assessment for human health</u>

In case relevant source-pathway-receptor-combinations are identified a generic quantitative risk assessment for human may be carried out in order to quantify the risks the contamination may pose to human health. This is done by applying a generic risk assessment model. Internationally, different generic models for risk assessment are applied. These models show varying degrees of complexity in investigation and many are related specifically to the local legislative requirements. Each has a slightly different emphasis, depending on the focus of the agency and the types of sites expected to be encountered. Examples of risk assessment models are presented in *Volume III-5.2-i Tools for risk assessment*.

For effective use of any of these models data from the detailed site investigation report are required as input. Otherwise, for this activity no specific measurements are performed.

Most of the models calculate the intake of contamination by humans, expressed in mg contaminant per kg bodyweight. To determine whether or not there are risks to human health, the intake of a contaminant needs to be compared to a certain critical exposure value. When this level is exceeded for one or more of the contaminants this implies the presence of an unacceptable risk for human health.

In case it is concluded that the results from this activity satisfactorily express the risks in the given situation the assessment of risks for human health may be concluded. However, most of the available generic models for risk assessment are 'conservative'. This means that the default parameters used and the calculation of the level of risk will tend to overestimate this level. This is an important drawback, because it should be avoided that model calculations indicate that there are no risks while in practice there are actual risks. Due to this conservative approach the model calculations may indicate risks to human health where in the actual situation there are no risks. If it is suspected that this situation occurs, the risk assessment can be refined by performing activity 4. Typically, the results of the risk assessment so far are discussed with the competent authority, to reach a shared conclusion on whether to perform Activity 4 or not.

Stakeholder	Interview objective	Level
Competent authority	provide information and discuss conclusion	level of competent authority

<u>Activity 4 – Perform a more detailed quantitative risk assessment for human health</u>

In this activity more detailed information is collected for a more refined site specific risk assessment. If so desired, this activity can also be carried out to support the result of the generic model calculation.

The site specific risk assessment is carried out by collecting additional relevant information, e.g. by measuring the concentration of substances in contact media such as indoor or outdoor air samples, drinking water samples, crop samples or dust samples. Care should be taken to measure in these samples the same contaminants that have been identified in the soil samples during the site investigation. Subsequently, the risk assessment model calculated concentrations in e.g. indoor air or crops can be replaced by measured concentrations. Because the results of these measurements are more reliable than the results of modelling, a final site specific conclusion based on measurements in contact media can be drawn.

<u>Activity 5 – Perform a risk assessment for the environment</u>

If the contaminated site is situated in an area with high ecological value (land use: forests and other natural area), it may be required to assess the risks the contamination poses to the environment. The decision on whether this requirement applies to the site at hand or not is usually discussed with the competent authority.

Stakeholder	Interview objective	Level
Competent authority	provide information and discuss conclusion	level of competent authority

For such an assessment a tiered approach is also applicable. An example of an available method is the Soil Quality Triad. This method of Dutch origin combines the results of three types of assessment: chemical analysis, toxicity tests and ecological field surveys. Based on integration of the results of these three surveys the assessment provides a sound basis for a decision on remediation.

5.2.3 Task 5.2 output

The output of Task 5.2 provides clear information whether the contamination causes unacceptable risks for human health and/or the environment or not. If risks are present, the assessment provides insight which part of the contamination causes risks and by which pathways. This is useful information for the development of remediation options.

The result of extensive detailed risk study might indicate there are no unacceptable risks involved for current and future land use. In that case the notification as contaminated site may be reconsidered. If risk assessment indicates there are no unacceptable risks for current land use but there may be unacceptable risks after change of land use the priority for remediation measures may be reconsidered and monitoring of the land use may be implemented.

The checklist of elements for a risk assessment report is presented in *Volume II-5.2-a.* The competent authority charged with reviewing the risk assessment report may refer to this checklist. First, it needs to be determined which of these elements are relevant for the situation at hand. The competent authority may then proceed by assessing whether the report contains all these relevant elements. Data in the report should be complete and presented clearly. Most important, the report should show that the data and other information underpin the conclusions.

Volume I

Step 5 Remediation investigation

Task 5.3 Setting remediation objectives and requirements

Step 5: Remediation investigation

Task 5.3: Setting remediation objectives and requirements

5.3.1 Introduction to and scope of Task 5.3

General description and connection to other Steps and Tasks
Task 5.3 is part of Step 5 Remediation Investigation and concerns the setting of remediation objectives and remediation requirements for the identified contaminated site.

Task 5.3 commences with the output from Task 5.2 which outlines where at the site contamination is resulting in unacceptable risks for the current or future site use. It ends with a clear focus on the remediation objectives and requirements including the considerations which have lead to them. This also forms the starting point for the subsequent Task 5.4.
The figure below shows how this Task is connected to the preceding and following Steps and Tasks within the sequence of site assessment and remediation.

Activities
The following activities are performed in Task 5.3:
1) Establish remediation objectives;
2) Establish remediation requirements.

Responsible Parties
The activities in this Task are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant.

The team involved requires knowledge of the remediation regulation and should demonstrate in-depth knowledge and experience of the environmental fate, transport and degradation characteristics of contaminants (e.g. mobility, biodegradability). In addition, the team should have experience of the performance of remediation techniques and their physical, hydrological and social impacts. Cooperation with the site owner (non-orphan site) and the competent authorities (orphan sites) would be appropriate, in view of the potentially considerable implications of decisions made at this stage.

A review and approval by the competent authorities is required before moving to the next task 5.4 ‘Development of Remediation Options’.

5.3.2 Guidance for performing the activities of Task 5.3

This section presents concise guidance for the performance of the activities within Task 5.3. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Establish remediation objectives

General principle governing this decision

The main aim of remediation of contaminated sites is to eliminate unacceptable risks of harm to human health and the environment or to reduce the risks to an acceptable level.

To eliminate the unacceptable risks complete removal or treatment of the contamination source is not always required. Often, the risk of actual exposure to high contaminant concentrations is limited, e.g. because the site is capped or because the contaminated material is above groundwater level. Therefore, the fundamental decision is to establish whether a complete restoration to pristine conditions is appropriate, or if an alternative approach is warranted. This approach would need to satisfactorily address the risks and would take into consideration the intended site use, costs, liability or long term obligations. This Section discusses the main considerations for this decision.

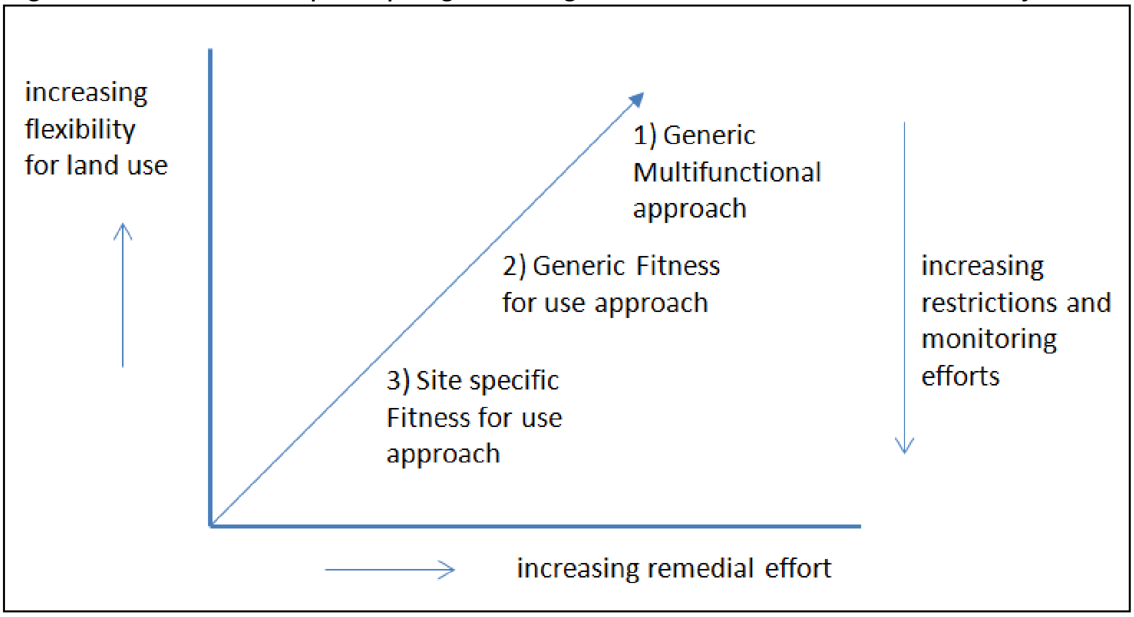
The decision on the remediation objectives is primarily governed by the general principle that more remediation effort results in increased land use flexibility/possibilities and less monitoring or maintenance requirements as illustrated in figure I-5.3.1.

The objective of complete restoration of a site to pristine conditions renders the site fit for all forms of land use. This is termed 'multifunctional', and requires a generic multifunctional approach, which will in practice mean complete removal of all contamination.

Alternatively, should complete restoration of the site be either not possible or desirable, the strategic decision will be to restore the site to such a level that is will be fit for the current or intended future use. This requires either a generic fitness for use or a site specific fitness for use approach. This approach can, for example, involve the blocking of exposure pathways or removal of affected receptors instead of removal of the source.

A generic multifunctional approach renders the site fit for all use without any post remediation constraints or liabilities. However, this approach typically involves high initial costs and sometimes high environmental impact regarding use of energy and materials and other negative effects. A fitness for use or cost effective approach is typically characterized by lower initial costs, but may result, depending on the situation, in considerable maintenance costs and site use restrictions.

Figure I.5.3.1General principle governing the decision on remediation objectives



In Box I-5.3.1 the major considerations which influence the selection of remediation objectives. For additional information, a.o. on international practices refer to *Background information for setting Remediation objectives, Volume II-5.3-a*.

Box I-5.3.1 Considerations for complete removal versus fitness for use

- Small site area and small volumes of contaminated material: complete removal or clean-up to background or target levels is relatively straightforward at such sites, and at relatively low cost.
- Liabilities: if the contamination is completely removed, there will be no potential future liabilities. This approach presents a high degree of confidence against any future legal claims or discussions regarding the presence of contamination. For this reason private companies may select this approach.
- Technical complexity and physical constraints, e.g. depth of the contaminants, groundwater depth, subsurface infrastructure, sensitive structures or the presence of other contaminants, may preclude complete removal;
- Long-term constraints and financial commitments, such as on-going monitoring and maintenance costs, and site use restrictions may not be appropriate.

If a fitness for use approach is selected, risk-based generic or site specific remediation target levels may be selected. The choice between either site specific or generic remediation target levels depends on cost-benefit considerations.

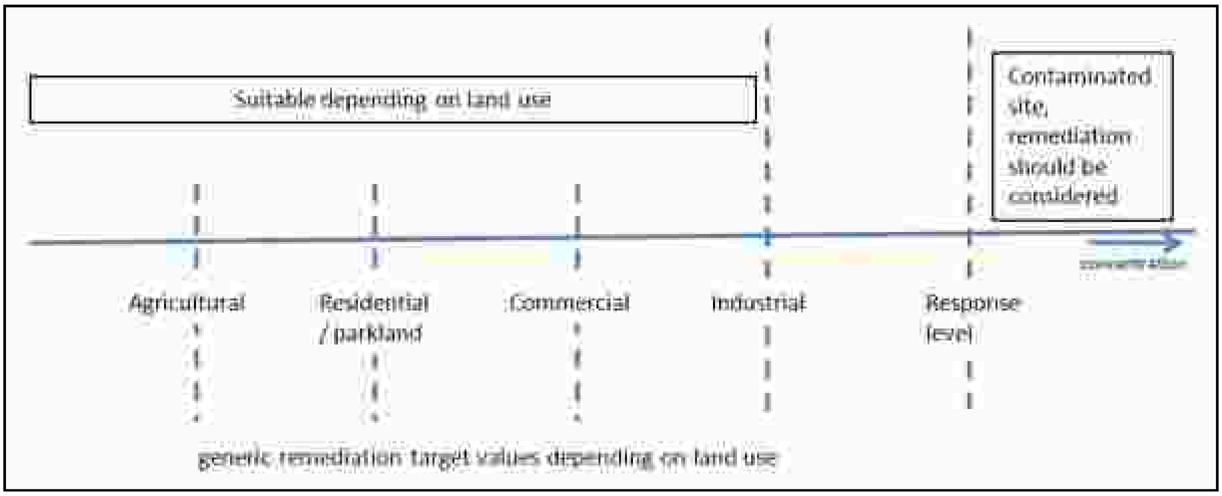
A generic target level will provide more future site use flexibility/possibilities. This because the target level is fit for a generic set of possible site uses within a particular land use category. Categories of land use are listed in Table I-5.3.1 below.

Table I-5.3.1 Categories of land use

Land use	Category of land use in regard of the generic remediation target level for soil and sediment
Agricultural land Kitchen garden Forests and other natural area	Agricultural
Habitation settlements (residential, school, kindergarten/playground, recreational park)	Residential / park land
Commercial	Commercial (relatively accessible sites)
Industrial Infrastructure (e.g. roads, parking, railway, subsurface cables and pipes) Waste land	Industrial (limited accessible sites)
Water bodies	For sediment depending on land use of the surrounding area
Mixed (to be specified for each use)	Select the most vulnerable of land use
Other (to be specified for each use)	Select the most vulnerable of land use

The decision on whether or not remediation is to be implemented is based on the assessment of contaminant concentration levels in soil (or sediment) and groundwater against the Response level. Remediation should result in a situation where the (lower) screening levels for the current or intended future land use are met. Figure I.5.3.2 below schematically shows the relation between the response levels on the one hand and the different screening levels on the other.

Figure I.5.3.2 Schematic overview of generic remediation target levels for soil and sediment and position relative to response levels



For the Screening levels the Canadian soil quality guidelines are applied. These generic soil quality guidelines present a level of negligible risk (soil remediated to these levels will represent a healthy, functioning ecosystem capable of sustaining the current and future uses of the site by ecological receptors and humans, including uses of groundwater). When the site investigation shows these levels are not exceeded no further investigation is required. These levels are below the Response levels which are based on the Dutch intervention values.

The Screening levels for soil and sediment are presented for four categories of land use: 1) agricultural, 2) residential/parkland, 3) commercial and 4) industrial land use. Each of these forms of land use represents a different impact of (contaminated) soil to humans and to the environment.
For groundwater the Indian Standards for Drinking Water are applied as generic target levels for remediation. If compounds are not addressed by these standards the generic remediation target levels are taken from Guidelines for Canadian Drinking Water Quality. Where Canadian values are also unavailable the levels from WHO Guidelines for Drinking water apply.

The Screening levels for the quality of soil, sediment, groundwater and surface water are listed in *Volume II-2.1-b*. It is proposed to align the generic remediation target levels with these site screening levels. In this way these levels can be regarded as remediation target levels within the framework of a generic fitness for use threat reduction. For comparison, the table also lists the response levels.

Application of generic remediation target levels is carried out as follows:

1) Determine the current or future use of the site and, if relevant, of groundwater and relate this use to one of the land use categories in Table I.5.3.1;
2) Determine remediation target values for soil (or sediment) and, if relevant, for groundwater by referring to the levels applicable to the relevant land use category in *Volume II-2.1-b Screening and Response levels*;
3) Establish whether specific conditions apply which may influence remediation target levels.

A site specific target level is tailor made for the site specific current or intended future site use (e.g. in case there are significant ecological concerns because of sensitive habitats for wildlife or endangered species). In case of special site characteristics (e.g. in case of a very large contaminated site which will result in very high remediation costs) or in case there are certain data gaps it may be recommended to develop site specific target levels as well. This offers cost effective remediation options, but minimizes site use flexibility/possibilities, because it is developed specifically for the use of the site at hand. Another advantage of using site specific target levels is that site specific background concentrations of naturally occurring substances can be taken into account (refer Box I-5.3.2).

Box I-5.3.2 Contaminants of natural origin

High background levels of naturally occurring substances may be present in soil or groundwater. For example, arsenic is a commonly occurring groundwater contaminant associated with particular geological formations. Remediating such contamination would be impracticable as natural replenishment of the contaminant would be inevitable. This underlines the importance to determine whether a contamination has been caused by human influence.

Cost benefit analysis is typically applied in cases of groundwater contamination. The costs associated with remediation of extensive plumes of dissolved contaminants within groundwater bodies can be extremely high without a clearly identified endpoint. The cost / benefit approach identifies a site specific remediation goal which optimises the remediation costs to reduce contaminant concentrations. Otherwise, the further, incremental reduction in contaminant concentrations achieved by additional effort can become significantly disproportionate to the cost involved.

The decision for such an approach will depend on the local circumstances. For example, if groundwater is the only source of drinking water and it is directly consumed after abstraction, cost / benefit analysis may be considered.

Activity 2 – Establish remediation requirements

Remediation requirements comprise the physical, functional or management tasks and the performance criteria which enable an effective remediation option.
Typical requirements include:

- Plans for redevelopment of site or the surrounding area may influence which remediation options may be developed.
- The degree to which the remediation option is robust (refer explanation in Box I-5.3.3 below).
- The extent to which management is necessary to implement site use restrictions, to monitor groundwater plumes, or the maintenance of pump and treat plant etc.
- Commercial and social aspects concerning property value, employment opportunities and the views of local stakeholders.

The requirements identified define the criteria which are incorporated into the remediation options appraisal (refer *Checklist Criteria for comparison and appraisal of remediation options, Volume II-5.5-a)*.

Box I-5.3.3 Explanation of robust (solid) remediation

Robust (solid) remediation options are able to adapt to changes in site or soil conditions without endangering the performance of the option. Examples of robust options include:

- A cover layer designed to provide intrinsic protection from unauthorized excavation and construction activities. This can be achieved by incorporating a durable layer within the clean cover system which is very hard to dig through without heavy machines. In case of sites influenced by occasional flooding a cover layer may be not a robust remediation due to vulnerability for erosion;
- Systems monitoring the spreading of groundwater plumes typically incorporate monitoring wells which are used for periodical sampling. In case the system is sensitive to changes in groundwater flow direction, or is situated in an area with periodical changes in groundwater use, the monitoring system can be designed to accommodate the abstraction of groundwater as well. In addition, automated sensors can be used for continuous monitoring of the groundwater flow;
- In urban build-up areas source removal by excavation and off-site disposal is generally inappropriate. In such cases a clean cover layer can be installed which can be designed for the specific site use. A uniform and deep cover layer would facilitate such future activities without the continuous risk of accidentally disturbing contamination below the cover layer.

5.3.3 Task 5.3 output

The output of Task 5.3 is a detailed description of the remediation objectives, the target levels to be achieved and performance requirements for the remediation of the site. This description should include the rationale leading to the resulting remediation objectives and performance requirements.

The results of Task 5.3 will largely determine which remediation options may be developed. Therefore, the output should be submitted to the competent authorities for review, even if a formal decision is not required.
During the following Task 5.4 remediation options are developed and the most favourable option is identified during Task 5.5. During these Tasks 5.4 and 5.5 the conclusion may be drawn that the performance requirements set in Task 5.3 are too stringent to meet. Therefore, it may be necessary to anticipate this situation by going through all these Tasks in an iterative way, combining development of remediation objectives, remediation requirements and remediation options.

Volume I

Step 5 Remediation investigation

Task 5.4 Development of remediation options

Step 5: Remediation investigation

Task 5.4 Development of remediation options

5.4.1 Introduction to and scope of task 5.4

General description and connection to other Steps and Tasks
Task 5.4 is part of Step 5 Remediation Investigation and concerns the development and suitability assessment of remediation options that may be appropriate to meet the remediation objectives established in Task 5.3. A remediation option is typically a combination of one or more remediation techniques that will enable to achieve the remediation objectives.

Task 5.4 commences with the assessment of the remediation objectives established in the preceding Task 5.3. It ends with the presentation of suitable remediation options from which one will be selected in the subsequent Task 5.5.
The figure below shows how this Task is connected to preceding and following Steps and Tasks within the sequence of site assessment and remediation.

Activities
The following activities are performed in Task 5.4:
1) Assess the remediation objectives and requirements;
2) Identify constraints to remediation;
3) Identify applicable remediation techniques;
4) Develop applicable remediation options.

Responsible parties
The activities in this Task are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant.

The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques.

5.4.2 Guidance for performing the Activities of Task 5.4

This section presents concise guidance for the performance of the activities within Task 5.4. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Assess the remediation objectives and requirements
All remediation options considered in Task 5.4 should be able to meet the remediation objectives and requirements. Therefore, the first activity is to carefully assess the objectives and requirements which are to be met, in order to identify performance criteria relevant for consideration in the remediation options appraisal.
An example of these criteria is the target level for contaminating substances in soil and in groundwater.

Activity 2 – Identify constraints to remediation
In addition to the remediation objectives and requirements there may also be constraints imposed on the remediation.

They do not have an impact on the remediation objectives or requirements, but may affect how these objectives can be achieved:
- They may restrict or limit the range of applicable remediation techniques;
- They may determine the technical specifications for the techniques.

Constraints comprise technical and non-technical issues. Some examples of constraints are listed in Box I-5.4.1below.

Potential constraints for remediation may be identified by the party or the parties responsible for the site, for example the site owner or developer or, in the case of orphan sites, the competent authority. Constraints may also arise from consultations with other stakeholders, e.g. the municipality regarding spatial planning of the surrounding area or the local community. As constraints can have considerable influence on the remediation, the performing agent should consult all stakeholders who may raise an issue which could constrain the proposed remediation.

If a large number of stakeholders is involved the list of constraints may grow to a considerable extent. At a later stage this may lead to the conclusion that they impose a prohibitive financial burden on the remediation or that conflicting interests may need to be dealt with. Therefore, the activities in this Task may need repeated reviews during later activities. When a certain constraint is subject to change the stakeholder linked to that specific constraint should always be consulted.

Box I-5.4.1 Examples of remediation constraints

Soil remediation is often performed as part of redevelopment of an area. This intention will typically have been established in Task 5.3, along with the remediation target levels (concentrations of contamination in soil, sediment, groundwater or surface water) to be achieved. In most cases, the remediation process would be aligned with the redevelopment, leading to constraints such as the following:

- The redevelopment will require the site to be available for the intended future use at a specific date. The remediation planning should therefore aim to be completed by that date. This time constraint would rule out remediation options which would require a lengthier period of time to complete.
- In case post remediation measures have to be implemented at the redeveloped site, these measures need to fit in the future site use. They should not give rise to impacts on site users from noise (e.g. a groundwater treatment plant) and should not need to be replaced on a regular basis (e.g. a groundwater pumping system).

Physical restrictions such as nearby structures that must not be destabilised, or services and communications that must not be interrupted, e.g. railroads or power lines:

- Contaminated material may be present at a site with historic or vulnerable buildings which may be afforded protection. Where contamination source excavation and removal is proposed, excavation techniques should be considered carefully, because such techniques may cause damage to the building. Where this is proposed, additional measures to protect the building should be examined. However, should these measures then turn out to be too expensive or too high risk, these techniques for source removal should be rejected.
- When buildings or structures are located near the remediation site, the groundwater level should not be lowered too much, to prevent destabilisation of foundations leading to their potential settlement. This constraint would limit the potential capacity of the proposed remediation technique, e.g. the abstraction rate and zone of influence of a pump and treat system.

During the implementation of remediation certain activities may cause nuisance e.g. noise, the spreading of dust or the temporary closure of major infrastructure. For sites situated in urban areas specific limits may be imposed on the degree to which this nuisance is acceptable (restricted operating hours or the use of less noisy equipment). It may also lead to the selection of a different access route to the site, a different type of pump and treat system or even to the use of a different type of remediation technique etc.

Other examples of constraints to remediation are:

- Specific issues raised by interested parties such as the future owner, or stakeholder expectations etc;
- Corporate environmental policies:
- A requirement to avoid long term costs;
- A requirement to optimize sustainability within each of the options;
- A requirement not to affect groundwater wells during the implementation of the remediation activities;
- Abundant rainfall or evaporation may influence groundwater and surface water levels and may influence certain remediation techniques.

Activity 3 – Identify applicable remediation techniques

A remediation option typically consists of a combination of remediation techniques tailored to meet specific site remediation objectives, requirements and constraints. To develop an option, the performing agent starts by identifying techniques applicable to the given situation from a list of all possible techniques. The *Overview of remediation techniques and Menu of options, Volume III-5.4-i* provide detailed information on techniques.

Applicable techniques are typically identified through a process of elimination, i.e. dismissal of techniques deemed unsuitable for the specific situation. This identification is based on the objectives and requirements developed in Task 5.3 and constraints identified in Activity 2 of this task. The data needed to perform this identification can be found in the applicability matrix and the generic and site specific characteristics and in the description of strengths and weaknesses, opportunities and threats of the remediation techniques (for both refer to *Volume III-5.4-i*).

Box I-5.4.2 Example: rejection of unsuitable remediation techniques

In this example, the remediation objective is the complete removal of all solid phase contamination. One of the principal constraints is the requirement that remediation must be completed within a period of a six months. This is because the redevelopment works programme requires the site to be available for the intended future use at that time. A number of the remediation techniques, or combinations thereof, will not meet this constraint and can, therefore, be rejected immediately. Only the identified techniques that can meet this constraint are considered further.

Potential techniques should not be hastily rejected as options that might have turned out to be applicable may not be given due consideration. For example: construction of a physical vertical groundwater barrier (cut-off wall) may result in the migration of polluted groundwater through the base of the confined contamination, and, therefore, this method may be rejected. However, this potential risk can be solved by combining the barrier with a groundwater extraction system. A combination of these two techniques may result in full confinement with the benefit of a low groundwater extraction flux, comprising a cost-effective solution.

An important note on the application of relatively unknown remediation techniques. A remediation technique must be technically proven before it can be applied with any guarantee of success. This means a newly developed, or otherwise unknown, remediation technique needs to be tested, at first under laboratory circumstances, but eventually also in the field, before it should be considered for application at any given site. The flowchart *Application newly developed remediation techniques, Volume II.5.4-a* provides more detailed guidance on this issue.

On completion of Activity 3 a list of potentially applicable remediation techniques should be recorded as the activity output. This should preferably also include technical specifications that should be taken into account (e.g. to meet the remediation requirements) and any possible data gaps and uncertainty to be addressed by additional detailed site investigation.

Activity 4 – Develop applicable remediation options

The implementation of a single remediation technique is typically insufficient to meet the identified remediation objectives, requirements and constraints. Hence, often two or more remediation techniques are combined in a remediation option.
The process of combining remediation techniques to form a remediation option is the scope of this activity. The result will be a number of potential remediation options each covering the whole range of remediation objectives.

The number of remediation options developed is typically three or four, depending on the site-specific remediation objectives, requirements and constraints. For each remediation option listed, all criteria on which the option will be evaluated during Task 5.5 should be described and illustrated. An overview of these criteria can be found in the *Checklist Criteria for comparison and appraisal of remediation options, Volume II-5.5-a.*

Whilst there is no established process that should be followed when developing the remediation options, an iterative procedure is recommended (refer Box I-5.4.3 for examples).

Box I-5.4.3 Example: reasons for iterative option development

At some point in the process of option development issues may arise which need further investigation before the option development can be finalised. Examples of such issues are:

- complete delineation of the contaminated area;
- assessment of biodegradation rates in the subsoil in order to establish whether biodegradability of a contaminated groundwater plume is a possible option;
- assessment of social impacts of the options, e.g. when an option implies the capping of a waste dumping site it may mean this will have a negative impact on employment of communities using the site for economical purposes.

In contrast some technical details can be dealt with during the Remediation design (Step 6). An example of this would be the measurement of soil permeability, to be assessed in Step 6 in order to design the spacing of groundwater abstraction wells.

Recommendations and suggestions are provided below to enable the performing agent in his task to develop the remediation options.

Best practice
The Menu of remediation options (refer *Volume III-5.4-i*) offers an overview of best practice for all types of contaminated sites included in the Typology.

These options present a blueprint of preferred ('prioritized') options for remediation, i.e. the theoretically most appropriate remediation option for a variety of settings. Please note that the site- specific objectives, requirements and constraints may be conducive to develop further remediation options which are not featured in the Menu of remediation options.

The Menu of remediation options provides a first indication of potential remediation options that may be suitable for the situation at hand. For small and simple sites one or more best practice methods included in the menu may directly apply. In more complex situations the best practice overview will help the performing agent to make the first steps in the development of options.

Conceptual Site Model
While developing remediation options, the Conceptual Site Model (CSM), including the description of the sources, pathways and receptors (SPR's), is a useful tool (refer *Volume III-2.2-i*).
The CSM enables to understand [i] how the identified sources, pathways and receptors combine to present unacceptable risks, [ii] how the pollutant linkages are interconnected and [iii] how intervention in respect of either one or more of the sources, pathways or receptors by implementing the actual remediation techniques can reduce the risks.

Some examples of the CSM approach to designing a remediation scheme are provided below. The text also illustrates the benefits of remediation techniques which either have an impact on more than one of the sources, pathways and receptors, or benefit from a combination of techniques applied to individual sources, pathways and receptors:

- *Source Intervention* can reduce the risk of leaching of chemicals leading to groundwater contamination. Source intervention can also prevent the contact between receptors and the source and thus reduce the human health risks without the need for any further pathway or receptor controls. Examples of source intervention are removal of the contamination source (e.g. by excavation) or treatment in situ (e.g. by in-situ bioremediation).

- *Pathway Intervention* will reduce the risks of contaminant migration. An example of pathway intervention is interception of contaminated groundwater including treatment and discharge. An important issue in such a case is that where the source remains untreated, the interception including treatment and discharge will be necessary for a considerable time. However, when the interception of the pathway is combined with reduction of leaching from the source, a more effective remediation solution can be achieved. Another example of pathway intervention is capping of contaminated soil material by applying a capping layer. The use of a permeable capping layer will only reduce the direct human contact. However, in case the capping layer includes a impermeable element, the risks of spreading of contaminants are also reduced rendering the technique more efficient.

- *Receptor Intervention* mainly involves site use restrictions such as controlling an individual's exposure to pollutants by administrative means. These controls may comprise legal or contractual restrictions on access to, or use of, a garden or play ground. Other measures are focused on the protection or removal of the receptor and can be classified as temporary safety measures. Examples include re-housing, prohibiting access by fencing the site, preventing the use of groundwater for a potable source, e.g. by closing wells and providing water by alternative means (piping system, tanks, trucks).

Models for groundwater flow and mass transport
Models for groundwater flow and mass transport can be used to understand the hydrogeological regime and the pollutant mass transport mechanism. They provide detailed insight into aspects such as groundwater flow direction, plume migration and biodegradation rates. The use of such models allows an assessment of the remediation option suitability (e.g. aquifer permeability and applicability of groundwater control), effectiveness (e.g. volume of groundwater required for full plume capture, or reduction of plume size achieved by source removal) and configuration (e.g. number, depth and spacing of wells). They may also enable predicting any undesired consequences (e.g. effect of lowering of groundwater table on the construction of buildings and structures, or drought).
During this Task the model calculations are used just to get a basic insight into the above mentioned aspects. In Task 6, Remediation design, more thorough model calculations are sometimes required to derive the actual technical details needed for the design and implementation of the remediation works.

Practical rules of thumb
During the process of development of options the following practical and generic rules of thumb can be applied by the performing agent:
- Remediation techniques for removing the contamination load within a plume are most cost effective when combined with flux reduction from the source.
- The use of natural soil processes improves the efficiency of the remediation approach. For example: if time and space are available, the removal of groundwater contamination is more efficient if natural attenuation can be applied using the original inherent soil capabilities for biodegradation. This technique is slow but costs are low, even when natural conditions are enhanced by injecting the substratum with nutrients, oxygen etc.
- A combination of techniques can be efficient. For example, the removal of contaminants by excavating can be very efficient but only to the groundwater level. Below this depth, in situ extraction techniques are more cost-effective.
- If redevelopment or new construction works are planned on a site, a combined execution of the activities is usually attractive from various perspectives, e.g. costs, time, sustainability, and nuisance (refer Box I-5.4.4 below).

Box I-5.4.4 Practical information: redevelopment and remediation

Remediation of a contaminated site may be executed as an integrated part of a redevelopment plan for the area. This approach provides multiple opportunities to combine activities and to save on costs for both the remediation and redevelopment activities. Examples of combined activities are: [i] the excavation of contaminated soil can present an opportunity to utilise the resulting void as a basement or parking lot or [ii] the construction of new roads, pavements and building floor slabs can provide effective cover layers as an alternative to the construction of a cover system above contaminated soil or [iii] the excavated material may be reused or recycled into new raw materials e.g. organic matter from landfill sites or clayey material for brick manufacture.

When combining site remediation with site redevelopment it is advisable to develop the remediation options as an integrated part of the redevelopment plans. The consultant charged with the remediation investigation should cooperate with the site owner or site redeveloper and the engineers responsible for the design of the redevelopment. This cooperation should start at an early stage of the preparation phase providing maximum opportunities to combine both remediation and redevelopment activities. If started in an early stage this cooperation the land use plan can easily be adapted to the contamination situation. Often it is economically sensible e.g. to plan a parking lot on a former gasoline station instead of a playground or school garden. Even after decontamination of land people may not be willing to use that land for residential or other purposes. The possibility of using the land for setting up solar power generation system may be considered.

Cost estimates
For all remediation options costing is required. These costs may be estimated with an accuracy of plus or minus 20%. This is sufficient in order to compare the magnitude of costs of the different remediation options.

5.4.3 Task 5.4 output

The output of Task 5.4 is a set of applicable remediation options appropriate for the identified remediation objectives, requirements and preconditions. All options should be described in such a way that the selection of the most favourable option can be carried out in the next Task. The description of these options should include the technical specifications that should be taken into account (e.g. performance criteria to meet the requirements) or any data gaps and uncertainties requiring detailed site investigation.

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Step 5 Remediation investigation

Task 5.5 Selection remediation option

Step 5: Remediation investigation

Task 5.5: Selection remediation option

5.5.1 Introduction to and scope of Task 5.5

General description and connection to other steps and tasks
Task 5.5 is part of Step 5 Remediation Investigation and concerns the selection of the most applicable remediation option, i.e. the option best meeting all objectives, requirements and constraints established in the previous steps. The selection of this option is basically performed by matching the output of the preceding Task 5.4, i.e. the characteristics of several remediation options, with a standardized set of criteria. The most applicable remediation option is put forward to the competent authority for approval and provides input for the detailed engineering in a Remediation design plan (DPR) in the subsequent Step 6.

The figure below shows how this task is connected to the preceding and following steps and tasks within the sequence of site assessment and remediation.

Activities
The following activities are performed in Task 5.5:
1) Compare and appraise remediation options;
2) Consult with relevant stakeholders;
3) Prepare remediation investigation report, including stakeholder views;
4) Review and approval of remediation investigation report and select most favourable remediation option.

Responsible parties
The activities in this Task are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant.

The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques.

A review by the competent authorities is required before moving to the next Step 6.

5.5.2 Guidance for performing the activities of Task 5.5

This section presents concise guidance for the performance of the activities within Task 5.5. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Compare and appraise remediation options

The previous Task 5.4 would have yielded a set of potentially applicable remediation options. In this Activity these options are compared and appraised, as a first move towards selection of the most favourable remediation option. The result of this Activity should enable stakeholder consultation (Activity 2), the writing of the Remediation investigation report (Activity 3) and the eventual selection of the most suitable remediation option (Activity 4).

Criteria to be included in the comparison and appraisal
The implementation of a remediation option can affect a wide variety of criteria like costs, site reuse potential and social impacts. The criteria that are expected to be affected by any of the remediation options should be used as criteria in the comparison and appraisal process. These may be selected from the comprehensive list of these criteria, presented in the *Checklist Criteria for comparison and appraisal of remediation options, Volume II-5.5-a*. They can also be located in the generic analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT) of remediation techniques in *The Overview of remediation techniques and Menu of options, Volume III.5.4-i*.

Methods for comparison and appraisal
Following structured and comprehensive methods of comparison and appraisal of remediation options may be applied: descriptive methods, qualitative overview methods and quantitative overview methods. It is advised to apply one of these methods to obtain an overview of all characteristics of the remediation options and the differences among them. Such a method may also serve as a useful tool for the stakeholder consultation. Which method is most suitable depends on the number of remediation options and the complexity of these options. Examples of these types of methods are presented in *Volume III-5.5-i*.

Some practical issues to consider during the comparison and appraisal process:

- An ideal remediation option meets all criteria in a well balanced way. If this balance is not met with either of the remediation options the process could result in an unsatisfactory remediation option. In that case it may be necessary [i] to reconsider the objectives, requirements and constraints that should to be addressed by the remediation, [ii] to adjust the redevelopment plans, [iii] to fine tune the remediation options or to develop new options;
- In most cases the process of design, evaluation and selection will not end up with one single solution unconditionally acceptable for all parties. These steps therefore often are made in an iterative process. During this iterative process the design and conditions should gradually develop towards a most favourable option. Trans-

parency in all activities and close contact with the important stakeholders is a key element in this optimising process;
- The comparison and appraisal process may also yield recommendations that will need attention during the subsequent design and implementation of a remediation option. Examples of such recommendations are presented in Box I-5.5.1 below.

Box I-5.5.1 Examples of recommendations that warrant attention in further steps

- A most favourable remediation option can be based on a technique which has only been used in laboratory and never in field conditions. In this case this option can be indicated as the most favourable option only after a field test or pilot remediation has proven to give a certain level of results (for guidance on this see Volume II-5.4-a).
- The exact delineation of a contamination should be assessed in case complete removal is anticipated.
- In case remediation of a groundwater plume is selected as the most favourable remediation option, the biodegradability of the contaminants should be confirmed by additional site assessment first.

<u>Activity 2 – Consult with relevant stakeholders</u>

The implementation of remediation measures may considerably affect stakeholders. The issues involved can be of a social or environmental nature, like noise and dust production by remediation equipment or trucks, and even temporary relocation of inhabitants. Different remediation options can also have different economic effects, as they may e.g. affect the value of the property differently. Therefore the selection and design of the remediation option should be subject to stakeholder consultation. The results of the comparison and appraisal of remediation options (Activity 1) provides a solid basis to start stakeholder consultation as they discuss all relevant issues like level of risk reduction, technical risks, costs, sustainability, planning, post remediation site use potential.

Stakeholders with partial responsibilities in the remediation process and stakeholders that may have to deal with impacts of the remediation, should be involved during the selection of the remediation option. Example of these stakeholders are:
- Municipal Water board or Water Sanitation Department: water quality and, if applicable, use of the water supply and sewage system for a prolonged period of time;
- Municipality or Traffic Police Authorities Transport Department: traffic issues related to the remediation works;
- Urban Development Department or Industries Department: possibilities for post remediation site use and, if applicable, site use restrictions.

Stakeholders that should at least be informed on the backgrounds and results of the remediation option are for example site users, inhabitants and other people with primary dependence on the site use. In case of larger impact by the remediation it may serve well to involve these stakeholders already in the process of development of remediation options. This action can be vital in gathering support for the selected remediation option. In cases where resistance against the selected remediation option runs high, the selected option may be modified or even reconsidered. In higher profile situations, it may be useful to involve local elected representatives, local political party workers, media agencies and noted local personalities in the stakeholder consultations.

The stakeholder consultation should yield detailed information on their interests, which should be considered while selecting the most favourable remediation option and also later, during the remediation design and implementation of the remediation works. In some cases the stakeholder consultation may even lead to development of a new remediation option that may be included in the selection process.

Activity 3 – Prepare remediation investigation report, including stakeholder views

The process of comparing, appraising and eventually selecting remediation options should be well documented. This is done in a Remediation investigation report which presents the results of the detailed site investigation (Task 5.1), the risk assessment (Task 5.2), the setting of the remediation objectives and requirements (Task 5.3), the development of the remediation options (Task 5.4) and the comparison and appraisal of the remediation options, including the stakeholder consultation (Task 5.5) (refer *Checklist Remediation investigation report, Volume II-5.5-b.*

Activity 4 – Review and approval of remediation investigation report and selection of most favourable remediation option

Once the selection of the most applicable remediation is completed, the resulting option should be put forward to the competent authority for approval, ref. *Checklist review and approval Remediation investigation report, Volume II-5.5-c*.

The implementation of a remediation work may require approval by other authorities, e.g. the local water board in case of effluents into water bodies under their jurisdiction. In such cases, a sound and timely coordination among the involved authorities is crucial to prevent conflicting requirements.

5.5.3 Task 5.5 output

The output of this Task 5.5 is a selected most favourable remediation option, approved by the competent authority and preferably accepted by as many stakeholders as possible. The Remediation investigation report, in which the development, comparison, appraisal and selection process of this remediation option is documented, provides insight in the rationale for the eventual selection of the remediation option and for the actions to meet stakeholder interests. That report also includes a list of issues that need to be addressed during the following steps.

Based on this output a Remediation design plan (DPR) is prepared in the subsequent Step 6.

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Step 6 Remediation design, DPR

Step 6: Remediation design, DPR.

6.1 Introduction to and scope of Step 6

General description and connection to other steps
Step 6 concerns the design of the remediation and the development of a Detailed Project Report (DPR). In the DPR a detailed description of the remediation activities is provided. Part of this DPR is an estimation of the costs required for the funding of the project (Step 7). The DPR is providing the technical information to be elaborated in the bidding documents during the implementation of the remediation (Step 8). Step 6 starts with a summary of the remediation option selected at the end of the preceding Step 5 Remediation investigation. It ends with the presentation and approval of the DPR.

The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.

Activities
Within this Step the following activities are to be performed:

1) Design of the remediation: the technical system for the remediation will be presented. Detailed descriptions and drawings of the remediation measures will be reported.
2) Costing and planning of the remediation: all activities are summarized and a costing is provided for each of these activities (volumes, amounts and unit prices). A planning of activities is made indicating the time involved for the activities.
3) Environmental and social impact assessment and consultation of stakeholders

Responsible parties
The activities listed above will typically be performed by technical experts in the specialized agency or consultant charged with the remediation investigation.. The work should be supervised by a senior colleague. The team involved should have in-depth knowledge of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques. The team involved should be able to interpret the technical information and link the necessary measures to costs involved. For various elements of the cost estimation information from authorities may be required.

6.2 Guidance for performing the activities of Step 6

This section presents concise guidance for the performance of the activities within Step 6. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 - Design of the remediation

The design of the remediation is meant to detail out the selected remediation option into separate, interconnected activities. The technical and organisational aspects of these activities and their environmental impact should be described in a Detailed Project Report or remediation design plan (DPR). For some of the technical measures it should be assessed if they are applicable for the specific site. Sometimes modelling can be required to assess the effects of the remedial measures e.g. the mass transport of contaminants when using ground water extraction or the degradation of contamination to predict the results of biological techniques.

The DPR is based on the selected remediation option during Task 5.5. If the remediation is combined with reconstruction or redevelopment activities at the site it should be described in detail how the activities of remediation and redevelopment are linked and which impact they have.

A stakeholder consultation is needed, both to inform the stakeholders on the intended remediation measures and to secure their support. The consultation may also yield information that can be useful in the final design of the remediation measures. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may for the state and national levels only be applicable to large scale sites.

In case it is expected that the remediation will leave no residual contamination the decision on land use after remediation closure needs to be taken at this stage. In such cases therefore, the remediation design also needs to address this issue. This will then necessitate the involvement of a land use designation authority, which may take the shape of an interdepartmental committee with land use experts.

Stakeholder	Interview objective	Level
Site owner	exchange information, secure support	site
Site operator's health facility director	exchange information, secure support	site
Local businesses, residents and NGO's	exchange information, secure support	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	exchange information, secure support	local
In case it is expected the remediation will leave no residual contamination: Land Registration Office	discuss conclusion on land use post remediation	district / local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	exchange information, secure support	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	exchange information, secure support	national
Competent authority	provide information and discuss conclusion	level of competent authority

In the DPR the remediation objective is described as detailed as possible. This allows for verification activities to be carried out, on the bases of which it is possible to conclude if the remediation objective is reached. For remediation techniques with can take a long period of time, the DPR should describe the management of the necessary monitoring activities to verify the progress of the remediation

If the remediation activities are causing waste, e.g. due to excavation, the Hazardous Waste Rules-2008 may apply with respect to transport, disposal or treatment of this material.

During the execution of remediation works unexpected issues will almost always occur. Examples include contaminated material in the subsoil which is present deeper than expected or permeability of the soil which is less than expected.
For the situation that the intended remediation objective cannot be achieved by the presented techniques, a fall-back scenario should be detailed and included in the DPR. This scenario provides technical measures by which the remediation objective eventually can be achieved.
Clear and measurable criteria for the success of the remediation should be part of the DPR. This allows the competent authority and the organization responsible for the remediation to make arrangements on the management of the remedial activities.

The remediation design plan / DPR has a standardized structure and content (refer *Checklist DPR including verification plan, Volume II-6-a*)

Activity 2 - Costing and planning of the remediation

All remediation activities are summarized and a costing is made for each of these activities. These activities do not only involve the technical measures of the remediation. The preparation of the work, including costs for demolishing building or replacement of inhabitants may be involved as well. The costs for management, supervision and verification of the remediation works should be included as well. The previous costs of investigation of the site and preparation of the remediation design may be summarized to the total of relevant costs.

The remediation may be combined with redevelopment of the site. It is important to distinguish costs for remediation and costs for redevelopment (e.g. a situation where an existing building should be demolished before remediation and reconstruction can take place. The demolition costs can be designated to the remediation as well as to the reconstruction). Depending on the financing parties of remediation and reconstruction this can be a major issue and point for discussion.

An overview of cost elements of a remediation is presented in the *Example format cost estimation remediation, Volume II-6-b*. The costing should include volumes, amounts and unit prices.

Some of the cost elements may be estimated quite accurately, some elements may be difficult to estimate (examples are provided in Box I-6.1). It may be useful to apply a bandwidth for elements which have large impact on the total costs.

Box I-6.1 Examples of uncertainties in cost estimates

- There may be uncertainties in the exact delineation of the contamination which can cause a deviation of the amount of contaminated material to be treated.
- The time necessary to achieve the desired results for an in-situ remediation.
- The starting point of the remediation project may not be known, which may have impact on the rate for disposal of excavated material on a TSDF.

Furthermore a planning of activities is made. In this planning the remediation activities as well as the verification activities are scheduled.

Activity 3 - Environmental and social impact assessment and stakeholder consultation

The remedial measures described in the DPR can have effects on the environment and the surroundings of the contaminated site. There may be negative effects from remedial measurements due to noise or dust by equipment used or by transport of contaminated material from the site.
During remediation the use of the site and surrounding area may be temporarily prohibited and this can have impact on communities using the site for economical purposes.

The environmental impact assessment should consider the effects of the remediation on the environment. It must include amongst others measures to minimise damage or nuisance caused by the remediation activities and measures to improve sustainability (e.g. reducing energy consumption). The social impact assessment must consider the effects of the remediation measures for the communities using the site. It should describe how communication is organised and what measures will be taken to minimise the effects of the remediation for the communities involved. It should also illustrate how the remediation of the site has positive effects on the possibilities for the owner and involved communities

All these effects are assessed in an Environmental and social impact assessment report (refer *Manual for environmental and social impact assessment for remediation of contaminated sites, Volume III-6-i*).

6.3 Step 6 output

The output of this step is a Detailed Project Report providing a clear and detailed description of the remediation system and the various techniques used. Furthermore a detailed planning and costing of the remedial measures are provided. Finally the report of an Environmental and social assessment is developed.
The competent authority has the responsibility for reviewing the DPR. If there is a necessity for involving stakeholders, the authority can share the report with these stakeholders. In that case maybe the costing can be regarded as non public element of the DPR.

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Step 7 DPR approval and financing

Step 7: DPR approval and financing

7.1 Introduction to and scope of Step 7

General description and connection to other steps
Step 7 concerns the approval of the remediation design in the DPR and the financing of the remediation works. Both these elements are required before getting into the actual process of remediation.
The figure below shows how this Step is connected to the preceding and subsequent Steps within the sequence of site assessment and remediation. The financing element of this Step 7 can start directly after notification of the contaminated site in Step 3.

Activities
Within this step a number of activities are to be performed. Most of these activities are on institutional, legal and financial aspects. For guidance on those activities we refer to the National Program for Remediation of Polluted Sites (Task 4 report, PWC Dec. 2015). Here, the guidance focuses on the one activity with technical/financial aspects:

1) Review and approval of DPR by the competent authority

Responsible Parties
Review is typically performed by senior staff members of the competent authority, in order to prepare the decision by the appropriate official. The team involved should be able to interpret the technical information of the DPR and link the necessary measures to costs involved.

7.2 Guidance for performing the activity of Step 7

This section presents concise guidance for the performance of the activity within Step 7. It is intended to enable the user to quickly gain an understanding of the necessary activity.

~~Activity 1 - Review and approval of DPR~~

The report of the remediation design / DPR will be reviewed by the competent authority. Points of attention for this review are provided in the *Checklist review and approval Detailed Project Report, Volume II-7-a:*

- The remediation objectives according to the selected remediation option (Task 5.5) should be met;
- The remediation should be technically well feasible;
- If the remediation is combined with reconstruction activities at the site the planning of the reconstruction does not have a negative impact on the remediation

measures (example: this could happen if in-situ remediation measures are applied and during the exploitation period of these measures groundwater extraction is applied to prepare reconstruction which can have a negative effect on the performance of the remediation);
- The results of the environmental and social impact assessment are acceptable and within regulatory permits. Where technically possible and economically reasonable additional measures will be applied to reduce negative impact of the remediation measures (examples: spraying of water in case of dust formation; temporary replacement of dwellings for residents during excavation);
- There are clear criteria to assess the progress and final result of the remediation (examples: permeability of a top clay layer used for containment of a site; concentration levels of pollutants and chemical properties of groundwater);
- The activities to verify the progress and results of the remediation are clearly described;
- Uncertainties which may have effect on the remediation result are indicated explicitly and the DPR provides scenarios and measures in case these uncertainties will occur.

7.3 Step 7 output

The output of this step is the approved DPR and certainty on budgets for the remediation and post remediation costs. Based on this the preparation of the remediation works can proceed.

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Step 8 Implementation of remediation

Task 8.1 Preparation and authorization

Step 8: Implementation of remediation

Task 8.1: Preparation and authorisation

8.1.1 Introduction to and scope of task 8.1

General description and connection to other Steps and Tasks

Step 8 concerns the implementation of the remediation of the established contaminated site. The remediation works have been described in the DPR (developed in Step 6) where the technical design of the selected remediation option (Task 5.5) is described in detail.

Step 8 is divided into three tasks: preparation and authorisation (Task 8.1), contracting (Task 8.2) and the execution and supervision and verification of the remediation (Task 8.3). Before the execution of the remediation works can start these remedial works should be authorised and necessary regulatory permits, licenses and/or consents should be met. This activity can take place parallel or in sequence with the contracting Step 8.2.

The figure below shows how this Task 8.1 is connected to the preceding and subsequent Steps and Tasks within the sequence of site assessment and remediation.

Activities
Within this Task 8.1 the following activities are to be performed:

1) Inventory of required permits.
2) Applying for the permits.

Responsible Parties
Generally, the organisation responsible for the remediation (authority, company or private party or person) will instruct the preparation of a project to ensure all regulatory obligations concerning the remediation works are met. This organisation can appoint a specialised third party, to take care for arranging these permits and licenses. The contractor may arrange these permits and licenses as a first step of the execution of the remediation works as well.
The team involved should be able to assess the information of the technical system and make conclusions on the required permits, licenses and consents. Knowledge of regional and local regulations is required as well.

8.1.2 Guidance for performing the activities of Task 8.1

This section presents concise guidance for the performance of the activities within Task 8.1. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 –Inventory of required permits

The required permits should be inventoried, refer *Checklist permits for remediation works, Volume II-8.1-a.* This is depending on the characteristics of the remediation design and the specific equipment the contractor will use during the execution of the remedial works, examples are provided in Box I-8.1.1 below.

Box I-8.1.1: Examples of activities for which the permits may be applicable

The remediation activities will have an impact on the contaminated site and its direct surroundings but the impact of the remediation may be more than that. Some examples:

- always transport of equipment to and from the site is involved in a remediation project;
- when removing of excavated material from the site there may be a large impact on the local transport network;
- at the site where treatment or disposal of the material takes place there may be a permanent installation which will require permits and licenses independently.

Activity 2 – Applying for the permits

The required permits, licenses and consents should be applied at the various governmental organisations. The municipal government and maybe different departments will surely be involved. Maybe the state government has to be consulted for specific regulations. Water boards may have to be involved if the remediation works have impact on ground water or surface water.

Providing detailed information of the impact and planning of the remediation works may be necessary during the application process. Part of this information may be obtained from the results of the Environmental and Social Impact Assessment, developed during Step 6 Remediation design, DPR.

8.1.3 Task 8.1 output

The output of this task 8.1 is a document including all obtained and signed permits, licenses and consents at this stage required for execution of the remediation works. May be the contractor will have to apply for permits just before the remediation works start in case specific equipment is involved.

This document with (copies of) all obtained permits, licenses and consents should always be readily available during the execution of the remediation works. In case the specific activities or specific equipment may be changed during the remedial works it is necessary to check if it is still possible to meet the obligations of the permits, licenses and consents.

Volume I

Step 8 Implementation of remediation

Task 8.2 Contracting

Step 8: Implementation of remediation

Task 8.2: Contracting

8.2.1 Introduction to and scope of task 8.2

General description and connection to other steps and tasks
Step 8 concerns the implementation of the remediation of the contaminated site. The remediation works are described in the DPR (developed in Step 6) wherein a technical design of the selected remediation option (Task 5.5) is elaborated.

Step 8 is divided into three tasks: preparation and authorisation (Task 8.1), contracting (Task 8.2) and the execution and supervision and verification of the remediation (Task 8.3).
The objective of Task 8.2 contracting is the selection and appointment of a contractor which can offer adequate results against acceptable costs.
Generally there are two main options for contracting: traditional contracting and design and build. Design and build implies the client directly employs a contractor to provide both design and implementation. With traditional contracting the client directly employs the designer for a DPR (Step 6) and the contractor for the remediation (Step 8) using separate contracts. In this section we will describe the traditional contracting process.

The contracting phase (Task 8.2) is carried out after the DPR approval and financing (Step 7) has been arranged and the authorization of the remediation by the competent authorities. The contracting is based on bid documents to be developed during this step. After the appointment of the works has taken place the execution of the remediation works can start.
The figure below shows how this Task 8.2 is connected to the preceding and subsequent Steps and Tasks within the sequence of site assessment and remediation.

Activities
Within this Task 8.2 the following activities are to be performed:
1) Preparation of bid document.
2) Selection and appointment of the contractor.

Responsible Parties
Generally, the client/organization responsible for the remediation (authority, company or private party or person) will instruct the development of bid documents and the contracting of a project. This organization can hire a consultant to develop the bid documents and to implement the contracting procedure. State and National Government needs to be involved throughout this Task.

The preparation of the bid documents and the contracting process should be supervised by senior colleagues with technical as well as financial background.

The team involved should demonstrate in-depth knowledge how to translate the remediation measures, described in the DPR into detailed technical activities. Knowledge of practical possibilities of technical solutions is necessary to develop these bid documents.
Furthermore experience with contracting procedures is required and capabilities on administrative, legal and financial aspects.

8.2.2 Guidance for performing the activities of Task 8.2

This section presents concise guidance for the performance of the activities within Task 8.2. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

<u>Activity 1 – Preparation of bid document</u>

In a bid document a very detailed technical description is provided of the remediation works as designed and reported in the DPR. It clearly defines the activities and measures and the results to be achieved by the contractor and the applicable criteria. It includes detailed description of activities, location of work, transport of equipment and traffic measures, building materials and waste material, temporary storage facilities at the site. In these descriptions reference is made to detailed drawings or pictures which have to be included (various scales; overviews and cross-sections; technical constructions). The bid document should describe possible preconditions for executing the work (e.g. accessibility of the site, security measures, daily routine time schedules).

Based on the bid document parties/contractors should be able to:
- develop a work plan of technical activities;
- include the health and safety measures for workers and people in neighboring area;
- identify the applicable equipment and project team (with possible subcontractors);
- calculate costs for an offer;
- develop a time schedule.

Despite of intensive investigation efforts during detailed site investigation there will always be some uncertainties regarding the exact delineation of the subsurface contamination or the behavior of substances in soil, sediment or groundwater. In the bid document clearly should be described how to deal with these uncertainties during the remediation works regarding the technical, legal and financial consequences.

Uncertainties are inevitable, due to the fact that the soil is largely invisible and any investigation is based on tests on a limited part of the total soil and groundwater volume. However, the uncertainties can be such that the investigation can be deemed insufficient. In such cases it may be considered to hold the Consultant liable for insufficient work. Therefore, this issue should be a point of attention in the drafting of the bid documents.

Activity 2 – Selection and appointment of contractor

The activities are depending on the chosen method of the tendering process. The tendering process is a method where the Indian Government, as well as Municipalities and most Corporations issue a procurement notice in newspapers, official government publications and over the internet for purchasing goods or services.
There are different tendering processes for different types of tenders.
The three types of tendering methods are:

1. Open Tendering;
2. Selective Tendering and
3. Negotiated Tendering.

Open Tendering Process
After the bid documents are finalised the tendering process comprises various stages.
The first stage includes the pre-qualification stage, where the client lays down criteria for qualifying for the work being tendered. This phase is considered as an important stage as it drastically cuts the number of bidders and selects only capable bidders.
The second stage is the tender invitation phase, where the client publishes or issues invitations to shortlisted bidders or to the public. This may not require media channels for communication.
The third stage is the tender clarifications and addenda phase, in which the client responds to the queries raised by the bidders in writing. It also engages possible issuance of tender addendums amending parts of the tender documents.
The fourth stage is the tender offer/bid submission phase where bids are presented in the form specified, mostly sealed envelopes and then there is the tender opening and the post tender clarification phase whereby the client goes through the tenders and seeks any clarification from the bidders.
The next stage is the award phase where the client issues an acceptance letter to the successful bidder who is usually, but not always, the lowest bidder and the last stage includes the formalisation of contract phase where the necessary documents are signed to formalize the agreement.

Selective tendering process
In a selective tendering process, the client selects only contractors that have delivered excellent results in previous similar tenders. This process includes three ways such as:

1. an advertisement may produce several interested contractors and suitable firms are selected to tender;
2. the consultants may contact those they would wish to put on an ad-hoc list and
3. many local authorities and national bodies keep approved lists of contractors in certain categories, such as work type and cost range.

Negotiated tendering process
In this process the client holds a one-to-one discussion with contractors to negotiate the terms of contract, as such tenders are mainly used for specialised projects like lift

systems, airport projects etc. at a larger level which includes a limited number of contractors who engage in these kind of projects from the industry.

In the Indian tendering scenario, frameworks are determined by guidelines set by the relevant international bodies including FIDIC (International Federation of Consulting Engineers for engineering) related tenders like computer tenders, civil work tenders and generators tenders.
However, the Indian Central and State Governments, Indian Municipalities and establishments such as Universities, the Military and Hospitals are governed by strict laws and only open competition bids are accepted.

It may be required to contract more than one party for the remediation works, an example is provided in Box I-8.2.1 below.

Box I-8.2.1 Example more than one party required to execute the work

It may be necessary to appoint more than one party to execute the work to be done. For instance in the situation where constructions present at the site have to be demolished anticipating the excavation of contaminated soil. Or the situation where a contractor executes an excavation work at the site and the excavated material is transported and treated by another contractor. For the supervision and verification of the remedial works the client always should appoint a third party which is independent from the contractor.

In the process of an open tendering for the remediation work there are various stages. The first stage includes the pre-qualification stage, where the client lays down criteria for qualifying for the work being tendered. This phase is considered as an important stage as it drastically cuts the number of bidders and selects only capable bidders.

Apart from financial and legal criteria there are several criteria possible to consider in the prequalification of a contractor. Some examples of these criteria are illustrated in Box I-8.2.2 below and more comprehensive in the *Checklist prequalification of contractors, Volume II-8.2-a*.

Box I-8.2.2 Examples of prequalification criteria

Company experience

- Track record of similar projects. Does the company or consortium have experience with the remediation techniques? Have these remediation works been implemented by the company in similar situations (type of contaminated site);
- Track record of projects with proven good project management skills;
- Company has appropriate health and safety policies and procedures in place;
- Pays attention to sustainability of certain aspects of the implementation (e.g. attention to save energy and to prevent nuisance);
- Quality management system.

Experience of Team and Team leader

- Good technical, management and communication skills;
- Capacity of the team is large enough to enable flexibility and to finalize the works according to the scheduled date;
- Awareness of policy and regulatory issues;
- Awareness of the need for verification;
- Ability to mobilize to the site in an acceptable period of time;
- Risk management approach to deal with uncertainties in the project.

8.2.3 Task 8.2 output

The output of this Task 8.2 is the contracting of a party, meeting the criteria of the bid documents, to implement the remediation works against agreed cost and time schedules.

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Step 8 Implementation of remediation

Task 8.3 Execution, supervision and verification of remediation works

Step 8: Implementation of remediation

Task 8.3: Execution, supervision and verification of remediation works

8.3.1 Introduction to and scope of Task 8.3

General description and connection to other Steps and Tasks
Task 8.3 concerns the execution of the remediation measures, as well as supervision and verification of the same.
The figure below shows how this Step is connected to preceding and following Steps and Tasks within the sequence of site assessment and remediation.

Activities
The following activities are performed in Task 8.3:
1) Prepare remediation measures;
2) Verify preparation of remediation measures;
3) Execute and manage remediation measures;
4) Verify remediation measures against contract and specifications;
5) Report verification results in a Remediation evaluation report.

Responsible parties
Activities 1 and 3 in this Task are typically carried out by technical specialists employed by a contractor. The team involved should demonstrate in-depth knowledge and experience of e.g. the remediation techniques and the characteristics of the contamination to be remediated.

Activities 2, 4 and 5 in this Task are typically carried out by technical specialists within a specialised consultant. It may be decided that these activities are assigned to SPCB, State and Central Government.

The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques.

The verification and reporting (Activities 4 and 5) are performed on behalf of the client and should therefore be carried out by a person or a team independent from the contractor. This requires special attention in case the supervision is carried out by specialists employed by the contractor. This is likely to happen in case the contractor has entered into a Design, Construct and Management contract with the client.

In case the competent authority performs verification of the progress and results this is usually done in addition to the verification as described in Activity 4.

8.3.2 Guidance for performing the activities

This section presents concise guidance for the performance of the activities within Task 8.3. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document as well as in other sources.

Activity 1 – Prepare remediation measures

The responsible party for the execution of the remediation measures, typically a contractor, will commence by preparing a detailed plan for the execution of the measures according to the obtained permits (Task 8.1) and the contract (Task 8.1). Referring to the DPR, prepared in Step 6, may be in order, as that provides important background information on the remediation. Besides the technical aspects of the measures this plan should contain a health and safety plan, aimed at protection of both the onsite workers and inhabitants and other users of the site and its surrounding area. Elements a Health and Safety plan should include are listed in the *Checklist Health and Safety plan, Volume II-8.3-a*. The specific safety measures depend of course on the nature of contaminants, the local situation of the site and Health and Safety Regulations. Furthermore, the plan should provide for efficient organisation and logistics of the remediation measures. Examples of constraints the plan may need to deal with are presented in Box I-8.3.1 below.

Box I.8.3.1 Examples of constraints for execution of remediation measures

Example situation: remediation measures are to be executed in an area where other activities are ongoing, e.g. a production unit at an industrial site.

In this example situation, the following constraints to the intended remediation measures may apply:

- Limited workspace, e.g. for placement of remediation equipment, for temporary storage of waste or for an on-site treatment plant;
- Limited access to the site for vehicles and capacity;
- Limited or otherwise regulated time, e.g. when the remediation is part of broader rehabilitation activities;
- Buildings and their foundations. When excavation is intended these may need to be temporarily stabilised;
- Cables, wiring and pipes for transporting electricity and liquid raw materials or waste. These may need to be temporarily redirected.

Activity 2 – Verify preparation of remediation measures

Like the remediation measures themselves, their preparation is also verified. This verification typically includes checks on whether the required permits have been issued prior to the start of the work, on whether the health and safety plan is adequate (refer *Checklist Health and Safety plan, Volume II 8.3-a)*, on whether the authorities have been informed about the start of works, and on whether the stakeholder involvement has been adequately organised.

The verification of the preparations also includes a check on whether the data on the situation at the site are still in accordance with the actual situation. The basis for this check is the remediation plan (approved DPR), prepared in Step 6. Especially in case a long time has passed since the remediation plan was developed the situation may have altered. In such situations it may be necessary to have the Conceptual Site Model updated, so the intended remediation measures can be modified accordingly. In case of major changes in the situation it may even be necessary to modify the DPR (Step 6). Examples of such a situation are: mobile contaminants may have moved further through the soil with groundwater flow or some digging has taken place at the site causing a displacement of superficially present contaminated material.

Activity 3 – Execute and manage remediation measures

To determine whether the intended remediation measures can effectively meet the remediation objectives, pilot testing may be conducted. Depending on the situation this pilot testing can be carried out before detailed design of the remediation measures or before the start of execution of the remediation measures.

Execution
Execution of the remediation measures takes place according to the remediation plan. That plan should contain a clear outline of every measure, demonstrating how it is performed, its frequency (if periodic), parameters to be measured or sampled, target levels and what to do whenever either critical deviations or non critical deviations occur. For guidance on this last item refer to Volume I, Step 11, Activity 3. Including a description of the aim and background of measures can help to gain support from affected parties.

Management and reporting
The contractor periodically informs the client on the progress of the remediation measures. These reports should provide at least the following information:
- Progress of measures against the planning. Identification of delays or potential delays;
- Description and photographic records of the executed activities;
- Required modifications to the remediation measures;
- Necessity of activities not expected before and not agreed in the contract;
- Forecast of the activities and implications for the budget when extra activities are needed;

- If applicable, health and safety accidents or environmental incidents;
- Details of site visits made by regulators;
- Evidence (e.g. results of measurements) of conformance with permits, licenses and/or consents.

Relevant stakeholders on the site and in its surroundings should also be periodically informed on the progress. To them, the testing of nuisance caused by remediation activities may be of special interest.

Stakeholder	Interview objective	Level
Site owner	provide information, discuss progress	site
Site operator's health facility director	provide information, discuss progress	site
Local businesses, residents and NGO's	provide information, discuss progress	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	provide information, discuss progress	local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	provide information, discuss progress	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	provide information, discuss progress	national
Competent authority	provide information, discuss progress	level of competent authority

Activity 4 – Verify remediation measures against contract and specifications

During the execution of the remedial measures the supervisor periodically verifies the conditions at the site. The actions this entails will have been outlined in the verification plan, developed in Step 6. This plan would also provide the frequency of the actions by the supervisor, the samples to take, what needs to be reported and otherwise communicated etc. The intensity of the actions to be performed may in certain situations require permanent presence of the supervisor at the site.

The verification focuses on whether the contractor executes the measures in conformity with the outline in the remediation plan (DPR), developed in Step 6. In case of deviations from that plan the supervisor discusses the reasons for this deviation with the contractor. In case the deviation necessitates modifications to the remediation measures the supervisor may impose these on the contractor. In case a deviation leads to a critical situation the supervisor may recommend to modify the remediation plan (DPR) or even to inform the competent authority, who may decide to temporarily discontinue the execution of the remediation measures. Box I-8.3.2 provides practical information how to deal with deviations from the remediation plan.

Box I-8.3.2 Practical information on dealing with deviation of remediation plan by the supervisor

Although a contaminated site may have been investigated thoroughly, almost always the contamination in the soil and groundwater has a different appearance and magnitude compared to the description in the preremediation reports. Any soil investigation is dependent on a relatively small amount of sampling compared to the volume of soil and groundwater and as such will give a different picture than reality.

A remediation plan/DPR describes the activities necessary to approach the contaminated situation as assessed. If the actual contaminated situation varies from the assessed situation the remediation works should be adjusted. For instance if in a corner of a site contamination was expected but during excavation this contamination is not found, the excavated area can be reduced compared to the boundaries described in the DPR. This is a sensible strategy the supervisor has to approve. Normally the DPR describes how to deal with deviations of the actual situation.

Another example of such a situation that may call for modification of the remediation plan is where during excavation contamination turns out to be present in much deeper soil layers than previously expected while the ongoing remediation measures are not sufficient to reach that depth.

The supervisors' periodic verifications also serves to manage the environmental aspects of the remediation. An example of this is periodic sampling of excavated material to determine its potential for reuse. In case excavated material turns out to be contaminated the supervisor may direct that it should be transported to a treatment plant or to a TSDF. If not contaminated he may indicate appropriate reuse options.

The periodic verifications include the collection of data, in conformity with the verification plan. Usually this is achieved by taking soil samples at defined locations in the wall or floor of an excavation pit and sending them to an accredited laboratory for testing. The periodic verification can also involve measuring the water quality after treatment, measuring the thickness of a capping layer and monitoring the nuisance at site boundaries (noise, dust, odour, etc.). The time span of this periodic testing is in line with the time span of the remediation measures and can cover several years.

In case unforeseen events considerably change the situation at the site the supervisor may impose modification of the remediation measures. An example of such a situation is when, through demolishing a building and its foundations, contaminated material has accidentally ended up among clean soil material.

The supervisor should keep a log in which he records daily events at the site and results of any measurements. This log will later serve to prepare the Remediation evaluation report (Activity 5).

A checklist of elements of supervision and verification is presented in the *Checklist supervision and verification of remediation measures, Volume II-8.3-b*.

The supervisor can also have a role in the health and safety measures by signalling unsafe situations, upon which the contractor may need to take the appropriate actions.

One of the most vital tasks of the supervisor is to perform verifications at preset critical moments in the remediation process. Example of such moments is the moment when an excavation has reached its predefined boundaries: before supplementing the excavated pit with clean soil material, the supervisor should take samples from the pit wall and bottom to verify whether the remediation objectives have been met.

Activity 5 – Report verification results in a Remediation evaluation report

The collected information on the verification activities are reported by the environmental supervisor, refer *Checklist Remediation evaluation report, Volume II-8.3-c*. All data, including copies of analytical reports and testing results and a logbook of the remediation period, are added to the report. The results of the remediation are compared to the expectations described in the remediation plan/DPR, e.g. are the concentration levels of the soil samples below the target levels as described in the DPR?

In the Remediation evaluation report a.o. following questions should be answered:
- Was it possible to verify the remediation results?
- Is the remediation result acceptable compared to the expectations in the DPR?
- Has the remediation been carried out in the way it was planned and approved before?
- If not, were the measures adjusted accordingly?
- Is contamination not being removed which requires post remediation action?

This evaluation report is the basis for the client and for the competent authority to decide on approval of the environmental results of the remediation and to take a decision on the possibilities for future land use.

8.3.3 Task 8.3 output

The output of this Task 8.3 is a Remediation evaluation report, to be reviewed and approved by the competent authority during Step 9.

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Step 9 Approval of remediation completion

Step 9: Approval of remediation completion

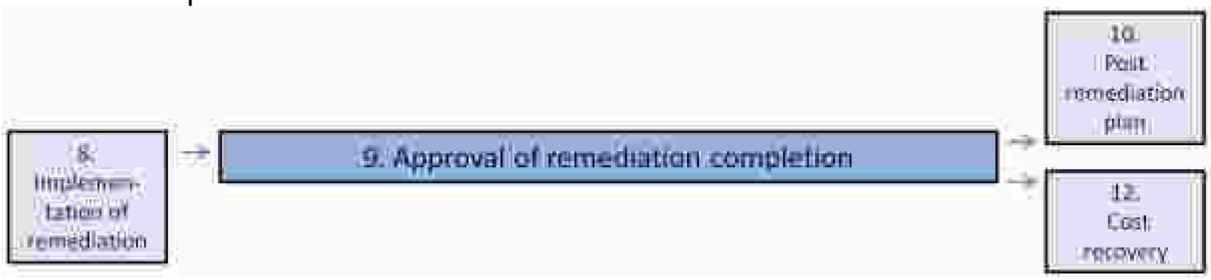
9.1 Introduction to and scope of Step 9

General description and connection to other Steps
Step 9 concerns the review and approval of the remediation activities by the competent authority.

After the remediation activities have been completed the activities and their results would have been presented in a remediation evaluation report (Step 8). These results need to be approved by the competent authority, based on a review of the same report, in this Step 9. In case the remediation has left no residual contamination on the site, the authority may unconditionally approve the remediation. In such a case steps 10 and 11 may be skipped altogether, so the next steps will be Step 12 Cost recovery, Step 13 Priority list deletion, and Step 14 Site reuse.

In case residual contamination has been left behind on the site after remediation, the competent authority may accompany the approval of the remediation with a decision that post remediation action needs to be carried out. In such a case, a post remediation plan will need to be developed in the subsequent Step 10.

Step 9 commences with a review of the remediation evaluation report plan developed in Task 8.3. It ends with the presentation of the decision.
The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.



Activities
The following activity is performed in Step 9:
1) Review the Remediation evaluation report and approval of the remediation completion.

Responsible parties
The activity in this Step is typically carried out by technical specialists within the competent authority for the remediation process.

The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of remediation techniques and the physical, hydrological and social impact of techniques, as well as awareness of social aspects and consequences for spatial planning.

9.2 Guidance for performing the activities of Step 9

This section presents concise guidance for the performance of the activity within Step 9. It is intended to enable the user to quickly gain an understanding of the necessary activity.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document.

<u>Activity 1 – Review the Remediation evaluation report and approval of the remediation completion</u>

Review of the remediation report
Step 9 primarily aims to review whether the results of the remediation, presented in the Remediation evaluation report, developed in Task 8.3, meet the expectations, raised by the agreed remediation design plan/DPR, developed in Step 6. A set of criteria for this review is presented in the *Checklist review and approval remediation completion, Volume II-9-a*.

Criteria for the success of the remediation can be very clear, e.g. reduction of the concentration of a certain parameter to below a certain level. In practice, it is not always easy to deal with such criteria. An example in Box I-9.1 below illustrates this.

Box I-9.1 Example of complication in dealing with remediation success criteria

Example situation: remediation was carried out by excavating contaminated soil material. During this excavation it turned out that the volume of contaminated soil material was considerably larger than expected based on the previous site investigation results. This because some soil material below a building foundation, where it could not be reached during the investigation, turned out to be contaminated. Upon encountering this material, the contractor has decided not to remove this contamination, due to disproportionate costs to reduce limited risks.

During review of the Remediation evaluation report, the competent authority may decide to accept the contractor’s decision, under the condition that post remediation measures are implemented to control risks associated with the residual contaminated soil material.

Remediation projects may comprise several phases, e.g. when excavation of contaminated soil material was followed by the extraction and treatment of contaminated groundwater. Another example is an in-situ remediation where after an initial phase of installing the equipment a remediation period of several of years followed. In such situations the Remediation evaluation report should expressly discuss all phases of the remediation. A common situation is that the last phase of remediation covers a considerable time period. In such a situation a remediation evaluation report covering all phases but the last one can be considered. In practice, a period of one year is commonly used, after which reports on intermediate results of the last phase can be submitted for review and approval.

In cases where post remediation measures had been integrated in the remediation strategy upfront, it can be beneficial to simultaneously review the post remediation plan, developed in Step 10, if this is already available.

Approval of the remediation results and presentation of conclusions on next step
Based on the outcome of the review (Activity 1) the competent authority develops and presents a conclusion on approval of the remediation results. This conclusion should also contain an outline of the current situation at the site, as well as the possibilities for site use. Essentially three types of conclusion are possible:

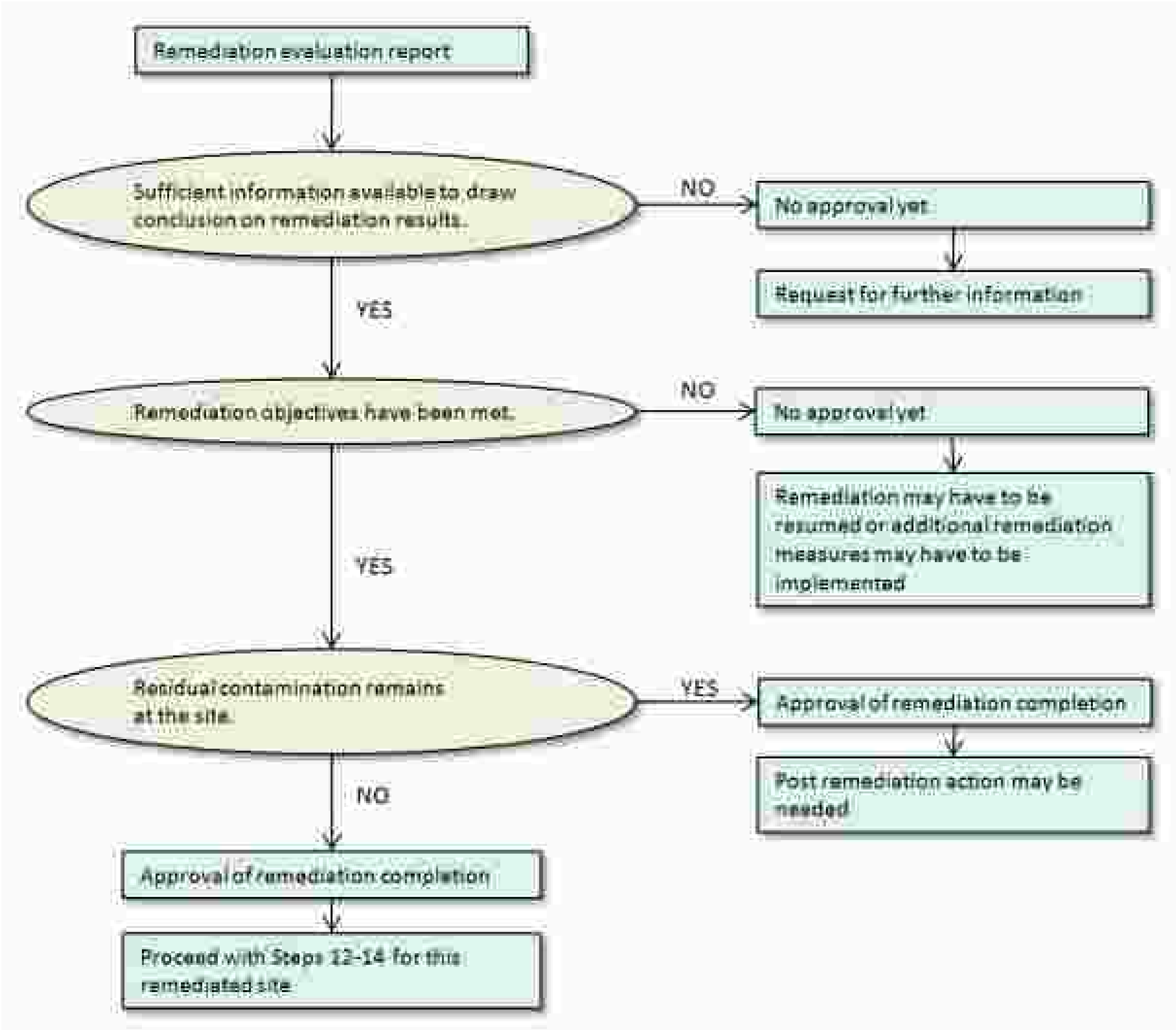
1. Gaps in the forwarded information bar a conclusion. In this case the competent authority may request completion of the remediation evaluation report, so as a conclusion can be prepared.

2. The remediation objectives have not been met. The competent authority may decide the remediation to be resumed or additional remediation measures should be implemented. In this case the competent authority may give appropriate instructions as to their implementation. In case this involves additional investigation the process is resumed at Task 5.1 Detailed site investigation. In case additional investigation is not needed the process is resumed at Step 6 Remediation design, DPR.

3. The remediation objectives have been met. The remediation phase may be formally terminated.
    a. residual contamination remains on the site. In this case post remediation measures may be needed. In case the Remediation evaluation report proposes such measures the competent authority may need to approve these measures (Step 10) and give instructions for implementation (Step 11). In case the Remediation evaluation report does not propose such measures, the competent authority may give instructions to develop such measures (Step 10) and for their implementation (Step 11);
    b. no residual contamination remains on site. In this case the competent authority may proceed with Step 12 Cost recovery, Step 13 Priority list deletion, and Step 14 Site reuse.

This review process is visualised in the flowchart below.

Figure I-9.1 Flowchart for review of remediation results and conclusion on next step.



9.3 Step 9 output

The output of Step 9 is a clear conclusion on approval of the remediation results. This conclusion should also contain an outline of the current situation at the site, as well as the possibilities for site use. Instructions for the next steps also form part of the output of Step 9.

Volume I
Step 10 Post remediation plan

Step 10 Post remediation plan

10.1 Introduction to and scope of Task 10

General description and connection to other Steps
Step 10 concerns design and approval of a Post remediation plan. Such a plan is required only when a remediation is completed while leaving residual contaminations at the site. In such cases site use restrictions are likely to be in force, and technical measures may be necessary to prevent future human and ecological risks and risks of spreading of the residual contaminations.

Step 10 commences with a review of the remediation evaluation report, developed in Task 8.3 and approved in Step 9, as that report establishes the need of post remediation measures. Step 10 ends with an approved post remediation plan, the basis for the implementation of the port remediation measures in Step 11.
The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.

Activities
The following activities are performed in Step 10:
1) Preparation of post remediation plan;
2) Review and approval of post remediation plan.

Responsible parties
The activities in this Step are typically carried out by technical specialists within the competent authority for the remediation process, or the appointed consultant. The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of post remediation techniques and the physical, hydrological and social impact of these techniques.

A review by the competent authority is required before moving to the next Step 11 Post remediation action.

10.2 Guidance for performing the activities of Step 10

This section presents concise guidance for the performance of the activity within Step 9. It is intended to enable the user to quickly gain an understanding of the necessary activity.

Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document.

Activity 1 Preparation of post remediation plan

The post remediation plan describes all the technical and supporting management activities such as monitoring, maintenance, repairs and corrective actions to keep a remediated site in such a state as to prevent future risks. The post remediation plan should provide for a long term guarantee to the competent authority for a long lasting and adequate risk control.

The nature of post remediation measures can be deceptively similar to certain types of remediation measures. Box I-10.1 below provides guidance in distinguishing the one from the other.

Box I-10.1 Post remediation measures versus remediation measures

Post remediation measures will start after the remediation works have been completed and the results have been approved by the competent authorities. Post remediation measures do not aim to remove the residual contaminants, but rather to control and fix the situation reached by the remediation measures and to prevent the residual contaminants to cause future human and ecological risks and risks of spreading. Post remediation measures typically are long term and can run up to several years or even decades.

By contrast, long term extensive remediation measures are performed during remediation. These measures resemble post remediation measures in that they are long term and can last up to several years. The difference with post remediation measures is that the long term extensive remediation measures are aimed to reach the remediation objectives by reducing the contaminant level. Such measures typically form part of in situ techniques, based on slow natural processes to degrade or precipitate contaminations.

The design of a post remediation plan should commence by a review of the remediation evaluation report, developed in Task 8.3 and approved in Step 9, as that report establishes the need of post remediation measures. In cases where residual contamination has remained at the site that report should also list the site use restrictions to prevent risks. Examples of these restrictions are presented in Box I-10.2 below.

Box I-10.2 Examples of site use restrictions

- no digging (either with or without human safety measures like gloves);
- no vegetable growing for human consumption;
- no use of groundwater for irrigation or human consumption;
- no cultivating of plants with roots growing to a depth > 0.5 m;
- no construction of residences (to prevent vapours from the soil to enter buildings);
- no site use change without prior consent by the competent authority.

Two different types of measures to prevent risks can be distinguished, examples of which are presented in Box I-10.3:

- *Management measures:* activities which are focused on compliance with the site use restrictions or the monitoring of a stable physical situation that can be disturbed by human impact or natural processes;
- *Technical measures:* activities which are focused on the maintenance and the continuity in operation of active measures.

Box. I. 10.3 Examples of post remediation measures

Management measures

- Registration of site use restrictions and administrative management of the land use;
- Monitoring compliance with site use restrictions;
- Raising of awareness;
- Monitoring of contaminant concentration levels in stable groundwater plume.

Technical measures

- Monitoring and maintenance of clean top layer covering contaminated material;
- Operation of geohydrological isolation of a groundwater plume, including operation of a pump and treat system;
- Maintenance of groundwater drainage system to prevent contaminated groundwater to enter residences;
- Monitoring of permeability of vertical barriers and maintenance of these barriers if necessary;
- Maintenance of the biological activity in the soil to be able to degrade remaining contamination;
- Maintenance of the monitoring system.

During the post remediation phase critical deviation points and non-critical deviation points may come up that might lead to future human and ecological risks and risks of spreading of the contaminations. These deviation points should be anticipated in the post remediation plan by outlining counter measures. Critical deviation points may result in additional site use restrictions. But if the risks due to the residual contaminations cannot be controlled by the post remediation measures, there may be a need to commence additional remediation measures. For the design and implementation of these measures a detailed project report (DPR), including an authorisation of the authorities is needed (Step 6). Examples of critical and non critical deviation points are presented in Box I-10.4 below.

Box I-10.4 Examples of critical and non-critical deviation points

An example of a non-critical deviation point is the following: the capping layer (covering a contaminated site) is slightly damaged. Due to the damage the thickness and/or the composition of the capping layer may not meet the original requirements anymore. By restoring the capping layer the situation at the site can be restored into the situation as it was directly after the implementation phase of the remediation.

An example of a critical deviation point is the following: the concentration of contaminations in groundwater are unexpectedly rising to a non acceptable level. The reduction of the concentrations can only be realised by implementing additional removal of the contaminated source.

The post remediation plan should include a list of the potential critical and non critical deviation points, a list of action levels, how these levels can be detected in time, what kind of counter measures might be adequate, as well as the design of the decision process on counter measures. Monitoring is a useful tool to keep an eye on all deviation points.

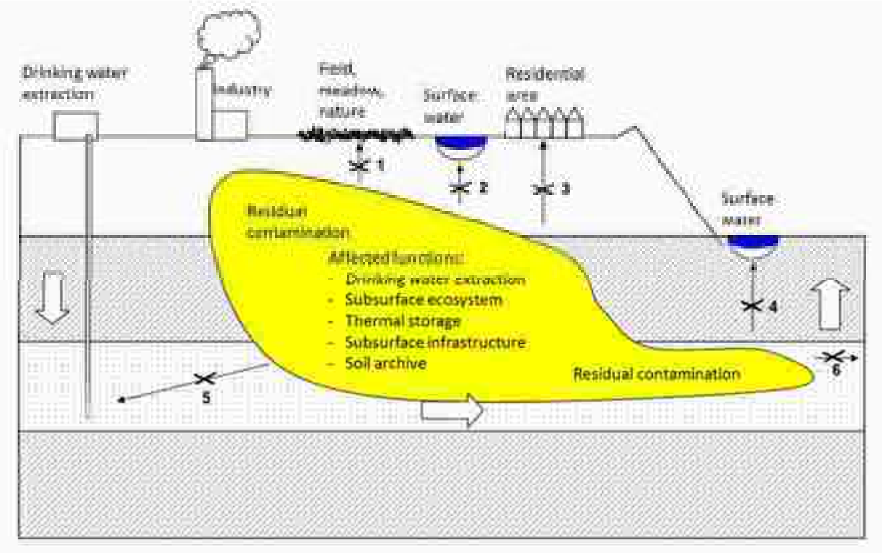
Strategy for monitoring groundwater

For monitoring of groundwater quality the following strategies may be applied (sometimes a combination of strategies is applied):

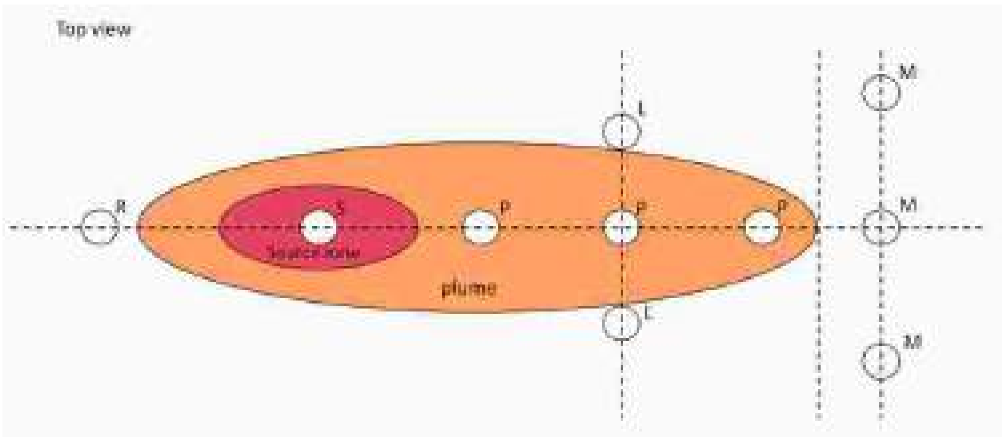
- Receptor based
- Plume based
- Flux based

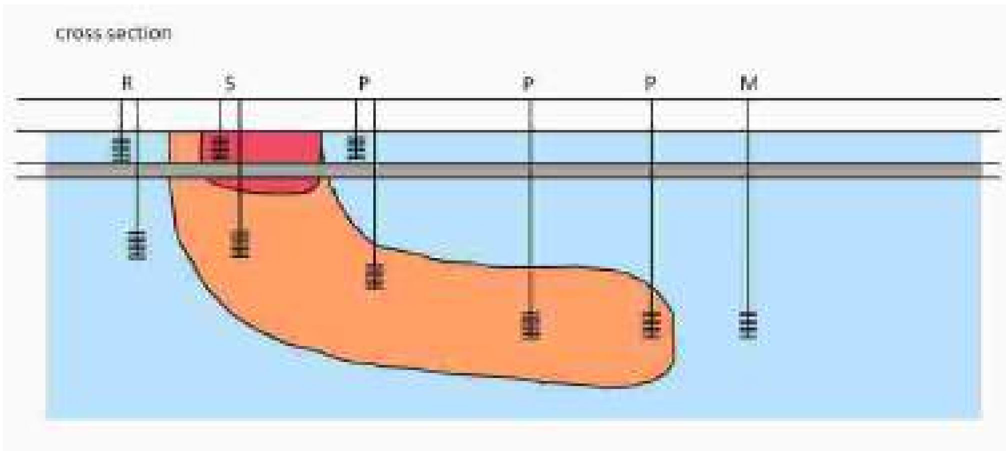
1) Receptor based strategy

Monitoring should indicate whether the contamination in groundwater is threatening receptors. This strategy is often applied in case of short distance between contaminated plume and receptor. Between the end of the plume and the receptor at least one monitoring well must be placed. The figure shows an example of a plume of residual contamination, various receptors and routes (indicated by crossed out arrows 1 through 6) between contamination and receptors that need to be monitored.



2) Plume based strategy
Information about the fate and behaviour of the contaminated plume has to be collected in order to enable conclusions on future behaviour. Based on trend analysis over a couple of years of measuring it can be underpinned if a plume is still expected to be stable, to move, to grow or to decline.
Below two figures illustrate the basic idea for the pattern for monitoring wells. Explanation of the codes that show the purpose of each well: R (Reference for background level); S (Source); P (Plume); L (Lateral plume expansion); M (general Monitoring).





In the direction of the plume monitoring wells will be placed in following order: R-S-P-P-P-M. Transverse thereto following monitoring wells will be placed: L-P-L to detect deviations of expected transport direction and M-M-M to detect the front of the plume. Depth of the wells are depending on soil profile and plume dimensions. Often wells have to placed at multiple depths related to the permeability of the soil layers. Minimum number of monitoring wells is to have R-S-P-M in the direction of transport, one line of wells L-P-L across the plume perpendicular to the direction of transport and one line of wells M-M-M in front of the plume, also perpendicular to the direction of transport.

3) Flux based
Monitoring wells are positioned transverse to transport direction of the plume in order to measure the amount of contaminated material which passes through this plane. This strategy is often applied in case of multiple plumes which are spreading towards one receptor.

Other elements of a Post remediation plan
Practical aspects of the implementation of the post remediation activities should be part of the post remediation plan. Depending on the situation at hand those aspects typically include:

- Scheme of monitoring activities;
- Scheme of maintenance, repairs and replacement of parts of the post remediation system, e.g. groundwater pumping system, horizontal capping layer, monitoring wells;
- Log of all recordings, activities, contacts and results of the post remediation actions;
- Periodic reporting of the site status;
- Planning schedule for all activities described.

A management scheme is necessary to describe all tasks, responsibilities and persons or institutions to which these are addressed to. As management can only be effective if based on periodic status reporting, the post remediation plan should state the frequency of post remediation status reporting.

The *Checklist Post remediation plan, Volume II-10-a* provides a comprehensive overview of elements a full scale post remediation plan may contain. The post remediation plan is forwarded to the competent authority for approval.

Stakeholder consultation
A stakeholder consultation is needed, both to inform the stakeholders on the post remediation plan and to secure their support. The consultation may also yield information that can be useful in the final design of the post remediation plan. Whether or not to include interviews with stakeholders at district, state and national level may involve the weighing of economic aspects. As a result, this may for the state and national levels only be applicable to large scale sites.
The decision on land use post remediation needs to be taken at this stage. Therefore, the post remediation plan also needs to address this issue. This necessitates the involvement of a land use designation authority, which may take the shape of an interdepartmental committee with land use experts.

Stakeholder	Interview objective	Level
Site owner	exchange information, secure support	site
Site operator's health facility director	exchange information, secure support	site
Local businesses, residents and NGO's	exchange information, secure support	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	exchange information, secure support	local
Land Registration Office	discuss conclusion on land use post remediation	district / local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	exchange information, secure support	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	exchange information, secure support	national

Activity 2 Review and approval of post remediation plan

The competent authority reviews the post remediation plan. The *Checklist review and approval Post remediation plan, Volume II-10-b* provides guidance for this Activity. The competent authority may also find guidance in the text on Activity 1 above.

10.3 Step 10 output

The output of this Step 10 is a Post remediation plan, approved by the competent authority, describing all activities needed to prevent future human and ecological risks and risks of spreading of the residual contamination left on the site after the finalization of the remediation.

Based on this output the post remediation activities can be implemented in the subsequent Step 11.

Volume I

Step 11 Post remediation action

Step 11: Post remediation action

11.1 Introduction to and scope of Step 11

General description and connection to other Steps
Step 11 concerns the implementation of the post remedial action outlined in the Post remediation plan. This is required only when a remediation is completed while leaving residual contaminations at the site. In such cases site use restrictions are likely to be in force, and technical measures may be necessary to prevent future human and ecological risks and risks of spreading of the residual contaminations.

Step 11 commences with a review of the Post remediation plan developed and approved in Step 10. It ends if and when an approved Post remediation status report demonstrates that the residual contaminations do no longer require attention. In certain situations Step 11 may go on in perpetuity, which may or may not bar site reuse.

If the situation on the site allows it, Steps 11 and 14 (Site reuse) can be implemented simultaneously.
The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.

Activities
The following activities are performed in Step 11:
1) Prepare Post remediation implementation programme;
2) Outsource implementation of post remediation activities;
3) Implement post remediation activities;
4) Supervise and verify post remediation activities and prepare periodical Post remediation status report;
5) Periodically review and approve Post remediation status report.

Responsible parties
Activity 3 in this Task is typically carried out by technical specialists employed by a contractor. The team involved should demonstrate in-depth knowledge and experience of e.g. the post remediation techniques and the characteristics of the contamination involved.

Activities 1, 2 and 4 in this Task are typically carried out by technical specialists within a specialised consultant. The team involved should demonstrate in-depth knowledge and experience of e.g. the characteristics of contaminations (e.g. mobility, biodegradability), performance of post remediation techniques and the physical, hydrological and social impact of these techniques.

The supervision and verification are performed on behalf of the client and should therefore be carried out by a person or a team independent from the contractor. This requires special attention in case the supervision is carried out by specialists employed by the contractor.

Activity 5 has to be carried out by experts of the competent authority.

11.2 Guidance for performing the activities of Step 11

> This section presents concise guidance for the performance of the activities within Step 11. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.
>
> Wherever relevant, reference is made to more detailed information, both in Volume II and Volume III of the Guidance Document.

Activity 1 – Prepare Post remediation implementation programme

The approved Post remediation plan is the basis for the implementation of post remediation action. In this Activity this plan is translated into a Post remediation implementation programme, essentially a smart list of operational measures to be implemented, typically over a time frame of two to five years. Most operational measures during post remediation will be repeated periodically. The frequency of this will largely determine the time frame of the implementation programme: the higher the frequency the shorter the time frame of the implementation programme. The frequency of the operational measures typically is high whenever a site is situated in a dynamic area. This warrants revision of the implementation programme after a relatively short period of time, say two years. A high frequency of operational measures is also often seen during the initial phase of post remediation, after which it may gradually slow down. In that situation revisions of the implementation programme tend to last longer as the post remediation progresses. Aspects related to the contracting phase (see under Activity 2) can also influence the time frame of an implementation programme.

In case the post remediation measures are to be assigned to a third party (see under Activity 2 below) the Post remediation implementation programme can be a useful Annex to the Terms of Reference.

The nature of post remediation measures can be deceptively similar to certain types of remediation measures. Box I-10.1 (see Volume I, Step 10) provides guidance in distinguishing the one from the other.

Post remediation is a matter of measures periodically repeated over a relatively long period of time, from years to decades and even longer. This means two things: firstly, management is crucial and can only be effective if based on periodic status reporting (see under Activity 4). Therefore, the Post remediation implementation programme should state the frequency of Post remediation status reporting. Secondly, a Post remediation implementation programme should contain measures in all of the following categories: monitoring, inspection, maintenance, replacement, management.

Situations with layers capping a residual contamination in soil and with residual contamination in groundwater make for the majority of all post remediation situations. Box I-11.1 below presents examples of implementation measures in all five categories for situations with capping layers, while Box I-11.2 does the same for situations with residual contamination in groundwater.

Box I-11.1 Examples of post remediation implementation measures for situations with a layer capping contamination in soil

Situation: during remediation (Step 8) a clean layer has been installed isolating a volume of contaminated soil. The capping layer effectively prevents human contact with the contaminated soil. With that, the remediation objective of blocking the pathway between the contaminated soil (source) and humans (receptors) has been met. The remediation has been reported and the report has been approved by the competent authority, effectively concluding the remediation (Step 9). In order to ensure the remediation objective is maintained for as long as is deemed necessary, it has been decided that post remediation action is needed.
The Post remediation plan (Step 10) states that the post remediation measures should ensure the capping layer continues to prevent receptors to get in contact with the contaminated soil. Measures to that end have been described in a general sense. In this Step 11 these are translated into implementation measures, e.g. the following:

- *monitoring measures*: yearly inspection of the thickness of the capping layer. The thickness should be at least 90% of the thickness upon end of remediation. During the inspection the integrity of the capping layer should be guaranteed. Therefore non destructive inspections are preferred before destructive methods. Example non-destructive sample methods are GRP (ground penetrating radar), surface elevation levelling (settling of the contaminated layer below the capping layer will be a point of uncertainty), visual inspection (suitable for identifying unauthorised activities, but has its limitations as it is impossible to estimate the thickness of a layer. Visual inspections typically are only applicable to signal cracks, ruptures, settling, and slides or shearing along slopes). Typical destructive sample methods are digging (with possibility for lines repairs due to the digging) or drilling. Markers or signalling layers in the capping-contamination transition zone may help to improve the quality of radar or prevent damage by drilling.
- *inspection measures*: inspect the capping layer every 6 months and record visible signs of erosion, washing, settling, unauthorised digging and unauthorised reuse of contaminated material in the capping layer.
- *maintenance measures*: restore the capping layer whenever monitoring or inspection measures demonstrate this is needed.
- *replacement measures*: see maintenance measures.
- *management measures*: 1) instructions on site use, 2) awareness campaign to prevent damage to a capping layer, 3) official procedure for approval of specific types of site use, e.g. construction of drainage in a capping layer.

Box I-11.2 Examples of post remediation implementation measures for situations with a residual contamination in groundwater

Situation: during remediation (Step 8) contamination in groundwater has been removed to such a degree that risks have become acceptable. With this result the remediation objective of getting the source in an acceptable state has been met. The remediation has been reported and the report has been approved by the competent authority, effectively concluding the remediation completion (Step 9). In order to ensure the remediation objective is maintained for as long as is deemed necessary, it has been decided that post remediation is needed.

The Post remediation plan (Step 10) states that the post remediation measures should ensure the contaminant levels in the groundwater remain at such levels as to keep the risks acceptable. Measures to that end have been described in a general sense. In this Step 11 these are translated into implementation measures, e.g. the following.

- *monitoring measures*:
  - 1) measure groundwater flow and sample contamination levels, relevant for the given situation and according to the applicable standards, at the monitoring wells shown on a map in following sequence: month 1, 3, 6, 9, 12 and afterwards every 6 months (related to seasonal influences). Report results and advise corrective action whenever these show concentration levels become unacceptably high or whenever the contaminated groundwater spreads beyond the predefined border.
  - 2) measure groundwater discharge by the pumps installed for post remediation and sample contamination levels on day 1, 3, 7, 14 and afterwards on monthly basis. Report measurement results and advise maintenance or replacement measures whenever the discharge deviates unacceptably from the predefined intended volume or concentration levels become unacceptably high.
  - 3) measure the groundwater level on day 1, 7, 14 and afterwards on monthly basis, report results and advise corrective action whenever the groundwater level exceeds a predefined action level or whenever volatile contaminations threaten to enter building basements. Corrective action can be e.g. temporary intensified monitoring or a more comprehensive testing method.
- *inspection measures*: inspect the groundwater post remediation system every month, record visible signs of wear and advise maintenance or replacement measures whenever this is deemed necessary. Automated process logging and alarm system may be used.
- *maintenance measures*: take whatever measures are needed to maintain the groundwater pumps and the water purifying plant in good working order, e.g. to prevent the pipes from leaking.
- *replacement measures*: replace monitoring wells, active carbon in a water purifying plant or water pumps whenever this is needed to keep the system in good working order.
- *management measures*: instructions on site use.

As can be seen in the examples in the boxes above, the description of every measure should show how it is performed, its frequency (if periodic), parameters to be measured or sampled, target levels and what to do whenever either critical deviations or non critical deviations occur. For guidance on this last item see under Activity 3 below. Including a description of the aim and background of measures can help to gain support from affected parties.

Stakeholder involvement
Stakeholder involvement is crucial for most of the post remediation sites as the site use and post remediation system are closely interdependent. Therefore, prior to post remediation site users and the community should be involved. This can be done by the formation of a local committee, functioning as a part of panchayat in rural areas or as a ward committee in urban areas. Consultation of local political leaders can help in a balanced communication towards the community.

Owners, site users, inhabitants and others with primary dependence on the use of the site should be informed about the intended site use restrictions, as well as about the necessity and eventually the results of the post remediation measures. Authorities on spatial planning and land use should be informed as well (State Government, Urban and Rural Development Department, Revenue Department, Environment Department).

Activity 2 – Assign implementation of post remediation activities

Post remediation occurs in a variety of situations. The decision to assign/outsource the implementation of post remediation measures depends on the scope of the measures to be implemented and the position and involvement of the site owner to the site. Examples of situations where the site owner may take the post remediation or part thereof upon himself are presented in Box I-11.3 below.

Box I-11.3 Examples of situations where site owner may perform post remediation

- A TSDF owner who possesses the skills required to maintain a capping layer may decide to implement post remediation measures himself;
- An owner of an operational industrial site may decide to implement management measures (like supervision of compliance with site use restrictions) himself. In this situation, he may still outsource the remaining technical measures;
- An owner of an operational industrial site who possesses the skills required to perform groundwater sampling may decide to implement monitoring measures himself. In this situation, he may still outsource the remaining technical measures.

In case it is decided to assign/outsource the implementation of post remediation measures or part thereof the procedure commences by the preparation of bid documents. These should at least include Terms of Reference. These can then be used in the prequalification, which should result in the selection of able contractors. Guidance on the prequalification can be found in the *Checklist prequalification for remediation, Volume II.8.2-a*.

Post remediation action typically lasts a long time, which is often not even to be determined beforehand. Therefore the issue of the time frame merits special attention, in addition to the generic elements listed in the checklist mentioned above. Some of the options to be considered for this are:

- A predefined period, typically covering two or three years. This period should not be too short to optimise the costs and to minimise loss of information and hands on experience due to the handing over of the archive and change of project team;
- A period aligned with the time scope of the Post remediation implementation programme, developed in Activity 1 above;
- A period aligned with site redevelopment planning;
- A period aligned the planning of major maintenance and revisions of parts of the system. For example, if the life span of a water treatment plant is expected to be fifteen years, that may also serve as the contract time frame;
- A period aligned with intended site ownership transaction;
- An undefined period. This may imply the contract will only be terminated if and when the post remediation is terminated.

In a phase that may literally proceed in perpetuity, an exit strategy warrants special attention. Whenever residual contaminations turn out to have been removed, either by natural causes (e.g. by biodegradation) or by implemented measures, termination of the post remediation action may be considered. This action commences by evaluating the new situation in the Post remediation status report (see under Activity 4 below). In case it is expected the situation in the field will remain more or less stable forever it will be useful to formulate an exit strategy. This strategy should include criteria at which the post remediation measures may be terminated, and a method for termination.

Once the contractor has been selected, a contract will be formulated. The following issues merit special attention, largely with regard to the extensive time frame:

- Scope of the contract. While a contract including all risks and all replacement of expensive parts of the remediation system will be costly, it should be considered that the replacement itself can also be very dear. Examples are the complete restoration of a capping layer after it has been washed away by monsoons or the replacement of a bio-screen earlier than predicted;
- Continuity of data, information and experience with the site should be guaranteed during the entire contract period and beyond, e.g. by using a data management system (preferably online) and a provision that all data and experience shall be handed over to the client upon termination of the contract;
- Continuity of post remediation activities should be guaranteed. While a full guarantee cannot be given a good track record and a periodic payment schedule may offer some basic security.

<u>Activity 3 – Implement post remediation activities</u>

The party responsible for Activity 3 proceeds to implement the measures outlined in the Post remediation implementation programme, developed in Activity 1. During implementation any deviation from what is expected warrants adequate intervention. Whenever a deviation occurs, it should first be assessed whether corrective measures will enable restoration of the situation before the deviation occurred. If this is the case the deviation is regarded as non critical, otherwise it is a critical deviation.

Handling of a critical deviation
A critical deviation impacts the integrity of the post remediation system and therefore calls for immediate intervention to prevent damage and risks. Examples of critical deviations are presented in Box I-11.4 below.

Box I-11.4 Examples of critical deviation points

- Evaporation of volatile contamination into buildings is much higher than predicted in the Post remediation plan. All implemented measures fail to prevent human exposure to these contaminations. This means additional remediation measures like additional source removal (e.g. digging of contaminated soil), breaking of pathway (installation of additional ventilation or dam proof floors in the building) or relocating of receptors (evacuation of building residents) need to be implemented to terminate the exposure;
- Current or future site use differs from the use as described in the Post remediation plan or in the latest Post remediation status report and will result in future risks. Either enforcement on the unauthorised site use should be performed or additional remediation measures need to be implemented to accommodate this site use.

As a deviation of this magnitude cannot be corrected with limited effort the Post remediation plan may need to be revised, meaning going back to Step 10 (e.g. more stringent site use restrictions are imposed) and proceeding from there. It may even be necessary to implement additional site investigation and additional remediation measures. This means going back to Step 5 and proceeding from there. In such cases the following actions should be taken, in this order:
- Implement appropriate temporary safety measures to prevent damage and risks;
- In case of risks inform the competent authority about the situation;
- Register the event and inform relevant stakeholders;
- Design remediation objectives, based on the new situation (Step 5);
- Design corrective measures (DPR) to meet new remediation objectives, and acquire approval from competent authority (Steps 6 and 7);
- Implement the corrective measures, revise Remediation evaluation report (Step 8) and acquire approval from competent authority (Step 9);
- Revise Post remediation plan (Step 10) and Post remediation implementation programme (Step 11, Activity 1);
- Implement revised Post remediation implementation programme (Step 11, Activity 3).

Handling of a non critical deviation
A non critical deviation can be corrected with limited effort and impact on the post remediation system. The deviation may have no effect on the evaluation of data, the performance of the post remediation system or the use of the site. Corrective measures will enable restoration of the situation before the deviation occurred. Examples of non critical deviations are presented in Box I-11.5 below.

Box I-11.5 Examples of non critical deviation points

- Geohydrological isolation system does not lead to a predefined lowering of the groundwater level. As an additional post remediation measure the discharge of the groundwater pumps may be adjusted;
- Capping layer shows limited damage. As an additional post remediation measure this may be repaired;
- Monitoring well is jammed with mud, rendering groundwater sampling impossible. As an additional post remediation measure a new monitoring well can be installed.

A non critical deviation may be countered by implementing the following actions, in this order:

- Register the event;
- If necessary implement immediate actions to prevent further escalation into actual risks and damage;
- Inform the party responsible for the post remedial actions about the situation;
- Inform other stakeholders to prevent further escalation;
- Implement corrective measures to reset the situation to before the deviation occurred. These measures can be of very different nature, such as an increase of the monitoring intensity, additional communication on site use restriction, additional supervision on site use or minor changes in technical specifications to make the system more intrinsic reliable;
- Evaluate the Post remediation implementation programme and revise to prevent repetition of the event (Step 11, Activity 1).

Health and safety

During the implementation of the post remediation activities health and safety measures should be taken into account, refer *Checklist Health and Safety plan, Volume II-8.3-a*.

Stakeholder involvement

During implementation, the site users should be kept well informed on implementation of measures and progress of the post remediation. Signposting will clarify site use restrictions to the community.

Registration

All implemented post remediation measures should be well documented and archived in a post remediation archive. This archive should contain the following data: implemented measure, date or dates of implementation, person in charge, working method and documents and instruments used, sample identification and laboratory performing analysis (if applicable) and results. This archive will be the basis for reference in case of unexpected performance of the post remediation system and for the Post remediation status report, developed in Activity 4.

Activity 4 – Supervise and verify post remediation measures and prepare and verify periodical Post remediation status report

Supervision of implementation of measures
When post remediation involves a complex structure of measures it may be useful to have the implementation of the measures supervised.

Preparation of Post remediation status report
As stated before, post remediation typically lasts a long time, measured in years or in decades. Therefore, the management of post remediation merits special attention. For effective management of such long lasting action periodic status reporting is needed. The frequency of these reports should be stated in the Post remediation plan (Step 10) as well as in the Post remediation implementation programme (see under Activity 1 above).

The periodic Post remediation status report should present a solid insight in the status of the site at the moments predefined in the Post remediation plan and in the Post remediation implementation programme. Based on this report the competent authority should be able to review the implementation of the post remediation measures and to draw conclusions on whether the risks are actually addressed in correspondence with the description in the Post remediation plan.

The preparation of a periodic Post remediation status report commences by analysing the results of the implementation of the measures (see Activity 3), to be found in the post remediation archive. These results should be especially screened on inconsistencies and deviations from the objectives preset in the Post remediation plan. The results are then summarised in the Post remediation status report, followed by an evaluation of the present status of the site. The report should also include conclusions on the functioning of the post remediation system, and, if applicable, suggestions for modifications thereof. In case this kind of suggestions are made, the Post remediation implementation programme should be revised accordingly (see Box I-11.6 below) and the suggested measures implemented.

The *Checklist Post remediation status report, Volume II-11-a* presents an overview of elements to include in the Post remediation status report.

Verification of Post remediation status report
The Post remediation status report is typically prepared by the party responsible for the implementation of the post remediation measures. In case of potential conflict of interest the Post remediation status report should be verified by an independent third party. In such a situation, this third party should be authorized to perform his own measurements and samplings for verification of the reported results.

Review of Post remediation status report
The Post remediation status report should be forwarded to the competent authority for review and approval (see under Activity 5 below).

Box I-11.6 Optimisation of the Post remediation implementation programme

The Post remediation plan describes the technical and management measurements needed to prevent future human and ecological risks and risks of spreading of the contaminations due to residual contaminations. During the execution of the post-remediation activities it may be concluded that the intensity of the post-remediation activities can be lowered without risks. For example when the results of monitoring indicate that concentration levels are continuously dropping. Using the CSM tool this process can be understood and it is predicted that concentrations will not increase in the future. Using this knowledge the monitoring frequency can be lowered accordingly.

Using this approach, theoretically all technical activities can be reduced to zero. Management activities can also be reduced but a minimum level of management will be needed as long a contaminations are present. It is very well conceivable that the communication on site use restrictions at the starting point of a redevelopment plan is a good example of the minimal level of management activity.

Activity 5 – Review and approval of Post remediation status report

The competent authority reviews the Post remediation status report. The *Checklist review and approval Post remediation status report, Volume II-11-b* provides guidance for the performance of this Activity.

In case the Post remediation status report proposes modifications to the post remediation system the competent authority may need to authorise these modifications.

In case the Post remediation status report proposes termination of the post remediation measures the competent authority will need to authorise this termination. In such cases a previously developed exit strategy should be present and should be used as a basis for this important decision.

11.3 Step 11 output

The output of this Step 11 is a Post remediation status report, approved by the competent authority, describing the current status of the site with ongoing post remediation measures.

Based on this output the post remediation measures can be continued according to the guidance in this Step 11, or, in some cases, terminated.

Volume I

Step 12 Cost recovery

Step 12: Cost recovery

12.1 Introduction to and scope of Step 12

General description and connection to other Steps
Step 12 concerns the activities required to recover the costs for the previously undertaken assessment, remediation and post remediation measures in case the costs have been funded by the government. This step is mostly concerned with organisational, legal and financial aspects. From a technical point of view it is important to present a clear overview of the costs which have been involved in the assessment and (post) remediation activities.

The figure below shows how this Step is connected to the preceding and subsequent steps within the sequence of site assessment and remediation. After each Step with large financial consequences action may be undertaken to recover costs. This regards not only the remediation works (Step 8) and the post remediation action (Step 11) but costs involved for preliminary investigation (Step 2) remediation investigation (Step 5) and development of DPR (Step 6) may be significant as well.

Activities
Within this step a number of activities are to be performed. Most of these activities are on institutional, legal and financial aspects. For guidance on those activities we refer to the National Program for Remediation of Polluted Sites (Task 4 report, PWC Dec. 2015). Here, the guidance focuses on the one activity with technical/financial aspects:

1) Prepare cost overview of executed assessment and (post) remediation works

Responsible Parties
The activity listed above will typically be performed by technical, legal and financial specialists of the competent authority may be supported by the specialized agency or consultant which have been involved in the DPR phase or the remediation phase of the project. For various elements of the cost estimation information from different authorities may be required.
The team involved should be able to assess the costs and to link the costs presented to the information in the technical reports. Review is typically performed by senior staff members.

12.2 Guidance for performing the activity of Step 12

This section presents concise guidance for the performance of the activities within Step 12. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

<u>Activity 1 – Prepare cost overview of executed assessment and (post) remediation works</u>

Where sites have been remediated using dedicated government funds, fully or partially, an attempt may be made to recover costs from the liable party.

In order to prepare an adequate cost overview it is required to identify which measures had to be taken for assessment, remediation and possible post remediation measures of the contaminated site. The following information should be collected:

- Evaluation reports of the remediation and post remediation works;
- The cost overviews of involved contractors, consultants, site investigators, laboratories, research institutes, other third parties and of involved governmental organisations;
- The DPR and the estimated remediation costs before start of the remediation. During Step 6 the cost estimation has been developed aimed to allocate/raise funds. This cost estimate, which should consist of a detailed listing of cost elements, should be used to compare to the actual involved costs, refer *Example format cost estimation remediation, Volume II-6-b*.

The costs involved may not only include the technical measures of the remediation. The preparation of the work, including costs for demolishing building or replacement of inhabitants may be included as well. The costs for management, supervision and verification of the remediation and post remediation works should be included too. The previous costs of investigation of the site and preparation of the remediation design may be summarized to the total of relevant costs.

The remediation may have been combined with redevelopment of the site. It is important to distinguish costs for remediation and costs for redevelopment (e.g. a situation where an existing building has been demolished before remediation and reconstruction could take place. The demolition costs may be designated to the remediation as well as to the reconstruction. If there haven't been made appointments on these issues this may be an important point for discussion when trying to recover costs.

12.3 Step 12 output

The output of this Step 12 is the overview of costs related to the executed assessment of the site, the preparation and execution, supervision of the remediation and post remediation works.
With this cost overview the necessary activities to recover the costs can proceed.

Volume I

Step 13 Priority list deletion

Step 13 Priority list deletion

13.1 Introduction to and scope of Step 13

General description and connection to other Steps

Step 13 concerns the deletion from the Priority list of a site where previous contamination has been remediated to such a degree that risks no longer exist or are deemed acceptable.

In case the remediation has left no residual contamination the competent authority would have declared the remediation to be completed and cleared the site for reuse. Where such a site was listed on the Priority list the competent authority for that list would in this Step 13 only need to mark the site as remediated and delete the site from the Priority list. In that situation there are no technical aspects to be discussed in this Step.

In case the remediation has left residual contamination the competent authority would have declared the remediation to be completed (Step 9). After that a post remediation plan would have been prepared and subsequently approved (Step 10), after which the post remediation action (Step 11) can commence to prevent future human and ecological risks and risks of spreading of the contaminations. In such a case site use restrictions are likely to apply. Step 13 commences with the assessment of applicable site use restrictions and ends with the marking of the conclusions on this in the database.

The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.

Activities
A number of activities are performed in Step 13. In this document only the technical aspects to these are discussed:

1) Assess and record site use restrictions.

Responsible parties
The activities in this step are typically carried out by the competent authority for the assessment and remediation process. The team involved should demonstrate ability to interpret the information and recommendations of site remediation works and post remediation status reports. This requires in-depth knowledge of and experience with the characteristics of contaminations (e.g. mobility, biodegradability) and its potential effects on humans and the environment.

13.2 Guidance for performing the activity of Step 13

This section presents concise guidance for the performance of the activities within Step 13. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Activity 1 – Assess and record site use restrictions

The situation discussed here is that of a remediated site with residual contaminants present at the time of commencement of this Step 13.

The presence of the residual contaminants is likely to have resulted in site use restrictions. These would be outlined in the post remediation plan (Step 10). In case the post remediation action is ongoing, the site use restrictions could also be outlined in the latest post remediation status report (Step 11). The party responsible for this Step 13 needs to assess these site use restrictions and have them recorded in the computerized database of contaminated sites maintained and updated by the competent authority.

Stakeholders need to be informed on the deletion of a site from the priority list. In case site use restrictions are imposed, these need to communicated to the stakeholders, as do any changes in the site use restrictions.

Stakeholder	Interview objective	Level
Site owner	provide information	site
Site operator's health facility director	provide information	site
Local businesses, residents and NGO's	provide information	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	provide information	local
In case site use restrictions need to be formally recorded: Land Registration Office	provide information	district / local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	provide information	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	provide information	national
Competent authority on land matters	discuss conclusion	district / local

13.3 Step 13 output

The output of this Step 13 is the deletion of the site from the Priority list and the registration of the restrictions that apply to the use of the site that needs to be recorded in the database of contaminated sites.

Volume I

Step 14 Site reuse

Step 14: Site Reuse

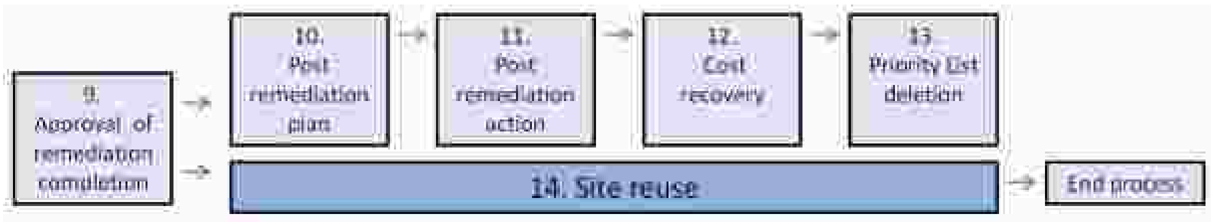
14.1 Introduction to and scope of Step 14

General description and connection to other Steps
Step 14 concerns the reuse of the remediated site. Step 14 commences with the handover of control of the site to the appropriate party, i.e. the former or the new site owner.

In case the remediation has left no residual contamination the competent authority would have declared the remediation to be completed and cleared the site for reuse (Step 9). Where such a site was listed on the Priority list the competent authority for that list would have marked the site as remediated (Step 13). In that situation there are no technical aspects to be discussed in this Step 14.

In case the remediation has left residual contamination the competent authority would have declared the remediation to be completed (Step 9). After that a post remediation plan would have been prepared and subsequently approved (Step 10), after which the post remediation action (Step 11) can commence to prevent future human and ecological risks and risks of spreading of the contaminations. If the situation on the site allows it, Steps 11 (post remediation activities) and 14 (site reuse) can be implemented simultaneously. This Step 14 presents guidance to the technical aspects of site reuse in such a situation.

The figure below shows how this Step is connected to preceding and following Steps within the sequence of site assessment and remediation.



Activities
The following activities are performed in Step 14:
1) Anticipate to site use restrictions;
2) Arrangements to enable post remediation action.

Responsible parties
The activities in this Step are typically carried out by the competent authority and the future site owner.

14.2 Guidance for performing the activities of Step 14

This section presents concise guidance for the performance of the activities within Step 14. It is intended to enable the user to quickly gain an understanding of the necessary activities while at the same time keeping an overview of the sequence of activities.

Activity 1 Anticipate to site use restrictions

The situation discussed here is that of a site at which remediation activities have been carried out but residual contaminants are still present at the time of handover of control to the new site owner.

The presence of the residual contaminants may have resulted in site use restrictions. These would be outlined in the post remediation plan (Step 10). In case the post remediation action is ongoing, the site use restrictions could also be outlined in the latest post remediation status report (Step 11). Violation of these site use restrictions may result in risks to human health or to the environment or in risks of spreading of the residual contaminants. Apart from the damage this may inflict, it is important to note that, depending on the legal situation, the site owner or the site user may be held responsible for this damage.

Change of site use not authorised by the post remediation plan or the latest post remediation status report will result in a critical deviation. This could imply that the site use should be reconsidered or that additional remediation measures need to be implemented to accommodate this site use. Where this occurs refer to Step 11 Post remediation action for guidance.

In case site use restrictions are imposed, these need to communicated to the stake-holders, as do any changes in the site use restrictions.

Stakeholder	Interview objective	Level
Site owner	provide information	site
Site operator's health facility director	provide information	site
Local businesses, residents and NGO's	provide information	site and direct vicinity
Municipal authorities. In case the potential contamination may include groundwater or surface water, including Water Supply and Sanitation	provide information	local
Land Registration Office	provide information on the change in land value for the revenue records	district / local
State authorities, including SPCB and, in case the potential contamination may include groundwater, Groundwater Authority	provide information	state
For large scale site: national authorities, including CPCB, Surveyor of India and Central Ground Water Board	provide information	national
Competent authority on land matters	discuss conclusion	district / local

Activity 2 Arrangements to enable post remediation action

The organization responsible for the post remediation action should have access to the site to implement the actions as outlined in the post remediation implementation programme or in the latest post remediation status report (Step 11). It is important to note that these actions may take place over an extensive time frame, expressed in years or even in decades or in perpetuity, and may in cases considerably affect site use. Where this occurs the competent authority may consider a temporary land use claim.

In case it is decided, by the competent authority or by the site owner, that the site owner will perform some or all post remediation action, the site owner can refer to Step 11 for guidance. He should note that all results may be subject to verification by an independent third party and will be subject to approval by the competent authority.

14.3 Step 14 output

The output of this Step 14 is, if necessary, a series of arrangements to enable implementation of post remediation actions as well as proper and effective site reuse simultaneously.

Volume I

Glossary

Volume I
Glossary of terms and topics

A

term / topic	definition
accreditation criteria	Criteria to be met for certification of a specific task or technical operation.
anthropogenic	Related to human activities.
aquifer	An underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well.

B

term / topic	definition
background concentration	The concentration of a substance in ground water, surface water, air, sediment, or soil at a source(s) or nearby reference location, and not attributable to the source(s) under consideration. Background samples may be contaminated, either by naturally occurring or manmade sources, but not by the source(s) under consideration.
biodegradability	Capability of being decomposed by bacteria or other living organisms in either one or more steps of decomposition and thereby lowering the concentration levels. Often associated with degradability of contaminants. Intermediate products may result in temporary rise in toxicity (e.g. vinyl chloride).
bioremediation	The use of either naturally occurring or deliberately introduced microorganisms to consume and break down environmental contaminations, in order to clean a polluted site
boring / borehole	Penetration into the subsurface with removal of soil/rock material by using, e.g., a hollow tubeshaped tool.

C

term / topic	definition
calibration	Mark (a gauge or a reading of an instrument) with a standard scale of readings.
competent authority	The public organisation bearing primary responsibility for the legal decisions, except those taken by a court of law, related to the assessment and remediation of a particular contaminated site or probably contaminated site.
Conceptual Site Model	A written or pictorial representation of an environmental system and the biological, physical, and chemical processes that determine the transport of contaminants from sources through environmental media to environmental receptors within the system.
constraints	Issues that do not have an impact on the remediation objectives or requirements, but that may affect how these objectives can be achieved.
complete removal	Removal of al contaminants from the soil or groundwater to a natural background level by the implementation of a remediation option
composition of the soil	The different parts (minerals, organic material, etc.) of which the soil is made of; the way in which the different parts are organized giving it a specific structure (e.g. geohydrological anisotropy)
containment	Control of migration of gaseous, liquid or solid contaminated media from a site by use of measures, such as covering systems, vertical in-ground barriers and in-ground horizontal barriers; depending on sitespecific factors, these measures may be used alone or in combination.

contaminant	Any substance, that is potentially hazardous to human health or the environment and is present in the environment at concentrations above its natural or background concentration.
contaminated site	A contaminated site is a delineated area consisting of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources. If on the basis of preliminary site assessment or preliminary site investigation or detailed site investigation, the constituents and characteristics of contaminants discharged or otherwise come to be located at the site, exist at or above Response levels and in conditions including possible combination of contaminants and interaction between contaminants and/or environmental constituents which pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity, in such case the site may be determined as contaminated site.
contamination	Discharge of contaminant at a site or migration of contaminant to a site.
contour maps	A map marked with contour lines connecting points of equal values (e.g. concentration level, hydraulic head).
cost benefit analysis	A systematic process for calculating and comparing costs and benefits of a remediation. The purpose is either to determine if it is a sound investment and decision or to provide a basis for comparing two or more remediation options.
cost effective	A form of economic analysis that compares the relative costs and outcomes of two or more remediation options. The analysis is often used where it may be inappropriate to monetize health effect.
cost recovery	Where sites have been rehabilitated using government funds, fully or partially, an attempt has to be made to recover the costs from the liable party. This may also be possible for orphan sites also.
critical deviations	Observed deviations of the CSM or the (post) remediation that will result in e.g. a de-functioning of the remediation technique, affect on the functional use of the site, the quality of the monitoring.

D

term / topic	**definition**
delineation	Process of finding boundaries of contamination at a contaminated site.
desk study	The gathering of information (geohydrology, history, etc.).
detailed site investigation	Main stage of intrusive site investigation, which involves the collection and analysis of soil and other media as a means of further informing the conceptual model and the risk assessment. This investigation may be undertaken in a single or a number of successive stages.
deviation point, critical	Event or development, occurring during post remediation, that is of such a kind that counter measures to restore the situation as reached by the remediation cannot be effective within the scope of the original post remediation plan.
deviation point, non critical	Event or development, occurring during post remediation, that is of such a kind that counter measures to restore the situation as reached by the remediation can be effective within the scope of the original post remediation plan.
discharge	Any act of spilling, releasing, leaking, dumping, pouring, pumping, emitting, emptying, injecting, escaping, leaching or disposing contaminants into the environment including drums, barrels, containers containing such contaminants.
Dispersion	*see migration*

DPR; Detailed Project Report	Report which provides details of the technical remediation activity to be conducted, cost and time of rehabilitation, stakeholder engagement, and post remediation monitoring.
drilling	Usually a vertical penetration into the subsurface with removal of soil/rock material by using motor-driven drilling equipment

E

term / topic	definition
ecological risk	Risks for ecology are formed when the biodiversity is affected (the contamination could cause a decline in species), when the recycling functions are affected and when bio-accumulation and poisoning can take place.
ecosystem	An ecosystem is a community of living organisms (plants, animals and microbes) in conjunction with the nonliving components of their environment (things like air, water and mineral soil), interacting as a system.
environment	Environment includes water, air and land and the inter- relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organism and property.
environmental and social impact assessment	the analyses and evaluation of the impact of soil remediation on the environment and/or society.
environmental transport	Movement of a chemical or physical agent in the environment after it has been released from a source to an environmental medium, for example, movement through the air, surface water, groundwater, soil, sediment, or food chain.
evaluation report	Report describing the execution and verification results of remedial actions.
evaporation	phase change from liquid into vapour
excavation	Removal of soil, fill, sediment, etc., from the ground for treatment or disposal.
exploratory holes	Drillings through which observations, samplings en measurements can be executed in order to get a better understanding of the Conceptual Site Model enabling site investigation and remediation.
exposure route	The process by which a contaminant or physical agent in the environment comes into direct contact with the body, tissues, or exchange boundaries of an environmental receptor organism, for example, ingestion, inhalation, dermal absorption, root uptake, and gill uptake.
ex-situ	Where contaminated material is removed from the ground prior to above-ground treatment or encapsulation and/or disposal on or off site.

F

term / topic	definition
fieldwork	Practical work (sampling, testing, measurements, observations) conducted by a researcher in the natural environment, rather than in a laboratory or office.
fitness for use	A remediation goal that meets a predefined site use, under anticipated (generic fitness for use) or specified user conditions (site specific fitness for use).
flux	The action or process of flowing or flowing out expressed as the amount of a substance passing a boundary within a specific time lapse.

G

term / topic	definition
generic remediation target levels	A preset level of concentration of a specific contaminant to be achieved without taking into account any site, area or site specific requirements are to be assessed.
groundwater	Water which is being held in, and can be recovered from, an underground formation.
groundwater level	Underground surface below which the ground is wholly saturated with water.
groundwater quality	The physical, chemical, and biological qualities of groundwater.

H

term / topic	definition
habitats	The natural home or environment of an animal, plant, or other organism.
human health	The health of human beings possibly affected by a contaminated site. (related to the NPRPS).
toxic substances	Any substance or preparation which, by reason of its chemical or physico-chemical properties or handling, is liable to cause harm to human beings, other living creatures, plant, micro-organism, property or the environment.
hazardous waste	Any waste which by reason of any of its physical, chemical, reactive, toxic, flammable, explosive or corrosive characteristics causes danger or is likely to cause danger to health or environment, whether alone or when in contact with other wastes or substances as defined in "Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008".

I

term / topic	definition
identification	Identification of probably contaminated sites is a legally mandated, structured procedure for identifying polluted sites and submitting their details for further investigation to authorities.
impermeable	Not allowing fluid to pass through.
Independent third party	A party not related to the case in any way. Commentary: in certain cases it is imaginable that the independent party is the competent authority. Examples of parties who cannot be regarded as independent party are site owner, any site occupier and any party involved in the site's development.
industrial processes	Processes in accordance with 'Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008'.
in-situ	Where contaminated material is treated without prior excavation (of solids) or abstraction (of liquids) from the ground.
investigated site	If on the basis of such assessment or investigation, the contaminants exist at or below screening levels and there is no existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity, in such case the site may be determined as investigated site.
investigation strategy	Plan of action designed to achieve of the CSM necessary for a specific step in the remediation process.
isolation	*see containment*

L

term / topic	definition
land use and site activity	Generic land use including residential, agricultural, industrial, commercial or public use and any site specific activity, whether designate in a plan in force by law or the actual use of such land or site, that may expose a receptor to a contaminant including but not limited to use of or contact with soil, use of or contact with surface water or municipal water supply and abstraction and use of or contact with groundwater and related activities including construction, excavation, drilling, demolition, industry, operation, process, residence, commerce, trade, entertainment, recreation, education, cultivation and movement of vehicles and people. Categories of land use applied in this report: Agriculture land, Waste land, Water bodies, Forests, Habitation settlement; Commercial, Industrial, Mixed, Other.
logbook	Systematic daily or hourly record of activities, readings, measurements, events, and/or occurrences.
long term extensive remediation measures	measures performed during remediation which may run for long periods of time (up to several years) to reach the remediation objectives.

M

term / topic	definition
maintenance	Activities carried out to ensure that remediation performs as required over a specified design life.
management of polluted / contaminated sites	Activities to respond to the (probable) threats to human health and/or the environment caused by contaminated sites. These activities can contain technical, legal, institutional and financial elements.
menu of options	Overview giving insight in the most likely ('prioritized') remediation objectives, most likely (non)technical choices for remediation measures and specific conditions or alternative approaches in a variety of settings for different types of contaminated sites.
migration	Transport of contaminants / constituents through soil and/or surface water.
migration pathway	The course through which contaminants in the environment may move away from the source(s) to potential receptors.
mobile substances / mobility	Matter possibly consisting of or containing contaminants that has the property of displacement in soil, groundwater or surface water due to different natural or chemical processes like e.g. mass flow, gravity flow, osmosis, mass transport, leaching
monitoring	Process of repetitive observation, for defined purposes of one or more elements of the environment according to pre-arranged schedules in space and time, using comparable methods for environmental sensing and data collection.
monitoring wells	Groundwater sampling point from which the quality (amount of contaminants, pH, minerals, etc.) of the groundwater can be determined.
multifunctional	The property of a site that it can be used for any kind of use without any restrictions due to the presence of contaminants.

N

term / topic	definition
Priority list	A list of confirmed contaminated sites ranked according to prioritization criteria to determine the order in which sites are to be remediated.
natural background concentration	Concentration of a substance that is derived solely from natural sources (i.e. of geonic origin), commonly expressed in terms of average, a range of values or a natural background value.
natural contaminants	Substances present in a relative high concentration level without antropogenic cause.

natural soil processes	Chemical, biological or physical soil characteristics that determine accommodation or buffering of changes in soil quality.

O

term / topic	definition
observation wells	*see monitoring wells*

P

term / topic	definition
pathway	Path a chemical takes from a source to a receptor. Each exposure pathway links a source to a receptor.
performance criteria	Criterion under which the remediation options can be implemented.
permits	An official document giving a party authorization to implement a certain activity.
plume	Contaminated groundwater containing constituents derived from the source of the contamination.
point source contamination	Distinct and delimited contamination emitting contaminated material to its surrounding (i.c. groundwater, vadose zone, free air, surface water) or plants, animals and microbes.
pollutant linkage	The combination of a contaminant, a receptor and a pathway can create a risk when they are linked together.
polluted site	Areas where hazardous substances exist at levels and in conditions which may pose existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living creatures, plants, micro-organisms, property, water quality or the environment in general, determined in the manner prescribed.
post remediation activities / measures	Activities necessary after the physical clean-up activities have been completed, in order to manage the situation regarding possible negative effects of remaining contamination. These activities can have technical, legal, institutional or financial aspects.
post remediation implementation programme	Programme for planning of operational activities in the post remediation phase. Such programmes may be aimed at the planning of monitoring, inspection, maintenance, replacement and management activities.
post remediation monitoring	Monitoring of the activities necessary after the physical clean-up activities, in order to manage the situation regarding possible negative effects of remaining pollution. These activities can have technical, legal, institutional or financial aspects.
post remediation plan	Plan describing all technical and supporting management activities needed to keep a remediated site where residual contamination remained in such a state as to prevent the residual contamination to pose risks to human health, the environment or spreading.
precipitate	Formation of a solid in a solution or inside another solid during a chemical reaction or by diffusion in a solid
preliminary investigation	A preliminary investigation of the site shall be conducted to understand if the site poses no/some threat to human health and environment and site inspection is then carried out for sites that have some threats by taking samples of air, water and soil at the site.
preliminary site assessment	Investigation if activities at a site might have caused contamination (reconnaissance) and confirmation of the presence or absence of contamination by limited sampling.
primary source	Contaminations found in the soil on a place where they initially entered the soil. E.g. the area immediately around a leaking oil drum
prioritization criteria	Criteria used to make a priority for assessment and rehabilitation of contaminated sites under NPRPS.

probably contaminated site	A probably contaminated site is an area (whether or not delineated) where the presence of contaminants is suspected but not conclusively determined or where contaminants exceed specified standards but the threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property with regard to present or future land use and site activity is not conclusively established. A probably contaminated site may require further investigation to establish whether it is a contaminated site that requires remediation. The area may consist of aggregation of contamination sources, the areas between contamination sources, and areas that may contain contaminants due to migration from contamination sources.
pump and treat	Extraction and subsequent treatment (purifying plant) of contaminated groundwater. Effluent is either injected into the soil again or disposed onto an open water system.

Q

term / topic	**definition**
QA/QC for site assessment	The combination of quality assurance, the process or set of processes used to measure and assure the quality of a site assessment, and quality control, the process of meeting the results of a site assessment to standards.
quality	Description of the chemical quality of the soil, groundwater, sediment or surface water.

R

term / topic	**definition**
receptor	Humans and other living organisms potentially exposed to and adversely affected by contaminants because they are present at the source(s) or along contaminant migration pathways.
redevelopment plan	Plan for any new construction(s) on a site or an area that has pre-existing uses.
remediated site	A site where remediation and post remediation measures have been implemented and there is no residual contamination.
remediation	The doing of any works, or carrying out of any operations or taking of any steps in relation to a polluted site for the purpose of (a) identifying or investigating or preventing or minimising or remedying or mitigating the adverse effects by reason of which polluted site is such site; (b) restoring the quality of environment, flora and fauna at the site to an acceptable level; and includes making of subsequent inspections from time to time for the purpose of keeping under review the condition of the site in question, in the manner prescribed.
remediation design	A technical design for remedial action at the site included in a Detailed Project Report.
remediation goal	*see remediation objective*
remediation objective	Generic term for any objective, including those related to technical (for example risk reduction, residual contamination concentrations or engineering performance), administrative and legal requirements.
remediation option	A means of reducing or controlling the risks associated with a particular source-pathway-receptor combination to a defined level.
remediation requirement	Preset conditions that need to be met before a remediation can be implemented as planned.
remediation target	*see remediation objective*
remediation technique	Physical tools and solutions that can be implemented to eliminate or reduce the presence or negative effects of contaminations in soil or groundwater.

residual contamination	After completion of remediation and post remediation measures, contaminants exist in excess of screening level or there may be existing or imminent threat to health, safety, welfare, comfort or life of human beings, other living species, water quality or the environment in general or to property, that may be mitigated or eliminated with land use and site activity restrictions.
resources	Commodities such as food, water, sand, agriculture land.
Response level	Generic concentrations of hazardous substances in soil and sediments at or above which it is very likely there is threat to human health or the environment, that may be imminent. At or above this level some form of response is required to provide an adequate level of safety to protect public health and/or the environment.
restricted site	A site where remediation and post remediation measures have been implemented and there is residual contamination requiring land use and site activity restrictions.
risk	A combination of the probability, or frequency of occurrence of a defined threat and the magnitude of the consequences of the occurrence related to combinations of Source, Pathway and Receptor.
risk assessment	The process of identifying, assessing and evaluating the risks that may be associated with a threat to human health and/or the environment at a contaminated site. Risk assessment can be carried out by a qualitative identification of potential risks or by calculation of dispersion and exposure.

S

term / topic	**definition**
safety	Freedom from unacceptable risk of harm (during assessment or remediation activities).
sample	Portion of material (soil, groundwater, sediment or surface water) selected from a larger quantity of material.
sample protocol	Technical guidance for the field team in order to ensure quality of sampling, ensure uniformity and to allow for effective assessment of fieldwork quality.
sampling strategy	Arrangement by which a sampling protocol is to be conducted.
sampling technique	All appropriate procedures and sampling devices to obtain and describe samples of soil, groundwater, sediment or surface water, either in the field or during transportation and in laboratory.
Screening level	Generic concentrations of hazardous substances in soil and sediments, groundwater and surface water at or below which potential risks to human health or the environment are not likely to occur and where no further investigation and assessment is needed. These Screening levels are distinguished for land use.
secondary source	Contaminations found in the soil after having been transported from a primary source. E.g. DNAPL layer found at the bottom of a aquifer
sediment	Soils and their parent material beneath the surface water body.
selection remediation option	Process of selection of the most favourable remediation option using certain selection criteria.
sensitive use	Use of land or surface water which is determining the risks for human health and/or the environment.
site	Any area, place, premise, establishment, land and related structures including well, pit, pond, lagoon, landfill, groundwater, sediments, building, structure, pipeline and container and any facility, factory, industry, operation, process or equipment located over such area.
site assessment	Investigation on the content, extent, delineation or risks of a (probably) contaminated site.
site inspection	Inventory and mapping of a probably contaminated site

Site Reuse	Local government shall designate the site use as per the remediation plan and handover the land for use.
site specific remediation target level	A preset target level that facilitates a specified predefined use of a single site.
soil	Upper layer of the Earth's crust transformed by weathering and physical/chemical and biological processes. It is composed of mineral particles, organic matter, water, air and living organisms organized in genetic soil horizons.
soil characterization	Determination of relevant physical, chemical and biological properties of the soil.
soil threatening activities	Activities possible causing a soil to get contaminated.
source	Source in relation to a contaminant means the location from which a contaminant has entered or may enter the environment and the soil, water, sediments that have been contaminated at the point of entry of the contaminant but excludes contamination through migration. (A primary source, such as a location at which drums have leaked onto surface soils, may produce a secondary source, such as contaminated soils; sources may hence be primary or secondary.)
spreading	*see migration*
stakeholder	person or organization who is affected by the effects of a contaminated site or has interest in the assessment and remediation activities at the site
stratigraphy	The order and relative position of geological strata (layers) and their relationship to the geological timescale.
substance	Any chemical element or chemical compound.
surface water	All water at the surface, including lakes, bays, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, wetlands, inlets, canals, oceans within the relevant territorial limits and all other bodies, natural or artificial, inland or coastal, fresh or salt.

T

term / topic	definition
target level / target values	A preset level of concentration of a specific contaminant to be achieved when implementing a remediation option.
temporary safety measures	Measures for preventing unacceptable risks pending final remedial measures.
tendering process	Development and implementation of bidding documents for outsourcing assessment activities and/or (post) remediation works.
threats to human health and/or the environment	The situation in which existing or imminent negative impact on human beings and or the environment can occur due to exposure to constituents present at a contaminated site.
topography	The arrangement of the natural and artificial physical features of an area.
toxic and hazardous substances	Substances/constituents as per the ‘Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008’.
tracers	(natural or injected) Matter carried by water which will give information concerning the direction and/or velocity of the water as well as potential contaminants which could be transported by the water.
TSDF	Treatment, Storage and Disposal Facility.
Typology	The taxonomic classification of characteristics found in contaminated sites, based on a set of common characteristics of sites (see Annex of this Glossary for extended explanation of Typology of contaminated sites).

V

term / topic	definition
verification	The process of demonstrating that the risk/threats has/have been reduced to meet (post) remediation criteria and objectives.

W

term / topic	definition
water body	A body of water forming a physiographical feature, for example a sea or a reservoir.

Annex to the Glossary

Explanation of Typology of contaminated sites

1 Introduction

The typology of contaminated sites offers important elements when developing a site assessment strategy and remediation options in a manageable way. These elements are activities leading to contamination, geometry and type of contamination. Combined with site specific information on chemical substances and soil characteristics this typology is useful to get insight in realistic remediation options to facilitate the process of remediation option appraisal.

2 Typology

Table T1 presents an overview of the typology, by showing all activities leading to contaminated soil and types of spreading. These activities are regardless of the party causing the contamination. E.g. liquid phase contaminations are not necessary focused only to industrial activities. On the other hand it is expected that most of this type of contaminations can be found in industrial areas. The following main types of contaminated sites are distinguished using this approach:

Source related:
- Type S1: Land bound solid phase contamination;
- Type S2: Water bound sediments solid phase contamination;
- Type L: Land bound liquid phase contamination. The source of this type of contaminations is connected to human activities or infrastructure.

Pathway related:
- Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids);
- Type P2: Groundwater contaminations.

Note 1: Although elements in the typology are based on the ‘source-pathway-receptor’ approach, it is not primary ‘receptor’ (risk) based. The typology is not based on risks (risks to human health, ecological risks, spreading or vaporizing). This is because site assessment and soil remediation options appraisal, for which this typology is developed, is not limited to the assessment of unacceptable risks, but needs to give insight in a contaminated site as a whole.

Note 2: depending on a specific situation:
- a combination of these types may be found on one site. Example: a land bound storage of Chromium containing hazardous waste (type S1), leaching Chromium to groundwater and leading to a contaminated groundwater plume (type P2). This combination of types on one single site could result in multiple site assessment strategies and multiple remedial options, each assessing the different types of contaminants (both the site assessment and remediation approach can be combined for practical reasons);
- multiple sites can form a cluster of contaminated sites of a specific type or combination of types. A combination of sites of a specific type in a single cluster or a combination of types on a single site can be recognized. These situations could be indicated as a “cluster-site” with a wide variety of scales. In general, the applicability of remediation techniques will not depend on this setting, but correct balancing of remediation techniques per type of site in a cluster will lead stakeholders to the best applicable remediation option.

Note 3: Both in type L as in type P1 liquid phase contaminants are involved. Type P1 is distinguished from type L by the specific type of contaminant, Non-Aqueous Phase Liquids (NAPL’s), which have a characteristic spreading pattern on or in the groundwater aquifer. This characteristic leads to different site assessment strategies, spreading mechanisms, risk profiles and remediation approaches for type P1 sites, as compared to type L sites. A type L site may, due to further spreading of the contaminant plume, develop over time into a type P1 site.

The main types listed above are based on normative characteristics, which play a role in determining the basics for remediation options. Side characteristics may do so as well, but their influence will in certain cases be restricted to the finer points (mostly technical details) in the selection of remediation options or to the planning or implementation of remediation actions. Thus subtypes come into perspective when remediation option appraisal is going into the second step of option appraisal, the detailed engineering phase. In this detailed engineering phase aspects have to be included related to contaminant specific specifications of remediation techniques, assessment of specific social aspects of the remediation actions or site use specific technical requirements.
Case example. The first step of a site specific remediation option appraisal, based on normative characteristics only, has shown that the remediation should be implemented within a period of less than two months and should result in a removal of all contaminants. In this case only then the site will meet the specific needs for planned reconstruction works. At this point it is already clear that only excavating techniques will be applicable, rendering the assessment of in situ techniques obsolete. This saves gathering and analysing detailed information on the performance of these techniques (e.g. contaminant related performance of in situ techniques) as this will not meet any purpose.

Subtypes can be distinguished based on the following secondary criteria:

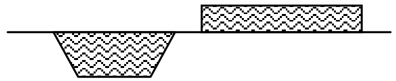
- **Type S1 and L** related subtypes are defined, based on the activity causing the contamination. HW-Schedule I (listing processes generating hazardous wastes) may help to focus on possible activities.
  In Table T1 these subtypes are coded ‘a’ through ‘f’ (type S) and ‘a’ through ‘d´ (type L).
  These subtypes are distinguished to support the site assessment.

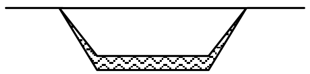
- **Type P1** related subtypes are defined, based on the bulk density of a NAPL (non aqueous phase liquids, dense and light).
  In Table T1 these subtypes are coded ‘a’ and ‘b’ (type P1).
  These subtypes are distinguished to support the site assessment.

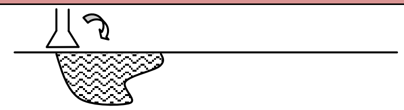
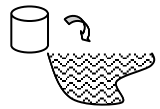
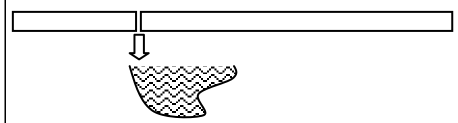
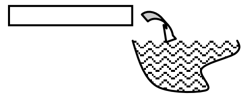
The typology is aimed to support the remediation options appraisal. Some examples to illustrate this point. A site assessment plan for a S1-f type contaminated site (deposition by flooding or washing) will focus on the boundaries of the flooded areas of a river system, easily recognizable on maps or areal pictures. Once the pattern of flooding is known an extensive sampling plan can be carried out to validate the flooding pattern and to validate the hypothesis on the spreading of the contamination with field data. By contrast, a site assessment plan for a S1-c type of contaminated site (storage of contaminated material) will focus on a relatively small area where human activities such as incineration have taken place.

The total volume of the removal of contaminated material, which accounts for the major part of remediation costs, will be smaller for a S1-e type of contaminated site (atmospheric deposition) than for a S1-a type (soil mixed with contaminated material). Therefore, it is more likely that the best applicable remediation option on a S1-e type site will be a complete removal of all contaminants, where for a S1-a type site a capping option is more likely to come into perspective.

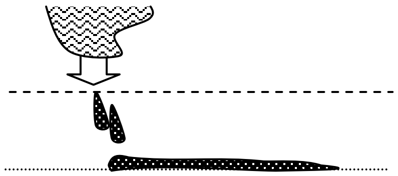
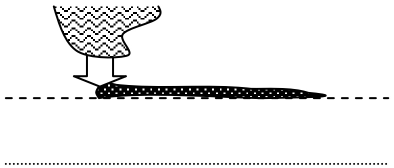
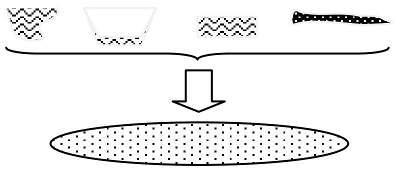
Table T1 Typology

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
S-1	Solid phase contamination (land bound site)		
S1-a *	Mixing the soil with contaminated material or materials containing contamination, not including agricultural activities.	Well defined body below surface level defined by boundaries of soil where soil is mixed with contaminants.	
S1-b **	Embankment, filling of pits or depressions, filling of surface waters with contaminated material or materials containing contamination.	Well defined body of non-mixed contaminants . E.g. storage of tailings.	
S1-c **	(Bulk) storage of contaminated material or materials containing contamination. (Industrial) activities in which contaminated solids are used. 'Leftovers' of incineration and burning of material.	Irregular shaped layer of contaminated material, recognizable as such. The shape of the contaminated site is related to the activity leading to the contamination	
S1-d *	Adding material containing contamination through agricultural activities (e.g. pesticides, fertilizers or additives to animal feed).	Agricultural site bound contaminations found up to a depth to which the soil is treated by ploughs and other agricultural tools.	
S1-e *	Atmospheric deposition (roads, railway, industries) of emissions or windblown dust.	Thin layered contaminations found over large areas with the highest concentrations close to the source following the prevailing wind direction.	
S1-f *	Deposition by flooding or washing.	Contaminations found in areas flooded by water systems or in downstream areas of flooding areas. The shape of the contaminated site is	

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
		determined by the flooding of flow of a water system.	
S-2	Solid phase contaminations (water bound site)		
S-2 **	Contaminated open water sediments.	Solid phase contaminants sedimented from surface water. The shape of the contaminates site corresponds to the shape of the water system itself. Contaminants may be bound to clay or organic compounds of sediments.	

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
L-1	Liquid phase contaminations		
L1-a *	(Business) activities involving fluids e.g. solvents, lubricants, paint, etc.	Liquid contamination in soil situated near a potential source of the contamination.	
L1-b *	Storage of liquids that contain contaminations in tanks or barrels (either storage on surface or subsurface).	Liquid contamination in soil situated at any place at a liquids storage site.	
L1-c *	Transfer and transport of fluids through linear infrastructure. Weak points are couplings, pressure regulators, valves, breakpoints and the passage through foundations / buildings.	Liquid contamination in soil situated at any place along a transport piping system or drains.	
L1-d	Spills or leaks of liquids. (either on surface or in rivers/lakes) *Note. Possibly leading to type S2 or P2.*	Liquid contamination in soil situated at the end of a transport piping or drain system.	

*) caused by multiple sources or situation where source cannot be attributed.

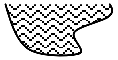
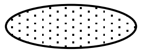
Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
P-1	Liquid phase related		
P1-a	Dense Non-Aqueous Phase Liquid (DNAPL [a])) in permeable soil. (bulk density > water)	Spreading of liquids due to gravity flow resulting in a characteristic spreading pattern. The DNAPL's laying of the botom of an aquiffer can result in a 'secondary source' of spreading of type P-2)	
P1-b	Light Non-Aqueous Phase Liquid (LNAPL [b])) in permeable soil. (bulk density < water)	Spreading of liquids in a characteristic spreading pattern of floating layers. The LNAPL's laying at the top of a water table can result in a 'secondary source' of spreading of type P-2)	
P-2	Leached or dissolved contaminants		
P-2	Groundwater contamination	Due to spreading of leachate or mobile dissolved contaminants in a permeable soil	

a) *A dense non-aqueous phase liquid or DNAPL is a liquid that is both denser than water and is immiscible in or does not dissolve in water. The term DNAPL is used primarily by environmental engineers and hydro geologists to describe contaminants in groundwater, surface water and sediments. DNAPLs tend to sink below the water table when spilled in significant quantities and only stop when they reach impermeable bedrock. Their penetration into an aquifer makes them difficult to locate and remediate. Examples of materials that are DNAPLs when spilled include chlorinated solvents or creosote.*

b) *Light Non-Aqueous Phase Liquid (LNAPL) is a groundwater contaminant that is not soluble and has a lower bulk density than water, which is the opposite of DNAPL. Once LNAPL infiltrates through the soil, it will stop at the water table. The effort to locate and remove*

LNAPL is relatively cheaper and easier than DNAPL because LNAPL will float on top of the water in the underground water table. Examples of LNAPLs are gasoline and other hydrocarbons.

Table T2 Key to icons in table T1

Icon	**Key**
	Solid waste or solid waste mixed with soil (all solid phase). Varying in shape, thickness and extent, depending on local conditions.
	Groundwater table Base of aquifer / top of impermeable layer.
	Liquid waste. Pure or mixed with soil.
	Leaching / spreading of contaminants to soil / groundwater. Depending on permeability of the soil.
	Contaminated groundwater plume. Depending on permeability of the soil.
	DNALP or LNAPL.
	Spill / leakage.
	Not soil related human activity / construction e.g. industrial process, storage, bulk transfer.

Colophon

Colophon

Context
The Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India, has taken up the Capacity Building for Industrial Pollution Management Project (CBIPMP) with the assistance of the World Bank. The intention is to develop a National Programme for Rehabilitation of Polluted Sites (NPRPS). Details of this project are available on the MoEF&CC website (http://moef.nic.in/sites/default/files/cbipmp/index.htm).

As a part of the CBIPMP project, MoEF&CC in March 2012 commissioned a consortium led by Grontmij Nederland BV (Netherlands) and otherwise comprising of Shah Technical Consultants Pvt.Ltd. (India), Technochem Agencies Pvt.Ltd. (India) and Indus Technologies Netherlands BV (Netherlands and India) to undertake a consultancy assignment for “Development of Methodologies for National Programme for Rehabilitation of Polluted Sites”.

The key objective of this assignment was to develop methodologies for the implementation of remediation projects in India by government and non-government agencies under the NPRPS. These methodologies mainly cover [i] the process for selecting and implementing preferred remediation options and [ii] the technical guidelines and standards that can be applied.

Development of the document
The Grontmij consortium has executed the assignment between April 2012 and December 2015, with its team of Dutch, Indian and international experts. The assignment comprised:

- a large number of desk studies on a wide variety of topics;
- review of national and international standards, practices, experience and learning;
- field visits to several contaminated sites in India;
- extensive discussions with several stakeholders, including CPCB, SPCBs, individual technical experts, academics and field staff in charge of the sites;
- discussions with experts outside the consortium;
- evaluation of previous reports, evaluation and incorporation of field tests conducted in the past and in parallel by other assignments;
- stakeholder meetings to gain input on draft reports;
- discussions with the Technical Expert Panel and supervising experts from the Ministry and World Bank.

In performing the study, a number of specific tasks have been carried out as mandated by the Terms of Reference of the assignment. For each task, a detailed report has been prepared by the Grontmij consortium. This Guidance document consists of three Volumes.

Key authors of this document include: Arthur de Groof, Paul Oude Boerrigter, Rob Heijer, Paul Verhaagen, Ravi Jambagi, Sukla Sen, Hemant Rane and Deepak Deshpande.

Initial use
The Guidance document provides MoEF&CC, agencies such as CPCB and SPCBs and various other stakeholders with a comprehensive reference manual to further develop the NPRPS effectively, educate and train key technical staff and to enable MoEF&CC to initiate necessary steps towards remediation of sites, whether identified at the time of publication or as yet to be identified.

National Program for Rehabilitation of Polluted Sites in India

Guidance document for assessment and remediation of contaminated sites in India

Volume II – Standards and checklists

1st Edition, December 2015

Ministry of Environment, Forest and Climate Change
Government of India

Volume II

Introduction and contents

Introduction to Volume II of the Guidance document for assessment and remediation of contaminated sites in India

This document encloses Volume II of the Guidance document for assessment and remediation of contaminated sites in India.
In this Guidance document the technical aspects of the entire process of intervention in a contaminated site, from its earliest identification to post remediation measures, is described in a sequence of fourteen distinct Steps. This set of Steps covers all activities that are performed in dealing with such a site. Wherever applicable, this Guidance document refers to these fourteen Steps. The same Steps, with identical descriptions, are also used in correlation with the non technical aspects, i.e. legal, financial and institutional, of dealing with polluted sites.

The fourteen Steps are visualised in figure II.1 below.

Figure II.1 The fourteen Steps in the site assessment and remediation process

Identification	Planning	Implementation	Post remediation
• Step 1: Identification of probably contaminated sites • Step 2: Preliminary investigation • Step 3: Notification of polluted site • Step 4: Priority list addition	• Step 5: Remediation investigation • Step 6: Remediation Design, DPR • Step 7: DPR approval and financing	• Step 8: Implementation of remediation • Step 9: Approval of remediation completion	• Step 10: Post remediation plan • Step 11: Post remediation action • Step 12: Cost recovery • Step 13: Priority list deletion • Step 14: Site reuse

This Guidance document is organised as a set of documents, arranged in three Volumes:
Volume I Methodologies and guidance
Volume II Standards and checklists
Volume III Tools and manuals

Volume I is the core of the Guidance document set. It presents guidance and instructions as to how to perform each of the fourteen Steps in the site assessment and remediation process. The correlation among the Steps is shown, to enable the user to see what happened before the Step he is involved in and what should happen after completion of that Step. Centred around a concise description of actions to perform the Step the user is involved in, the guidance details aspects for an effective performance, like data needed and where these may be found, and control mechanisms. Wherever relevant, the guidance includes references to Volume II and III and to websites and documents. Volume I is set up in such a way that it may be used in capacity building. It also includes an introduction for aimed at decision makers.

This **Volume II** contains reference data in various forms. Engineers dealing with contaminated sites may use Volume II on a day to day basis to refer to data, standards, criteria and checklists. Every one of these is linked by a reference to one or more descriptions of Steps in Volume I. Therefore this Volume II document should be used in conjunction with the other two Volumes.

Volume III contains more extensive data like technical manuals. Examples of manuals presented in Volume III include a Site Inspection Protocol, points of attention for laboratory testing, an overview of available remediation techniques, and methods for the evaluation of remediation options. Like Volume II, Volume III is intended for day to day reference by engineers dealing with contaminated sites.

Contents of Volume II

Volume II

1-a Example petition format for identification of probably contaminated sites

Volume II-1-a
Example petition format for identification of probably contaminated sites

1 Introduction

This information is most relevant for Step 1, Identification of probably contaminated sites. During the data collection information regarding newly recognized probably contaminated sites may be partly derived from petitions, reports, complaints etc. from local or state level agencies, general public and NGOs received by the competent authority. The use of a standardised petition format will improve the completeness and quality of the information necessary for submission of a well-founded petition for which below an example petition format is provided.

2 Example petition format for identification of probably contaminated sites

Example petition format for identification of probably contaminated sites
The completed form should be delivered to the nearest office of the competent authority.

Objective of this petition
This petition provides the site details and background information related to a probably contaminated site.

Applicant Details

Name of petitioner	
Address	
Email	
Telephone number	

Site Details, (please provide a description where possible)

Relation of the petitioner to the site:
Owner of the site, tenant of the site, occupier or resident of the site or nearby site, use of the site for specific purpose, etc.

Site Location and description:
Address or coordinates. Attach a plan, sketch map / drawing with landmark information clearly identifying the site. If not possible describe the surrounding area and distance to notable landmarks, roads, rivers, etc.

Description of the landuse:
Habitation settlement/residential, agricultural land, commercial, industrial, forests, park, water body, waste land, or other (one or multiple types of landuse can be described).

Description of the signs of suspected contamination:
For example: well water that is discoloured or with bad taste or smell; unpleasant smells related to waste material or soil surface; human and animal health problems not related to general diseases or lack of food and water; damaged crops, plants or trees not to be related to lack of water or nutrients; . containers containing suspected chemical substances.

Description of substances involved:
If possible please provide a description on the substances including symbols and / or labels on containers, chemical name (common name), solid/liquid/gas form, type of smell and colour.

Description of possible cause of the contamination:
Presence of (former or existing) industry buildings, materials stockpiles, industrial process equipment, storage tanks, broken pipelines, illegal dumping etc.

Description of previous involvement of local or regional governmental agencies regarding contamination of the site (if applicable):

Date of receipt of the petition:
Reference number:

Volume II

1-b Checklist relevant data for identification of probably contaminated sites

Volume II-1-b
Checklist relevant data for identification of probably contaminated sites

1 Introduction

This information is most relevant for Step 1, Identification of probably contaminated sites. During the data review information regarding new probably contaminated sites may be partly derived from petitions, reports, complaints etc. from local, state level agencies, government agencies, general public and NGOs received by the competent authority or they may be collected by reviewing registers and plans. The data necessary for identification of probably contaminated sites are described in the below checklist.

2 Checklist relevant data for identification of probably contaminated sites

No.	Topic	Explanation	Data Provider / Source	Obligatory	Sta tus	Comments
	Administrative elements					
1.0	State name		Provided by source	Yes		
1.2	Site name		Provided by source	Yes		
1.3	Address	Street, Street number, Postal code, City	Provided by source	Yes		
1.4.1 1.4.2 1.4.3	GPS coordinates /and elevation:	Latitude, longitude and altitude in center of the site entered as decimal	Provided by source or established based on address	Prefereably		
1.5.1 1.5.2 1.5.3	Land use	Current land use Previous land use Future land use	Provided by source or established based on address or site visit	Prefereably		
1.6.1 1.6.2 1.6.3	Owner	current owner previous owner contact with owner	Provided by source			
	Essential information for decision on step 1					
1.12	Industry type, which has caused contamination	Selection from a non-exhaustive list of industries	Provided by source and assessed according to list	At least one of item 1.12, 2.2, 2.3, 2.4 and 2.6 shall be stated		
2.2	Type of contamination according to definition from MoEF	Effluent, Air, Municipal Solid Waste, Bio-Medical Waste, Hazardous Waste, Ship Break Waste or Any other.	Provided by source and assessed according to list			
2.3	"Industrial processes" which caused the contamination	According to Schedule I – Hazardous Wastes Rules, 2008	Provided by source and assessed according to list			
2.4	Type of hazardous waste	According to Schedule I – Hazardous Wastes Rules, 2008	Provided by source and assessed according to list			
2.6	Contaminants of concern - CoC - (chemical name(s))	Multiple contaminated can be selected	Provided by source and assessed according to the chemicals listed in the Screening Levels and Response Levels			

	Useful information but not essential in step 1					
3.1	Geology at the site (is the groundwater geologically protected?)	Broad description of the typical stratigraphical sequences from topsoil to deepest acquifer	Provided by source or search on website of Central Groundwater Board, Ministry of Water Resources: http://cgwb.gov.in/	Prefereably		
3.4	Is the site within a groundwater recharge zone?	Area with drinking water interest: - Potable water supply; - Acquifer potential - Minor acquifer/Non potable water	Provided by source or search on website of Central Groundwater Board, Ministry of Water Resources: http://cgwb.gov.in/	Prefereably		
3.5.1 3.5.2	Drinking water intake; distance to nearest well and number of wells within 1 km of site	Private wells Public wells	Provided by source or search on website of Central Groundwater Board, Ministry of Water Resources: http://cgwb.gov.in/	Prefereably		
4.2	Name and distance to nearest surface water body (m)			Prefereably		
4.3	Type of Surface Water Body	Pond, Small lake, Large lake, Small river/stream, Large river, Wetland or Other		Prefereably		
4.4	Any sensitive use of surface water?	Drinking water, Irrigation, Use in commercial food production, Water recreational area, Fishing or Other		Prefereably		
4.5	Distance to Sensitive Ecological areas (m)	E.g. reserves, wetland		Prefereably		
5.2.3	Approximated Population within 1 km from the site			Prefereably		
12.1	Name of institution / source which has identified the site as 'probably contaminated'	Point out institution(s) and contact person	Provided by source	Yes		
-	Reason why the site is considered as 'probably contaminated'		Provided by source	Yes		

Explanatory Notes:
No.: the numbers relate to the topics in the database of contaminated sites
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: remarks to be entered by reviewer on the results for this topic

Volume II

2.1-a Checklist prequalification for site investigation

Volume II-2.1-a
Checklist prequalification for site investigation including ToR

1 Introduction

This information is most relevant for Step 2, Preliminary investigation, Step 5, Remediation investigation and Step 6, Remediation design, DPR. The investigation activities is usually commissioned to an independent third party investigator, typically a specialized organization (agency, research institute, consultants, contractors and laboratories), where teams of specialists are involved in assessment and remediation projects. This checklist is also useful for Task 8.3, Execution, supervision and verification of remediation works.

The client who contracts out this assignment may be a private person, private organization or the local, State or Central authority. This checklist provides support for the client in the selection of a specialized agency. To ensure a good quality investigation, it is vital that this third party can demonstrate the expertise, skills and compliance relevant for the assignment. Where available, it is preferable if this is supported by relevant accreditations.

At the outset, it is very important that the client provides clear Terms of Reference (ToR), which should at least include the objectives of the investigation, the required output and the possible constraints. Without a clear ToR the third party may interpret the situation differently resulting in the proposed activities not leading to the required output. Furthermore, in case more than one party is requested to tender an offer, an unclear ToR can lead to differences that render a fair comparison impossible. If the client is a private organization it may be advisable to contact the competent authority for assistance.

2 Checklist for prequalification for site investigation

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main aim of the appointment	
Date of recording	
Recording official	

Prequalification criteria for selection of the specialized organization (aspects marked * may only be relevant for projects with an estimated cost threshold value of for remediation of 10.000.000 Rupee);	**Status**	**Comments**
Information about the Firm: Firm's Background and registration Financial background* such as		

- tax clearance by financial authority (have all taxes been paid during the last 3 years? - ... other examples? Type of firm – Pvt. Ltd..- Proprietary – Partnership Work experience Professional liability insurance		
Technical capability: Firm's work experience Field technique equipment Accredited laboratory (refer explanation below) Laboratory equipments Labours (skilled & unskilled) Staff experience in similar projects		
Management capability: Cost control Schedule / time Control Quality Management System* Quality assurance* Number of technical and non-technical staff Experience in social aspects regarding investigation of sites for environmental reasons.		
Past experience: Scale of projects completed Type of projects completed Experience in local area Five projects of similar type completed Time overruns in past projects* Cost overruns in past projects* Quality achieved in past project*		
Health and safety policy: Safety management system Accidents in past projects Insurance of personnel		
Use of Information Technology & Services: Project Management Software Personnel knowledge in IT / Software Level of Technology		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Accreditation Standards for Laboratory

For field work and laboratory testing quality assurance can substantially improve the quality of the deliverables. In India, for a great number of laboratory activities accreditation schemes have been implemented. It may be anticipated that in future similar schemes may be implemented for field work and for chemical analysis of soil, sediment and groundwater samples.

Accreditation is considered as the first essential step for facilitating mutual acceptance of test results and measurement data. Confidence in accreditation is obtained by a transparent system of control over the accredited laboratories and an assurance given by the accreditation body that the accredited laboratory fulfils the accreditation criteria at all times. Accredited laboratories can objectively state conformance of specified products or services to specified requirements.

The Government of India has authorized NABL as the accreditation body for testing and calibration laboratories. NABL is a registered society under the Societies Registration Act 1860. It operates as an autonomous body under the aegis of in the Department of Science and Technology (DST), Ministry of Science and Technology, Government of India. NABL has been established with the objective of providing Government, Industry Associations and Industry in general with a scheme of laboratory accreditation which involves third-party assessment of the technical competence of testing and calibration laboratories.

In the current global scenario an essential pre-requisite of trade is that any product or service accepted formally in one economy must also be free to circulate in other economies without having to undergo extensive re-testing. To ensure that this principle is upheld accreditations granted by foreign accreditation bodies are also valid in India, provided the granting body has signed the ILAC MRA (International Laboratory Accreditation Co-operation Mutual Recognition Agreement) for the relevant accreditation standard.

Preferably, the laboratory testing of samples from contaminated sites should be carried out by laboratories working under internationally recognized accreditation standards. The laboratory accreditation services to testing and calibration laboratories are provided in accordance with ISO/ IEC 17025: 2005 'General Requirements for the Competence of Testing and Calibration Laboratories'.

NABL Accreditation is currently given in dozens of fields and disciplines or groups. The criteria for standard laboratories for relevant fields for contaminated sites can be found in the following links:

- NABL General information brochure, NABL-100 document, 201206291037-NABL-100-doc.pdf
- NABL specific guidelines for chemical testing laboratories, NABL-103 document, 201206281205-NABL-103-doc.pdf

3 Elements for Terms of Reference for site assessment

3.1 Introduction

This section presents the elements that should be included in any Terms of Reference for effective completion of a number of activities in the site assessment process. The elements describing the Scope of Work, which are specific to the activity at hand, are preceded by a list of generic elements that should be included in any ToR, irrespective of the activity it is designed for.

3.2 Generic elements

The Terms of Reference should include at least the following elements:

- Location of site and explanation of the situation of the site with regard to contamination of soil, sediment, groundwater or surface water;
- Summary of activities regarding assessment and/or remediation which already have been carried out;
- Objective of the project;
- Phases of the project (if applicable)
- Scope of Work, a detailed description of activities (according to the 14 step framework. See Annexure 4 for that framework);
- Expected outputs of the project (reports, drawings, etc.);
- Timeline;
- Procedure for review of draft and final reports;
- Qualifications for agency and project team;
- Expected communication with client and facilities to be provided by client;
- Financial-economic conditions for the project.

3.3 Scope of Work elements

3.3.1 Introduction

In a Terms of Reference for a site assessment the Scope of Work provides a detailed description of activities to be performed. Below, we present the Scope of Work elements to be included in Terms of Reference for the following site assessment activities (position in 14 step framework is indicated between brackets):

- Preliminary site investigation (Step 2, Task 2.2);
- Detailed site investigation (Step 5, Task 5.1);
- Risk Assessment (Step 5, Task 5.2);
- Setting remediation objectives and requirements (Step 5, Task 5.3), Development of remediation options (Step 5, Task 5.4), and Selection remediation option (Task 5, Step 5.5);
- Remediation design, DPR (Step 6).

3.3.2 Preliminary site investigation (Step 2, Task 2.2)

Within this task the following activities are performed:

- Design of the investigation and testing strategy
- Fieldwork and laboratory testing
- Comparison of the test results with standards
- The above mentioned activities are carried out leading to a report including following sections:

Site identification: site name, address, owner, coordinates;

Site description

- History of site use (ownership, operators, users, raw materials, waste related activities, permits, etc.)
- Environs of the site (land use, groundwater use, use of water bodies, estimated number of residents or onsite workers, estimated distances to sensitive use, etc.)

- Climate data (precipitation, temperature and derived information/estimated parameters such as evapo-transpiration and groundwater recharge rate estimated from this data
- Geology and hydrogeology (stratigraphy, aquifers, depth and permeability of subsurface layers, possible karst features, etc.)
- Hydrology and surface water (distance from site to water bodies, migration paths of rainfall to surface water, drainage, flooding patterns)
- Results from previous investigations or incidental data
- Result of site inspection
- Hypothesis on type and characteristics of the contamination
- Features / targets for investigation

Site inspection including:
- Identification of previous and current land use pattern of the site
- Current sources of hazardous waste generation contributing to the pollution of the site and disposal practices in the influence area.
- Site photographs
- Identification of parameters causing immediate threat to the ecology and environment.
- Discussion with local people and other informed people, district administration, municipal and regulatory authorities, NGOS, etc.
- Selection of the available observation wells (Bore Well) in the watershed covering the site, for monitoring water level and quality monitoring at appropriate locations, & Inventory details like total depth of the well, Water column; Frequency of sampling (Pre monsoon/ Post monsoon)

Investigation Strategy
- Draft Conceptual Site Model
- Screening and sampling strategy
- Fieldwork screening methods
- Exploratory hole / sample location pattern (grid or targeted) and numbers of samples (soil, sediment and groundwater) , including benchmark / background samples
- Use of composite and single samples
- Parameters for laboratory testing and chemical analysis methods / detection limits
- Applied method for quality control (QA/QC)

Fieldwork results, interpretation and reporting including
- Site conditions during fieldwork (e.g. dates, weather conditions, access to locations, etc.)
- Visual / olfactory evidence of contamination
- Results of screening techniques (if applied)
- Description of ground conditions and subsurface structure (borehole / exploratory hole log description)
- Selection of samples to be tested
- Laboratory test results
- Comparison of laboratory test results to standards (Screening levels and Response levels)
- Does the site meet the definition of ‘Contaminated Site’?
- Recommendation for:
  - further investigation (yes/no);
  - notification as contaminated site (yes/no) leading to prioritisation and remediation investigation;
  - temporary safety measures if in the present situation significant risks to human health or environment are expected.

3.3.3 Detailed site investigation (Step 5, Task 5.1)
Within this task the following activities are performed:
- Development of investigation strategy
- Fieldwork and laboratory testing
- Analysis and interpretation of exploratory data

The above mentioned activities are carried out leading to a report including following sections:

Introduction and background information

- Description of the site (e.g. name, address, site plan and size);
- Reason for the detailed site investigation;
- Summary of the previous investigations at the site;
- Information of the parties involved in the remediation investigation process and allocation of their roles;
- Scope of the investigation;
- Explanation of the structure of the report.

Site situation

- The lay-out on the site (present land use, infrastructure, buildings, use of the surrounding area, included natural features such as lakes, rivers, streams found at least partially within the boundaries of the property) and in the area beyond the site covering the pathway;
- Description of history of the land use and possible causes of the contamination (included constructed features such as, underground storage tanks, lagoons, ditches, sumps within buildings, and waste storage areas);
- Typology of the contaminated site;
- Geology, geohydrology and soil structure and ground conditions of the site in case of contaminated soil and groundwater (depth of groundwater, thickness of aquifers, seasonal groundwater fluctuations; the lithology and vertical permeability of the unsaturated zone; the stratigraphy, structure, geometry, porosity, hydraulic conductivity, storage properties, transmissivity, and groundwater flow direction of the saturated zone).
- If monitoring or drinking water wells have been installed: review of the monitoring results; include data why and when a well was installed and by whom and technical data (depth, filter length, monitoring data, sample and lab methods)
- Soil survey information at a scale of 1:20 000 or larger; on-site map and appropriate cross-sections showing soil types, soil depth and other soil parameters that may be related to location and extent of contaminants;
- Climatic conditions (precipitation, seasonal variations, estimated infiltration rates);
- Morphological and hydraulic aspects including e.g. seasonal variations in water level and floods and and areas affected by floods to estimate the impact of contaminated sediments.

Investigation strategy

- The conceptual site model (CSM) with the combinations of source-pathway-receptor) of concern. A detailed description of the present contamination with characteristics (parameters, concentration, extent in horizontal and vertical direction, mobility, density);
- Data gaps in the CSM and points for investigation;
- Screening and sampling technical equipment;
- Sampling rationale and design (media, locations, pattern and depth of samples), including background samples;
- Number of samples;
- Screening of observations wells or necessity for drilling new wells;
- Methods for establishing stratigraphy and characteristics of subsurface layers;
- Analytical test parameters / determinants required.

Fieldwork and laboratory testing

- Description of executed activities;
- Site conditions during fieldwork (e.g. dates, weather conditions, access to locations, etc.)
- Visual / olfactory evidence of contamination
- Results of screening techniques (if applied)
- Description of ground conditions and subsurface structure (borehole / exploratory hole log description) or water body;
- Selection of samples to be tested;
- Laboratory test results;

- Quality assurance and quality control;
- Possible deviations from sample plan and reasons involved.

Analysis and interpretation of exploratory data
- Comparison of laboratory test results to standards (Screening levels and Response levels);
- Description of situation of the contamination in the various media (soil, groundwater, sediment, surface water, air, biota) including depth and extent of contamination and including estimated quantity of polluted media;
- Implications of contamination, soil structure and general physical, chemical, ecological and spatial site conditions for remediation options;
- Development of groundwater flow, surface water flow, and mass transport models. (if required);
- (Seasonal) contour maps of groundwater flow and explanation of estimated groundwater processes;
- Possible influence of seasonal climatological situation on groundwater and surface water;
- Contour maps and cross-sections to show spatial distribution of contaminants; graphical displays that present the available data in their spatial context; sample values for data on maps or cross-sections; colours; grey scales, or symbols to high-light the locations of the highest sample values;
- Updated Conceptual Site Model, identifying sources, pathways and receptors.

Conclusions and recommendation
- Conclusions on the scope and objectives of the investigation with clear indication of known data gaps and possible uncertainties;
- Recommendations for
  - further investigation;
  - temporary safety measures if in the present situation significant risks to human health or environment are expected. This may include monitoring of a contaminated plume in groundwater.

Annexes
- Topographical map of area with location of the site
- Detailed site survey plan with location of sampling points
- Methods of fieldwork and laboratory testing
- Borehole / exploratory excavation logs with explanation codes
- Relevant screening and response levels
- Laboratory reports
- Calculations or modelling results and explanation characteristics of the model used
- Maps indicating contamination of soil, sediment and groundwater
- Background literature and sources
- Photographic record

3.3.4 Risk Assessment (Step 5, Task 5.2)
Within this task the following activities are performed:
- Assess contaminant concentration levels;
- Identify applicable source-pathway-receptor-combinations for human health;
- Perform a generic quantitative risk assessment for human health;
- If necessary, perform a more detailed quantitative risk assessment for human health;
- If necessary, perform a risk assessment for the environment;
- The above mentioned activities are carried out leading to a report including following sections:

Introduction and background information
- Description of the site (e.g. name, owner, address, site plan and size, GPS-coordinates);
- Summary of the previous investigations at the site;
- Information of the parties involved in the assessment and remediation process and allocation of their roles;
- Reason for and objectives of risk assessment.

Site situation

- The situation of the contamination at the site (present land use, infrastructure, buildings, use of the surrounding area);
- Description of history of the land use and cause of the contamination;
- Description of area with respect to existing land use, demographic profile, social economic and environmental conditions of the people in receptor areas, flora and fauna;
- Comparison of concentration levels against Screening and Response levels.

Relevant source-pathway-receptor combinations

- The conceptual site model (CSM) with the combinations of source-pathway-receptor of concern. A detailed description of the present contamination with characteristics (parameters, concentration, extent in horizontal and vertical direction, mobility, density);
- Relevant exposure pathways, preferably illustrated with diagram.

Results of generic quantitative risk assessment modelling

- Tool/model used to quantify risks
- Site-specific information used for modelling
  - Representative concentrations in soil, sediment and groundwater
  - Size of contamination in soil (3D)
  - Size of contamination in groundwater (3D)
  - Size of the site (contaminated and not contaminated)
  - Level of groundwater
  - Soil type (%organic matter, % clay, grain size, hard rock)
  - Surface water in the environment
  - Drinking water extension in the environment
  - Groundwater flow direction and estimated speed
  - Use of the contaminated site and the vicinity
  - Establishment of the site (buildings, basements, roads, crops)
  - Receptors on-site and off-site
- Model results and comparison to critical exposure value

Results of detailed quantitative risk assessment

- Reason for detailed quantitative risk assessment
- Collection of additional information (methodology used for obtaining data)
- Data obtained, e.g. contaminants investigated, contaminant concentration levels in the relevant contact media (e.g. air, dust), relevant specific circumstances
- Results

Conclusions and communication

- Clear statement on unacceptable risks identified
- Possible uncertainties and information gaps, necessity for further investigation
- Recommendations for further steps, setting remediation options and development of remediation options

3.3.5 Setting remediation objectives and requirements (Step 5, Task 5.3), Development of remediation options (Step 5, Task 5.4), Selection remediation option (Step 5, Task 5.5)

Within task 5.3 (Setting remediation objectives and requirements) the following activities are performed:

- Establish remediation objectives;
- Establish remediation requirements.

Within task 5.4 (development of remediation options) the following activities are performed:

- Assess the remediation objectives and requirements;
- Identify constraints to remediation;
- Identify applicable remediation techniques;
- Develop applicable remediation options.

Within task 5.5 (selection remediation option) the following activities are performed:
- Compare and appraise remediation options;
- Consult with relevant stakeholders;
- Prepare remediation investigation report, including stakeholder views;
- Review and approval of remediation investigation report and select most favourable remediation option.

The above mentioned activities are carried out leading to a report including following sections:

CSM and risk assessment
- Historical information of the site including subsequent site and groundwater use, industrial processes leading to soil contamination
- Geology
- Geohydrology
- Description of all contaminations (sources) including spreading processes (pathways)
- Description of risks (receptors)

Remediation objectives
- Risks to be remediated
- Objectives of the remediation
- Requirements of the remediation including other activities which are executed simultaneously (redevelopment)
- Stakeholders
- Funds
- Other legislation to be met
- Preconditions to be met with the remediation

Description remediation options
- Technical aspects to achieve the remediation objective an requirements
- Effects on surrounding and counter measures: sound, noise, soil vibration, groundwater drop, traffic hinder (intensity and duration), stability of soil
- Practical aspects of implementation: preparation of / on the site, safety measures
- Measurements / sampling program to verify the progress and final result of the implementation phase
- Communication with stakeholders prior to, during and after the remediation
- Production and/or usage of: energy, soil, air, water and activities or technical measures to dispose of products
- Risks and mitigating measures during implementation: technical, planning, concentration levels
- Legal aspects: permits and legal constraints
- Planning: preparation phase, implementation, extensive phase of in situ techniques, post remediation measures
- Post remediation measures: description of residual contaminations and subsequent technical and management measures necessary to prevent future human and ecological risks and risks of spreading of the contaminations
- Costs: implementation, post remediation phase and risks
- Point for further investigation during DPR or pilot phase

Evaluation of possible remediation options
- Points for evaluations
- Method for evaluations
- Evaluations of options (qualitative or quantitative)
- Selection of most favourable remediation option
- Point for further investigation during DPR or pilot phase

Annexes
- Maps, x-sections, tables technical schemes

3.3.6 Remediation design, DPR (Step 6)

Within this Step the following activities are to be performed:

- Design of the remediation: the technical system for the remediation will be presented. Detailed descriptions and drawings of the remediation measures will be reported.
- Costing and planning of the remediation: all activities are summarized and a costing is provided for each of these activities (volumes, amounts and unit prices). A planning of activities is made indicating the time involved for the activities.
- Environmental and social impact assessment and consultation of stakeholders
- The above mentioned activities are carried out leading to a report including following sections:

Introduction and background information

- Description of the site (e.g. name, owner, address, GPS-coordinates, site plan and size);
- Reason for the remediation;
- Summary of the previous investigations at the site;
- Information of the parties involved in the remediation process and allocation of their roles.

Site situation

- The situation of the contamination at the site (present land use, infrastructure, buildings, use of the surrounding area);
- Description of history of the land use and cause of the contamination;
- Typology of the contaminated site;
- Geology, geohydrology and soil structure and ground conditions of the site in case of contaminated soil and groundwater.
- Morphological and hydraulic aspects in case of contaminated sediments in surface water and seasonal variations in water level;
- The conceptual site model with the combinations of source-pathway-receptor) of concern. A detailed description of the present contamination with characteristics (parameters, concentration, extent in horizontal and vertical direction, mobility, density);

- Remediation approach
- Objective of the remediation related to regulatory requirements and the selected remediation option;
- Combination of the remediation with reconstruction activities at the site, possible impact on planning and results of the remediation measures and description of measures to manage this impact;
- Targets levels of the remediation to be achieved;
- Remediation techniques to be used: technical description;
- Stages in the remediation process (if appropriate);
- Necessity of a pilot testing of the remediation technique.

Detailed description of the remediation process

- Preparation activities:
  - removal of buildings, infrastructure, foundations, tanks in order to achieve access to the contaminated material; if removal is not possible, which working constraints will have to be dealt with;
  - mobilisation of equipment to the site;
  - necessary staff during the remediation;
  - organising the working and storage areas at the site;
  - possible access limitations to parts of the site or the neighbouring area;
  - availability of suitably licensed treatment or disposal capacity off site;
- Overview of the necessary permits and licenses;
- Measures necessary to prevent damage or nuisance (such as dust, odours, noise and dirt on roads) on the site and in the surrounding area (including possible transport of removed waste to a treatment or disposal site);
- Measures to improve sustainability aspects (e.g. reducing energy);
- When excavation of soil or dredging of sediment is part of the remediation strategy:

- o size and contours of the excavation (area and depth);
  - o estimated volume of material to be excavated (in-situ and after excavation) and destination of the material (on-site rearranging or off-site treatment or disposal, for which the procedures of HWR-2008 may apply);
  - o necessary abstraction of groundwater;
  - o in case of dredging sediment: necessary preparation on the water way, lake, river or canal;
  - o temporary storage of material in depots;
  - o quality of the clean material to be used to replace the removed contaminated material;
- When groundwater abstraction is part of the remediation strategy:
  - o Pattern and depth of wells;
  - o Volume and planning of the abstraction period;
  - o Results model calculations of the groundwater remediation;
  - o Method of discharging abstracted water and necessary treatment;
- When in-situ techniques are part of the remediation strategy:
  - o Equipment to be installed (indication, pattern and specific location);
  - o Maintenance activities during the active phase of the remediation;
- Checkpoints during the remediation process and action levels or other criteria for assessment the intermediate results;
- Possible effects of the remediation measures and mitigating activities to be carried out to minimize these effects;
- Possible uncertainties in the situation (e.g. the delineation of the contamination is not very detailed at one side of the location) and ways of dealing with these risks.
- Planning of the remediation activities (project implementation schedule);
- Programme for supervision and environmental verification;
- Suggestions for sampling, testing and other measurements related to verification (to be elaborated further in a verification plan):
  - o what are be the key parameters to verify the success of the progressing remediation;
  - o which monitoring equipment should be installed before and during the remediation.
- Expected restrictions to future land use after finalizing the remediation activities;
- Identification of the need for post remediation activities;
- Health and safety aspects during the remediation:
  - o possible exposure to contaminated material by skin contact, ingestion or inhalation;
  - o necessary measures to prevent these risks (description of these measures to be elaborated in step 8);
  - o safety measures regarding equipment and transport.
- Record keeping, use of a log;
- Estimation of costs, with distinction between costs for installing equipment, short term measures and costs for long term remediation and maintenance. Sometime an analysis of risks and variation of the costs;
- Insurance;
- Communication aspects in the process of implementation of the remediation. These communication aspects are related to restrictions and nuisance during the remediation and the possible restriction for land use in the final situation. Relevant stakeholders for the communication should be indicated;
- Maps, drawings, calculations must be added as annexed to the remediation design report.

Content of verification plan

This Section presents a generic checklist for a verification plan, being part of the Detailed Project Report. In this verification plan the activities are described for verifying the results of the remediation.

Supervision and environmental verification

- Description of the tasks of the supervision and environmental verification of remediation works;
- Possible response actions to deal with uncertainties;
- Critical points in the remediation process where the progress should be assessed, a list of critical points during the remediation is given below (examples are the moment where an excavation; has reached its ultimate boundaries. Before supplementing with clean soil/material samples should be taken from the pit wall and bottom. Another example is a check on reaching the

intended depth for a groundwater extraction or treatment unit and verifying the number and pattern of extraction wells);
- Log with daily information of the site: remediation activities; verification activities; visits of regulators, accidents, injuries; etcetera;
- Results of sampling and testing the quality of removed or treated contaminated material and the quality of remaining soil or sediment;
- Results of (periodical) testing of the quality of surface water or groundwater;
- All executed measurements to check health and safety aspects and compliance with environmental permits and licenses;

Communication
- Overview of institutions and persons involved (names, addresses, telephone numbers, email);
- Appointments on communication with stakeholders (authorities, companies, community, press);
- Procedure for reporting for critical and non-critical deviation of the DPR;
- Procedure for reporting incidents and accidents at the site during the remediation;
- Planning of reporting interim and final results in an evaluation report to the authority.

Monitoring programme
- For long-term remediation projects where in-situ techniques are used or where groundwater is extracted and remediated monitoring of interim results is a very important activity to verify if the remediation results are heading in the right direction;
- Part of the monitoring programme is a planned sampling and testing strategy for the quality of soil, groundwater, sediments or surface water (if appropriate);
- Criteria for the evaluation of interim results of the remediation (e.g. the concentration gradient of a parameter in groundwater);
- Action levels for evaluation or response actions.

Volume II

2.1-b Screening and response levels

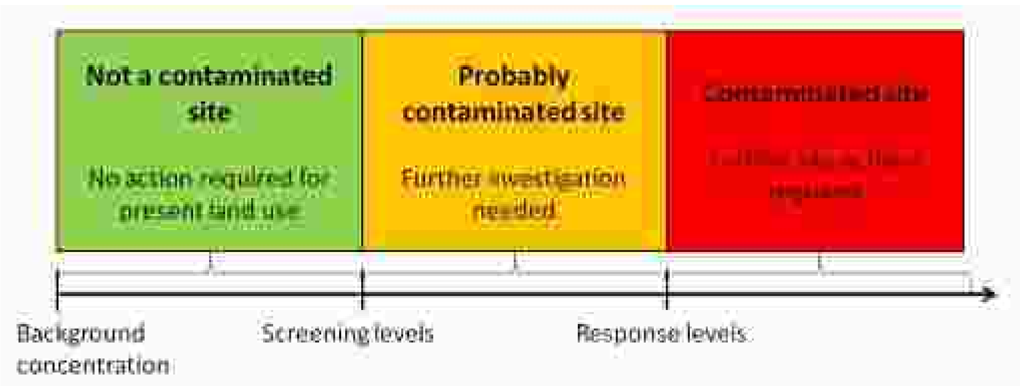
Volume II-2.1-b
Screening and Response levels

1 Introduction

This information is relevant for various Steps and Tasks in the assessment and remediation process.
Screening and Response levels are important to assess the level of contamination.

Screening levels are generic concentrations of hazardous substances in soil and sediments, groundwater and surface water at or below which potential risks to human health or the environment are not likely to occur and where no further investigation and assessment is needed. These Screening levels are distinguished for land use.

Response levels are generic concentrations of hazardous substances in soil and sediments at or above which it is very likely there is threat to human health or the environment, that may be imminent. At or above this level some form of response is required to provide an adequate level of safety to protect public health and/or the environment.



Note that that for certain contaminants such as Persistent Organic Pollutants, no background concentrations should be used, as there is no natural background for these substances.

2 Screening and Response levels

The table on next pages provides the Screening and Response levels.

Chemical Name	Chemical Groups	**Hazardous waste** (levels Schedule II, HW Rules, 2008) 1)	**Soil (Screening and Response Levels)**					**Groundwater for drinking water (Screening levels)** 4)			**Surface water Quality (Screening levels)**					
			Response levels (Dutch Intervention levels) 2)	**Screening levels** Soil Quality Guidelines for the Protection of Environmental and Human Health 3)				Indian Standard for Drinking Water * (Maximum acceptable concentration)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commercial	Industrial				Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
1,1,1-Trichloroethane (TCA)	Halogenated aliphatic compounds	5000	15	0,1	5	50	50	-	-	-					-	-
1,1,2,2- Tetrachloroethene (PCE)	Halogenated aliphatic compounds	5000	8,8	0,1	0,2	0,5	0,6	-	0.03	0,04	-	-	-	-	110	-
1,1,2,2-Tetrachlorethane	Halogenated aliphatic compounds	5000		0,1	5	50	50	-			-	-	-	-	-	-
1,1,2-Trichloroethane	Halogenated aliphatic compounds	5000	10	0,1	5	50	50	-	-		-	-	-	-	-	-
1,1,2-Trichloroethene (TCE)	Halogenated aliphatic compounds	5000	2,5	0,01	0,01	0,01	0,01	-	0.005	0,02	-	-	-	-	21	-/50
1,1-Dichloroethane	Halogenated aliphatic compounds	5000	15	0,1	5	50	50	-	-		-	-	-	-	-	-
1,1-Dichloroethene	Halogenated aliphatic compounds	5000	0,3	0,1	5	50	50	-	0.014		-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	Halogenated aromatic compounds	50	2,2	0,05	2	10	10	-	-		-	-	-	-	1,8	-
1,2,3,5-Tetrachlorobenzene	Halogenated aromatic compounds	50	2,2	0,05	2	10	10	-	-		-	-	-	-	-	-
1,2,3-Trichlorobenzene	Halogenated aromatic compounds	50	11	0,05	2	10	10	-	-		-	-	-	-	8	-
1,2,4,5-Tetrachlorobenzene	Halogenated aromatic compounds	50	2,2	0,05	2	10	10	-	-		-	-	-	-	-	-
1,2,4-Trichlorobenzene	Halogenated aromatic compounds	50	11	0,05	2	10	10	-	-		-	-	-	-	24	-
1,2-Dichlorobenzene	Halogenated aromatic compounds	50	19	0,1	1	10	10	-	-	1	-	-	-	-	0,7	-
1,2-Dichloroethane	Halogenated aliphatic compounds	5000	6,4	0,1	5	50	50	0,003	0.005	0,003	-	-	-	-	100	-/5
1,2-Dichloroethene	Halogenated aliphatic compounds	5000	1	0,1	5	50	50	-	-	0,05	-	-	-	-	-	-
1,2-Dichloropropane	Halogenated aliphatic compounds	5000	2	0,1	5	50	50	-	-	0,04	-	-	-	-	-	-
1,2-Dichloropropene (cis and trans)	Halogenated aliphatic compounds	5000		0,1	5	50	50	-	-		-	-	-	-	-	-
1,3,5-Trichlorobenzene	Halogenated aromatic compounds	50		0,05	2	10	10	-	-		-	-	-	-	-	-
1,3-Dichlorobenzene	Halogenated aromatic compounds	50		0,1	1	10	10	-	-		-	-	-	-	150	-
1,4-Dichlorobenzene	Halogenated aromatic compounds	50		0,1	1	10	10	-	0.005	0,3	-	-	-	-	26	-
1,4-Dioxane		-		-	-	-	-	-	-	0,05	-	-	-	-	-	-
2,3,4,6-Tetrachlorophenol	Halogenated aromatic compounds	50		0,05	0,5	5	5	-	0.1		-	-	-	-	-	-
2,4,6-Trichlorophenol	Halogenated aromatic compounds	50		0,05	0,5	5	5	-	0.005	0,2	-	-	-	-	-	-
2,4-Dichlorophenol	Halogenated aromatic compounds	50		0,05	0,5	5	5	-	0.9		-	-	-	-	-	-
2,4-Dichlorophenoxyacetic acid (2,4-D)	Pesticides (Phenoxy herbicide)	-		-	-	-	-	0,03	-	0,03	-	-	-	-	-	-
3-Iodo-2-propynyl butyl carbamate	Pesticides, Carbamate	-		-	-	-	-	-	-		-	-	-	-	1,9	-
Acenaphthene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤	-	-		-	-	-	-	5,8	-
Acenaphthylene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤	-	-		-	-	-	-	-	-
Acridine	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤	-	-		-	-	-	-	4,4	-
Aldicarb	Pesticides, Carbamate	-		-	-	-	-	-	0.009	0,01	-	-	-	-	1	54,9/11
Aldrin	Pesticides, Organochlorine	50	0,32	-	-	-	-	0.00003	0.0007	0,00003	-	-	-	-	0.004	-
Aliphatics nonchlorinated (each)	Non-halogenated aliphatic compounds	-		0,3	-	-	-	-	-		-	-	-	-	-	-
Aluminium	Metal	-		-	-	-	-	0.03	-		-	-	-	-	Variable	5000/5000
Ammonia (total)	Inorganic	20000		-	-	-	-	0,5	-		5			5	Table	-
Ammonia (un-ionized)	Inorganic	-		-	-	-	-				-	-	-	-	19	-
Aniline	Organic	-		-	-	-	-		-		-	-	-	-	2,2	-
Anthracene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,012	-
Antimony (metallic)	Inorganic	50	22	20	20	40	40		0.006	0,02	-	-	-	-	-	-
Arsenic	Metal	50	50 (76)!	12	12	12	12	0,01	0.01	0,01	0,2	0,2	0,2	0,2	5	100/25

Chemical Name	Chemical Groups	Hazardous waste (levels Schedule II, HW Rules, 2008) [1]	Soil (Screening and Response Levels): Response levels (Dutch Intervention levels) [2]	Soil: Screening levels – Soil Quality Guidelines for the Protection of Environmental and Human Health [3]: Agricultural	Residential/-parkland	Commer-cial	Industrial	Groundwater for drinking water (Screening levels) [4]: Indian Standard for Drinking Water * (Maximum acceptable concentra-tion)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	Surface water Quality (Screening levels): The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants: Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Canadian Water Quality Guidelines for the Protection of **Aquatic Life**: Longterm in Freshwater	Canadian Water Quality Guidelines for the Protection of **Agriculture**: Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
Asbestos		5000	100	-	-	-	-		-		-	-	-	-		-
Atrazine	Pesticides, Triazine	-	0,71	-	-	-	-	0.002	0.005	0,002	-	-	-	-	1,8	10/5
Barium	Inorganic	20000	-	750	500	2000	2000	0.7	1.0	0,7	-	-	-	-	-	-
Benzene	Monocyclic aromatic compounds	50	1.1	0.05 ¤	0.5 ¤	5 ¤	5 ¤		0.005		0,01*	-	0,01*	0,01*	370	-
Benzo(a)anthracen	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,018	-
Benzo(a)pyrene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		0.00001		-	-	-	-	0,015	-
Benzo(b)fluoranthene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	-	-
Benzo(k)fluoranthene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	-	-
Beryllium	Inorganic	50		4	4	8	8		-		-	-	-	-	-	100/100
Boron	Inorganic	-		2	-	-	-	0,5	5.0		-	-	-	-	1.5mg/L	5000/5000
Bromacil	Pesticides	-		-	-	-	-		-		-	-	-	-	5	0,2/1100
Bromoxynil	Pesticides, Benzonitrile	-		-	-	-	-		0.005		-	-	-	-	5	0,33/11
Cadmium	Metal	50	13	1,4	10	22	22	0.003	0.005		2	1	-	2	Equation	5,1/80
Calcium	Inorganic	-		-	-	-	-	75	-		-	-	-	-	-	-/1000000
Captan	Pesticides	-		-	-	-	-		-		-	-	-	-	1,3	-/13
Carbaryl	Pesticides, Carbamate	-	0,45	-	-	-	-		-		0.01	-	0.01	0.01	0,2	-/1100
Carbofuran	Pesticides, Carbamate	-	0,017	-	-	-	-		0.09		-	-	-	-	1,8	-/45
Chlordane	Pesticides, Organochlorine	50	4	-	-	-	-		-		-	-	-	-	0.006	-/7
Chloride	Inorganic	-		-	-	-	-	250	-		-	-	-	-	or 120 mg/L	Variable/-
Chlorothalonil	Pesticides	-		-	-	-	-		-		-	-	-	-	0,18	crops)/170
Chlorpyrifos	Pesticides, Organophosphorus	5000		-	-	-	-	0,03	0.09	0,03	-	-	-	-	0,002	-/24
Chromium (total)	Metal	-	-	64	64	87	87		0.05	0,05	2	2	-	2	-	-
Chromium, hexavalent (Cr(VI))	Metal	50	50 (78)!	0,4	0,4	1,4	1,4	0.05	-		0,1	2	-	1	1	8/50
Chromium, trivalent (Cr(III))	Metal	5000	180	-	-	-	-		-		-	-	-	-	8,9	4,9/50
Chrysene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	-	-
Cobalt	Inorganic	5000	190	40	50	300	300		-		-	-	-	-	-	50/1000
Coliforms, fecal (Escherichia coli)	Biological	-		-	-	-	-		-		-	-	-	-	-	mL/-
Coliforms, total	Biological	-		-	-	-	-				-	-	-	-	-	mL
Colour	Physical	-		-	-	-	-	5 Hazen Units	-		-	-	-	-	Narrative	-
Conductivity	Physical	-		2 dS/m	2 dS/m	4 dS/m	4 dS/m		-		-	-	-	-	-	-
Copper	Metal	5000	190	63	63	91	91	0.05	-	2	3	3	-	3	Equation	Variable/variabl e
Cyanazine	Pesticides, Triazine	-		-	-	-	-		0.01	0,0006	-	-	-	-	2	0,5/10
Cyanide	Inorganic	50	50	0,9	0,9	8	8	0.05	0.2	0,07	0,2	2	0,2	0,2	5 (as free CN)	-/-
Cyanobacteria	Biological	-		-	-	-	-	-	0.0015		-	-	-	-	-	-/-
Debris	Physical	-		-	-	-	-	-	-		-	-	-	-	-	-/-
Deltamethrin	Pesticides	-		-	-	-	-	-	-		-	-	-	-	0,0004	-/2.5
Di(2-ethylhexyl) phthalate	Phthalate esters	-		-	-	-	-	-	-		-	-	-	-	16	-/-
Di-n-butyl phthalate	Phthalate esters	-		-	-	-	-	-	-		-	-	-	-	19	-/-

Chemical Name	Chemical Groups	**Hazardous waste** (levels Schedule II, HW Rules, 2008) [1]	**Soil (Screening and Response Levels)**					**Groundwater for drinking water (Screening levels)** [4]			**Surface water Quality (Screening levels)**					
			Response levels (Dutch Inter-vention levels) [2]	**Screening levels** Soil Quality Guidelines for the Protection of Environmental and Human Health [3]				Indian Standard for Drinking Water * (Maximum acceptable concentra-tion)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commer-cial	Industrial				Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
Di-n-octyl phthalate	Phthalate esters	-		-	-	-	-	-	-		-	-	-	-	-	-/-
Dibenz(a,h)anthracene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤	-	-		-	-	-	-	-	-/-
Dibromochloromethane	Halogenated methanes	5000		-	-	-	-	0.1	-		-	-	-	-	-	-/100
Dicamba	Pesticides, Aromatic Carboxylic Acid	-		-	-	-	-		-		-	-	-	-	10	0,006/122
DDT Total (Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane)	Pesticides, Organochlorine	50	1,7	0,7	0,7	12	12	0,001	-	0,001	10*)	-	10*)	10*)	0.001	-/30
DDD (Dichloro diphenyl dichloroethane, 2,2-Bis (p-chlorophenyl)-1,1-dichloroethane)	Pesticides, Organochlorine	50	34	-	-	-	-	0,001	-	0,001	-	-	-	-		-
DDE (Dichloro diphenyl ethylene, 1,1-Dichloro-2,2-bis(p-chlorophenyl)-ethene)	Pesticides, Organochlorine	50	2,3	-	-	-	-	0,001	-	0,001	-	-	-	-		-
DDT (Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane)	Pesticides, Organochlorine	50	1,7	-	-	-	-	0,001	-	0,001	-	-	-	-		-
Dichlorobromomethane	Halogenated methanes	5000		-	-	-	-	-	-		-	-	-	-	-	-/100
Dichloromethane (Methylene chloride)	Halogenated aliphatic compounds	5000	3,9	0,1	5	50	50	-	0.05	0,02	-	-	-	-	98,1	-/50
Dichlorophenols	Chlorinated phenols	50	22	0,05	0,5	5	5	-	0.9		-	-	-	-	0,2	
Diclofop-methyl	Pesticides	-		-	-	-	-	-	-		-	-	-	-	6,1	0,18/9
Didecyl dimethyl ammonium chloride	Pesticides	-		-	-	-	-	-	-		-	-	-	-	1,5	-
Dieldrin	Pesticides, Organochlorine	50	-	-	-	-	-	0.00003	-	0.00003	-	-	-	-		-
Diethylene glycol	Glycols	-		-	-	-	-	-	-		-	-	-	-	-	-
Diisopropanolamine	Organic	-		180	180	180	180	-	-		-	-	-	-	1600	2 000/-
Dimethoate	Pesticides, Organophosphorus	5000		-	-	-	-	-	-	0,006	-	-	-	-	6,2	-/3
Dinoseb	Pesticides	-		-	-	-	-	-	0.01		-	-	-	-	0,05	16/150
Dissolved gas supersaturation	Physical	-		-	-	-	-	-	-		-	-	-	-	Narrative	-
Dissolved oxygen	Inorganic	-		-	-	-	-		-		-	-	-	-	-	-
Endosulfan	Pesticides, Organochlorine	50	4	-	-	-	-	0.0004	-		10*)	-	10*)	10*)	0,003	-
Endrin	Pesticides, Organochlorine	50	-	-	-	-	-		-	0,0006	-	-	-	-	0.0023	-
Ethylbenzene	Monocyclic aromatic compounds	20000	110	0.1	5	50	50		-	0,3	-	-	-	-	90	-/2.4
Ethylene glycol	Glycols	-		960	960	960	960		-		-	-	-	-	192 000	-
Fluoranthene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,04	-
Fluorene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	3	-
Fluorine		5000		-	-	-	-		-		-	-	-	-		-
Fluoride	Inorganic	5000		200	400	2000	2000	1.0	1.5	1,5	2	15	-	15	120	1000/variable
Glyphosate	Pesticides, Organophosphorus	5000		-	-	-	-		0.28		-	-	-	-	800	-/280
Heptachlor	Pesticides, Organochlorine	50	4	-	-	-	-		-		-	-	-	-	0.01	-/3
Hexachlorobenzene	Halogenated aromatic compounds	50	2	0,05	2	10	10		-		-	-	-	-	-	-/0.52
Hexachlorobutadiene	Halogenated aliphatic compounds	5000		-	-	-	-		-		-	-	-	-	1,3	No data
Hexachlorocyclohexane (HCH)	Pesticides, Organochlorine	50	-	0,01	-	-	-		-		-	-	-	-	0,01	-/4

Chemical Name	Chemical Groups	**Hazardous waste** (levels Schedule II, HW Rules, 2008) [1]	**Soil (Screening and Response Levels)**					**Groundwater for drinking water (Screening levels)** [4]			**Surface water Quality (Screening levels)**					
			Response levels (Dutch Inter-vention levels) [2]	**Screening levels** Soil Quality Guidelines for the Protection of Environmental and Human Health [3]				Indian Standard for Drinking Water * (Maximum acceptable concentra-tion)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commer-cial	Industrial				Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
Hexachlorocyclohexane (alfa HCH)	Pesticides, Organochlorine	-	17	-	-	-	-		-		-	-	-	-		
Hexachlorocyclohexane (beta HCH)	Pesticides, Organochlorine	-	1,6	-	-	-	-		-		-	-	-	-		
Hexachlorocyclohexane (delta HCH)	Pesticides, Organochlorine	-		-	-	-	-		-		-	-	-	-		
Hydrazine(s)		5000							-		-	-	-	-		-
Imidacloprid		-		-	-	-	-		-		-	-	-	-	0,23	-
Indeno(1,2,3-c,d)pyrene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	No data	-
Iron	Inorganic	-		-	-	-	-	0.3			3	3	-	3	300	5000/'-
Lead	Metal	5000	530	70	140	260	600	0.01	0.01		0,1	1	-	2	Equation	200/100
Lindane (gamma HCH)	Pesticides, Organochlorine	50	1,2	-	-	-	-	0.002	-		-	-	-	-		
Linuron	Pesticides	-		-	-	-	-		-		-	-	-	-	7	0,071/-
Lithium	Inorganic	-		-	-	-	-		-		-	-	-	-	-	2500/-
Malathione	Pesticide, Organophosphorus	5000		-	-	-	-	0.19	0.19		10	-	10	10		-
Manganese	Inorganic	-		-	-	-	-	0.1			2	2	-	2	-	200/-
Mercury (inorganic)	Metal	50	36	6,6	6,6	24	50	0.001	0.001		0,01	0,01	-	0,01	0,026	-
Methoprene		-		-	-	-	-		-		-	-	-	-	Organism	-
Methyl tertiary-butyl ether (MTBE)	Aliphatic ether	-		-	-	-	-		-		-	-	-	-	10 000	-
MCPA (Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid)	Pesticides	-	4	-	-	-	-		0.1		-	-	-	-	2,6	0,025/25
Methylmercury	Organic	5000		-	-	-	-		-						0,004	-
Methylparathion	Pesticide, Organophosphorus	5000		-	-	-	-	0.0003	-		10	-	10	10		-
Metolachlor	Pesticide, Organophosphorus	50		-	-	-	-		0.05						7,8	28/50
Metribuzin	Pesticides, Triazine	-		-	-	-	-		0.08		-	-	-	-	1	0,5/80
Molybdenum	Inorganic	5000	190	5	10	40	40	0.07	.-	0,07	-	-	-	-	73	Narrative/500
Monobromomethane	Halogenated aliphatic compounds	5000		-	-	-	-		-		-	-	-	-	-	-
Monochlorobenzene	Halogenated aromatic compounds	50	15	0,1	1	10	10		0.08		-	-	-	-	1,3	-
Monochloromethane	Halogenated aliphatic compounds	5000		-	-	-	-		-		-	-	-	-	-	-
Monochlorophenols	Chlorinated phenols	50	5,4	0,05	0,5	5	5		-		-	-	-	-	7	-
Naphthalene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	1,1	-
Nickel	Metal	5000	100	50	50	50	50	0.02	-	0,07	3	3	-	5	Equation	200/1000
Nitrate	Inorganic nitrogen compounds	20000		-	-	-	-	45	45	50	10	-	-	20	13 mg/L	-
Nitrate + Nitrite	Inorganic nitrogen compounds	20000		-	-	-	-		-		-	-	-	-	-	NO3+NO2-N
Nitrite	Inorganic nitrogen compounds	5000		-	-	-	-		-	3	-	-	-	-	60 NO2-N	-/10 000 NO2-N
Nonylphenol and its ethoxylates	Nonylphenol and its ethoxylates	-		5,7	5,7	14	14		-		-	-	-	-	1	-
Nutrients		-		-	-	-	-		-		-	-	-	-	Framework	-
n-hexane	Aliphatic hydrocarbon	-		0.49/6.5 #	0.49/6.5 #	6.5/21 #	6.5/21 #		-		-	-	-	-	-	-
Parathione	Pesticide, Organophosphorus	5000							-		-	-	-	-		-
Pentachlorobenzene	Halogenated aromatic compounds	50	6,7	0,05	2	10	10		-		-	-	-	-	6	-
Pentachlorophenol	Halogenated aromatic compounds	50	12	7,6	7,6	7,6	7,6		0.06	0,009	-	-	-	-	0,5	-

Chemical Name	Chemical Groups	Hazardous waste (levels Schedule II, HW Rules, 2008) [1)]	Soil (Screening and Response Levels)					Groundwater for drinking water (Screening levels) [4)]			Surface water Quality (Screening levels)					
			Response levels (Dutch Inter-vention levels) [2)]	Screening levels Soil Quality Guidelines for the Protection of Environmental and Human Health [3)]				Indian Standard for Drinking Water * (Maximum acceptable concentra-tion)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commer-cial	Industrial				Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
Permethrin	Pesticides, Organochlorine compounds	50		-	-	-	-		-		-	-	-	-	0,004	-
Phenanthrene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,4	-
Phenolic compounds (as C6H5OH)	compounds	5000	14	0,1	1	10	10	0.001	-		1	5	-	5	-	-
Phenols (mono- & dihydric)	Aromatic hydroxy compounds	5000		3,8	3,8	3,8	3,8		-		-	-	-	-	4	-/2
Phenoxy herbicides	Pesticides	-		-	-	-	-		-		-	-	-	-	4	-/100
Phosphorus (as P)	Inorganic	20000		-	-	-	-		-		5	-	-	-	Framework	-
Phthalic acid esters (each)	Phthalate esters	-		30	-	-	-		-		-	-	-	-	-	-
Picloram	Pesticides	-		-	-	-	-		-		-	-	-	-	29	-/190
PCBs (Polychlorinated biphenyls)	Polychlorinated biphenyls	50	1	0,5	1,3	33	33	0.0005	-		-	-	-	-	0.001	-
Poly cyclic Hydrocarbon (PAH)	Polycyclic aromatic hydrocarbons (PAH)	-	40					0.0001	-		-	-	-	-	-	-
Polychlorinated dibenzo-p-dioxins/dibenzo furans	Polychlorinated dioxins and furans	-	0,00018	4 ng TEQ.kg-1	4 ng TEQ.kg-1	4 ng TEQ.kg-1	4 ng TEQ.kg-1		-		-	-	-	-	-	-
Propylene glycol	Glycols	-		-	-	-	-		-		-	-	-	-	500 000	-
Pyrene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,025	-
pH	Inorganic Acidity, alkalinity and pH	-		6 to 8	6 to 8	6 to 8	6 to 8	6.5-8.5			5,5 - 9,0	5,5 - 9,0	5,5 - 9,0	5,5 - 9,0	6.5 to 9.0	-
Quinoline	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	3,4	-
Reactive Chlorine Species	Inorganic Reactive chlorine compunds	-		-	-	-	-		-		-	-	-	-	0,5	-
Salinity	Physical	-		-	-	-	-		-		-	-	-	-	-	-
Selenium	Inorganic	50		1	1	2,9	2,9	0.01	0.01	0,01	0,05	0,05	-	0,05	1	Variable/50
Silver	Inorganic	5000		20	20	40	40	0,1	-		-	-	-	-	0,1	-
Simazine	Pesticides, Triazine	-		-	-	-	-		0.01	0,002	-	-	-	-	10	0,5
Sodium adsorption ratio		-		5	5	12	12		-		-	-	-	-	-	-
Streambed substrate	solids Total particulate matter	-		-	-	-	-		-		-	-	-	-	Narrative	-
Styrene	Monocyclic aromatic compounds	20000	86	0,1	5	50	50		-	0,02	-	-	-	-	72	-
Sulfolane	Organic sulphur compound	-		0,8	0,8	0,8	0,8		-		-	-	-	-	50 000	500
Sulphate	Inorganic Inorganic sulphur compounds	-		-	-	-	-	200	-		-	-	-	-	-	No data
Sulphur (elemental)	Inorganic Inorganic sulphur compounds	50000		500	-	-	-		-		-	-	-	-	-	-
Suspended sediments	solids Total particulate matter	-		-	-	-	-		-		-	-	-	-	Narrative	-
Tebuthiuron	Pesticides	-		-	-	-	-		-		-	-	-	-	1,6	tame hays, and
Tellurium		50		-	-	-	-		-		-	-	-	-		-
Temperature	Physical Temperature	-		-	-	-	-		-		above				Narrative	-
Tetrachloromethane	Halogenated aliphatic compounds	5000	0,7	0,1	5	50	50		-		-	-	-	-	13,3	-/5
Tetrachlorophenols	Halogenated aromatic compounds	50	21	0,05	0,5	5	5		0.1		-	-	-	-	1	-
Thallium	Inorganic	50		1	1	1	1		-		-	-	-	-	0,8	-
Thiophene	Miscellaneous organic compound	-		0,1	-	-	-		-		-	-	-	-	-	-
Tin (inorganic)	Inorganic	5000		5	50	300	300		-		-	-	-	-	-	-
Tin (organic)		50		-	-	-	-		-		-	-	-	-	-	-
Toluene	Monocyclic aromatic compounds	20000	32	0.1	3	30	30		-	0,7	-	-	-	-	2	-/24
Total dissolved solids (TDS)	solids	-		-	-	-	-	500	-		100	600	200	100	-	00
Total hydrocarbons (TPH) (mineral oil)		50000	5000	-	-	-	-	0,5	-		10	20	10	20	-	-

Chemical Name	Chemical Groups	Hazardous waste (levels Schedule II, HW Rules, 2008) [1)]	Soil (Screening and Response Levels)					Groundwater for drinking water (Screening levels) [4)]			Surface water Quality (Screening levels)					
			Response levels (Dutch Inter-vention levels) [2)]	Screening levels Soil Quality Guidelines for the Protection of Environmental and Human Health [3)]				Indian Standard for Drinking Water * (Maximum acceptable concentra-tion)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commer-cial	Industrial				Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
Toxaphene	Pesticides, Organochlorine	50		-	-	-	-		-		-	-	-	-	0.008	-/5
Triallate	Pesticides, Carbamate	-		-	-	-	-		-		-	-	-	-	0,24	-/230
Tribromomethane	Halogenated aliphatic compounds	5000		-	-	-	-		-		-	-	-	-	-	-/100
Tributyltin	Organotin compounds	50		-	-	-	-		-		-	-	-	-	0,008	-/250
Trichlorfon		-		-	-	-	-		-		-	-	-	-	0,009	-
Trichloromethane (chloroform)	Halogenated aliphatic compounds	5000	0,7	0,1	5	50	50	0,2	-	0,3	-	-	-	-	1,8	-/100
Trichlorophenols	Halogenated aromatic compounds	50	22	0,05	0,5	5	5		0.005		-	-	-	-	18	-
Tricyclohexyltin	Organotin compounds	-		-	-	-	-		-		-	-	-	-	-	-/250
Trifluralin	Pesticides, Dinitroaniline	-		-	-	-	-		-	0,02	-	-	-	-	0,2	-/45
Triphenyltin	Organotin compounds	50		-	-	-	-		-		-	-	-	-	0,022	-/820
Turbidity	solids Total particulate matter	-		-	-	-	-	1 NTU	0.1-1.0 NTU		-	-	-	-	Narrative	-
Tungsten compounds		5000		-	-	-	-		-		-	-	-	-	-	-
Uranium	Inorganic	-		23	23	33	300		0.0s	0,015	-	-	-	-	15	10/200
Vinylchloride	Halogenated aliphatic compounds	5000	0,1	-	-	-	-		0.002	0,0003	-	-	-	-	-	-
Vanadium	Inorganic	5000		130	130	130	130		-		0,2	0,2	-	0,2	-	100/100
Xylene	Monocyclic aromatic compounds	20000	17	0.1	5	50	50		-	0,5	-	-	-	-	-	-
Zinc	Metal	20000	720	200	200	360	360	5	-		5	15	-	15	30	-/50000

NR: No relaxation

¤: CCME (Canadian Council of Ministers of the Environment). 1991. Interim Canadian environmental quality criteria for contaminated sites. CCME, Winnipeg.

#: coarse/fine sediment.

!: xx (yy): xx is value from HWR 2008; yy is Dutch Intervention values. In this case levels from HWR are used because these are lowest.

*: IS: 10500:2012

1) referring to schedule II of the Hazardus Waste rules, 2008. These levels are not relevant for the assessment of contaminated sites, but may apply if during remediation material is excavated, transported and disposed of or treated.
Note: the total content of the various substances in categories 50, 5000, 20000 and 50000 are indicated, should not exceed the specified levels to be determinated as hazardous waste.

2) referring to Dutch intervention values (of the Circulaire bodemsanering - Circular Soil Remediation) which represent a level above which unacceptable risks may occur. The risk model by which these levels were determined takes into account a residential situation where people live and partly eat crops from the site. In this way these levels provide a relatively low level of risk, i.e. a conservative approach. The levels in this list are fixed number, no dependency on soil characteristics has to be applied.

3) referring to CCME Canadian Environmental Quality Guidelines, these levels represent a level of negligible risk and provide a level that is regarded to enable a healthy functioning system for different types of land use.

4) Groundwater for drinking water Screening levels: If Indian Standard for Drinking Water is not available for that parameter first referring to Guidelines for Canadian Drinkwater Quality and secondly to WHO Guidelines for drinking water.

Volume II

2.1-c Checklist preliminary site assessment report

Volume II-2.1-c
Checklist preliminary site assessment report

1 Introduction

This information is most relevant for review of the result of Task 2.1, the preliminary site assessment report. Below table provides the elements of such a report. These elements relate to the list of contents of the Site Inspection Form – Template of the *Site Inspection Protocol, Volume III-2.1-i.*

2 Checklist preliminary site assessment report

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the preliminary site assessment	
Date of recording	
Recording official	

No.	Topic	Obligatory	Status	Comments
1	Existing and general information (to be filled in before Site Inspection)	Yes		
2	Overall assessment of data and data gaps (assessed before Site Inspection)	Yes		
3	On site Reconnaissance	Yes		
4	Off site Reconnaissance	Yes		
5	Miscellaneous	Yes		
6	SITE map	Yes		
7	Sampling	Yes		
8	Overall assessment of pathways, exposure, impacts and contamination	Yes		
9	Draft Conceptual site model (CSM)	Yes		
10	Photographic Record	Yes		
11	Analysis results from sampling (table with results from sampling)	Yes		
12	Data sheet with extract of existing data from Geoenviron database – prior to Site Inspection	Yes		

Explanatory Notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: remarks to be entered by reviewer on the results for this topic

Volume II

2.2-a Checklist preliminary site investigation report

Volume II-2.2-a
Checklist preliminary site investigation report

1 Introduction

This information is most relevant for review of the output of Task 2.2, a preliminary site investigation report. The checklist below provides the elements that may be included in such a report. The specific situation determines which elements are required in a given report.

The topics in the checklist may be used as elements in Terms of Reference for the investigation of a specific site.

2 Checklist preliminary site investigation report

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the preliminary site investigation	
Date of recording	
Recording official	

No.	Topic	Data Provider / Source	Obligatory	Status	Comments
Name of investigating agency and report date					
Site identification					
	State name	Provided by client	Yes		
	Site owner	Provided by client			
	Site name	Provided by client	Yes		
	Address	Provided by client	Yes		
	GPS coordinates /and elevation: latitude and longitude in centre of the site entered as decimal	Provided by client or established based on address	Preferably		
	Current land use	Provided by client	Preferably		
Introduction					
	Purpose and scope of the investigation	Provided by client	Yes		
	Explanation of the structure of the report	Investigating agency	Preferably		
Site description					
	Explanation of information sources	Investigating agency	Yes		
	History of site use (ownership, operators, users, raw materials, waste related activities, permits, etc)	Investigation agency (Client, informed parties, discussion with local people, district administration and government databases)	Yes		

	Environs of the site (land use, groundwater use, use of water bodies, estimated number of residents or onsite workers, estimated distances to sensitive use, etc.)	Investigating agency (partly provided by government agencies)			
	Climate data (precipitation, temperature and derived information/estimated parameters such as evapo-transpiration and groundwater recharge rate estimated from this data				
	Geology and hydrogeology (stratigraphy, aquifers, depth and permeability of subsurface layers, possible karst features, etc.)	Provided by source or search of website of Central Groundwater Board, Ministry of Water Resources: http://cgwb.gov.in/	Yes		
	Hydrology and surface water (distance from site to water bodies, migration paths of rainfall to surface water, drainage, flooding patterns)				
	Results from previous investigations or incidental data	Client	If relevant		
	Result of site inspection	Investigating agency	If applicable		
	Hypothesis on type and characteristics of the contamination	Investigating agency	Yes		
	Features / targets for investigation	Client and investigating agency	If relevant		
Investigation Strategy					
	Draft Conceptual Site Model	Investigating agency	Yes		
	Screening and sampling strategy	Investigating agency	Yes		
	Fieldwork screening methods (rapid assessment tools)	Investigating agency	If applicable		
	Exploratory hole / sample location pattern (grid or targeted) and numbers of samples (soil, sediment and groundwater) , including benchmark / background samples	Investigating agency	Yes		
	Parameters for laboratory testing and chemical analysis methods / detection limits	Investigating agency	Yes		
	Applied method for quality control (QA/QC)	Investigating agency	Yes		
Fieldwork results and interpretation					
	Site conditions during fieldwork (e.g. dates, weather conditions, access to locations, etc.)	Investigating agency	Yes		
	Visual / olfactory evidence of contamination	Investigating agency, fieldwork personnel	Preferably		
	Results of screening techniques (if applied)	Investigating agency, fieldwork personnel	If applied		
	Description of ground conditions and subsurface structure (borehole / exploratory hole log description)	Investigating agency, fieldwork personnel	Yes		

	Selection of samples to be tested	Investigating agency, engineer	Yes		
	Laboratory test results	Laboratory reports	Yes		
	Comparison of laboratory test results to standards (Screening levels and Response levels)	Investigating agency	Yes		
Conclusions and recommendations					
	Does the site meet the definition of 'Contaminated Site'? (yes/no/uncertain)	Investigating agency	Yes		
	Relevant sources, pathways and receptors (soil exposure and air pathways, groundwater pathways, surface water pathways). Updated Conceptual Site Model.	Investigating agency	Yes		
	Recommendation for: • further investigation (yes/no); • notification as contaminated site (yes/no) leading to prioritisation and remediation investigation; • temporary safety measures if in the present situation significant risks to human health or environment are expected.	Investigating agency	Yes		
Annexes					
	Topographical map of area with location of the site	Client of investigating agency	Yes		
	Detailed site survey plan with location of sampling points	Investigating agency	Yes		
	Methods of fieldwork and laboratory testing	Investigating agency	Preferably		
	Borehole / exploratory excavation logs with explanation codes	Investigating agency, fieldwork personnel	Yes		
	Relevant screening and response levels	Competent authority	Yes		
	Laboratory results (including original reports) of sample analyses (soil and groundwater separately)	Laboratory	Yes		
	QA/QC results	Investigating agency			
	Photographic record	Investigating agency	Preferably		

Explanatory Notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: remarks to be entered by reviewer on the results for this topic

Volume II

2.2-b Checklist review and approval preliminary site investigation report

Volume II-2.2-b
Checklist review and approval preliminary site investigation report

1 Introduction

This information is most relevant for Step 2, Preliminary Investigation. The report of the preliminary site investigation is to be reviewed by the competent authority to prepare the decision by the appropriate official.
The checklist below provides the points of attention for the review.

2 Checklist review and approval preliminary site investigation report

The checklist below can be used to review the preliminary site investigation. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the preliminary site investigation	
Date of recording	
Recording official	

No.	Topic		Obligatory	Status	Comments
1	Checklist preliminary site investigation report	Evaluation if the report contains the elements necessary for a preliminary site investigation (refer Volume II-2.2-b)	Yes		
2	Skills and accreditations	Evaluation if the specialized agency or consultant charged with the preliminary site investigation meets the required skills and accreditations (refer Volume II-2.1-a)	Yes		
3	Stakeholder rights and interests	Evaluation if stakeholders have been involved during the course of the investigation.	Yes		
4	Points of interest to assess the results of the investigation	• All sources, pathways and receptors are identified; • Samples have been taken to assess the level of contamination of the sources and the transport via pathways • The activities to analyse the results of the investigation and comparison with the Screening and Response levels are clearly described; • Uncertainties that can have effect on the investigation result are indicated explicitly;	Yes		

		• Is cross checking of third party values required, e.g. samples and laboratory testing?			
5	Conclusion	Can preliminary site investigation report be approved? If not, which further information is required?	Yes		

Explanatory Notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: remarks to be entered by reviewer on the results for this topic

Volume II

3-a Checklist restrictions to site use and temporary safety measures

Volume II-3-a
Checklist restrictions to site use and temporary safety measures

1 Introduction

This information is most relevant for Step 3 Notification of polluted sites.

Results of (preliminary) investigation of a site may indicate actual or potential threats for human health or for the environment. In such a situation it may be necessary to organize a quick response to these threats, especially in case remediation measures are not expected to be implemented in the near future. In such a situation, restrictions to the current site use or emergency hazardous waste removal can be imposed and, to ensure proper implementation, temporary safety measures can be taken.

The checklist below provides examples for these site use restrictions and temporary safety measures regarding the protection of human health. Where surface water is involved, these measures can be applied when the water quality is negatively impacted by a contaminated site (e.g. by diffusion from contaminated sediments), or when in the current situation effluents from industrial processes and sewerage are still being discharged and are reaching, directly or indirectly, the surface water.

Measures regarding ecology (plants and animals) are part of the later steps in the process of remediation of a site. The same applies to measures regarding the prevention of threats for situations of future land use.

2 Identification of site use restrictions and temporary safety measures

The checklist below can be used to identify potential site use restrictions. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)				
Main results of the preliminary site investigation				
Date of recording				
Recording official				
Annexes#)				
Current land use	**Potential restrictions to site use when concentration levels in soil or sediment in contact zone*) exceed Response levels**	**Conclusion on whether restrictions should be applied (Yes/No) and remarks**	**Potential restrictions to site use when concentration levels in groundwater or surface water exceed Screening levels**	**Conclusion on whether restrictions should be applied (Yes/No) and remarks**
Habitation settlement/residential or school or playground or garden/park	Prohibit use of the site for current purpose. Prevent new building activities.		Prevent contact with or consumption of groundwater or surface water.	
Industrial or other commercial land	Prevent contact of labor with contaminated material. Prevent new building activities.		Prohibit extraction of groundwater or use of surface water, unless being used not for sensitive purposes (e.g. cooling water in an industrial process).	
Agricultural land	Testing of concentration levels in grass or crops and if these exceed product quality levels, prohibit the consumption of crops and prohibit livestock.		Prohibit use of drinking water for livestock and use of groundwater for irrigation.	
Forests and other natural area	Discourage or prohibit access to site.		Prohibit extraction of groundwater or use of surface water.	
Waste land	Discourage or prohibit access to site.		Prohibit extraction of groundwater or use of surface water.	
Open water body	Prevent contact with contaminated sediment.		Prevent contact with or consumption of surface water.	
Mixed and Other land use	To be derived from above suggestions.		To be derived from above suggestions.	

*) contact zone means the top level of soil and sediment (between 0.0 and 1.0 meters below the surface)

#) Annexes may include a more detailed description of site use restrictions to be imposed or temporary safety measures to ensure implementation of these, and, if applicable, a map clearly showing the area or areas on which imposed measures apply

3 Examples of temporary safety measures

Potential temporary safety measures to prevent unacceptable risks from contact with contaminated soil or sediment:

- Restrict public access to a site by placing fencing and/or by security;
- Discourage access to a site by posting warning signs;
- Assessing the need to temporarily relocate population;
- Physical emergency removal of (most) hazardous substances;
- Stabilizing waste sources such as leaking drums;
- Applying shallow top coat of clean material on locations where obvious contaminated material is present;
- Applying cover on unpaved surfaces.

In case of imminent health hazards these measures should be implemented immediately.

Potential temporary safety measures to prevent unacceptable risks from contact with contaminated groundwater and surface water:

- Temporary treatment of extracted groundwater / surface water;
- Closing groundwater extraction wells;
- Monitoring groundwater quality and spreading of contaminated plume (refer to *Volume I-11* for guidance on monitoring measures);
- Providing alternative supply of fresh water for consumption or for agricultural purposes;
- Discouraging or prohibiting use of water for bathing or swimming.

In case at a contaminated site contamination of soil, sediment, groundwater or surface water still takes place from spills measures should be taken to prevent this new contamination referring to the regulations of Section 7 of Environment (Protection) Act 1986 and to Section 3 and Schedule I of Environment (Protection) Rules, 1986.

In India there are a number of methods and measures available and used to contain or arrest a spill from a broken/damaged circular pipeline and fittings:

- There are devices which include an adaptor sleeve clamp with a provision to reasonably secure and block the liquid leakage from the pipeline. The leakage arresting device is provided in a form of ready for installation to block leakages even in locations / units requiring high standard of safety. These devices can be indigenously prepared at sites and applied or are readily available in the market.
- There are other measures adopted to contain the online leak by application of different metal putties such as Express Titanium Putty and Sticks, Steel Putty, Bronze Putty, Aluminium Putty, Underwater Putty etc. depending upon the method of characteristics (MOC) of leaking pipeline.
- Urethane impregnated, water activated special pipe tap kits designed to permanently stop live leakage up-to 4” diameter and 60 PSI are also available and used.
- Pipe Sealer is used to seal and lock threaded pipes and fittings leakages.
- Single component room temperature vulcanizing silicone sealant that forms rubber like material is widely used in leak sealing.

Volume II

4-a Checklist information for application prioritization system

Volume II-4-a
Checklist information for application prioritization system

1 Introduction

This information is most relevant for Step 4 Priority list addition. The text below presents additional guidance for the parameters needed to apply the prioritisation system. This should serve the performing party in acquiring the correct parameters.

For detailed guidance on the prioritisation algorithm we refer to the Report of Prioritization of sites (part of NPRPS-Inventory and mapping of contaminated sites, COWI, December 2015).

2 Additional guidance

Table: list of parameters and initial parameter values (source: Report of Prioritization of sites, COWI December 2015)

Parameter	S-P-R	Description	Basis	Range	Data Source
C	Source	Source concentration	Marks as Low, Med, High or Ratio to Screening Level	0 – 10	To be obtained from Site Inspection and/or from previous investigation performed at the site
Q		Quantity of source	Volume, or Low, Med, High	0 – 5	To be obtained from desktop study and/or Site Inspection
T		Toxicity Factor	A list of Chemicals	0 – 5	Obtained from the GeoEnviron Database (International classification)
M		Mobility Factor	List – chemical characteristics	0 – 5	Obtained from the GeoEnviron Database (International classification)
F	Pathway	Pathway Factor	Conn x Att	0.8-1	To be calculated based on Conn and Att
		Conn (Containment)	Site Report	0.4-0.5	Technical judgement based on site access
		Att (Attenuation)	Pathway, tables	0.4-0.5	Reflecting directness of path to receptor (including distance to receptor and groundwater vulnerability)
L	Receptors	Land use at the site	Scoring Low, Med, High Risk	0 – 10	Same classification used in Stage I prioritization
P		Population at risk	Estimated within 1 km. Log(pop) or Low, Med, High	0 – 10	Same classification used in Stage I prioritization

S		Sensitivity of receptor	Professional judgement; Scoring Low, Med, High	0 – 30	Based on observation from Site Inspection e.g. part of the population is particularly at risk or disadvantaged. Based on observed exposure to contaminants, observed impacts and generally emergency response considerations (observed conditions that may warrant immediate or emergency action (e.g. heavily contaminated groundwater/surface water used for drinking water or direct contact to heavily contaminated soil))
G		Groundwater system at risk	Use/importance of aquifer; Low, Med, High	0 – 10	Same classification used in Stage I prioritization.
SW		Surface water at risk	Use/importance of surface water; Low, Med, High	0 – 10	
E		Sensitive ecosystems	Distance to designated reserves, etc.; Low, Med, High	0 – 5	Scoring based on distance and type of sensitive ecosystems

Source

The source term is a measure of the scale and risk of the critical contaminant. This is in common with most of the systems reviewed, the approach here uses one “dominant” contaminant, but it is possible to use a combination where there are high values for several different contaminants.

The basic source term is the concentration (C) of the pollutant at the site in relation to the relevant screening value. This number can be a score reflecting the extent of the over-standard compared to the screening value. With limited sampling this parameter can be based on a professional judgement. Where there is a very wide range of high values across sites, the logarithm of the values can be used. The current uses of the site are taken into account by selecting the screening value appropriate for that land use. In cases where there is no information on the concentration (or where the sampling data is very limited or unreliable), it is possible to use estimates of the typical levels of contamination using data from similar sites or informed judgments.

To characterize the source better, terms are added for the quantity (Q), the toxicity (T) and the mobility of the contaminant (M).

The quantity is scored in terms of an estimate of size (small, medium, large). This factor can also be used to reflect a source that is a cluster of industries, where the value of Q is increased to capture the overall scale of the collective source. This is equivalent to the CEPI factor for the scale of industrial activity.

Toxicity scores are based on specific characteristics of the contaminant, as recorded in the scientific literature. The scores have been defined according to the toxicity as classified by the Department of Environment in England (DOE), and are available in the GeoEnviron database.

Mobility scores are based on specific characteristics of the contaminant, as recorded in the scientific literature. The scores have been defined according to the toxicity as classified by the Department of Environment in England (DOE), and are available in the GeoEnviron database.

Pathway

The pathway term is a measure of how direct the path from the source to the receptor is. In this model, it is structured to be a modifier of the source term.

For sites where the critical receptor is actually on the site (for example people living on polluted land), then the pathway is direct and the pathway factor (F) is unity. A land use risk factor (L) is incorporated to reflect a generalized concept of the pathway and receptor, in cases where there is little information on these. Where the receptors are off-site, then some reduction in the risk will occur, based on two main factors. First, the existence or provision of containment (or restriction of access) will reduce exposure to the source. Second, distance from the source will normally reduce the exposure (simple geometry shows that the concentration will drop with increasing radius from the site) unless there is a narrow and direct pathway (such as prevailing winds, a defined groundwater plume or a waterway).

The factor F is therefore a function of (i) containment, and (ii) attenuation. Containment is estimated in terms of the “Access to the site from local communities”. Attenuation depends on the pathway and requires judgment to assess, but there is some guidance from international practice, which suggests the appropriate ranges. The approach used is based on the parameters: distance to private wells; distance to public wells; distance to the nearest habitation and the “Aquifer protection” (Groundwater vulnerability) which refers to the degree of protection provided to the aquifer by the overlying geology. For example, an aquifer overlain by a thick clay layer will be much less vulnerable to contamination than one overlain by sand and gravel. The key factors that define the vulnerability of groundwater are: presence and nature of overlying soil; presence and nature of drift; nature of the geological strata; depth of the unsaturated zone.

Receptor

The fundamental receptor is the population potentially exposed (P), and in the present formulation, additional receptor parameters can be used for groundwater (G), surface water (W) and for sensitive environments (E). These parameters are added to the human receptor score. This means that a site which has many impacts will get a high score, while a site that has serious ecological impacts, but limited human ones (for example) will be given a score to reflect this risk. Plausible values for these parameters are being tested empirically.

The fundamental receptor is the population potentially exposed (P). This is calculated based on approach described in the Site Inspection Report. The relevant population has to be identified in order to characterize P. This will be estimated based on distance (population within 1 km of radius). The population at risk a can be determined from readily available maps (whether hard copy or GIS).

The current “Land use” at the site (L) is also included as a parameter although it is our experience from Task 1 (data collection), that information about land use can be difficult to obtain in a desktop study. The classification of land use has been defined by MoEF: Agricultural land, Waste land, Water bodies, forests, Habitation settlement, Commercial, Industrial, Mixed, Other, Not known.

Groundwater (G) and surface water (SW) at risk are included in the receptor parameters. These parameters are added to the human receptor score. Generic information can be obtained from the Central Ground Water Board and State Governments for Rivers. More specific information can be obtained during site visit/investigation.
Where the data required is not available, implementation of the method can be based on assumptions. In such cases, we propose to assume a worst case scenario for each situation. Further information should then be collected in order to verify assumptions made and further refine the priority listing. Hazard scores in relation to ground and surface water receptors is taken into account based on the industry profile. Furthermore, the use/importance of the groundwater and surface water is also incorporated in the score.

Scoring for sensitive ecosystems are based on distance and type of ecosystems. If an ecosystem is not near the site, a low value will be given for the specific site.

The model includes a sensitivity factor (S) which would signify that the exposed population (or environment) were particularly at risk or disadvantaged.

Volume II

5.1-a Checklist Detailed site investigation report

Volume II-5.1-a
Checklist detailed site investigation report

1 Introduction

This information is most relevant for Task 5.1 Detailed site investigation in Step 5, Remediation investigation.
A detailed site investigation provides clear information on the extent of the nature, extent and concentrations of the substances at the contaminated site and on the site conditions.
The checklist below provides the points of attention for the detailed site investigation report. In a way it can be regarded as a table of content for the report. For specific sites some of the elements can be found not applicable.

The topics in this checklist may be used as elements in Terms of Reference for the investigation of a specific site.

2 Checklist detailed site investigation report

The checklist below can be used to identify and assess the content of the detailed site investigation. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the detailed site investigation	
Date of recording	
Recording official	

Content of detailed site investigation report	Status	Comments
Introduction and background information • Description of the site (e.g. name, address, site plan and size); • Reason for the detailed site investigation; • Summary of the previous investigations at the site; • Information of the parties involved in the remediation investigation process and allocation of their roles; • Scope of the investigation; • Explanation of the structure of the report.		
Site situation • The lay-out on the site (present land use, infrastructure, buildings, use of the surrounding area, included natural features such as lakes, rivers, streams found at least partially within the boundaries of the property) and in the area beyond the site covering the pathway;		

• Description of history of the land use and possible causes of the contamination (included constructed features such as, underground storage tanks, lagoons, ditches, sumps within buildings, and waste storage areas); • Typology of the contaminated site; • Geology, geohydrology and soil structure and ground conditions of the site in case of contaminated soil and groundwater (depth of groundwater, thickness of aquifers, seasonal groundwater fluctuations; the lithology and vertical permeability of the unsaturated zone; the stratigraphy, structure, geometry, porosity, hydraulic conductivity, storage properties, transmissivity, and groundwater flow direction of the saturated zone). • If monitoring or drinking water wells have been installed: review of the monitoring results; include data why and when a well was installed and by whom and technical data (depth, filter length, monitoring data, sample and lab methods) • Soil survey information at a scale of 1:20 000 or larger; on-site map and appropriate cross-sections showing soil types, soil depth and other soil parameters that may be related to location and extent of contaminants; • Climatic conditions (precipitation, seasonal variations, estimated infiltration rates); • Morphological and hydraulic aspects including e.g. seasonal variations in water level and floods and and areas affected by floods to estimate the impact of contaminated sediments.		
Investigation strategy • The conceptual site model (CSM) with the combinations of source-pathway-receptor) of concern. A detailed description of the present contamination with characteristics (parameters, concentration, extent in horizontal and vertical direction, mobility, density); • Data gaps in the CSM and points for investigation; • Screening and sampling technical equipment; • Sampling rationale and design (media, locations, pattern and depth of samples), including background samples; • Number of samples; • Screening of observations wells or necessity for drilling new wells; • Methods for establishing stratigraphy and characteristics of subsurface layers; • Analytical test parameters / determinants required.		
Fieldwork and laboratory testing • Description of executed activities; • Site conditions during fieldwork (e.g. dates, weather conditions, access to locations, etc.) • Visual / olfactory evidence of contamination • Results of screening techniques (if applied) • Description of ground conditions and subsurface structure (borehole / exploratory hole log description) or water body; • Selection of samples to be tested; • Laboratory test results; • Quality assurance and quality control; • Possible deviations from sample plan and reasons involved.		

Analysis and interpretation of exploratory data • Comparison of laboratory test results to standards (Screening levels and Response levels); • Description of situation of the contamination in the various media (soil, groundwater, sediment, surface water, air, biota) including depth and extent of contamination and including estimated quantity of polluted media; • Development of groundwater flow, surface water flow, and mass transport models. (if required) • Implications of contamination, soil structure and general physical, chemical, ecological and spatial site conditions for remediation options; • (Seasonal) contour maps of groundwater flow and explanation of estimated groundwater processes; • Possible influence of seasonal climatological situation on groundwater and surface water; • Contour maps and cross-sections to show spatial distribution of contaminants; graphical displays that present the available data in their spatial context; sample values for data on maps or cross-sections; colors; grey scales, or symbols to high-light the locations of the highest sample values; • Updated Conceptual Site Model, identifying sources, pathways and receptors.		

Conclusions and recommendation
• Conclusions on the scope and objectives of the investigation with clear indication of known data gaps and possible uncertainties;
• Recommendations for
  ○ further investigation;
  ○ temporary safety measures if in the present situation significant risks to human health or environment are expected. This may include monitoring of a contaminated plume in groundwater.		

Annexes • Topographical map of area with location of the site • Detailed site survey plan with location of sampling points • Methods of fieldwork and laboratory testing • Borehole / exploratory excavation logs with explanation codes • Relevant screening and response levels • Laboratory reports • Calculations or modelling results and explanation characteristics of the model used • Maps indicating contamination of soil, sediment and groundwater • Background literature and sources • Photographic record		

Explanotary notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

5.2-a Checklist risk assessment report

Volume II-5.2-a
Checklist risk assessment report

1 Introduction

This information is most relevant for Task 5.2, Risk Assessment. The table below presents a checklist of all elements a report on risk assessment may contain. As such, it may serve the performing consultant as well as the reviewing authority. It should be noted that the selection of elements any specific report should contain depends on the specific situation. Therefore, any review should be preceded by an analysis of which elements are relevant for the situation at hand.

The report on risk assessment may be integrated into the report of the detailed site assessment.

2 Checklist risk assessment report

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the risk assessment	
Date of recording	
Recording official	

Content of Risk assessment report	Status	Comments
Introduction and background information • Description of the site (e.g. name, owner, address, site plan and size, GPS-coordinates); • Summary of the previous investigations at the site; • Information of the parties involved in the assessment and remediation process and allocation of their roles; • Reason for and objectives of risk assessment.		
Site situation • The situation of the contamination at the site (present land use, infrastructure, buildings, use of the surrounding area); • Description of history of the land use and cause of the contamination; • Description of area with respect to existing land use, demographic profile, social economic and environmental conditions of the people in receptor areas, flora and fauna; • Comparison of concentration levels against Screening and Response levels.		

Content of Risk assessment report	Status	Comments
Relevant source-pathway-receptor combinations • The conceptual site model (CSM) with the combinations of source-pathway-receptor of concern. A detailed description of the present contamination with characteristics (parameters, concentration, extent in horizontal and vertical direction, mobility, density); • Relevant exposure pathways, preferably illustrated with diagram.		

Results of generic quantitative risk assessment modelling
• Tool/model used to quantify risks
• Site-specific information used for modelling
  o Representative concentrations in soil, sediment and groundwater
  o Size of contamination in soil (3D)
  o Size of contamination in groundwater (3D)
  o Size of the site (contaminated and not contaminated)
  o Level of groundwater
  o Soil type (%organic matter, % clay, grain size, hard rock)
  o Surface water in the environment
  o Drinking water extension in the environment
  o Groundwater flow direction and estimated speed
  o Use of the contaminated site and the vicinity
  o Establishment of the site (buildings, basements, roads, crops)
  o Receptors on-site and off-site
• Model results and comparison to critical exposure value		

Results of detailed quantitative risk assessment • Reason for detailed quantitative risk assessment • Collection of additional information (methodology used for obtaining data) • Data obtained, e.g. contaminants investigated, contaminant concentration levels in the relevant contact media (e.g. air, dust), relevant specific circumstances • Results		
Conclusions and communication • Clear statement on unacceptable risks identified • Possible uncertainties and information gaps, necessity for further investigation • Recommendations for further steps, setting remediation options and development of remediation options		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

5.3-a Background information for setting remediation objectives

Volume II-5.3-a
Background information for setting Remediation objectives

1 Introduction

This information is most relevant for Task 5.3 Development of remediation options. In developing effective targets for remediation it is important to discuss the policy goal on contaminated sites. This is related to the definition of contaminated sites, the inventory of sites and the technical, financial, legal and organisational possibilities to implement the NPRPS.

Contaminated sites are defined by situations which pose existing or imminent threats to human health and/or the environment. Remediation should be aimed at reducing these threats. The threats have been determined for the present or expected future land use. An important decision needed from the competent authority is the form(s) of land use and the level of protection the remediation should take into account. A sensitive form of land use (e.g. residential area) requires more remediation effort than a less sensitive form of land use (e.g. industrial area). This with respect to human health as well as regarding the ecological value of an area.

To reduce the threats for an intended form of land use an intervention is required in the source-pathway-receptor-combination of a specific situation. This means that either the source needs to be reduced, the pathway between source and receptor needs to be cut off or the receptor needs to be protected or removed. Section 5.4 in Volume II presents options for such remediation interventions.

The key issue is to what level the threats should be reduced. In this regard, there are three options to consider:

Approach 1, Generic total threat reduction in soil, sediment or groundwater
Implementation of the approach of generic total threat reduction is aimed at reducing the identified threats to zero level, rendering the site fit for any use (‘multifunctional’). Internationally, ‘zero’ is most commonly translated into ‘as low as technically achievable’. To achieve this the source of the contamination needs to be removed or treated completely, as contaminant concentration levels need to be reduced to background levels.

Approach 2a, Generic fitness for use threat reduction in soil or sediments
Implementation of the approach of generic fitness for use threat reduction in soil or sediment is aimed at reducing threats to a generic acceptable level given the site's present and/or future use. To achieve this:

- The constituents in the source of the contamination need to be removed or treated to a generic level set for the present and/or intended future land use, or
- The pathway from contamination to receptor needs to be cut off, or
- The receptor needs to be protected or removed.

Approach 2b, Cost effective groundwater approach
Implementation of the cost effective groundwater approach is aimed at reducing threats to an acceptable level, while the remediation action is still cost effective. To achieve this contaminants are removed from the pathway to a degree where the costs of the removal is in balance with the amount of contaminants (mass) removed from the pathway. Contaminants in the source of the contamination are removed or treated to such a degree that this action benefits the actions in the pathway. Whenever the receptor is threatened it needs to be protected.

Approach 3a, Site specific fitness for use threat reduction in soil or sediments
Implementation of this approach is aimed at reducing threats to a site-specific acceptable level given the site's present and/or future use. To achieve this:

- The contamination needs to be removed to a predetermined site-specific level at which the contamination is considered to present no threat. This remediation level is based on site-specific risk assessment and is typically less strict than the generic (robust for all uses) level, or
- The pathway of the contamination to the receptor needs to be cut off exactly according to a specific use and spatial planning of the site, or
- The receptor needs to be protected or removed.

The required remediation efforts are most comprehensive in approach 1), less in approach 2a),most limited in approach 3a) and cost balanced in approach 2b). Conversely, the flexibility of the present and future land use and absence of restrictions and required efforts for monitoring and control increase from approach 3) to approach 1). Figure II-5.3-a.1 below illustrates this for soil and sediments and figure II-5.3-a.2 for groundwater.

Figure II.5.3-a.1 Remediation effort and consequences for the different approaches to remediation of soil or sediment

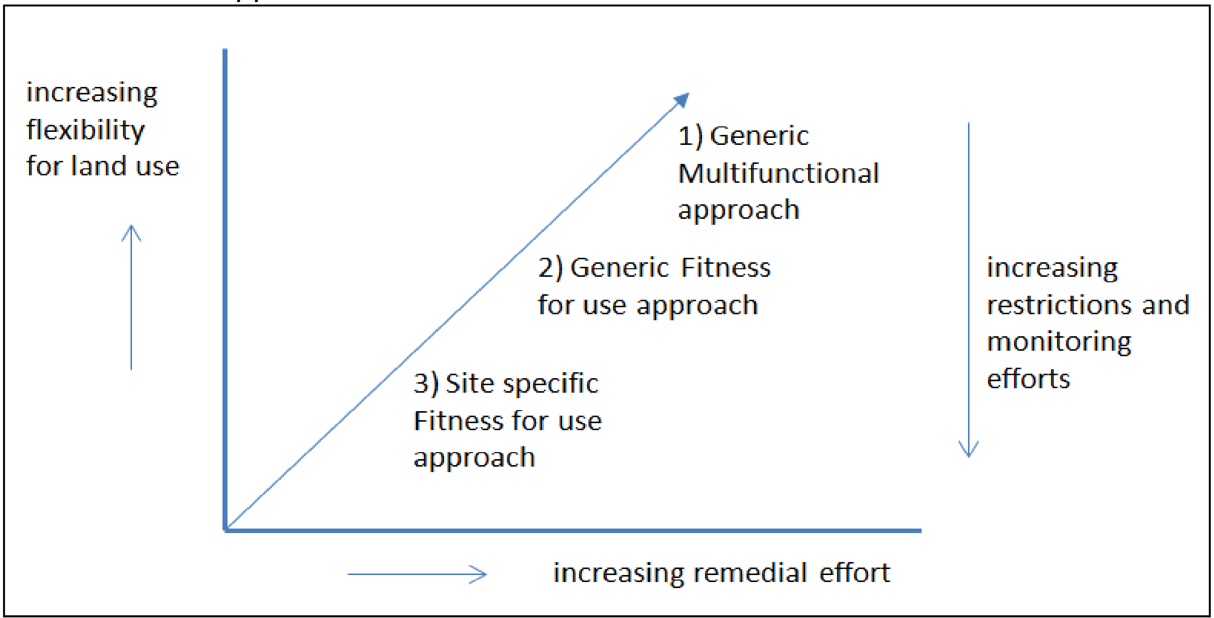
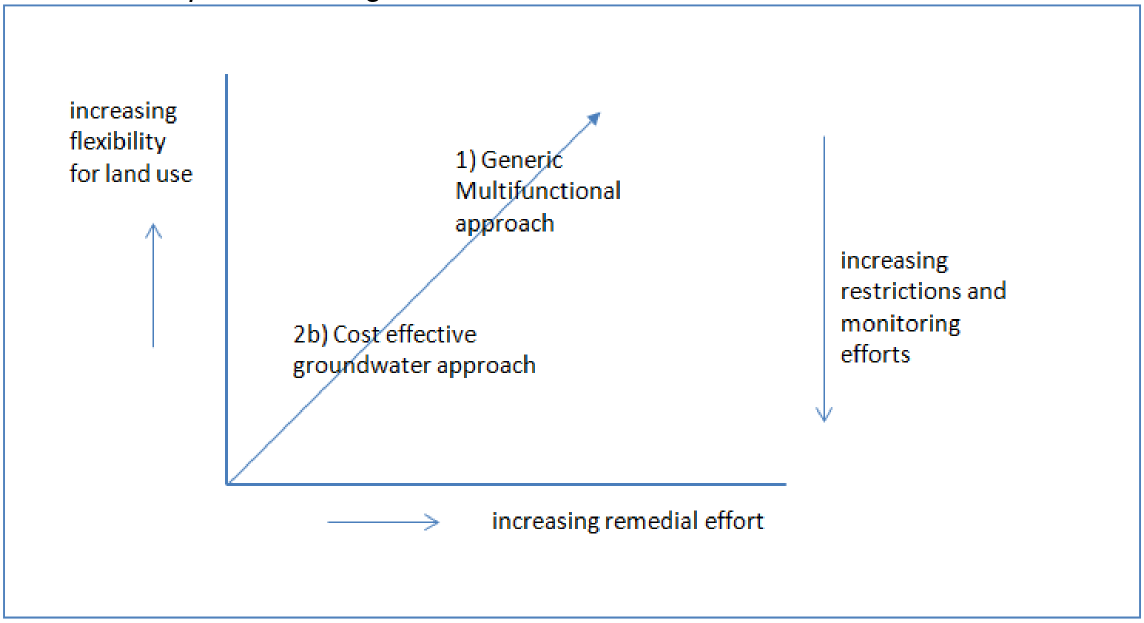


Figure II-5.3-a.2.2 Remediation effort and consequences for the different approaches to groundwater remediation



2 Standard based approach: multifunctional remediation

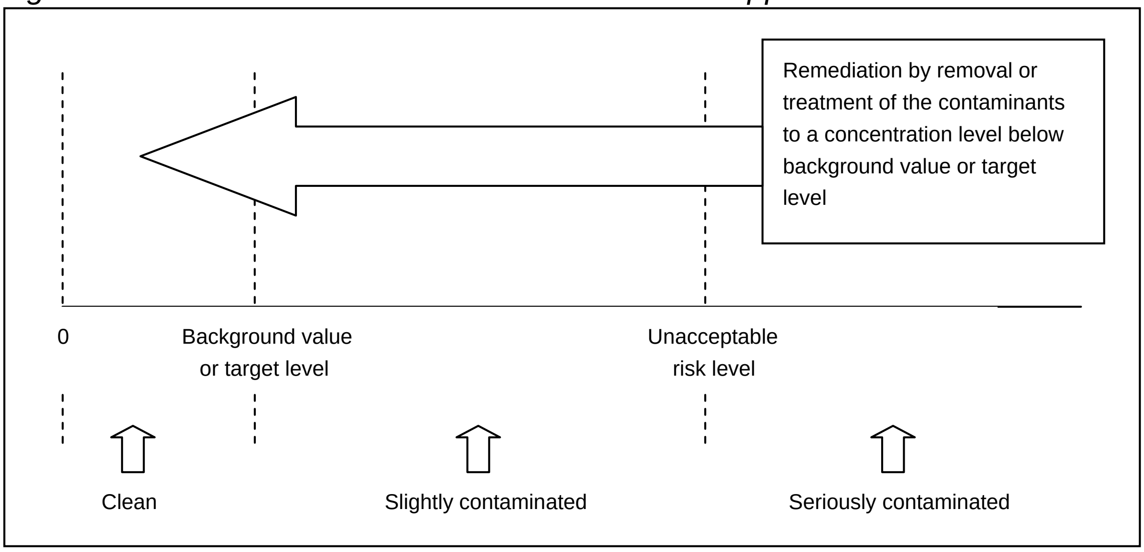
In most of the countries presently dealing with soil remediation the wheels have been set in motion by major incidents. Especially where these cases received widespread media attention governments were quick to respond. The clearest example of this is the United States where, barely a year after Love Canal became a household name, the federal Comprehensive Environmental Response and Liabilities Act (CERCLA) came into force (1980). Perhaps most remarkable was the fact that, aside from the development of regulation, the (sometimes huge) funds needed for concrete action also came swiftly. This was the case in the US, but also in the Netherlands, where, as in the US, a residential district built on top of a dangerous chemical waste dump (in Lekkerkerk) was the catalyst. The examples mentioned here had impact across national borders, as was the case with the Seveso explosion in northern Italy, which prompted other countries and the EU into action.

As the incidents were major, created clear danger to human health and to the environment in general, regulations in those early days tended to be strict. The front running countries, especially in Europe (e.g. Denmark and the Netherlands), generally adopted the principle of multifunctionality, meaning they aimed at remediating all contaminated land to pristine conditions. This would entail the restoration of soil quality from an intervention value back to a standard target level or natural background level regardless of site characteristics or site use. The objective of this approach was to reach a situation in which the remediated sites would be fit for all use after remediation. To reach this objective, all contaminated sites would need to be remediated back to pristine conditions.

This approach also meant a standard based approach, consisting of either complete removal or removal to a specific concentration, where criteria did not take into account the present or future use of the site. The obvious advantage of this approach is a simple, very clear decision-making system, easy to apply and hardly giving any space for discussion as the target levels are well defined and non negotiable.

If multifunctional soil remediation is impossible for site specific reasons containment of the contamination is a fall back option. As this containment needs to reach a situation comparable to complete removal it needs to be designed in such a way that its application results in the lowest possible emission and multiple site use options. Figure II.5.3-a.2 demonstrates the multifunctional soil remediation approach.

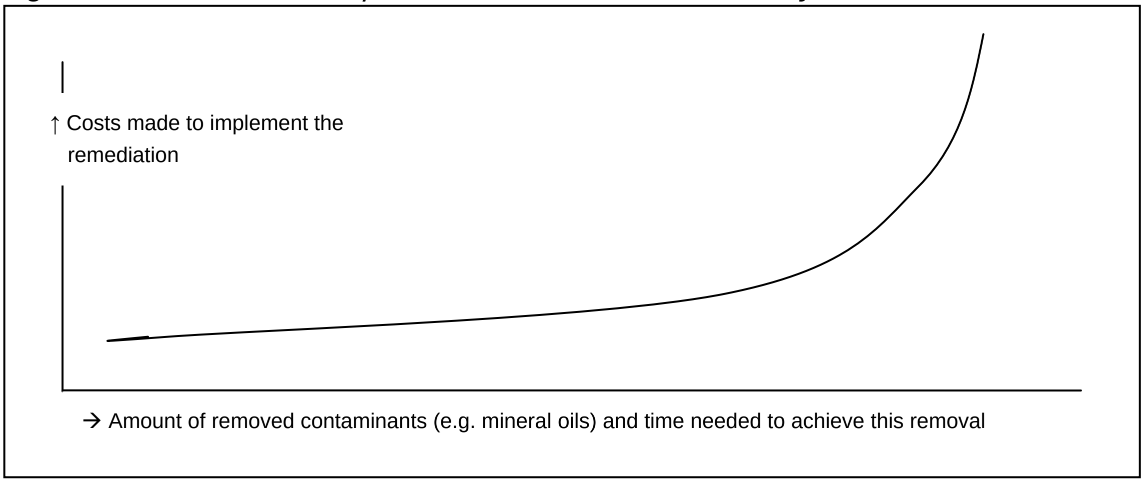
Figure II.5.3-a.2 Multifunctional soil remediation approach



The notion that “multifunctionality should be the ultimate aim of contaminated land remediation, as being the only truly sustainable option” certainly seems a defendable one. Especially if we consider the direct link that was made almost one on one in those days between soil contamination and very serious threats to human health. Actually, the Netherlands has long defended the principle of multifunctionality in practice. Even after a study in the early 1990s had shown that pursuing this strategy would amount to an estimated cost of € 45 billion (equivalent to close to € 75 billion or U$ 100 billion of today). Or, as it was translated then, even with more than € half a billion per annum (to be borne by a population of around 17 million) it would take a full century for the operation to be completed. This example illustrates what became clear elsewhere as follows: “[multifunctionality] may not be technically feasible, nor economically viable in the short term.”

An example, showing the costs and inefficiency of a multifunctional remediation approach: the removal of the final ‘drop’ of mineral oil from a mineral oil contaminated soil is a technical challenge disproportionate to its achievement. The same goes for the costs, as well as for the energy needed: the extraction of the last drop is likely to demand much more energy than represented by the drop itself. Figure II.5.3-a.3 demonstrates this principle, which helps to determine a site based optimum in the remediation target to be established.

Figure II.5.3-a.3 Principle of soil remediation efficiency



Note. Scales in this figure are arbitrary

During the first half of the 1990s the idea also gained ground that (re)development was actually slowed down considerably (‘stagnation’ was the word used) by the soil contamination on many urban, and otherwise prime, sites. This raised the question whether the policies in place influenced this stagnation in any way. Looking back, this certainly seems to be the case: the more stringent the policy leaned towards a standard based multifunctional approach, the higher the cost of remediation would be, leading to a significantly reduced interest in (potentially) contaminated sites by developers. Even in the densely populated areas of north-western Europe the economically best option often was to develop a Greenfield.

While some countries, notably Finland, the Netherlands and Switzerland, have retained, at least in theory, the ultimate goal of multifunctionality, risk based criteria tied to land use are presently in use in most countries.

With the drawbacks of the multifunctional approach apparent, that does not mean this approach has been phased out completely: it is still used in specific circumstances. For instance, in case the contaminated area is small, the costs of a multifunctional approach are relatively low. And a standard based approach may well be the most appropriate option for the liable party when his policy is to avoid any future liability issues.

3 Risk based approach: fitness for use remediation

From the previous Section we can digest that the multifunctional soil remediation approach is generally speaking not necessary from a health and environmental point of view, economically not feasible and not sustainable. The general response has been the introduction of a risk based approach. This approach focuses on the removal or treatment of contaminants as far as needed to reach a quality fit for one or more specific functional site uses, assessing all unacceptable risks prior to remediation. The result is an approach with “less stringent generic criteria tied to risk and future land use, and more flexible site-specific risk assessment and clean up procedures”.

This approach can be based on either generic target levels for different types of land use or on site specific target levels. In either case, within this fitness for use approach the remediation measures can provide a generic protection level for a form of land use or can be directed to a very specific spatial design of the intended land use. An example to illustrate this: for a residential area the remediation measures can be designed with maximum flexibility of the exact use of land within the boundaries of the site. In this way everywhere houses can be built and gardens with crops can be situated everywhere. However, remediation measures can also be designed for a very specific spatial plan for a residential area: this enables contamination levels below roads and buildings to be higher than the concentration levels in the gardens. While this way remediation efforts can be limited this approach also results in more restrictions for future use of the site, and this specific spatial site plan needs to be maintained and monitored.

In this ‘fitness for use’ approach the risks the contamination poses to human health and the environment are decreased to a level acceptable for the present land use. In case land use is expected to change in the near future, present as well as projected land use can form the basis for this approach. A basic principle that has been retained in taking the step towards a risk based approach is called the ‘stand still’: for each site reuse or redevelopment the soil and groundwater quality should at least be fixed or improved.

Figures II.5.3-a.4 and II.5.3-a.5 show the principle of the ‘fitness for use’ (risk based) approach.

Figure II.5.3-a.4 'Fitness for use' approach of the source: reducing levels of contamination in soil

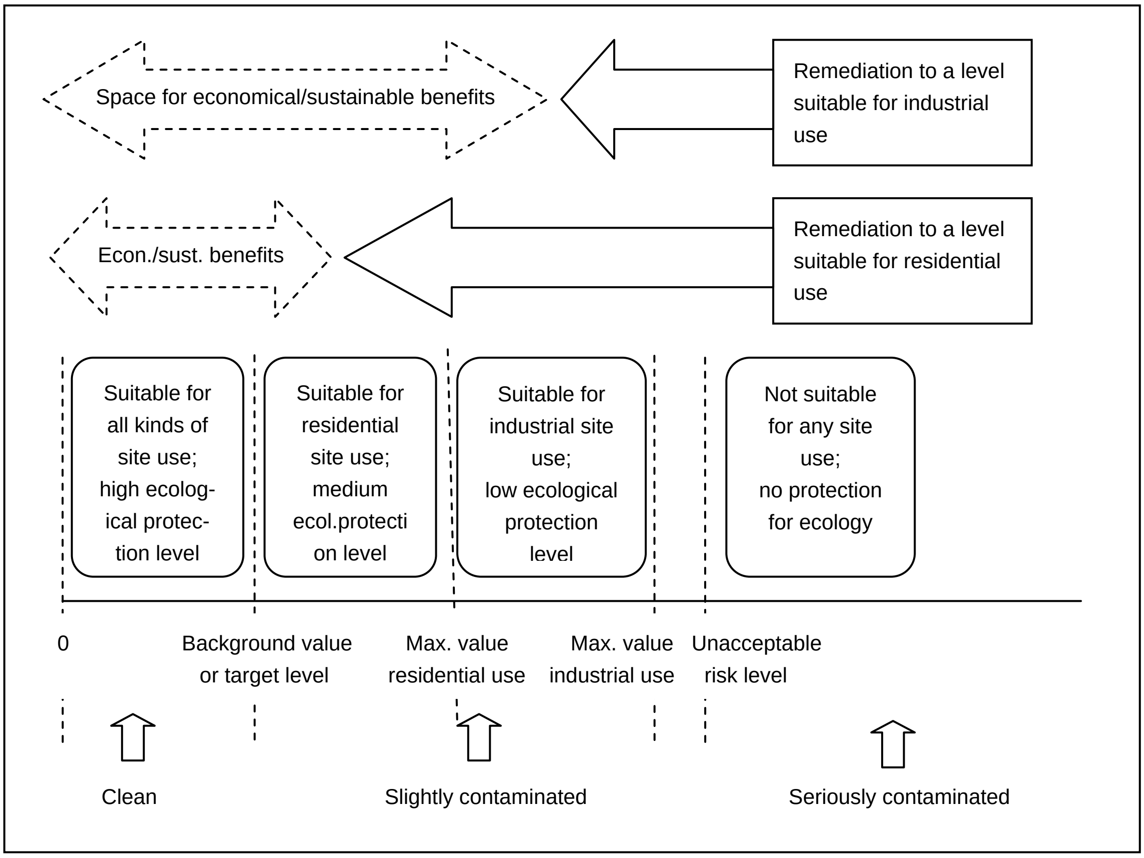
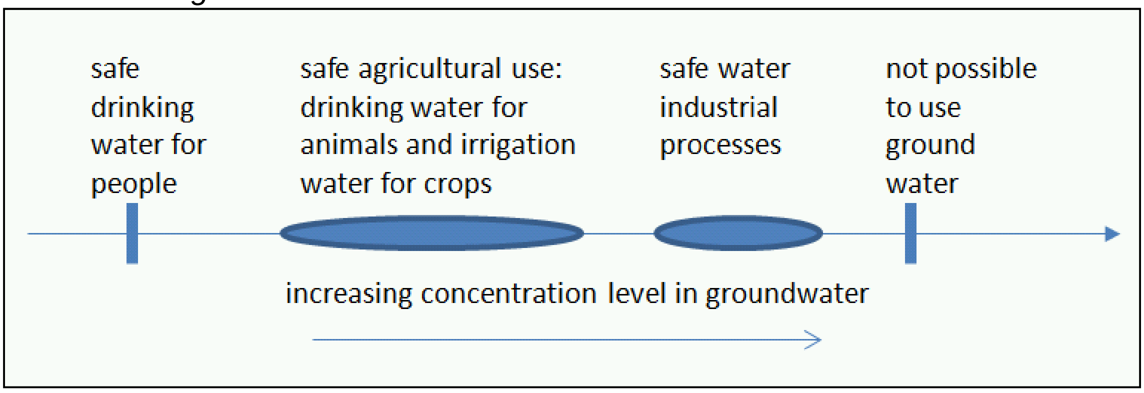


Figure II.5.3-a.5 'Fitness for use' approach of the source: reducing levels of contamination in groundwater



For each source-pathway-receptor-combination this approach can be used. In cases of immobile soil contamination, such as many heavy metals, this will result in assessing the quality of the top layer only, as the quality of this part of the soil is responsible for most human and environmental risks. The assessment of mobile contaminations is presented in Section 5 Cost effective groundwater approach.

In case only the top layer has to be assessed, much effort can be saved on the assessment of the contamination below the top layer. Using this approach, a risk based site management framework can be built, providing an opportunity to balance between a scientific underpinning of the assessments and pragmatism to deal with contaminated sites, anticipating site specific or region specific preconditions. The maximum values for site use offer basic safety warranties.

A contamination without any receptors does not present any risks. In case it is decided to remediate such a contaminated site anyway, e.g. to improve the quality of an aquifer to meet drinking water standards, there may be time to consider alternative remediation options. At this point even more cost effective remediation approaches come into view.

A more recent development is to combine sustainability aspects with the ‘fitness for use’ approach, offering a balance between human health and environmental protection versus the opportunity to reuse contaminated soil and to optimize economic aspects of site redevelopment. This approach offers a lot of space for economical and sustainable benefits without any public health or safety sacrifices. When developing a national program for remediation of multiple contaminated sites, these benefits are crucial for the feasibility of the complete program.

4 Preliminary conclusion for applicability in India

From the Sections 2 and 3 above it can be derived that a standard based approach is, in comparison with a risk based approach, relatively simple and easy to understand, also for non professionals. This characteristic can help in drawing support, especially from residents, when proposing remediation solutions. On the other hand, a standard based approach is less flexible: once the standards have been set the system in a way determines which decisions need to be taken in individual cases. Experience shows that this can lead to remediation approaches hardly taking into account the local situation. Moreover, the standard based approaches have shown a tendency to require considerably more financial means.

By contrast, a risk based approach is aimed specifically at developing remediation options fitting the local situation. Furthermore, a risk based approach in assessing remediation options seamlessly fits on to the site assessment phase, which usually includes risk assessment to determine the need to remediate. Also, in a risk based approach, individual site specific targets for remediation sometimes can be combined with other target values, e.g. drinking water standards. A risk based approach, however, requires more data, in particular on the local situation. In most cases, the investment in acquiring these data yields larger returns later, by saving significantly on the costs of the remediation, which, after all, is aimed at the specific situation.

India is a cost sensitive market, meaning that any solution needs to use local components, hardware, engineering, skill level of operators, level of automation, etc. India is also very diverse, geographically, as well as socially, culturally and ethnically. This means the general approach should enable stakeholders to tailor remediation options to any local situation. This has implications at all levels of abstraction, from the regional cultural situation right down to the practical level, taking into account aspects such as the availability of electric power.

Based on the above, the risk based approach seems, in general, to provide the best opportunities for India. Having said that, it should be noted that the risk based approach also requires more knowledge than the standard based approach. This is an important point considering soil remediation is a nascent profession in India at the time of writing this document. Therefore, development of a sound structure for knowledge development and dissemination merits due attention.

5 Cost effective groundwater approach

This information is most relevant for Tasks 5.4 and 5.5, in cases where the remediation option to be selected involves dealing with groundwater contamination.

Contamination in groundwater can spread to huge volumes and contaminate large areas. In areas where groundwater or downstream surface water is used as a drinking water source, groundwater contamination is likely to affect this strategic and fundamental asset.

Figure II.5.3-a.3 illustrates that remediation of contaminated groundwater can be very cost intensive and can take a long time. In cases where costs are expected to be too high, it could be interesting to consider cost effective approaches. Costs and amount of contamination to be removed are balanced with the functional use of the groundwater. Such an approach is only possible if there are no actual risks to human health or the environment, or where these risks can be addressed during the remediation phase, or in case pre-consumption treatment of local produced groundwater is feasible. This is because cost effective approaches of groundwater contaminations often mean a long term remediation process such as natural attenuation (NA) or long term groundwater management.

Basic principles of cost effective groundwater approaches are:

- maximum use of natural attenuation techniques;
- long term monitoring of potential hazards;
- assessing sources of spreading. As the remediation of the source of spreading is a relatively cost intensive operation, the remediation of the source can be balanced to the level of spreading which is acceptable;
- use of fall back scenarios only in case of unacceptable spreading (actual threatened receptor).

Cost effective remediation of groundwater offers opportunities for alternative solutions by combining different groundwater uses. For example, a costly pump and treat remediation of a groundwater contamination can be combined with other parties using groundwater for industrial use or irrigation. After having treated the contaminated groundwater it can be offered for use by other parties or even for drinking water supply, thereby effectively reducing the remediation costs. If necessary, a temporary drinking water piping system can be implemented as a safety measure before and during the remediation works.

Volume II

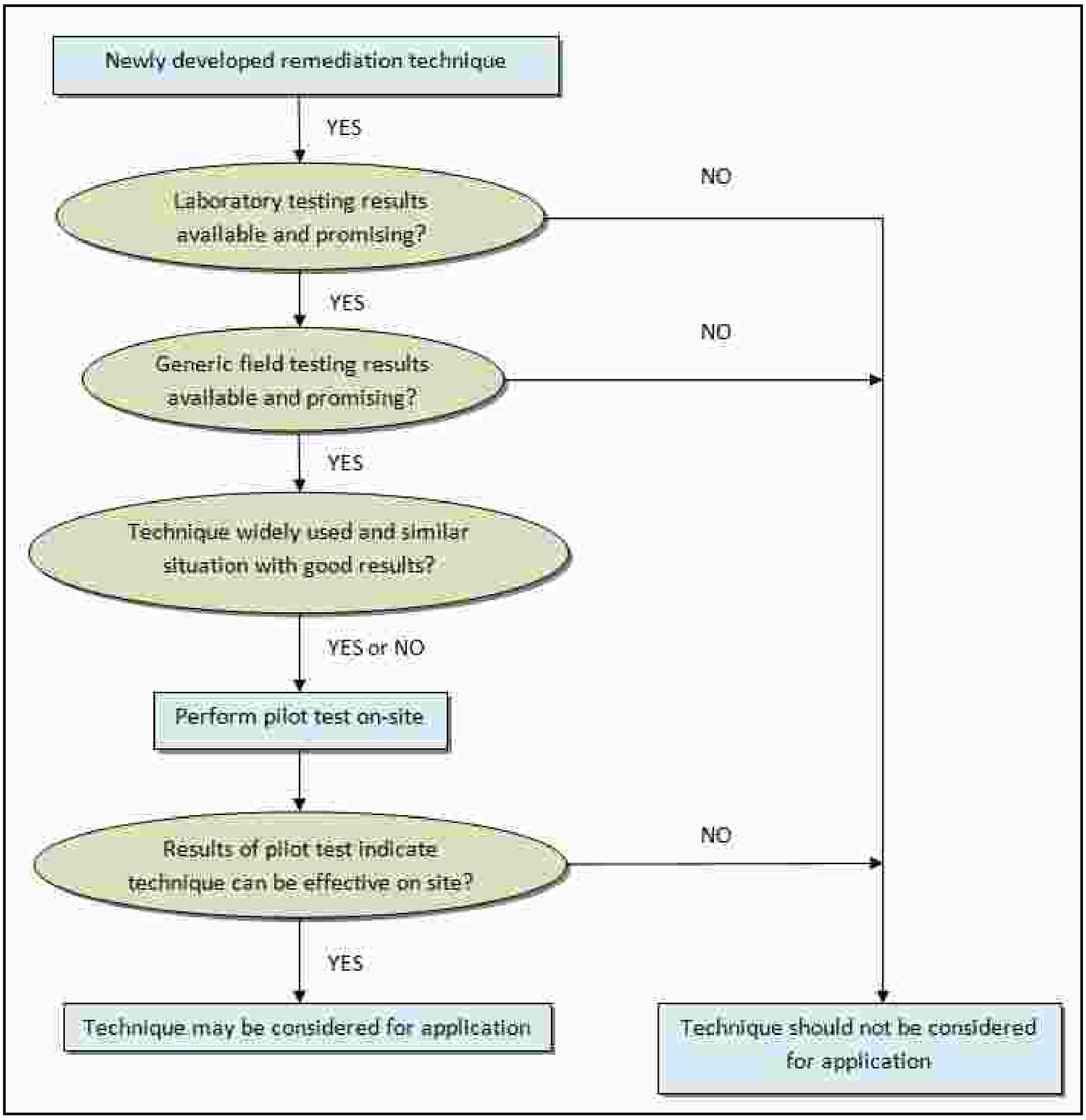
5.4-a Flowchart application newly developed remediation techniques

Volume II-5.4-a
Flowchart application newly developed remediation techniques

1 Introduction

This information is most relevant for Task 5.4, Development of remediation options.
A remediation technique must be technically proven before it can be applied with any guarantee of success. This means a newly developed remediation technique needs to be tested, first under laboratory circumstances, but eventually also in the field, before it should be considered for application at a specific site.
The flowchart below presents guidance on the process of considering newly developed remediation techniques for application.

2 Flowchart application newly developed remediation techniques



Volume II

5.5-a Checklist criteria for comparison and appraisal of remediation options

Volume II-5.5-a
Checklist Criteria for comparison and appraisal of remediation options

1 Introduction

This information is most relevant for Tasks 5.4 Development of remediation options and Task 5.5 Selection remediation option.

All remediation options should meet the main aim for remediation: reducing the significant risk to an acceptable level. In case this level is not reached by a remediation option, either additional measures are necessary or the remediation option is not appropriate for the case at hand.

The applicability and expected success of remediation options can be assessed using criteria. These criteria can be divided into two groups:

Generic criteria that should be assessed, regardless of the setting of the site:

- Risk reduction potential: degree to which health and environmental risks are reduced beyond the target level of remediation, offering an extra surplus of risk reduction or protection. Applicable to both immobile and mobile contaminants.
- Technical success potential: technical complexity, implementability, robustness (intrinsic capacity of the technical measures to accommodate changes in circumstances or performance), and the availability of technical capacity. If the technical risks related to these technical aspects are low or can be mitigated, the technical success potential can be regarded as high.
- Cost and benefits. Included are:
  - Costs for activities like post remediation actions and measures needed due to failure of originally planned measures;
  - Benefits due increased value of the site and to combined implementation with site redevelopment.
- Sustainability: influence of the remediation on other environmental aspects, e.g. air quality, space, ecology, waste, energy.

Criteria of which the assessment will depend on site specific circumstances and preconditions:

- Time: time needed to implement the remediation objective. Note: the time needed to implement post remediation actions is considered as a cost and/or social aspect.
- Post remediation site use: degree to which the site can be used for present, planned or not yet known site uses regarding its technical characteristics.
- Social criteria: social acceptance and impacts:
  - Physical Impacts to neighbourhood such as noise, dust, odour, traffic;
  - Changes in the way the local communities function;
  - Changes that could affect the site usage by communities.

The selection of remediation options is a balancing act: one option can be favourable regarding one criterion but can have a negative score on other criteria.
Below, the elements for consideration in the appraisal and selection of remediation options are presented for each criterion.

Elements for consideration for the generic criteria
Criterion: risk reduction potential

- Level of risk reduction: the more the level of risk is reduced the more guarantees can be given the remediation will be adequate and more forms of land use can be practised without threats to health or environment;
- Phasing of remediation: stepwise improvement of a site's situation is preferable when final targets can be met in the future. Provided that most important actual risks are in sight and dealt with as needed. Stepwise improvement means a reduction in remediation efforts and provides more opportunity for natural breakdown of contaminants;
- Size of contamination source: total removal or treatment of the constituents at contaminated sites with a relatively small and well accessible source of contamination is preferable;
- Volume of contamination: the volume of contamination that could be left on site is often too small compared to the efforts required to remove all of it. The extra efforts include the design process of a ‘fitness for use’ approach, remediation actions that are likely to be required if the site will be redeveloped again after a period of time or post remediation actions for management of the contaminations remaining on site;
- Surrounding area: when in a larger area more than one site is contaminated it often makes sense to develop a management strategy for the approach of the whole area rather than taking extensive remediation measures only at that specific site;
- Removal of load: the more kilograms of contamination is removed from the soil, the more the remediation will have a long term impact. Condition however is that the constituents have not been transformed into more toxic or mobile components;
- Liability: in certain cases third parties choose to avoid any risk of liability. In those cases, a remediation where all contamination is removed or treated is the best bet to not end up with post remediation obligations;
- Options for alignment with other developments: if remediation of a site is combined with the redevelopment of the site the redevelopment influences the selection of the remediation option. The alignment of the remediation design to the redevelopment plan (and vice versa). In some cases, land use planning may have to be adapted to the contamination situation, e.g. considering remediation of a former toxic waste dump for agricultural or housing purposes would require high costs, whereas the use as an industrial area may be very cost-effective.

Criterion: technical success potential
This criterion involves technical complexity, implementability, robustness (intrinsic capacity of the technical measures to accommodate changes in circumstances or performance), and the availability of technical capacity.

- Robustness: the remediation measures should remain effective, also under changing conditions or in case of poor maintenance. The measures should be ‘simple if possible, and complex only when necessary’;
- Stage of development of remediation technique: in case a remediation technique has only proven itself on a laboratory scale, no guarantees for reaching the remediation objective can be given. Proven remediation techniques should be preferred, innovative techniques may be considered after a well documented field trial shows potential success. Pilot tests may help to establish whether the technique is applicable under the specific situations at hand. This means a newly developed remediation technique needs to be tested, first in laboratory circumstances, but eventually also in the field, before it should be considered for application at any given site;
- Risk of failure: when risk of failure of the remediation strategy is considerable, additional costs to implement a fall back scenario should be taken into account.

Criterion: costs and benefits
- Costs for post remediation actions and extra measures needed due to failure;
- Benefits due to increased value of the site and to alignment of implementation with site redevelopment;
- Total budget of the redevelopment and, within that, means available for remediation measures.

Criterion: sustainability
- Influence of the remediation on other environmental aspects, e.g. air quality, space, ecology, waste, energy.

Elements for consideration for the site specific criteria
Criterion: time
This criterion is about the time needed to reach the remediation objective. Note: the time needed to implement post remediation actions is considered as a cost and/or a social aspect.
- Time aspects: the longer a remediation takes the higher the risk of ‘loss of control’. Especially in case long term post remediation measures should be taken, this is an important element.

Criterion: post remediation site use
This criterion is about the degree to which the site can be used for present, planned or not yet known site uses regarding its technical characteristics. Examples of this are 1) A complex and high-tech system (walls, interception system, ...) will be out of balance when changes on the site are made. A flexible system can easily accommodate those changes during its lifespan, 2) The more of the contaminants is removed during the remediation phase, the less risks will emerge in case of site use changes, and 3) Changes in site conditions can remobilize contaminants immobilized during the remediation phase.
- Disinvestments in case of site use changes: the more costs are spent on physical measures, the more costs are lost in case these measures need to be removed during future redevelopment. This can be avoided by later site use restrictions, but these will be difficult to maintain. A better solution is offered if this is considered as a design starting point;

- Time available for remediation: in case of a redevelopment plan a short and high cost remediation approach can be selected just to prepare the site within certain planning limits for the actual redevelopment. In cases where little time is left for remediation, a standard based high cost remediation approach taking only little time, might be selected.

Social criteria: social acceptance and impacts
- Physical Impacts to neighbourhood such as noise, dust, odour, traffic;
- Changes in the way the local communities function;
- Changes that could affect the site usage by communities;
- The degree to which a function fitted remediation may be aligned with redevelopment objectives.

Volume II

5.5-b Checklist Remediation investigation report

Volume II-5.5-b
Checklist Remediation investigation report

1 Introduction

This information is most relevant for Task 5.5 Selection remediation option. The investigation leading to the selection of the most applicable remediation option is reported in a Remediation investigation report. This checklist presents the aspects that should be addressed in such a report. This general checklist should be adjusted for a specific situation.

2 Checklist Remediation investigation report

The checklist below can be used to identify and assess the content of the detailed site investigation. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the Remediation investigation	
Date of recording	
Recording official	

No.	Topic		Obligatory	Status	Comments
1	**CSM and risk assessment**				
	A	Historical information of the site including subsequent site and groundwater use, industrial processes leading to soil contamination	Yes		
	B	Geology	Yes		
	C	Geohydrologie	Yes		
	D	Description of all contaminations (sources) including spreading processes (pathways)	Yes		
	E	Description of risks (receptors)	Yes		
2	**Remediation objectives**				
	A	Risks to be remediated	Yes		
	B	Objectives of the remediation	Yes		
	C	Requirements of the remediation including other activities which are executed simultaneously (redevelopment)	Yes		
	D	Stakeholders	Yes		
	E	Funds	Yes		
	F	Other legislation to be met	Yes		
	G	Preconditions to be met with the remediation	Yes		
3	**Description remediation options**				
	A	Technical aspects to achieve the remediation objective an requirements	Yes		
	B	Effects on surrounding and counter measures: sound, noise, soil vibration, groundwater drop, traffic hinder (intensity and duration), stability of soil	Yes		
	C	Practical aspects of implementation: preparation of / on the site, safety measures	Yes		
	D	Measurements / sampling program to verify the progress and final result of the implementation phase	Yes		

	E	Communication with stakeholders prior to, during and after the remediation	Yes		
	F	Production and/or usage of: energy, soil, air, water and activities or technical measures to dispose of products	Yes		
	G	Risks and mitigating measures during implementation: technical, planning, concentration levels	Yes		
	H	Legal aspects: permits and legal constraints	Yes		
	I	Planning: preparation phase, implementation, extensive phase of in situ techniques, post remediation measures	Yes		
	J	Post remediation measures: description of residual contaminations and subsequent technical and management measures necessary to prevent future human and ecological risks and risks of spreading of the contaminations	Yes		
	K	Costs: implementation, post remediation phase and risks	Yes		
	L	Point for further investigation during DPR or pilot phase	Yes		
4	**Evaluation of possible remediation options**				
	A	Points for evaluations	Yes		
	B	Method for evaluations	Yes		
	C	Evaluations of options (qualitative or quantitative)	Yes		
	D	Selection of most favourable remediation option	Yes		
	E	Point for further investigation during DPR or pilot phase			
5	**Annexes**				
		Maps, x-sections, tables technical schemes	Yes		

Explanotary notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

5.5-c Checklist review and approval Remediation investigation report

Volume II-5.5-c
Checklist Review and approval Remediation investigation report

1 Introduction

This information is most relevant for Step 5, Remediation investigation. The report of the Remediation investigation is to be reviewed by the competent authority to prepare the decision by the appropriate official.
The checklist below provides the points of attention for the review.

2 Checklist review and approval Remediation investigation report

The checklist below can be used to review the preliminary site investigation. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the Remediation investi-gation	
Date of recording	
Recording official	

No.	**Topic**		**Obligatory**	**Status**	**Comments**
1	Checklist Remediation investigation report	Evaluation if the report meets all elements for a Remediation Investigation Report VII-5.5-b.	Yes		
2	Skills and accreditations	Evaluation if the specialized agency or consultant charged with Remediation investigation report meets the required skills and accreditations.	Yes		
3	Stakeholder rights and interests	Evaluation if the stakeholder rights are guaranteed. A thorough stakeholder involvement offers a good basis for securing stakeholder warranties.	Yes		
4	Third party values	Validation by third parties of key elements to evalu-ate potential risks of individual options [1].	Yes		
5	Points of interest to assess the results of the Report	• Is any remediation option with potential better result missing? • Are the remediation objectives of all described options likely to be reached when implementing these options? • Are all options well described to make a final selection? • Does the evaluation / ranking of all options meet all objectives and requirements set (including those from other legislation)?	Yes		
6	Conclusion	Can Remediation investigation report be approved? If not, which further information is required?	Yes		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic
[1] e.g. risk assessment calculations, samplings, results of pilot testing

Volume II

6-a Checklist DPR including verification plan

Volume II-6-a
Checklist DPR including verification plan

1 Introduction

This information is most relevant for Step 6, Remediation design, DPR.
The design of the remediation is meant to detail out the selected remediation option into separate activities. These technical and organisational aspects of these activities and their environmental impact should be described in Detailed Project Report or remediation design plan (DPR).

The checklist below provides the points of attention when designing the remediation activities. In a way it can be regarded as a table of content for DPR. The elements of a verification plan are included in this table. For specific sites some of the elements can be found not applicable.

2 Checklist DPR including verification plan

The checklist below can be used to identify and assess the different elements of the DPR. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the DPR	
Date of recording	
Recording official	

Content of DPR	Status	Comments
Introduction and background information • Description of the site (e.g. name, owner, address, GPS-coordinates, site plan and size); • Reason for the remediation; • Summary of the previous investigations at the site; • Information of the parties involved in the remediation process and allocation of their roles.		
Site situation • The situation of the contamination at the site (present land use, infrastructure, buildings, use of the surrounding area); • Description of history of the land use and cause of the contamination; • Typology of the contaminated site; • Geology, geohydrology and soil structure and ground conditions of the site in case of contaminated soil and groundwater.		

• Morphological and hydraulic aspects in case of contaminated sediments in surface water and seasonal variations in water level; • The conceptual site model with the combinations of source-pathway-receptor) of concern. A detailed description of the present contamination with characteristics (parameters, concentration, extent in horizontal and vertical direction, mobility, density);		
Remediation approach • Objective of the remediation related to regulatory requirements and the selected remediation option; • Combination of the remediation with reconstruction activities at the site, possible impact on planning and results of the remediation measures and description of measures to manage this impact; • Targets levels of the remediation to be achieved; • Remediation techniques to be used: technical description; • Stages in the remediation process (if appropriate); • Necessity of a pilot testing of the remediation technique.		

Detailed description of the remediation process
• Preparation activities:
  ◦ removal of buildings, infrastructure, foundations, tanks in order to achieve access to the contaminated material; if removal is not possible, which working constraints will have to be dealt with;
  ◦ mobilisation of equipment to the site;
  ◦ necessary staff during the remediation;
  ◦ organising the working and storage areas at the site;
  ◦ possible access limitations to parts of the site or the neighbouring area;
  ◦ availability of suitably licensed treatment or disposal capacity off site;
• Overview of the necessary permits and licenses;
• Measures necessary to prevent damage or nuisance (such as dust, odours, noise and dirt on roads) on the site and in the surrounding area (including possible transport of removed waste to a treatment or disposal site);
• Measures to improve sustainability aspects (e.g. reducing energy);
• When excavation of soil or dredging of sediment is part of the remediation strategy:
  ◦ size and contours of the excavation (area and depth);
  ◦ estimated volume of material to be excavated (in-situ and after excavation) and destination of the material (on-site rearranging or off-site treatment or disposal, for which the procedures of HWR-2008 may apply);
  ◦ necessary abstraction of groundwater;
  ◦ in case of dredging sediment: necessary preparation on the water way, lake, river or canal;
  ◦ temporary storage of material in depots;
  ◦ quality of the clean material to be used to replace the removed contaminated material;		

• When groundwater abstraction is part of the remediation strategy:
  ◦ Pattern and depth of wells;
  ◦ Volume and planning of the abstraction period;
  ◦ Results model calculations of the groundwater remediation;
  ◦ Method of discharging abstracted water and necessary treatment;
• When in-situ techniques are part of the remediation strategy:
  ◦ Equipment to be installed (indication, pattern and specific location);
  ◦ Maintenance activities during the active phase of the remediation;
• Checkpoints during the remediation process and action levels or other criteria for assessment the intermediate results;
• Possible effects of the remediation measures and mitigating activities to be carried out to minimize these effects;
• Possible uncertainties in the situation (e.g. the delineation of the contamination is not very detailed at one side of the location) and ways of dealing with these risks.
• Planning of the remediation activities (project implementation schedule);
• Programme for supervision and environmental verification;
• Suggestions for sampling, testing and other measurements related to verification (to be elaborated further in a verification plan):
  ◦ what are be the key parameters to verify the success of the progressing remediation;
  ◦ which monitoring equipment should be installed before and during the remediation.
• Expected restrictions to future land use after finalizing the remediation activities;
• Identification of the need for post remediation activities;
• Health and safety aspects during the remediation:
  ◦ possible exposure to contaminated material by skin contact, ingestion or inhalation;
  ◦ necessary measures to prevent these risks (description of these measures to be elaborated in step 8);
  ◦ safety measures regarding equipment and transport.
• Record keeping, use of a log;
• Estimation of costs, with distinction between costs for installing equipment, short term measures and costs for long term remediation and maintenance. Sometime an analysis of risks and variation of the costs;
• Insurance;
• Communication aspects in the process of implementation of the remediation. These communication aspects are related to restrictions and nuisance during the remediation and the possible restriction for land use in the final situation. Relevant stakeholders for the communication should be indicated;
• Maps, drawings, calculations must be added as annexed to the remediation design report.		

Content of verification plan This Section presents a generic checklist for a verification plan, being part of the Detailed Project Report. In this verification plan the activities are described for verifying the results of the remediation.		
Supervision and environmental verification • Description of the tasks of the supervision and environmental verification of remediation works; • Possible response actions to deal with uncertainties; • Critical points in the remediation process where the progress should be assessed, a list of critical points during the remediation is given below (examples are the moment where an excavation; has reached its ultimate boundaries. Before supplementing with clean soil/material samples should be taken from the pit wall and bottom. Another example is a check on reaching the intended depth for a groundwater extraction or treatment unit and verifying the number and pattern of extraction wells); • Log with daily information of the site: remediation activities; verification activities; visits of regulators, accidents, injuries; etcetera; • Results of sampling and testing the quality of removed or treated contaminated material and the quality of remaining soil or sediment; • Results of (periodical) testing of the quality of surface water or groundwater; • All executed measurements to check health and safety aspects and compliance with environmental permits and licenses;		
Communication • Overview of institutions and persons involved (names, addresses, telephone numbers, email); • Appointments on communication with stakeholders (authorities, companies, community, press); • Procedure for reporting for critical and non critical deviation of the DPR; • Procedure for reporting incidents and accidents at the site during the remediation; • Planning of reporting interim and final results in an evaluation report to the authority.		
Monitoring programme • For long-term remediation projects where in-situ techniques are used or where groundwater is extracted and remediated monitoring of interim results is a very important activity to verify if the remediation results are heading in the right direction; • Part of the monitoring programme is a planned sampling and testing strategy for the quality of soil, groundwater, sediments or surface water (if appropriate); • Criteria for the evaluation of interim results of the remediation (e.g. the concentration gradient of a parameter in groundwater); • Action levels for evaluation or response actions.		

Explanotary notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

6-b Example format cost estimation remediation

Volume II-6-b
Example format cost estimation remediation

1 Introduction

This information is most relevant for Step 6, Remediation design, DPR.
All remediation activities descried in the DPR are summarized and a costing is made for each of these activities. These activities do not only involve the technical measures of the remediation. The preparation of the work, including costs for demolishing building or replacement of inhabitants may be involved as well. The costs for management, supervision and verification of the remediation works should be included as well. The previous costs of investigation of the site and preparation of the remediation design may be summarized to the total of relevant costs.

2 Example format cost estimation remediation

An overview of cost elements of a remediation is presented in this Example format. The costing should include volumes, amounts and unit prices.

Some of the cost elements may be estimated quite accurately, some elements may be difficult to estimate. It may be useful to apply a bandwidth for elements which have large impact on the total costs.

Estimation of remediation costs

example: soil excavation, off site treatment of soil, groundwater abstraction and treatment

no	discription activities	unit [1]	cost / unit	quantity	amount (INR excl taxes)
A	**Preparation remediation [2]**				
	surveying of site lay out	item			
	establishing boundaries of remediation site and install temporary fences with signs	item			
	construction of temporary access road to the site	item			
	installing and renting temporary office space for contractor and project manager	week			
	removal of surface covering (asphalt etc.)	m2			
	removal of surface covering (vegetation)	m2			
	removal of buidlings or other objects on the site	item			
	mains: installation of water & electricty to the site	item			
	sub-total preparation of remediation				
B	**Excavation of contaminted soil [3]**				
	Excavation of non contaminted soil and transport to depot on site	m3			
	Excavation of contaminted soil	m3			
	transport of contaminated soil for off-site treatment or landfilling [4]	MT			
	delivery and transport to the site of non contaminated soil	m3			
	reuse of non contaminated soil from the site	m3			
	filling of excavation pits with non contaminated soil including compacting	m3			
	repaving of surface	m2			
	replanting of the site	m2			
	sub-total excavation of contaminated soil				
C	**Groundwater remediation: installation of abstraction wells and treatment plant for contaminated water [5]**				
	borings for installation groundwater abstraction wells. Depth 20 m-bg including well screens	item			
	undergound mains: piping for water including underground installation, electricity for wells	m1			
	installation of pumps to be installed in wells (deepwells)	item			
	well covering for abstraction wells	item			
	preparation of site for location treatment plant	item			
	on site installation of treatment plant. Capacity 10-20 m3/h	item			
	connecting wells etc. to equipment	item			
	start up process treatment plant	item			
	sub total installation of wells and treatment plant				
D	**General costs [6]**				
	on-site guidance & project management during excavation and installation of groundwater remediation	weeks			
	permitting	item			
	preparation of contract and tendering of the works	item			
	insurances	item			
	general costs, contracting costs	item			
	subtotal general costs				
E	**Off-site treatment contaminated soil [7]**				
	off-site treatment or lanfdilling of contaminated soil	MT			
	sub-total treatment contaminated soil				
	total investment (A, B, C, D, E)				
	Operational costs groundwater remediation				
F	**Operation groundwater remediation [8]**				
	operation of water treatment plant incl. minor adjustments	month			
	maintenance treatment plant and abstraction wells etc	month			
	electricity consumption kwh/year	month			
	groundwater sampling on the site and surrounding area for verification remediation process	item			
	groundwater analyses verification remediation process	piece			
	project management groundwater remediation	month			
	report on remediation progress	piece			
	final report evaluation on the remediation	item			
	subtotal groundwater remediation				
	total operational costs (F)				
	Total costs excluding taxes				-

[1] type of unit is depending on the activity
[2] this section should specify all contracting actions before actual remediation starts. Remediation plans etc. are not included.
[3] this section should specify all actions related to the excavation of contaminated soil
[4] site for the soil treatment should be known before remediation start
[5] this section should specify all actions related to the installation of the groundwater remediation system
[6] this section includes mainly project management issues carried out by a consultant
[7] the method for soil treatment should be known before remediation start
[8] this section includes the operational costs for the groundwater remediation

Estimation of remediation costs

example: soil vapor extraction and in-situ air sparging

no	discription activities	unit [1]	cost / unit	quantity	amount (INR excl taxes)
A	**Preparation remediation [2]**				
	surveying of site lay out	item			
	establishing boundaries of remediation site and install temporary fences with signs	item			
	construction of temporary access road to the site	item			
	installing and renting temporary office space for contractor and project manager	week			
	mains: installation of water & electricty to the site	item			
	sub-total preparation of remediation				
B	**Pilot plant soil vapor extractie & air sparging [3]**				
	design of pilot plant	item			
	installation soil vapor extraction wells incliding drilling and well material	piece			
	installation air sparging well incliding drilling and well material	piece			
	installation of SVE and air sparging equipment	item			
	piping for the wells and connection to SVE-blower and Air sparging compressor	item			
	base line measurement soil and groundwater before start pilot	item			
	start pliot and initial measurements	item			
	monitoring during pilot (various measurements and sampling)	week			
	analyses (soil air, water) during pilot	piece			
	operational costs SVE and air sparging during pilot	week			
	report pilot including assessment of application and design details for full scale remediation	item			
	sub-total pilot				
C	**Installation of soil vapor extraction & air sparging system**				
	borings for installation of SVE and air sparging wells	item			
	installation of SVE wells, depth 5 m -bgs	piece			
	installation of air sparging wells , depth 10 m -bgs	piece			
	undergound mains: piping for SVE and air sparging underground installation	m1			
	installation of SVE and air sparging equipment for full scale remediation	item			
	installation for off gas air treatment: activated carbon	item			
	connecting varius well etc. to equipment for SVE and air sparging	item			
	sub total installation of SVE and air sparging and off gas treatment plant				
D	**General costs [4]**				
	on-site guidance & project management during installation of in-situ systems	weeks			
	permitting	item			
	preparation of contract and tendering of the works	item			
	insurances	item			
	general costs, contracting costs	item			
	subtotal general costs				
E	**Off-site treatment contaminated soil [5]**				
	off-site treatment or landfilling of contaminated soil	MT			
	sub-total treatment contaminated soil				
	total investment (A, B, C, D, E)				
	Operational costs in-situ remediation				
F	**Operation SVE & air sparging**				
	operation of soil vapor extraction system	month			
	maintenance and replacing activated carbon off gas treatment plant	month			
	electricity consumption kwh/year	month			
	removal of installations including off gas treatment plant	item			
	sub-total operation in-situ system				
G	**Project management in-situ remediation [6]**				
	soil gas sampling on the site verification remediation process	item			
	ground & groundwater analyses verification remediation process	piece			
	project management in-situ remediation	month			
	analyses (soil air, water)	piece			
	report on remediation progress	piece			
	final report evaluation on the remediation	item			
	subtotal project management				
	total operational costs (F+G)				
	Total costs excluding taxes				-

[1] type of unit is depending on the activity
[2] this section should specify all contracting actions before actual remediation starts.
[3] a pilot plant is not always required
[4] this section includes mainly project management issues carried out by a consultant
[5] this only applies for the core drillings of the wells
[6] in-situ remediations require various measurements to control all the systems and operation

Volume II

7-a Checklist review and approval Detailed Project Report

Volume II-7-a
Checklist review and approval Detailed Project Report

1 Introduction

This information is most relevant for Step 6, Remediation design, DPR. The Detailed Project Report of the specific site is to be reviewed by the competent authority to prepare the decision by the appropriate official.
The checklist below provides the points of attention for the review.

2 Checklist review and approval Detailed Project Report

The checklist below can be used to review the DPR. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the DPR	
Date of recording	
Recording official	

No.	Topic		Obligatory	Status	Comments
1	Checklist Detailed Project Report including verification plan	Evaluation if the report meets the elements necessary for a DPR (see VII-6-a)	Yes		
2	Skills and accreditations	Evaluation if the specialized agency or consultant charged with the DPR meets the required skills and accreditations	Yes		
3	Stakeholder rights and interests	Evaluation if the stakeholder rights are guaranteed. A thorough stakeholder involvement offers a good basis for securing stakeholder warranties. Have the results of the environmental and social impact assessment been shared with relevant stakeholders?	Yes		
4	Points of interest to assess the results of the remediation	• The remediation objectives according to the selected remediation option (in task 5.5) should be met; • The remediation should be technically well feasible; • The results of the environmental and social impact assessment are acceptable and within regulatory permits. Additional measures will be applied where negative impact of the remediation measures may occur;	Yes		

		• There are clear criteria to assess the progress and final result of the remediation; • The activities to verify the progress and results of the remediation are clearly described; • Uncertainties which may have effect on the remediation result are indicated explicitly and the DPR provides scenarios and measures in case these uncertainties will occur.			
5	Conclusion	Can Detailed Project Report be approved? If not, which further information is required?	Yes		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

8.1-a Checklist permits for remediation works

Volume II-8.1-a
Checklist permits for remediation works

1 Introduction

This information is most relevant for Step 8, Implementation of remediation.
This Section presents a checklist of the regulatory permits, licenses and/or consents that should be applied for during the preparation and authorization (Task 8.1).

This is a generic checklist, to be adjusted to the situation of a specific remediation project. Depending on the local or regional regulations the necessary permits and licenses will vary. Aspects relating to land ownership and land use are not included in this checklist.

2 Checklist permits for remediation works

The checklist below may be used to identify and assess the required permits. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the DPR: description of remediation design	
Date of recording	
Recording official	

Permit, license, consent	Status	Comments
Environmental Clearance (to be confirmed from competent Authority) (Clearance from MoEF) • Environmental Clearance will include Environmental Impact Assessment, Public Hearing etc. as stipulated in EIA notification SO.1533 dated 14.09.2006		
Preparation of the site (permission from Urban development) • Demolition or removal of buildings or infrastructure; • Cutting trees; • Constructions in canals, rivers or lakes anticipating dredging of sediment.		
Waste management licenses (permission from Pollution Control Board) • License to excavate or extract polluted material at the site and to store it temporarily; • Way of treatment of this material at the site (mobile plant for on-site treatment);		

• Transportation of waste material (distance, final destination, means of transport, route of transport with impact of dust and noise on inhabitants along the route).		
Groundwater abstraction and purification permits (Permission from Ground Water Board) • Groundwater abstracted from the soil per day; • Groundwater abstraction from wells (volume, radius of influence);		
Treatment and discharge of water (Permission from Pollution Control Board) • Installation and operation for treatment/purification of extracted groundwater; • Discharge of treated water into surface water or sewage system.		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

References:

- EIA so1533.pdf
- The Water (Prevention and Control of Pollution) Rules 1975.pdf
- THE AIR (PREVENTION AND CONTROL OF POLLUTION) RULES, 1982.pdf
- The Environment (Protection) Rules, 1986.pdf
- HWRulesFinalNoti240908.pdf
- MSW Rules 2000.pdf
- The Bio-Medical Waste (Management and Handling) Rules, 1998.pdf
- The Noise Pollution (Regulation and Control) Rules, 2000.pdf
- The Plastic Waste (Management & Handling) Rules, 2011.pdf
- THE PUBLIC LIABILITY INSURANCE RULES, 1991.pdf
- Central Motor Vehicles Rules 1989.htm
- MODEL RULES FA 1948.htm
- The Chemical Accidents (Emergency Planning, Preparedness, and Response) Rules, 1996.pdf
- National Green Tribunal Act 2010.pdf

Volume II

8.2-a Checklist prequalification for remediation

Volume II-8.2-a
Checklist prequalification for remediation

1 Introduction

This information is most relevant for Step 8, Implementation investigation. The remediation works may be appointed to a third party, typically a contractor. This checklist is also useful for Step 11, Post remediation activities.

The client who contracts out this assignment may be a private person, private organization or the local, State or Central authority. This checklist provides support for the client in the selection of a contractor. To ensure a good quality remediation, it is vital that this third party can demonstrate the expertise, skills and compliance relevant for the assignment. Where available, it is preferable if this is supported by relevant accreditations.

At the outset, it is very important that the client/organization responsible for remediation provides clear Terms of Reference (ToR), which should at least include the objectives of the remediation, the required output and the possible constraints. These should be described in the bid document, developed in Task 8.2 Contracting. Without a clear bid document the third party may interpret the situation differently resulting in the proposed activities not leading to the required output. Furthermore, if more than one party is requested to tender an offer, an unclear bid document can lead to differences that render a fair comparison impossible. If the client is a private organization it may be advisable to contact the competent authority for assistance.

2 Checklist for the prequalification for remediation

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main aim of the appointment	
Date of recording	
Recording official	

Prequalification criteria for selection of the specialized organization	Status	Comments
Information about Firm: Firm’s Background; Firm’s Registration; Firm’s Class Certificate; Bank Solvency; Banking History; Tax History; Liability History;		

Black Listing History; Joint ventures / tie ups; Type of firm – Pvt. Ltd..- Proprietary – Partnership; Work experience: Bid capacity.		
Financial capability: Financial statement & Profit & Loss of last 5 years; Return on net worth ratio; Quick ratio; Current ratio; Asset turnover ratio; Ratio of Fixed assets / long term Liabilities; Debt ratio; Insurance of equipment; Working capital.		
Technical capability: Firm's building work experience; Equipment and Plant ownership by the contractor; Onsite laboratory equipments; Experienced project managers / civil engineers / electrical engineers; Labours (skilled & unskilled); Training programme for the personnel; Personnel experience in similar projects; Job expertise.		
Management capability: Business evaluation; Change in core Management; Head office organization structure; Coordination & safe administration; Number of technical staff; Number of non-technical staff; Failure to complete past project; Current work load; Research & Development.		
Construction capability: Cost control; Schedule / time Control; Quality Management System; Quality assurance; Resource Management; Number of Sub-contractors & Work load on sub-contractor; Method of procurement.		

Past experience: Scale of projects completed; Type of projects completed; Experience in local area; Similar type of 5 projects completed; Time overruns in past projects; Cost overruns in past projects; Quality achieved in past project. Experience in social aspects regarding investigation of sites for environmental reasons.		
Reputation condition: Arbitration History; Trade History; Past relationship with Client / consultant; Awards; Past projects claims History; Termination of contract; Relationship with sub-contractor.		
Health and safety policy: Safety management system Accidents in past projects Insurance of personnel		
Use of Information Technology & Services: Project Management Software Personnel knowledge in IT / Software Level of Technology		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

8.3-a Checklist Health and Safety plan

Volume II-8.3-a
Checklist Health and Safety plan

1 Introduction

This information is most relevant for Task 8.3 Execution, supervision and verification remediation works, and for Step 11 Post remediation action.

2 Checklist Health and Safety plan

The checklist below provides the elements that should be included in any Health and Safely plan for a soil remediation project. For specific sites some of the elements can be found not applicable. The checklist may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Contractor	
Supervisor	

Content of Health and Safety plan	Status	Comments
All onsite workers should be provided with the following materials • Jackboots, resistant to chemicals and with a safety sole (steel plate); • Liquid tight overall; • Liquid tight gloves; • Safety helmet. Additional materials in case the presence of toxic fumes or dust (e.g. asbestos) is expected: • breath and eye protection; • measurement instruments.		
Measures in preparation of remediation • Prepare Health and Safety plan; • Start log; • Mark “contaminated zone” and mark “clean zones”; • Ensure availability of first aid materials and relevant first aid knowledge; • Inform onsite workers on relevant Health and Safety aspects, through oral and written information and education.		
Hygiene during remediation measures • Limit the number of people needed in the contaminated area; • Work with machines as much as possible; • Have onsite workers work on the windward side of the contamination whenever possible; • Prohibit observation by means of smelling; • In case of handling barrels full protective measures (including breathing protection) apply (see above);		

Content of Health and Safety plan	Status	Comments
• Forbid eating, drinking and smoking in the contaminated area; • Ensure that, whenever people leave the contaminated area, boots are cleaned and coveralls are left in the contaminated area; • Prevent the generation of dust (e.g. by spraying water); • Ensure availability of face and breath protection throughout; • Forbid open fire. Machinery: • Ensure any excavating equipment is provided with overpressure cabin and dust filter.		
Optional measurements during remediation measures • PID (Photo Ionization Detector); • Toximeter (gas testing vials); • Cyanide measurements; • H_2S-measurements; • Active coals vials; • Personal air sampling by badges (attachment of badges near inhalation zone); • Explosion meters (oxygen-explosion meter).		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

8.3-b Checklist supervision and verification remediation measures

Volume II-8.3-b
Checklist supervision and verification remediation measures

1 Introduction

This information is most relevant for Task 8.3, Execution, supervision and verification remediation measures. The performance of supervision and verification of remediation measures is usually commissioned to an independent third party environmental supervisor

2 Checklist supervision and verification remediation measures

The checklist below provides the elements that should be monitored during supervision and verification of remediation measures. For specific sites some of the elements can be found not applicable. The checklist may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Summary of remediation works	
Date of recording	
Contractor	
Recording supervisor	

Supervision and verification of remediation measures	Status	Comments
Supervision and verification (technical) *Elements for supervision and verification plan* • Outline supervisor tasks; • Potential response actions to deviations from remediation plan; • Critical activities in the remediation process. A list of these is presented in the table below this one. *Elements for ongoing supervision and verification* • Log on daily progress of remediation, supervision and verification measures, like visits by regulators; • Results of sampling and testing the quality of removed or treated contaminated material and the quality of remaining soil or sediment; • Results of (periodical) testing of the quality of surface water or groundwater; • Results of all measurements performed to check health and safety aspects and compliance with environmental permits and licenses;		
Communication *Elements for supervision and verification plan* • Contact information of institutions and persons involved (names, addresses, telephone numbers, email addresses); • Agreed actions concerning communication with stakeholders (authorities, companies, community, press);		

Supervision and verification of remediation measures	Status	Comments
• Procedure for reporting critical and non critical deviation from the DPR; • Procedure for reporting incidents and accidents at the site during the remediation; • Planning of reporting interim and final results in an evaluation report to the authority; • Verification of results of remediation has to be carried out by a party independent from contractor, owner, occupier and other stakeholders. *Elements for ongoing supervision and verification* • Record events concerning communication and their results in the daily log.		
Monitoring (only in long-term remediation projects) *Elements for supervision and verification plan* • Sampling and testing strategy for monitoring the quality of soil, groundwater, sediments or surface water (whatever is appropriate); • Criteria for the evaluation of interim results of the remediation (e.g. the concentration gradient of a parameter in groundwater); • Action levels for evaluation or response actions.		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Critical activities during remediation

Critical activities during remediation	Aim and most relevant elements of activity
Installation of systems for management or isolation or in situ remediation	Affix systems (withdrawals, cleansing, retaining walls) needed to create the desired (management) situation
Controlling of operating systems	Assess whether commissioned systems comply with technical requirements
Sampling of excavated material	Assess potential reuse options of excavated material. Classify according to HWR (2008) to determine hazardous waste
Assessing excavated material for processing capabilities	Clear and correct manner of assessment
Sampling of air or water	Correctly perform sampling and analysis of effects on environment
Assessing the processing capabilities of air or water (discharge, purify)	Correct and honest manner considering possible processing options based on sampling results
Checking progress of remediation measures	Clear management of the implementation process on quality, quantity and time
Recording of and approving delivery of the work undertaken	Clear determination that meets objective or design work carried out and change (transfer) responsibilities
Documenting of agreements prepared during execution of remediation measures (technical, organizational, financial)	Clear commitment of appointments, arguments which may lead to changes to the original plan of specifications and conditions
Final check of excavated material (soil and groundwater)	Clear provision end situation
Evaluation of work undertaken	Interpretation and assessment of work undertaken, as well as the end result achieved in relation to objective of the remediation
Preparing remediation evaluation report	Clear documentation of basic information and information during the execution and outcome of the remediation

Critical activities during remediation	Aim and most relevant elements of activity
Assessing whether management or post remediation activities are needed	Assess whether remediation can be considered as completed or that the after-care phase must be restarted or management
Commissioning of systems	Set of systems that these both individually and jointly meet the technical and environmental conditions for the management and aftercare
Assessing need for modification of systems	Assess whether and which additional measures are needed to systems individually, or collectively, to work better
Drafting of post remediation programme	Picture of programmatically monitoring, maintenance and replacement activities
Determining restrictions for land use	Unambiguous picture of restrictions as a result of measures selected must be made to the use of the location
Drafting report on post remediation activities	Unambiguous commitment of basic information, objective and approach/programming during post remediation phase
Running post remediation programme	Structured system to perform work to maintain and monitor for proper operation
Evaluation of results of implementation programme	Interpretation and evaluation of work carried out and the results obtained in relation to objective
Provision necessary modifications work, installations or objective	Assess whether and which additional measures are needed to meet the objective of ensuring better, or to what extent adjustment of the objective is necessary
Determining progress or end of management or post remediation phase	Unambiguous determination of the status of the project in relation to the objective

Volume II

8.3-c Checklist remediation evaluation report

Volume II-8.3-c
Checklist Remediation evaluation report

1 Introduction

This information is most relevant for Task 8.3, Execution, supervision and verification remediation works, and for Step 9, Approval remediation completion.

2 Checklist Remediation evaluation report

The checklist below provides the elements that should be included in the Remediation evaluation report. For specific sites some of the elements can be found not applicable. The checklist may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the remediation	
Date of recording	
Recording official	

Content of Remediation evaluation report	**Obligatory**	**Status**	**Comments**
Introduction and background information			
Site metadata (e.g. name, owner, address, GPS-coordinates, site plan and size)	Yes		
Reason for the remediation	Yes		
Summary of the previous investigations and the situation of the contamination at the site (description of history of the land use and the conceptual site model with the applicable combinations of source-pathway-receptor)	Yes		
Agreed remediation objectives and target values	Yes		
Overview of the relevant permits and licenses	Yes		
Summary of the remediation strategy	Yes		
Summary of the intended activities during verification according to the agreed verification plan, including methodologies used for data collection and interpretation	Yes		
Information of the parties involved in the remediation process and their roles	Yes		
Remediation process			
Selected remediation option and specific techniques used	Yes		
Sequential overview of performed remediation activities and parallel supervising and verification activities	Yes		
Summary of incidents and performed mitigating measures	If applicable		
Summary of deviations from the original remediation plan and performed mitigating measures. Including analyses of technical (remediation goal and levels), financial (development of costs compared to the initial cost estimate and	If applicable		

Content of Remediation evaluation report	Obligatory	Status	Comments
contracted activities; note for evaluation purposes only to optimize future site remediations), legal (e.g. site reuse restrictions) and organisational aspects (consequences for post remediation).			
Results of the remediation: ° volume of waste, soil or sediment removed or treated; ° volume of groundwater or surface water removed or treated; ° volume and quality of (liquid) waste transported off-site; ° volume and quality of material imported to the site; ° data on the quality of capping layers or barriers (including depth, thickness, permeability); ° information on permanent remediation installation (for in-situ treatment or containment of the contaminated site); ° Annexes with the original test results, photographs, drawings, measurement results, registration documents etc.	All elements that are applicable		
Results of verification measurements (e.g. sampling of extracted material or sampling of pit wall)	Yes		
Results of monitoring of the remediation progress or the attainment of remediation target (e.g. testing surface water or groundwater quality)	If applicable		
Results of the monitoring to demonstrate compliance with health, safety and environmental requirements (according to the health and safety plan and the regulatory permits, licenses and consents)	Yes		
Conclusion on the remediation results			
Description of the situation after completion of the works, supported by a review of the conceptual site model and a description of the rate of contaminant mass reduction and/or removal	Yes		
A conclusion on the effects of deviations of the performed activities, related to the activities as planned in the DPR	If applicable		
Clear conclusion on whether the remediation objectives have been met	Yes		
Identification of the need for post remediation action, and if that is the case, description of monitoring and maintenance requirements to ensure that the performed remediation action remains effective and that the residual contamination will not cause risks for human health or the environment	Yes		
Restrictions to future land use and activities	If applicable		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

9-a Checklist review and approval Remediation completion

Volume II-9-a
Checklist review and approval Remediation completion

1 Introduction

This information is most relevant for Step 9, Approval remediation completion. The results of the remediation have been described in an evaluation (or clean-up) report which is to be reviewed by the competent authority to prepare the decision by the appropriate official. The checklist below provides the points of attention for the review.

2 Checklist review and approval Remediation completion

The checklist below can be used to review the remediation evaluation (clean-up) report. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the remediation	
Date of recording	
Recording official	

No.	Topic		Obligatory	Status	Comments
1	Checklist Remediation evaluation report	Evaluation on whether the Remediation evaluation report meets the requirements of the Checklist Remediation evaluation report (Volume II-8.3-c)	Yes		
2	Verification of the remediation	Results of the verification of the remediation results by an independent third party	Yes		
3	Skills and accreditations	Evaluation on whether the specialized agency or consultant responsible for the preparation of the Remediation evaluation report meets the required skills and accreditations	Yes		
4	Validity of values	When doubting results: cross-check third party values	If necessary		
5	Stakeholder rights and interests	Evaluation on whether the stakeholder rights are guaranteed. A thorough stakeholder involvement offers a good basis for securing stakeholder warranties	Yes		
6	Long term guarantees A B C D	Evaluation if the Remediation evaluation report offers adequate long term guarantees for risk protection and liability. Aspects involved are: Technical aspects Legal aspects Financial aspects Management aspects	Yes		
7	Conclusion	Can remediation completion be approved? If not, which information has to be provided or which activities have to be carried out?	Yes		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

10-a Checklist Post remediation plan

Volume II-10-a
Checklist Post remediation plan

1 Introduction

This information is most relevant for step 10, Post remediation plan (PRP).
Such a plan is required only when a remediation is completed while leaving residual contaminations at the site. In such cases site use restrictions are likely to be in force, and technical measures may be necessary to prevent future human and ecological risks and risks of spreading of the residual contaminations.

The post remediation plan describes all the technical and supporting management activities such as monitoring, maintenance, repairs and corrective actions to keep a remediated site in such a state as to prevent future risks. The post remediation plan should provide for a long term guarantee to the competent authority for a long lasting and adequate risk control.

The checklist below provides a comprehensive overview of elements a full scale post remediation plan may contain. The checklist indicates for every element whether it is obligatory. The post remediation plan is forwarded to the competent authority for approval.

2 Checklist Post remediation plan

Site ID (Name User and Owner, Address, GPS-coordinates)	
Summary of Post remediation plan	
Date of recording	
Recording official	

No.	Topic		Obligatory	Status	Comments
1	**Conditions and basic data**				
	A	Description of the site and the already executed assessment and remediation steps. What was the initial remediation target and what has been the result of the remediation.	Yes		
	B	Delineation of the contamination still present at the site, based on the authorized final cleanup report. This should include the Conceptual Site Model and, if available, a model describing the geohydrology and geographical distribution of the contamination.	Yes		
	C	Description of and data on the post remediation measures. This should include the objective and technical aspects of the remediation including applicable drawings with all technical details (e.g. a cross section drawing of the composition of a cover layer; a map with the precise situation of monitoring wells with indication of depth of the wells).	If applicable		
	D	If applicable a prognosis on the functioning of the post remediation measures over time and an overview of processes that may affect this functioning in the future (e.g. for a cover layer the possibility that degradation occurs due to specific forms of land use).	If applicable		

No.		Topic	Obligatory	Status	Comments
	E	Site use restrictions related to the contamination still present and related to the post remedial activities. These restrictions have to be taken into account both on the site itself as well as outside the site.	Yes		
2	**Methodology for development of the PRP**				
	A	Description of the post remediation measures.			
	B	Overview of critical deviation points and action levels to be developed in a set of clear criteria for action (e.g. the depth of a cover layer after remediation was 1.5 meters. In that case the action level can be 1.3 meters. If the result of monitoring indicates a depth of 1.2 meters at a certain point an action has to take place).	Yes		
	C	Description of the post remediation measures and if applicable associated maintenance.	Yes		
	D	Monitoring and maintenance program, developed on the basis of: • the forecast on the functioning of the post remediation measures and the processes that may affect this functioning. The effects of seasonal variations are taken into account; • applicable permits; • Site (re)use and/or (re)development activities.	Yes		
	E	The program describes the sampling, inspection and/or measuring program (only if applicable): • the quality of the soil, (ground)water, air and/or sediments. The effects of spatial variation in monitoring data are taken into account; • the quality and functioning of the post remediation system and checks on specific equipment.	If applicable		
	F	Calamity plan, describing actions in case of emergencies (e.g. change in groundwater flow direction leading to a situation where polluted groundwater will flow in the direction of houses leading to the action of prevention measures on evaporation of volatile components from soil. Another example is the erosion of a cover layer leading to a situation where contact of people with contaminated material can take place again. This leads to an action to restore the cover layer).	Yes		
3	**Analysis and evaluation**				
	A	Description of the status of the post remediation situation (i.e. the post remediation system and its delineation) at the time of writing the PRP, including deviations from the situation as described in the authorized final cleanup report.	Yes		
	B	Evaluation of the deviations in the post remediation situation described above. This should include the description of mitigating measures to restore the original situation in case of non critical deviation points and suggestions for implementation of measures to correct critical deviation points.	Yes		
4	**Management and finance**				
	A	The responsible party including contact information	Yes		
	B	Organisation of tasks and responsibilities	Yes		
	C	Planning of all activities	Yes		
	D	Procedure in case of violation of site use restriction or intended site use changes (e.g. redevelopment)	Yes		
	E	Cost estimation of the various activities	Yes		

Explanatory Notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: remarks to be entered by reviewer on the results for this topic

Volume II

10-b Checklist review and approval Post remediation plan

Volume II-10-b
Checklist review and approval Post remediation plan

1 Introduction

This information is most relevant for Step 10, Post remediation plan. The report of the Post remediation plan is to be reviewed by the competent authority to prepare the decision by the appropriate official.
The checklist below provides the points of attention for the review.

2 Checklist review and approval Post remediation plan

The checklist below can be used to review the Post remediation plan. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main conclusions of the Post remediation plan	
Date of recording	
Recording official	

No.	**Topic**		**Obliga-tory**	**Status**	**Comments**
1	Checklist Post remediation plan	Evaluation if the PRP meets the Checklist Post remediation plan (Volume II-10-a)	Yes		
2	Skills and accreditations	Evaluation if the specialized agency or consultant charged with the design and drawing of the PRP meets the required skills and accreditations	Yes		
3	Stakeholder rights and interests	Evaluation if the stakeholder rights are guaranteed. A thorough stakeholder involvement offers a good basis for securing stakeholder warranties	Yes		
4	Long term guarantees	Evaluation if the PRP offers adequate long term guarantees for risk protection and liability. Aspects involved are:	Yes		
	A	Technical aspects			
	B	Legal aspects			
	C	Financial aspects			
	D	Management aspects			
5	Conclusion	Can Post remediation plan be approved? If not, which further information is required?	Yes		

Explanatory Notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: remarks to be entered by reviewer on the results for this topic

Volume II

11-a Checklist Post remediation status report

Volume II-11-a
Checklist Post remediation status report

1 Introduction

This information is most relevant for step 11 Post remediation action.
Post remediation measures may go on for years or even decades. This necessitates updates on the status of the post remediation measures at regular intervals, to be reported in a Post remediation status report. This checklist presents the aspects that should be addressed in such a report. This general checklist should be adjusted for a specific situation.

2 Checklist Post remediation status report

No.	Topic		Obligatory	Status	Comments
1	Introduction				
	A	Client name, site owner, GPS-coordinates, contact details	Yes		
	B	Type of contamination and description whether the contamination is present in soil, sediment, surface water or groundwater	Yes		
	C	Cause and goals for activities and summary of the Post remediation implementation plan (PRIP) applicable for the site	Yes		
	D	Definition of assumptions, including general assumptions described in the Post Remediation Plan (PRP) and translation to the PRIP's			
	E	Status of the remediation measure and contaminations as described in the latest Remediation works report or if more recent the latest PRSR including of a description of the optimized processes implemented since the latest PRSR	Yes		
	F	Report reading instructions	Yes		
2	Background information				
	A	Site metadata, like site address, surface area, site owner name and contact details, present and intended future use, land register details and geographical coordinates			
	B	Reference to the authorized final cleanup report, including its title, author, project number and date), and data on the listing of the site in the NPRPS, including the relevant formal listing decision	Yes		
	C	Historical data and site description, including type of (past and current) industrial activities and site assessments. Of the latter, data should be included on the title, consultant, project number, date and the assessment's framework	Yes		
	D	Detailed description, including maps and soil profiles, of the remaining contamination, for soil, sediment, surface water or groundwater. This should include data on the type of contamination, its geographical distribution, (maximum) measured values and a reference to contamination map(s)	Yes		
	E	Detailed description of technical and management measures and necessary technical equipment	If applicable		
	F	Description of site use and site use restrictions	Yes		
	G	Description of the site ownership legal situation	Yes		
	H	A list of all post remediation measures stakeholders, including the names of the organizations, contact details, and names of contact persons	Yes		
	I	Description of general organizational aspects	Yes		
	J	Description of necessary permits and exemptions	Yes		
	K	Referring to the Post remediation plan and the approval of it by the authorities	Yes		

	L	Clear definition of the boundaries where the post remediation activities are related to	Yes		
	M	Referring to previous PRSR's	Yes		
3	Implementation of post remediation activities				
	A	Chronological description of the executed activities	Yes		
	B	Results of the monitoring (measurements and observations with indication of parameter, time and place, referring to maps of the monitoring system). In annexes of the PRSR all detailed documentation should be added	Yes		
	C	Conclusions on changes in e.g. concentration values in groundwater or direction of groundwater flow, referring to action values	Yes		
	D	Executed repair, maintenance or mitigating measures of non critical deviation points	Yes		
	E	Bottlenecks which have proved to be and description of the executed actions after discovery of these kind of occurrences			
	F	Critical deviation points and suggestions for mitigating measures including technical, financial, time and organisational aspects	Yes		
4	Conclusions and recommendations				
	A	Evaluation of the results of the post remedial activities referring to the intention and to the action levels as described in the PRP	Yes		
	B	Critical or non critical deviations which have occurred during the post remediation period. Evaluation of the cause of these deviations and suggestions for mitigating measures	If applicable		
	C	Suggestion for possible adjustments in the post remedial activities	If applicable		
	D	Suggestion for exit of post remediation phase including data or procedure proving the validity of this exit	If applicable		

Explanatory notes:
Status: yes (information available), no (information not available), action (essential information, must be collected)
Comments: possibility for remarks by reviewer on the results for this topic

Volume II

11-b Checklist review and approval Post remediation status report

Volume II-11-b
Checklist review and approval Post remediation status report

1 Introduction

This information is most relevant for Step 11, Post remediation action. The results of the post remediation action have been described in a Post remediation status report (PRSR) which is to be reviewed by the competent authority to prepare the decision by the appropriate official.
The checklist below provides the points of attention for the review.

2 Checklist review and approval Post remediation status report

The checklist below can be used to review the Post remediation status report. It may be copied and filled in as if it were a form.

Site ID (Name User and Owner, Address, GPS-coordinates)	
Main results of the Post Remediation action	
Date of recording	
Recording official	

No.	Topic		Obliga-tory	Status	Comments
1	Checklist Post Remediation Status Report	Evaluation if the Post Remediation Status Report (PRSR) meets the requirements of the Checklist Post Remediation Status Report (Volume II-11-a)	Yes		
2	Validation of the PRSR	Results of the validation of the PRSR by an independent third party	Yes		
3	Skills and accredita-tions	Evaluation if the specialized agency or consultant charged with the design and drawing of the Post Remediation Plan meets the required skills and accredita-tions	Yes		
4	Validity of values	When doubting results: cross-check third party values	If neces-sary		
5	Stakeholder rights and interests	Evaluation if the stakeholder rights are guaranteed. A thorough stakeholder in-volvement offers a good basis for securing stakeholder warranties	Yes		

6	Long term guarantees	Evaluation if the Post Remediation Plan offers adequate long term guarantees for risk protection and liability. Aspects involved are:	Yes		
	A	Technical aspects			
	B	Legal aspects			
	C	Financial aspects			
	D	Management aspects			
7	Conclusion	Can Post remediation activities be approved? If not, which information has to be provided or which activities have to be carried out?	Yes		

National Program for Rehabilitation of Polluted Sites in India

Guidance document for assessment and remediation of contaminated sites in India

Volume III – Tools and manuals

1st Edition, December 2015

Ministry of Environment, Forest and Climate Change
Government of India

Volume III
Introduction and contents

Introduction to Volume III of the Guidance document for assessment and remediation of contaminated sites in India

This document encloses Volume III of the Guidance document for assessment and remediation of contaminated sites in India.
In this Guidance document the technical aspects of the entire process of intervention in a contaminated site, from its earliest identification to post remediation measures, is described in a sequence of fourteen distinct Steps. This set of Steps covers all activities that are performed in dealing with such a site. Wherever applicable, this Guidance document refers to these fourteen Steps. The same Steps, with identical descriptions, are also used in correlation with the non technical aspects, i.e. legal, financial and institutional, of dealing with polluted sites.

The fourteen Steps are visualised in figure III.1 below.

Figure III.1 The fourteen Steps in the site assessment and remediation process

Identification	Planning	Implementation	Post remediation
• Step 1: Identification of probably contaminated sites • Step 2: Preliminary investigation • Step 3: Notification of polluted site • Step 4: Priority list addition	• Step 5: Remediation investigation • Step 6: Remediation Design, DPR • Step 7: DPR approval and financing	• Step 8: Implementation of remediation • Step 9: Approval of remediation completion	• Step 10: Post remediation plan • Step 11: Post remediation action • Step 12: Cost recovery • Step 13: Priority list deletion • Step 14: Site reuse

This Guidance document is organised as a set of documents, arranged in three Volumes:

Volume I	Methodologies and guidance
Volume II	Standards and checklists
Volume III	Tools and manuals

Volume I is the core of the Guidance document set. It presents guidance and instructions as to how to perform each of the fourteen Steps in the site assessment and remediation process. The correlation among the Steps is shown, to enable the user to see what happened before the Step he is involved in and what should happen after completion of that Step. Centred around a concise description of actions to perform the Step the user is involved in, the guidance details aspects for an effective performance, like data needed and where these may be found, and control mechanisms. Wherever relevant, the guidance includes references to Volume II and III and to websites and documents. Volume I is set up in such a way that it may be used in capacity building. It also includes an introduction for aimed at decision makers.

Volume II contains reference data in various forms. Engineers dealing with contaminated sites may use Volume II on a day to day basis to refer to data, standards, criteria and checklists. Every one of these is linked by a reference to one or more descriptions of Steps in Volume I.

This **Volume III** contains more extensive data like technical manuals. Examples of manuals presented in Volume III include a Site Inspection Protocol, points of attention for fieldwork and laboratory testing, an overview of available remediation techniques, and methods for the evaluation of remediation options. Like Volume II, Volume III is intended for day to day reference by engineers dealing with contaminated sites.
This Volume III document should be used in conjunction with the other two Volumes.

Contents of Volume III

Volume III

2.1-i Site Inspection Protocol

Volume III-2.1-i
Site Inspection Protocol

1 Introduction

The Site Inspection Protocol (SIP) provides comprehensive information on preparation, execution and reporting of a preliminary site assessment.
This information is therefore most relevant for Task 2.1 Preliminary site assessment but provides valuable information for Step 1 Identification of probably contaminated sites and Task 2.2 Preliminary site investigation and Task 5.1 Detailed site investigation as well.

This Site Inspection Protocol (version December 2015) is one of the reports by COWI-consortium resulting from the assignment 'Inventory and mapping of probably contaminated sites in India' as part of the NPRPS.

2 Site Inspection Protocol

The SIP document is included in this Guidance document on following pages.

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MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

INVENTORY AND MAPPING OF PROBABLY CONTAMI-NATED SITES IN INDIA

SITE INSPECTION PROTOCOL (SIP)

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CONTENTS

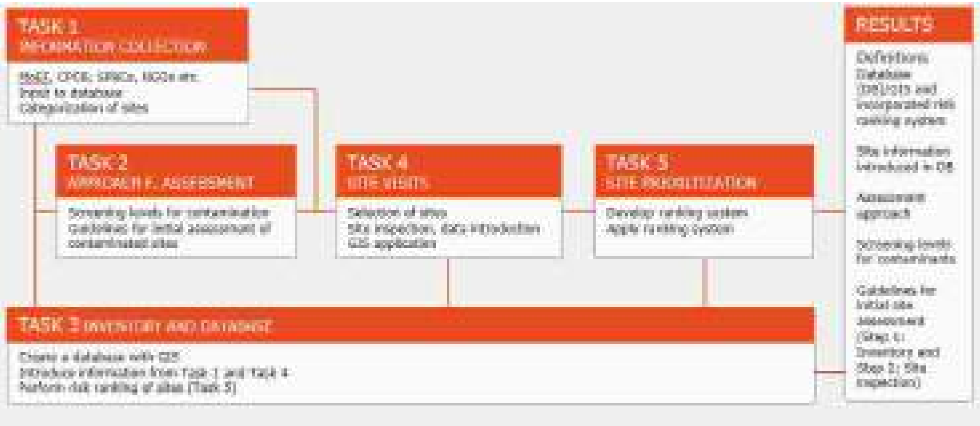
APPENDICES

1 Introduction and Objective

The current Report provides the “Site Investigation Protocol” for the project *Inventory and Mapping of Probably Contaminated Sites In India*, which was awarded by the Ministry of Environment and Forest to a Consortium consisting of COWI as lead partner in association with KADAM, Witteveen+Bos and Tauw as sub-consultants. The Project is funded by the World Bank (WB). Our work is coordinated with the other two assignments of the National Programme for Rehabilitation of Polluted Sites (NPRPS); Assignment 2: the Development of Methodologies for NPRPS and Assignment 3: Development of National Programme for Rehabilitation of Polluted Sites.

The site inspection is a field visit to observe the site and the potential sources of contamination (on-site reconnaissance) and to undertake a perimeter survey of the facility as well as a survey of the local site environs (off-site reconnaissance). During this site inspection information is obtained to fill the gaps and the existing available information is verified.

The Site Inspecton Protocol is a part of Task 2 in the project and has been used at 100 inspected sites in Task 4 of this assignment, see the relation between the tasks shown in the figure below.



The 14 step

In the National Program for Rehabilitation of Polluted Sites (NPRPS) of Assignment 3 and the Guidance Document for Assessment and Remediation of Contaminated Sites in India (Assignment 2), the entire process of intervention on a contaminated site, from its earliest identification to post remediation measures, is described in a sequence of 14 distinct steps. This set of steps covers all activities that are performed in dealing with such a site. Wherever applicable, this Site Inspection Protocol refers to these 14 steps.

The 14 steps are visualised in Figure 1-1. A more detailed description of the 14 steps is presented in our Task 2 Report.

Identification	Planning	Implementation	Post remediation
› Step 1: Identification of probably contaminated sites › **Step 2: Preliminary Investigation** › Step 3: Notification of polluted site › Step 4: Priority list addition	› Step 5: Remediation Investigation › Step 6: Remediation Design, DPR › Step 7: DPR approval and financing	› Step 8: Implementation of remediation › Step 9: Approval of remediation completion	› Step 10: Post remediation plan › Step 11: Post remediation action › Step 12: Cost recovery › Step 13: Priority list deletion › Step 14: Site reuse

Figure 1-1 The 14 steps

Step 2

The purpose of the Preliminary Investigation (Step 2) is to establish whether or not a site should be regarded as a contaminated site. This Step 2 is divided into two Steps: Preliminary Site Assessment (Step 2.1) and Preliminary Site Investigation (Step 2.2).

The objective of the Preliminary Site Assessment (Step 2.1) is to focus, as quickly as possible, on imminent threats to human health and/or the environment, to verify if the site is a contaminated site. Step 2.1 includes a desk top study, a site inspection with limited sampling and a brief reporting. Step 2.1 builds on information obtained in Step 1 Identification of probably contaminated site, for the specific sites assessed in Step 2.1.

The objective of the Preliminary Site Investigation (Step 2.2) is to identify all sources of contamination and the relevant pathways linking them to the receptors of concern. Step 2.2 includes planning of the investigation strategy, fieldwork with soil and water sampling and analysis, and reporting. Step 2.2 builds on information obtained in Step 2.1 Preliminary Site Assessment.

This Site Inspection Protocol is a guidance document for how to conduct Step 2.1 (Preliminary assessment). With reference to the 14 steps process for identification and assessment of contaminated sites, the frame for Step 2.1 can be illustrated as in Figure 1-2.

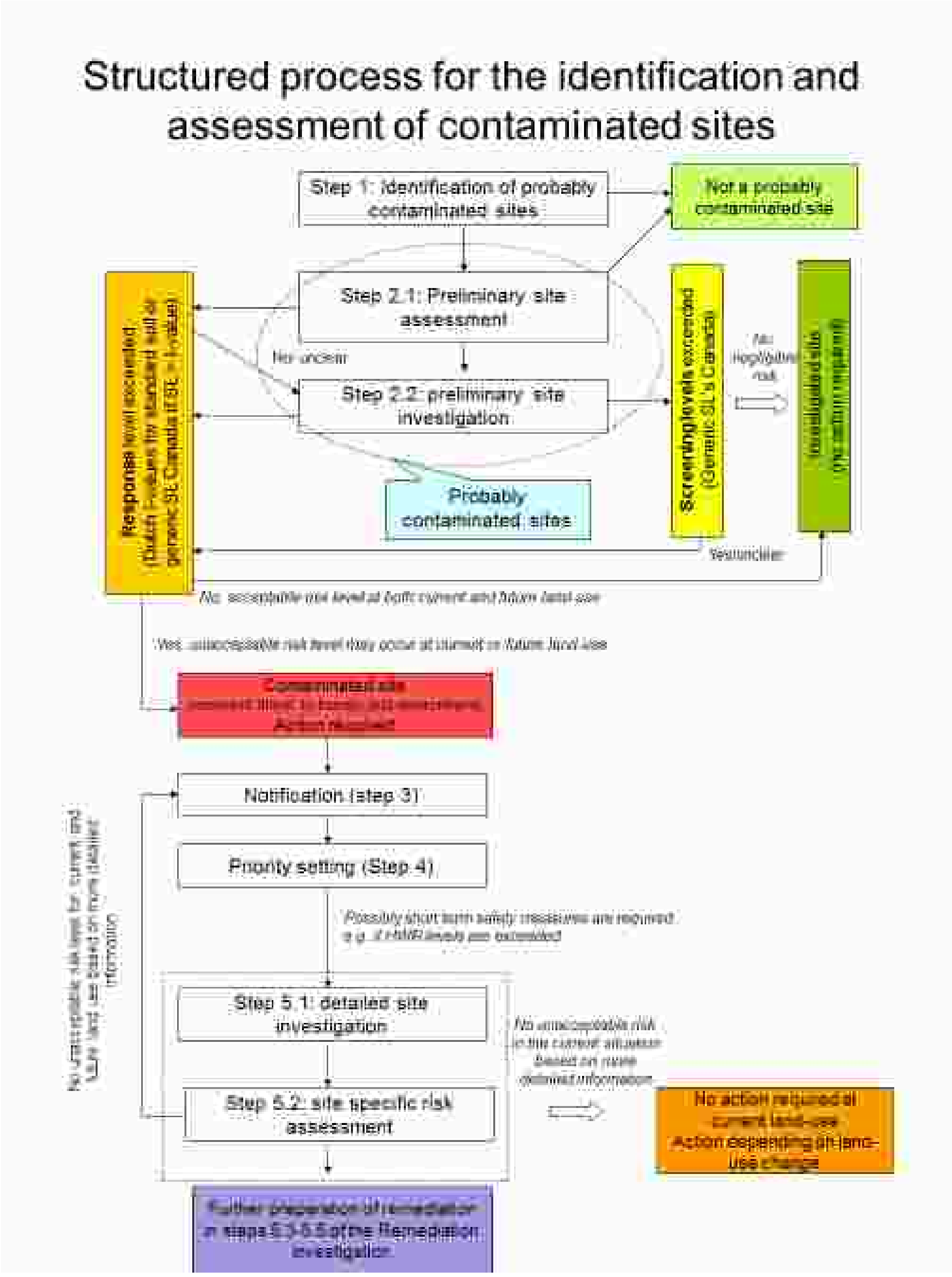
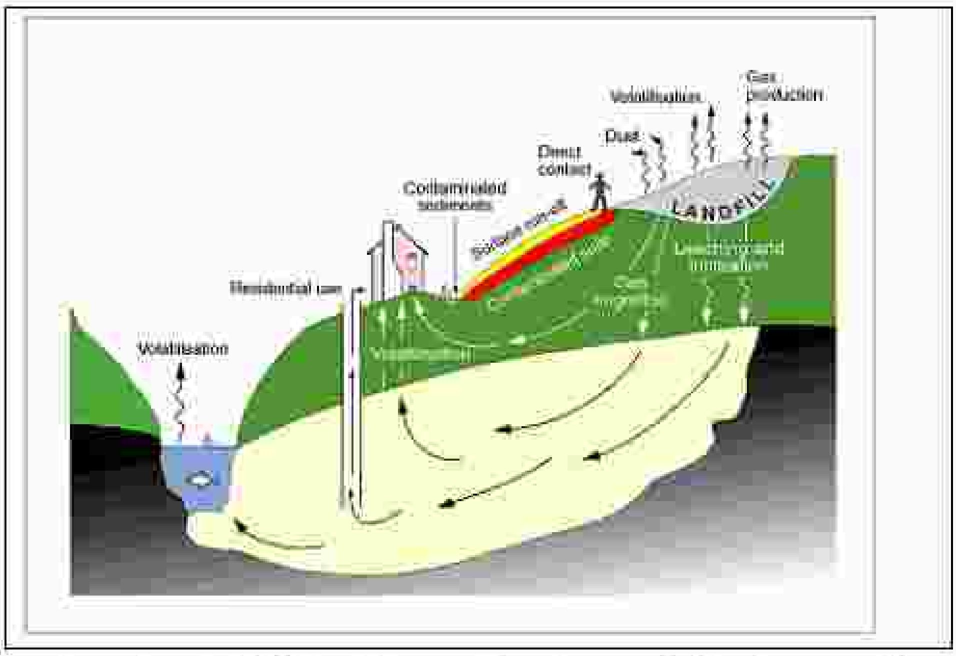


Figure 1-2 Structured process

Site inspection

A site inspection is carried out to verify the information of the desk study including a field visit to visually observe the site and its environs and to collect additional information to supplement the initial assessment under Task 1 (Step 1).

The overall approach for the Site Inspection is to gather information to set up a Conceptual Site Model (CSM). Such a model is developed by integrating as much relevant information on the contaminant situation as possible. This helps to understand the mechanics of the site, and may result in an image like the one in Figure 1-3.



Source: Petts, J. and G. Eduljee. Environmental Impact Assessment for Waste Treatment and Disposal Facilities, p. 229. John Wiley and Sons, Chichester, 1994.

Figure 1-3 Conceptual site model

The CSM is based on the 'Source – Pathway – Receptor' approach (SPR), see definition below.

Source – Pathway – Receptor
Source: An area where a hazardous substance may have been deposited, stored, disposed, or placed. Also, soil that may have become contaminated as a result of hazardous substance migration. In general, however, the volumes of air, groundwater, surface water, and surface water sediments that may have become contaminated through migration are not considered sources.
Pathway: The environmental medium through which a hazardous substance may threaten receptors. The migration and threat potential through the groundwater, surface water, air, and soil exposure pathways is assessed.
Receptor: A physical or environmental receptor that is within the receptor distance limit for a particular pathway. Receptors may include wells and surface water intakes supplying drinking water, fisheries, sensitive environments, and resources.

The site investigation includes:

- On-site reconnaissance: This gives the opportunity to visually observe the site and the sources.

- Off-site reconnaissance: An off-site reconnaissance typically includes a perimeter survey of the facility and a local site environs survey.

- Limited sampling: at the locations where main sources of contamination and relevant pathways to possible affected receptors are expected, limited sampling and testing is carried out.

- The results are compared with the Screening and Response levels and a conclusion is drawn as to whether or not the site should be regarded as a contaminated site. Recommendations on the necessity to carry out preliminary site investigation (Step 2.2) and specific aims of that investigation are presented.

- Reporting of results of the preliminary site assessment and review of the report.

Responsible Parties

This activity is typically carried out by technical specialists from the specialized agency/consultant appointed to carry out the preliminary investigation. The work should be supervised by a senior colleague, and close cooperation with the competent authority is necessary to collect important information during the desk study and to prepare the site inspection and sampling.

The team involved should demonstrate in-depth knowledge and experience in the assessment of contaminated sites, including interpretation of topographic and geological maps and reports. The field work team should have relevant expertise, experience and skills for the site inspection and sampling. The laboratory work has to be carried out by an accredited laboratory.

The guidance for conducting a Site Inspection is described in the following chapters.

2 Preparation before site inspection

Before visiting a site the following preparations must be made.

Step 1 Arrange access

Coordinate your site visit with the project coordinator to make sure access to the site is arranged. Identify a local contact or guide. Discuss any potential health and safety issues with regard to the site.

Step 2 Make arrangement with important stakeholders

Try to make arrangement with important stakeholders (e.g. Site owner/operater, Key State/Municipal officials, Key NGO Agency, Local Health Facility Director).

Step 3 Review the site and make a work plan

To prepare for the site reconnaissance, review what is known about the site and what remains unknown according to the Data Sheet in Task 1 (see example of completed Data Sheet in Appendix E).

Review the results of the desk study which is carried out in Step 1 of the 14 steps as described in Section 1 in the Guidance Document of the Assignment 2, Methodologies for the NPRPS, Volume Volume II-1-a (Petition format) and in Volume II-1-b (Checklist).

Of special interest is information about previous investigations at the site to see if there are available and reliable data available, primary data which can be used in the assessment of the site. Sampling points (on site/off site) should be marked on a map and primary data should be illustrated in a table. The below points should be considered when assessing existing primary data:

› Determine what data are available;
› Evaluate purpose and scope of previous investigations;
› Review sampling locations, dates, depths, and sample descriptions;
› Evaluate the sampling results and hazardous substance concentrations;
› Review field preparation and collection techniques for previous samples;
› Review available laboratory documentation;
› Assess usability of previous primary data.

The available reviewed information and the newly collected information can be summarised in a table, and information gaps should be indicated before the site inspection is carried out (reference to Appendix F in the SIP and Appendix E Section 2 SIP Form: Overall assessment of data and data gaps).

Examine available maps, such as from Google Maps, Google Earth, Bing Maps or government sources, to familiarize yourself with the area and key features such as the locations of roads, residential areas, industrial or mining areas and water bodies. Look for sampling data from other research projects.

Based on all the compiled information, a work plan should be made prior to the site inspection. This work plan should include all reconnaissance activities and identify the specific information to be collected e.g. sampling from drinking water wells, noting the local hydrogeology, estimating the population at risk, interviews with specific stakeholders (such as occupants, current or former owners, neighbours, manager, employees and government officials) etc.

Step 4 Prepare your equipment

The following equipment is required:

- Camera (check batteries);
- Notepad, site review questionnaire and pen. Please take detailed notes;
- Map of the site (printed from Google Maps, Google Earth, Bing Maps or a local map);
- GPS device;
- Personal protective equipment. If you need to purchase protective equipment, please contact the coordinator of the survey team. Safety is very important. Be careful and avoid potentially dangerous situations. See the Health and Safety section for further information.

Step 5 Prepare sampling equipment

The following equipment is required:

- Something to collect samples (auger or shovel, spoon and bottle);
- Storage containers for samples (jars for soil, preserved bottles for water);
- A permanent pen to mark samples;
- A water pump with clean sampling hose or (disposable) bailers;
- Cool box to store samples.

Follow the sample protocol in Appendix A.

The samples should be tested in a laboratory to assess the levels of contamination. Laboratories should operate in accordance with specific accreditation criteria (refer to Checklist prequalification for site investigation, Development of Methodologies for NPRPS, Guidance Document, Volume II-2.1-a).

3 Health and safety guidelines

3.1 Introduction

This Chapter provides an overview of the health and safety guidelines which should be followed before, during and after the site visits by people involved.

Before each site visit the coordinator of the team must:

› evaluate potential health and safety hazards;
› identify appropriate controls and precautions to eliminate or reduce risks;
› brief other involved parties coming to the site on general and any specific health and safety requirements.

3.2 Risk screening

Before conducting a site visit, the coordinator and the team itself must identify the potential hazards that they may encounter at the site. The different types of potential hazards are included in Table 3-1.

Table 3-1 Potential hazards

Type of hazard	Examples	Notes
Chemical hazard	Chemical pollutants present at the site	Awareness of the presence of hazardous waste and pollutants is very important. Review previous studies or publications related the area, identify potential sources
Physical hazard	Noise, slips, falls, climate conditions, sharps and needles from hospital wastes	Take into account the layout and state of the site, particularly any holes, excavations, buildings etc. Attention should be paid to expected local weather
Biological hazard	Bacteria, viruses, parasites, animal bites, hospital waste (blood and other body fluids, bandages, etc.)	Awareness of the presence of dangerous animals (e.g. snakes, scorpions) is very important. Sewage water and dead animals are a source for pathogens and bacteria

Once hazards have been identified, the coordinator of the team must estimate the probability that the expected extent of exposure to the identified hazards will put the inspection team at significant risk. The principal pathways of exposure at contaminated sites are normally ingestion, inhalation and direct contact, but other possible exposures should be considered.

In addition, the coordinator of the team must determine what measures the team must take to reduce the probability that the exposure to these hazards will cause injury or endanger wellbeing (such as wearing personal protective equipment, etc.).

N.B. Sites with ***radioactive waste or possible radiation exposures*** are excluded from site visits because these sites require specific health and safety measures.

3.3 Personal protection equipment (PPE)

The inspection team must have access to essential personal protective equipment (PPE). The coordinator of the team must identify and check the correct use of appropriate PPE during site visits.

Basic equipment includes:

- Boots (closed shoes are required – open toe shoes are not allowed); Its recommendated to use footwear (shoes, boots, wellingtons) according to e.g. European S3 standard (200 joule toe cap protection, fully enclosed heel, antistatic properties, energy absorption of seat region, water penetration and water absorption resistance, sole penetration resistance, cleated outsole, http://en.wikipedia.org/wiki/Steel-toe_boot) . Especially on waste dumpsites, mining tips and scrapyards, sole penetration resistance is essential. Also, boots above ankle height reduce snake bite risk by approximately 90%;
- Protective clothing such as pants with long legs and long-sleeved shirts are required;
- Dust mask must be worn whenever there is potential exposure to (hazardous) dust; Reference to suitable mask types, e.g. as published by Draeger (see [1] e.g. http://www.draeger.ae/media/10/03/67/10036736/filter_selection_guide_br_9046529_en.pdf , p. 6).
- Goggles or safety glasses must be worn whenever there is the presence of particles in the air that may damage the eyes (for example, significant amounts of dust) or when there is the risk of splash or splatter of contaminated substances;
- Gloves, if touching, picking up or sampling of any material, soil or water.

Other PPE may be identified as relevant to a specific site. PPE should be inspected before every site visit and be cleaned, repaired or replaced if needed.

3.4 Site visit

Before starting each new day of site inspections, a toolbox meeting is given by the coordinator of the team. During these toolbox meetings, safety procedures will be explained to each member of the field team.

During the site visit the team must:

- Wear appropriate PPE (see above);
- Wash hands before eating anything (even if gloves are worn during the visit);
- Not enter confined areas. These are areas large enough for a person to enter, but with limited ventilation and/or limited or restricted means of entry or exit;
- Be cautious in areas that may be slippery due to water, mud, steep slopes, etc.;
- Be cautious if using ladders or stairways that may be unsafe;
- Be cautious in elevated areas;
- Be aware that hazardous material and toxic contamination may look harmless. Allways, take precautions.

Touching or any contact with human and animal fluids and waste, or dead animals, should be avoided during site visits. Bacteria, viruses, parasites can be present in human and animal fluids and waste such as blood, faeces and urine.

After the site visit the team must:

- Wash hands and face before eating anything;

- Change from working clothes and shoes. Take showers before entering into close contact with other people, particularly pregnant women and/or children;

- Clean shoes to remove any mud or soil on them, wear gloves during the cleaning and make sure that the removed soil is collected and disposed of properly or is left at the site;

- Wash clothing before wearing again.

Communicate lessons learned during the site visits to the coordinators from the other teams to prevent future incidents.

4 Existing and general information

Before you start your site investigation, first complete the Data Sheet in Appendix F as well as possible by conducting a desk research..

Make use of internet, Google Earth, the Black Smith Institute inventory (if available) and other sources.

Based on this desk study establish:

› Evaluation of existing data e.g. existing primary data (see Appendix F);

› Assessment of important data gaps which must be obtained in the Site Inspection;

› Assessment of CosC and which contaminants to analyse (based on industry type and available information);

› Initial assessment of samples to be taken, e.g. samples in a known source area or from a drinking water tube/surface water body;

› Identify focus points for Site Inspection e.g. drinking water wells, hydrogeology, population at risc, interview with specific stakeholder etc.

Fill in the following table before your site visit. Use and verify the information available in the Data Sheet.

Data sheet no. #		
1.	**General Site Information**	
1.0	State Name	
1.1	ID number (State-district-xx)	
1.2	Site Name	
1.3	Address (Street, Street number, postal code)	
1.4	GPS coordinates /and elevation (x, y coordinates of the corners of perimeter) - (The coordinates should be written in Geographic latitude and longitude (North and East) for use in India	Location of coordinates is shown on map in section 6

Data sheet no. #		
	throughout the report) (add more points if required)	
1.4.1/ 1.4.2	1	X:
		Y:
	2	X:
		Y:
	3	X:
		Y:
	4	X:
		Y:
1.4.3	Altitude (m above sea level)	
1.6.1	Who is the current owner (name and address)	
1.6.2	Who was the previous owner (name and address)	
1.6.3	What is the current status of contact with owner	
		1=Owner known and in communication with regulator; 2=Owner known but not available/communicating; 3=Owner not known
	Site Access (yes/no, any restrictions?). Will the Consultant have access to the site for field investigations	
	Contact person	
	Phone number	
	What are the available dates / hours to visit the site?	
	Are safety measures required by the owner of the site? If so, which safety measures? Are there any known dangers which a visitor should be aware of like unstable buildings and structures, toxic liquids, holes etc.).	
	Is there a permission to visit / investigate the whole site?	
1.10 + 1.11	**Historical review and overall Site description** Describe historical information about the site (industrial activities, including maps of features of these sites e.g., production area, storage area, underground storage tanks, information on reported spills/dumping etc. Give an overall description of the site including a clear description of the type of site e.g.: i) is the site a point site with former or ongoing industrial activities on the site; ii) is the site an industrial area (with cluster of industries = Area Site) with no clear source of contamination); iii) is the site an area (e.g. waste land/water body/habitation area) where contamination has been spread via effluent or dumping of waste from an industry (or number of industries) which is placed outside the site boundary. Specify if there are any uncertainties with the Site Definition.	
1.16	Extend of data available (if any).	
		A=Almost no information; B=Desk top study performed but no primary data; C=Site

Data sheet no. #		
		investigations performed an primary data available; D=Ongoing remediation; E=Other (specify).
1.17	Previous or ongoing remediation activities (if any)	
2.	**Source of contamination and waste characteristics**	
2.7.1	Give a brief summary of previous investigations performed at the site and in the vicinity (if any). Describe results of soil, air, groundwater and surface water on/off the site (if any). Analysis results should be included. For soil analysis max concentrations in should be reported if possible distinguish between top soil and deeper soil contamination. Depth must always be specified. For groundwater data depth of sample should be reported.	
2.7.2	Compare primary data with SSLs and Response Levels. Calculate the over standard ratio of the maximum concentration level compared to the screening value.	
3.	**Groundwater use and characteristics**	
3.1	Geology at the site. Give an overall description.	
		Broad description of the typical stratigraphical sequences from topsoil to deepest aquifer. Based on earlier studies and / or general knowledge.
3.2.1	Hydrogeology - Overall description.	
		Describe the depth of aquifers which is relevant for migration of contamination and drinking water/irrigation. The aquifers can be secondary/shallow aquifers and deeper aquifers (primary aquifers). Also, describe soil type of aquifers (sand, clay, bedrock, other) based on earlier studies and / or general knowledge.
3.2.2	Hydrogeology - Groundwater flow direction	
		Describe direction for each aquifer(if any information).
10.	**Overall Location and site description**	

#: refer to category in Data Sheet

4.1 Overall assessment of data and data gaps (assessed before Site Inspection)

Item	
Assessment of available data (e.g. analytical results). Can existing data be used to assess present contamination at the site?	
What are the Chemicals of Concern (CoCs)?	
What are the data gaps? (Description of site, location of site, etc.)	
Give an initial assessment of the samples to be taken (soil, groundwater, surface water, other?)	
What are the focus points during the Site inspection?	
Identify important stakeholders who should participate in the Site Inspection	

5 On site reconnaissance

Fill in the following table during your site visit based on interview of the contact person and own observations. Verify the information as is available in the Database.

Take photographs of all relevant observations. In some cases, a photograph is obligatory.

Provide any obtained additional relevant information which cannot be filled into the table with site ID and data number corresponding with the table.

Date and time of site visit	…
Site investigation conducted by	… ….
Spoken with	… …
Weather conditions during visit	…

Data sheet no. 1. #	General site information	
1.15	Operational status	 1 = Active/ongoing; 2 = Closed; 3 = Abandoned; 4 = Other (specify)
1.5.1	What is the current land use?	…
1.5.2	What was the previous land	…

Data sheet no.				
	use?			
1.5.3	What is the future land use (planned)	...		
		1 = Agricultural land; 2 = Waste land; 3 = Water bodies; 4 = Forests; 5 = Habitation settlement (Residential/School/Kindergarten); 6 = Commercial; 7 = Industrial, 8 = Mixed (to be specified for each case) and 9 = Other (to be specified in each case)		
1.7	Name(s) of polluter(s)			
		E.g. Name and address of industry, institution or person who caused the contamination		
1.8	Approximate area of site (m2)	...	m2	
	Built-up area (m2 or percentage of total)	...	%	
	Paved area (m2 or percentage of total)	...	%	
	Non-paved area (m2 or percentage of total)	...	%	
1.9	Topography			
		1 = Water; 2 = Plains; 3 = Mountains; 4 = Hills; 5 = Any other (specify)		
1.10	Type of site			
		1 = “Point”site (single industry/dumpsite); 2 = ”Area”site(Industrial area or estate (cluster); 3 = Any other (specify)		
1.12	Industry type (which have caused contamination)	...		
		(select from Basetable 4 of the Data sheet in Annex F)		
1.13	Period of operation/contamination (year)	...		
		Enter period of operation (from – to) Period of contamination (from – to) based on available information		
1.14	Is the site classified before or after the development of HW rules in 1989 (Before / After)			
2.	**Source of contamination and waste characteristics**			

Data sheet no.			
	Are there dump sites present? Describe	yes / no	....
2.1.1	Physically state of waste as deposited		
		1 = Solid, 2 = Sludge, 3 = Powder, 4 = Liquid, 5 = Gas, 6 = unknown, 7 = Any other (specify)	
2.1.2	Origin of the deposit		
		1 = dump, 2 = leakage, 3 = fluviatile deposit (sediment), 4 = areal deposit, 5 = storage, 6 = Effluent (wastewater) 7 = Any other (specify)	
2.1.3	Position in soil/effluent		
		1 = On the surface; 2 = In the soil; 3 = In effluent (wastewater); 4 = Any other (specify)	
2.1.4	Is there visual contamination		
		Describe visual contamination in soil; groundwater; surface water; effluent	
2.1.5	Is there vegetation stress		
		Describe any sign of vegetation stress	
2.1.6	Area of contaminated soil		
		Area of the above source or area of HW deposited	
2.1.7	Volumen of contaminated soil		
		m3 / mt (source in soil or HW deposited)	
2.1.8	Is the source area delineated		
2.1.9	Area of contaminated groundwater		
		If plume is delineated assess the area of the plume (lengt (m), widht (m) area (m2)	
2.2	Type of contamination according to definition from MoeF		
		1 = Effluent; 2 = Air; 3 = Municipal Solid Waste; 4 = Bio-medical Waste; 5 = Hazardous Waste; 6 = Ship Break Waste; 7 = Any other (specify)	
2.3	"Industrial processes" which caused the contamination (According to Base table 5 of the Data sheet in Annex F)	...	

Data sheet no.					
2.4	Type of hazardous waste				
		According to Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.) - select from Basetable 6 of the Data sheet in Annex F			
2.5	Hazardous Waste Constituents				
		According to Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.) - select from Basetable 7 4 of the Data sheet in Annex F			
2.6	What are the COC's? (use UBI Appendix C)	...			
	What potential sources of contamination are present? Quantify as much as possible (area and/or volume) Describe	....			
	Are there storage tanks present at the site? Specify number, sub surface or on surface, content (chemical) (If specification is available, please add)	yes / no	... (number)	sub surface / on surface / both	content
	Is there visible soil contamination present?	yes / no		Take 1 to 2 samples of most contaminated sites	
	What is the level (intensity) of visible soil contamination?	low / medium / high impact		Take photo	
	What is the scale of visible soil contamination? (percentage of total site size)	< 10% / 10 - 50% / >50%			
	Are the buildings visibly contaminated?	yes / no / NA			
	What is the level (intensity) of the building/ infrastructure visible contamination?	low / medium / high impact / NA		Take photo	
	What is the scale of the visible building/ infrastructure contamination? (percentage of total buildings/ infrastructure)	< 10% / 10 - 50% / >50% / NA			

Data sheet no.				
	Are there materials present which might contain asbestos? (corrugated roofing panels			
	Is the present contamination local (hot spot) or diffuse?	hot spot / diffuse / both / none		
3.	**Groundwater use and characteristics**			
3.2.3	Hydrogeology - Depth to water table (m below subsurface, use wet season estimate).	 Describe the depth to the water table for each aquifer. Based on local knowledge or information from Ground water Authorities or data from Site Inspection		
3.3	Current and future expected use of any aquifer for groundwater use	 Describe current and future planned use of any aquifer		
3.4	Is the site within a groundwater recharge zone	 1 = Area with special drinking water interest (i.e. major aquifer/potable water supply) 2 = Areas with drinking water interest (aquifer with major aquifer potential) 3 = Areas with borderline drinking water interest (minor aquifer/ non potable water		
	Are there groundwater wells present on site? If so what use (consumption / domestic / industrial), what yield?	yes / no	consumption / domestic / industrial	**Take photo**
	Are there indications of groundwater pollution; e.g. smelling wells. If yes, what is the level (intensity) of groundwater contamination (if noticeable)?	yes / no / NA	...	**Take sample**
4.	**Surface water use and characteristics**			
4.1	Any drainage system (run off system) on site	... General description of (drain, trenches, streams) or streams at the site which can transport the contamination outside the premise to surface water bodies		
4.3	Type of Surface water Body	 1 = Pond (less than 1 hectare), 2 = Small lake (1-10 hectares), 3 = Large lake (more than 10 hectares), 4 = Small river/stream, 5 =		

Data sheet no.				
		Large river, 6 = Wetland, 7 = Other (specify if possible)		
4.4	Any sensitive use of surface water			
		1 = Drinking Water, 2 = Irrigation, 3 = Use in commercial food production, 4 = Water recreational area (e.g. bathing, marina), 5 = Fishing, 6 = Other (specify if possible)		
4.6	Are there signs of flooding? Describe	yes / no	...	
	If so, what is the water table to the surrounding surface? (m below ssl)	... m - ssl		
	Is there any discharge to the surface water visible? Describe	yes / no / NA	...	**Take photo** **Take sample**
	Is the surface water visibly contaminated? Describe	yes / no / NA	...	**Take photo**
5.	**Soil exposure characteristics**			
5.1.1	Access to the site from local communities			
		1 = Site secured and access controlled 2 = Site not secured but access limited 3 = Open site with regular public activity, 4 = Other (specify)		
5.1.2	Is there inhabitation on the site? If so how many people? How many children?	yes / no	... (number)	... (number)
5.1.3	How many workers are working on site? (Number)	...	Remarks: ..	
5.1.4	Specify other activities if any	...		
	Is there agricultural use at the site (crop growing / keeping of domestic stock)? Describe	yes / no	...	
6.	**Air exposure characteristics**			
6.1	What are the prevailing wind directions?	N / NE / E / SE / S / SW / W / NW / unknown		
	Is there a noticeable (smell) /bad air quality at the site?	yes / no	...	

Data sheet no.			
	Dust visible? Describe		

#: refer to category in Data Sheet

6 Off site reconnaissance

After the site visit ,make a tour around the site to assess the environmental impact on the surroundings. Fill in the table below based on your observations and possible interviews with local people.

Verify the information as is available in the Database.

Take photographs of all striking and relevant observations. In some cases, a photograph is obligatory.

Provide any obtained additional information which cannot be filled into the table with site ID and data number corresponding with the table.

Data sheet No #				
3.	**Groundwater use and characteristics**			
	Are there groundwater wells present? If so what use (consumption / domestic / industrial).	yes / no	consumption / domestic use / industrial	**Take photo** **Take sample if notice-able pollution is present**
3.5.1	Private wells (distances to nearest well and approximate number of wells within 1 km from the site)	... meters	... (number)	
3.5.2	Public wells (distances to nearest well and number of wells within 1 km from the site)	... meters	... (number)	
4.	**Surface water use and characteristics**			

4.1	Any drainage system (run off system) outside the site	...		
		General description of (drain, trenches, streams) or streams at the site which can transport the contamination outside the premises to surface water bodies		
4.2	Name and distance to nearest surface water body (m)			
4.3	Type of Surface water Body			
		1 = Pond (less than 1 hectare), 2 = Small lake (1-10 hectares), 3 = Large lake (more than 10 hectares), 4 = Small river/stream, 5 = Large river, 6 = Wetland, 7 = Other (specify if possible)		
4.4	Any sensitive use of surface water			
		1 = Drinking Water, 2 = Irrigation, 3 = Use in commercial food production, 4 = Water recreational area (e.g. bathing, marina), 5 = Fishing, 6 = Other (specify if possible)		
	Is there surface water directly next to the site? If so, what type	yes / no	...	
	What distance is the water table to the surrounding surface? (m below ssl)	... m - ssl		
	Is there visible discharge from the site visible? (Describe)	yes / no / NA	...	**Take photo** **Take sample**
	Is the surface water visibly contaminated? (Describe)	yes / no / NA	...	**Take photo and take sample**
4.5	What is the distance to sensitive environments and Wetlands (m)? (Describe)	... meters	...	
5.	**Soil exposure characteristics**			
5.2.1	What is the land use in the vicinity of the site?	1 = Agricultural land; 2 = Waste land; 3 = Water bodies; 4 = Forests; 5 = Habitation settlement (Residential/School/Kindergarten0; 6 = Commercial; 7 = Industrial, 8 = Mixed (to be specified for each case) and 9 = Other (to be specified in each case)		
	North	...		
	East	...		
	South	...		
	West	...		

	Are there crops grown next to the site? (Describe)	yes / no	...	**Take photo**
	Is there domestic stock present next to the site?	yes / no	...	**Take photo**
5.2.2	What is the distance to the nearest habitation? (Describe)	... meters	...	**Take photo**
	Approximate number of people living within 100 meter	... (number)		
5.2.3	Approximate number of people living within 1 km	... (number)		
5.2.4	What is the distance to other sensitive activities e.g. schools, nursery, allotments (m)? (Describe)	... meters	...	
7.	**Socio economic aspects**			
7.1	Describe general socio economic conditions			
		E.g. employment rate, in-come, rate woman/man, rate in age, population density, occupation, alphabetise, religion, value of site/buildings, possibilities of temporary site clearance, social sensibility land user(s),		
7.2	Drinking water source	...		
		Describe drinking water source (e.g. public water supply based on groundwater) for the population in he vicinity of the site (within 1 km)		

#: refer to category in Data Sheet

7 Miscellaneous

1.18	**Complaints**: List any other pending complaints, claims, liabilities, non-compliances, conversations with site personnel or neighbours, and other relevant matters related to soil and groundwater pollution aspects
	Data gaps: List major (if any) data gaps or uncertainties which still occur after the conducted Site Inspections (e.g. insufficient information about geology/hydrogeology)
	Emergency response considerations: List observed conditions that may warrant immediate or emergency action (e.g. heavely contaminated groundwater/surface water used for drinking water, unrestricted public access to exposed hazardous substances etc.)

8 SITE map

Provide a sketch of the site's lay-out (include at least main occurrences and main sources and pathways of pollution):

MAP THE SITE

Draw or copy a map of the site that shows the pollution source, the pathways to humans, the location of your samples and any pollution hotspots, neighborhoods that might be affected, and any other relevant landmarks or sites.

A digital map is preferable, though hand-drawn maps are acceptable.

DIGITAL MAPS

Digital maps can be drawn using bing (http://www.bing.com/maps/), Google Earth or a number of other free software applications.

Bing Maps (*Figure 1*)

1. Right Click on location > "Add a Pushpin" Name and Save thew Pushpin
2. Mark area of contamination using area tool in "My Places Editor"
3. Actions > Export > KML

Google Earth

1. Use Path tool to draw area.
2. Save Path
3. Right Click Path in Places Menu > Save Place As > KML

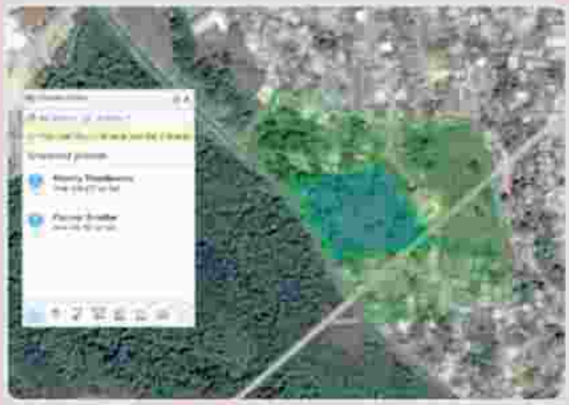


Fig. 1. Created in Bing Maps and exported to KML. This simple map sufficiently demonstrates the pollution source and affected area.

9 Sampling

To make a first assessment of the present contamination, samples will be taken during the site visit. This sampling concentrates on the source of contamination and the water as a pathway. This sampling is meant as a first assessment of the site based on actual concentration levels.

Sampling of source area:

› Samples of soil will be taken at places where contamination is visible/noticeable on the surface or (if no contamination is visible) at the locations where "sources" are most likely, given the (former) activities on the site. In case of surface water, this can also be a sample of the top sediment;

› If a discharge is present, an effluent sample will be taken;

› Surface water samples will be taken if there is clearly a surface water contamination noticeable.

Sampling of pathways:

› Groundwater samples will be taken from tube wells if they are present on the site or in its vicinity.

QC sampling:

› For reasons of quality assurance, a fraction of the samples will be taken in duplicate and sent to a other laboratory (see Section 13.2);

› The sampling procedure should also include the use of trip blank, field blank and equipment blank samples.

Describe the samples taken in the table below. For the sampling protocol, see Appendix A.

Always use the uniform sample coding as described in Appendix A.

The objective of the quantitative analyses is to obtain a first assessment of levels of contamination at the site.

When taking samples, customization of the sampling program (locations and type) is important and must be determined by the expert in the field. Some important considerations are:

- Sample the most visible contaminated media (soil / sediment / water), because this gives a first impression of the levels of contamination;
- If possible, sample areas that can be accessed by humans, exposure of humans is be possible (see Appendix A);
- If present, always take a water sample from (drinking) water wells (if many drinking water wells, give priority to drinking water wells in downstreams areas);
- If it is probable that larger areas of soil are contaminated by non-volatile compounds like metals, TPH and/or PAH, make at least 1 composite sample of the most sensitive area (residential area, playground, agricultural fields) according the protocol in Appendix A.

Other possible locations for sampling of sources and pathways:

- Visual indication of cause of pollution such as the presence of (former) industrial process equipment, storage tanks, broken pipelines, etc;
- Visual evidence of hazardous material by means of colour or odour or the composition of material, or uneven ground surface;
- Reported location with confirmed high concentration levels in previous sampling results;
- Where an incident (spill / uncontrolled release) has occurred identified by a former employee of a company;
- Areas which can easily be accessed by humans and areas of sensitive use (residential, playground, agriculture);
- Drinking water wells downstream of the site (collect groundwater samples to assess if this pathway is contaminated);
- Surface water at or near the site if expected to be contaminated by hazardous waste material;
- At discharge points with noticeable contamination an effluent sample should be taken;
- In cases of sites with effluent discharges a ‘source sample’ should also include a sample of the sediment.

Site ID + number	soil / water	Date for sampling	Targeted or composite	Location (description and GPS coordinates if available)	Parameters analysed	Motivation of sampling *
1.						
2.						
3.						
4.						

*: Motivation (e.g. visible contamination, source area). Must also include information about landuse (only soil) and location of sample (inside/outside the site)

10 Overall assessment of pathways, exposure, impacts and contamination

The initial conclusions from the Site Inspections should be filled into the table below:

Data sheet No #		
8.	**Pathways, exposure impacts and risc from contamination**	
8.1	Potential/observed pathways for spreading of contaminants at the site	
		1 = Groundwater pathway, 2 = Surface Water pathway, 3 = Soil exposure pathway, 4 = Air pathway 5 = Any other (specify)
8.2	Potential/observed exposure to contaminants	
		1 = Direct human contact, 2 = Ingestion (soil, food) 3 = Groundwater use (Drinking water, Irrigation), 4 = Inhalation of polluted air/dust, 5 = Surface water use (drinking water, bathing, fishing), 6 = Sensitive environments, 7 = Other (specify)
8.3	Describe observed impacts (if any)	
		E.g. observed impacts on humans, animals, flora, fauna
8.4	Estimation of population at risk (see Appendix B) <1000 1.000 – 5.000 5.000 – 10.000 10.000 – 20.000 20.000 – 50.000 50.000 – 100.000 100.000 – 200.000 200.000 – 500.000	Specify

Data sheet No #		
	>500.000	
9.1/ 9.2/ 9.3	Typology of contaminated site according to standard, see Appendix D (Note that more than one typology can be applicable): **S-1 Soil phase contaminations (land bound site):** (Subdivided into S1 – a; S1 – b; S1 – c; S1 – d; S1 – e; S1 – f) **S-2 (Solid phase contaminations (water bound site)** **L-1 (Liquid phase contaminations)** (Subdivided into L1 – a; L1 – b; L1 – c; 1 – d) **P-1 Liquid phase related** (Subdivided into P1 – a; P1 – b) **P-2 Groundwater contamination** (Leached or dissolved contaminants) Specify overall typology and, if possible, also subdivision of typology	
	Assessment of contamination from Site Inspection (based on analytical results from Site Inspection – see Section 11 and 12) (Specify most critical contaminants, specify if concentrations exceed SSLs and Response Levels) If lack of data, include results from previous investigations (if any)	Soil: Groundwater: Surface water:

Data sheet No #		
	Conclusion and recommendations: Assess whether or not the site meets the definition of contaminated site. Describe recommendation for the next step in the assessment and remediation process. If the information is too insuffiecient to draw a conclusion, a recommendation for further investigation should be provided.	

#: refer to category in Data Sheet

Comparing testing results with standard

The laboratory testing will result in a list of concentration levels for various parameters/substances. These concentration levels have to be compared with the Screening Levels and the Response Levels, refer to Appendix G.

The outcome of the comparison will determine whether or not the site should be regarded as a contaminated site. The following situations can occur:

› If the contaminants exist at or below Screening Levels, the site cannot directly be regarded as ‘not a probably contaminated site’. This, because of the fact that only a limited number of samples were taken. Further investigation is necessary to assess if there are any further sources of contamination at the site which may cause a risk to present or future land use. This can be done by a preliminary site investigation.

› If the contaminants exist at or above Screening Levels but at or below Response Levels, the site may be determined as 'probably contaminated site'. Then, a preliminary site investigation should be carried out as well. This is because of the fact that only a limited number of samples were taken and there may be other locations on the site where higher concentration of contaminants occur.

› If the contaminants exist at or above Response Levels, the site can be classified as 'a contaminated site'. Often it is not clear, if all sources and pathways have been identified and samples have actually been taken. In that case, a preliminary site investigation is necessary. If it is clear that all sources and relevant pathways have been identified and samples were taken from these points, no preliminary site investigation is necessary. In that case, the site may be notified directly as 'a contaminated site' and prioritisation can take place (Step 3 and Step 4 of the assessment and remediation process, see Section 1).

11 Draft Conceptual Site Model (CSM)

A Conceptual Site Model is a simple, schematized description and/or visualisation of the (assumed) situation of contamination (source, nature and levels of contamination, distribution), the physical system (geology), processes which influence the spreading of contaminants (geochemistry and (geo)hydrology) and receptors of contaminants (land use, threatened objects). The CSM should at least provide understanding of the relevant source - pathways - receptors at the site.

The Guidance Document of the Development of Methodologies for NPRPS, *"Volume III-2.2-I Manual Conceptual Site Model and identifying the Source-Pathway-Receptor (Assignment 2)"* further describes how to develop a Conceptual Site Model and its role in the assessment and remediation of sites. Developing a CSM is an iterative process and acts as baseline for the next step in the investigation chain.

Based on the available information provide a sketch of the site's Conceptual Site Model:

Sketch a 2D cross section, and try to include as much of the following items:

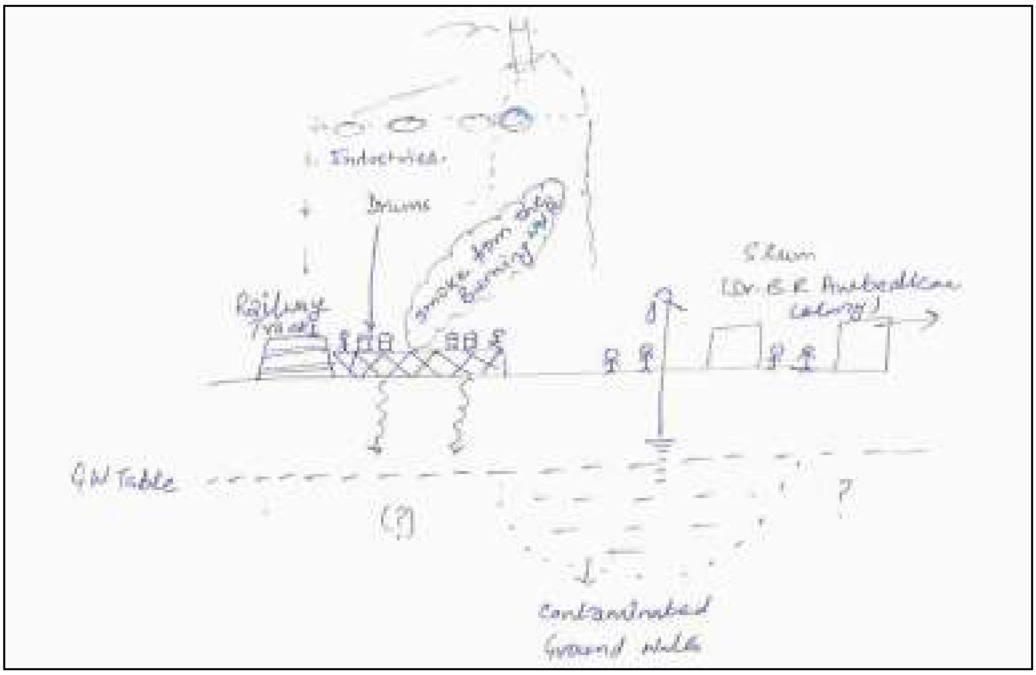
› Source areas

› Plume

› Pathways (groundwater, surface water, soil, air)

- Receptors: Presence of people, physical resources (drinking water wells or surface water intakes), and environmental resources (sensitive environments, fisheries) that might be threatened by release of a hazardous substance from the site.
- Geology
- (Geo) hydrology
- Data gaps.

Example of CSM:



12 Photographic record

Please include several photos that best illustrate the soil and groundwater quality related aspects and issues:

Number	Description	Location

Mark the point of view and number on a printout of Google Earth, Google maps or Bing Maps.

13 Quality assurance and quality control

13.1 Reporting the site visit

After each site visit, the team makes a Site Investigation Form, according to Appendix E.

It is very important that the form is filled in completely, consistently and elaborately.

Draft Forms must be checked by a technical specialists with relevant experience within this field. After processing the comments, the final draft and final version must be checked by a senior specialist by signing the document.

13.2 Laboratory analyses

The laboratory work has to be carried out by an accredited laboratory. Before sampling, it must be ensured that the detection limit is below the screening levels, preferable a factor 10 below the screening level.

If there is doubt about the quality of the analyses, cross-checking of 5% of the samples by a second laboratory can be conducted. Sites for these cross-checks are determined by the project leader. Samples from these sites are taken in duplo and analysed by both laboratories. The results from both laboratories will be presented and possible differences will be discussed.

Appendix A Sample protocol

This section provides technical guidance for step 2.1 (Preliminary assessemt) for the field staff in order to ensure quality of sampling, ensure uniformity and to allow for effective assessment of fieldwork quality.

For a more comphrehensive description of techniques used for site investigation (most relevant for Task 2.2, Preliminary site investigation, and Task 5.1, Detailed site investigation) references is made to The Guidance Document of the Development of Methodologies for NPRPS Guidance document Volume III-2.2-ii. This Guidance document provides a first overview of techniques, which are widely used e.g. Screening techniques, Sampling collection techniques. For more detailed information on sample collection, extraction and testing site investigation tools the user may refer to more detailed data such as:

› Field Sampling and Analysis Technologies Matrix and Reference Guide, Prepared by the Naval Facilities Engineering Command and the U.S. Environmental Protection Agency: http://www.frtr.gov/site/toc.html

› Dutch directive on restoration and management of soil, groundwater and sediment, provides information on 130 techniques for investigation: http://www.bodemrichtlijn.nl/Tools/bodemonderzoekstechnieken/applicatiezoeken-naar-onderzoekstechnieken (English translation is provided on this internet page).

0. Sampling strategy

Soil sampling:

probable distribution of contamination	Examples	sampling strategy
Spot	spills, confined contaminated areas, storage tanks e.g.	take 1 to 2 topsoil samples from the most visible contaminated areas
Diffuse	embankments, larger areas covered with contaminated materials, like dumpsites storage areas e.g.	make a composite sample from 3 to 5 parts from the topsoil with comparable characteristics.

Make sure that the soil samples are taken from 1) areas with highest concentration (to compare with SSLs and Response Levels) and 2) areas with the most sensitive landuse.

Groundwater sampling:

Take 1 to 2 groundwater samples from tube wells in anticipated downstream direction on site and/or in the direct vicinity of the site. Select the tube wells with the most sensitive use, used for drinking water purpose, used by a school, e.g.

Surface water sampling:

If it is clear that the source of contamination is caused by surface water based on unnatural colours, smell and/or visible contamination like a floating layer, a sample of the surface water is taken.

1. Drilling

- Use an auger or shovel depending on soil type;
- Use HDPE or PE foil to lay down soil;
- Make a picture/drawing of the position of the drilling and its surrounding and make a picture/drawing of the soil profile;
- Restore all boreholes and surface level with soil after sampling;
- Clean the drilling equipment with water;
- Mark the position of the drilling on the map and record the position with GPS.

2. Soil profile description

A bore log is recorded on a bore log form. The following data (where applicable) must be reported in such a log in the proper place:

- Project number;
- Project title;
- Name of driller;
- Date of execution;
- Number of sampling points;
- Number of samples taken and sampling sections with depth;
- Groundwater level (in meters in relation to ground level);
- Depths of the bottom of the various soil layers;
- Texture of the various soil layers;
- Details on the various soil layers, including the estimated quantities;
- Odours given off by the various soil layers;
- Colours of the various soil layers. The colour can be determined either individually or using Munsell Soil Colour Charts (http://munsell.com/color-products/color-communications-products/environmental-color-communication/munsell-soil-color-charts/), which can be considered international standard
- Boring system used.

3. Soil sampling

- Wear gloves during sampling to prevent contaminated soil from coming into contact with your hands;

- Sampling must occur per type of soil (based on texture and organic matter content) and per degree of contamination (based on sensory observations), and normally at most 50 cm of excavated material may be collected per sampling jar.

Instructions for filling a sampling jar:

- Collect the least "smeared" soil by using a spoon or the cap of the sampling jar. Scrape the soil to be sampled into the sampling jar using the inside (be-

cause of the ink) of the sampling jar's cap;
The cap should not be used for filling the jar, as soil and gravel will make it difficult to close the cap. Use of a trowel or spatula should be preferred.

- For technical reasons, clay and loam usually need to be sampled by breaking off pieces of clay by hand (wear clean latex gloves!) or by cutting with a clean spatula or spoon;

- Make sure that the mass of soil in a sampling jar is representative of the section from which it has been taken by ensuring that the locations of the subsamples are proportionally distributed over that section;

- Each sampling jar must be filled to the limit. Clean the screw thread of the jar and of the cap and screw the cap on tightly to lower the chance of contaminants evaporating. The soil in the jar should be compressed to the maximum to reduce pore space and headspace, to reduce loss of volatile substances.

- Immediately store the samples at a low temperature (<5 degrees celcius). Storage of samples at low temperatures should be extended with the advice that samples should reach the laboratory asap, and that laboratories offer information about maximum storage time before analysis will be affected.

4. Groundwater sampling

- Measure groundwater level in relation to the top of the well and surface level if possible;

- Purging a monitoring well before sampling is important and enhances the quality and representativeness of a groundwater sample. Rinse until at least 3 x the volume of the well's waterbearing part has been removed.

  Air bubbles in the water samples should be avoided, as volatiles may escape from the water and the air oxygen may cause degradation or oxidation of contaminants. Bottles and vials should be filled above maximum forming a meniscus, screw on the cap carefully, turn the bottle upside-down to check for air. If an air bubble is visible, open again, use the cap to fill the bottle up to the meniscus, etc.

- Measure pH and temperature of the groundwater;

- Code the (preserved) sampling bottle (see coding of samples);

- If analysis on heavy metals is required, the sampled groundwater needs to be filtered through a 0.45 µm filter in the field;

- To minimize turbulence during the sampling, run the pump at low capacity, tilt the bottle and lead the water along the bottle's wall;

- The sample volume, packaging and preservation method must be in agreement with the analytical requirements;

- Immediately store the samples at a low temperature (<5 degrees celcius). Storage of samples at low temperatures should be extended with the advice that samples should reach the laboratory asap, and that laboratories offer information about maximum storage time before analysis will be affected. Also, it should be kept in mind that sampling is the biggest source of errors in environmental assessments, not the precision of the machines in the lab.

The following should be reported:

- Well number (see coding of samples);
- Groundwater level in relation to the well's top and surface level;
- The well's depth in relation to its top and surface level;
- pH and temperature
- Purged volume;
- Date of execution;
- Name of sampler.

5. Labelling of samples

In the field, the following is marked on the jar or bottle with an indelible felt-tip pen:

- Site identification number;
- Sample code (see coding of samples);
- Sample or well depth;
- Date of sampling.

6. Coding of drillings and samples

Following coding of drillings and samples will be used:

type of drilling and sampling activity	**code**
shallow drilling and soil sampling	S1, S2, etc.
(deep)well and groundwater sampling	DW1, DW2 etc.
sediment sampling	SS1, SS2 etc.
surface water sampling	SW1, SW2 etc.
composite sample soil	CS1, CS2 etc.
composite sample sediment	CSS1, CSS2 etc.

For example, two soil samples and one groundwater sample taken at a site in the State Andhra Pradesh with ID number AP-500-1 will get the following codes:

- AP-500-1 S1
- AP-500-1 S2
- AP-500-1 DW1

And one soil sample and one groundwater sample taken at a site in the State Bihar with ID number BR-851-1 will get the following codes:

- BR-851-1 S1
- BR-851-1 DW1

7. Amount of samples

It has to be stated that sampling in general only include limited samples of soil and water samples (typically groundwater and surface water). Normally, no deeper soil sampling will be conducted (samples will be taken with shovel or hand auger). Groundwater samples will normally be taken from existing borings on-site and/or off site (if any). For certain type of sites (e.g. spill from underground storage tanks), it can be necessary to use machine driven borings equipment to reach the necessary depth for taking out soil samples. The requested number of samples will depend of the site specific conditions. 1-3 soil samples from source areas and 1-2 water samples from existing wells or surface water is the minimum number of samples. In case for example different sources are present at one site, more samples can be taken. It has to be stated that the objective of the sampling is not to have complete understanding of sources or the spreading of the contamination. This more detailed sampling will be performed in Step 2.2 (Preliminary investigation) and in Step 5 (Remediation Investigation).

8. Storage and shipment of soil samples

Sampling jars and bottles filled with soil and groundwater must be stored at a location which is as cool as possible (approximately 2 - 4 degrees Celsius) and protected from sunlight during the remainder of the field work. After the field work, the soil samples must be transported to the laboratory as soon as possible.

9. Field logbook

A field logbook is intended to provide data and observations required for participants to reconstruct events that occurred during the field work.

The field logbook should contain the following information per site:

› Personal data on team members, site contact person(s);
› Times of arrival and departure of team members;
› Summary of all discussions and agreements made with team members and site owners/stakeholders;
› Explanations of all deviations from the original field sampling plan;
› Descriptions of problems which occurred at the site, noting when and how it occurred, and how it is being addressed;
› Personal protective measures taken;
› Drilling and sampling information: identification number of boreholes, borehole logs, samples etc.;
› Groundwater purging: amount of groundwater purged and yield of well, pH and EC measurement;
› Monitoring well information: identification number, depth of well, samples etc.

Appendix B Estimation of people at risk

Estimated Population at Risk (methodology according to Blacksmith Institute Toxic Site Identification Program – Investigator Handbook):

Population at risk - one of the most important input parameter to the prioritization of probably contaminated sites and should be calculated for all sites.

This is your estimate of the number of people that could be exposed to this pollution at a level (dose) that could impair their health. The ISS should identify both the likely number of people impacted and the total number that might be impacted in a worst case. For example the likely population at risk could be:

- the local residents in a neighbourhood with contaminated soil; or
- the number of school children and residents in the immediate vicinity of a lead smelter or other toxic air pollution source; or
- the population drinking contaminated groundwater.

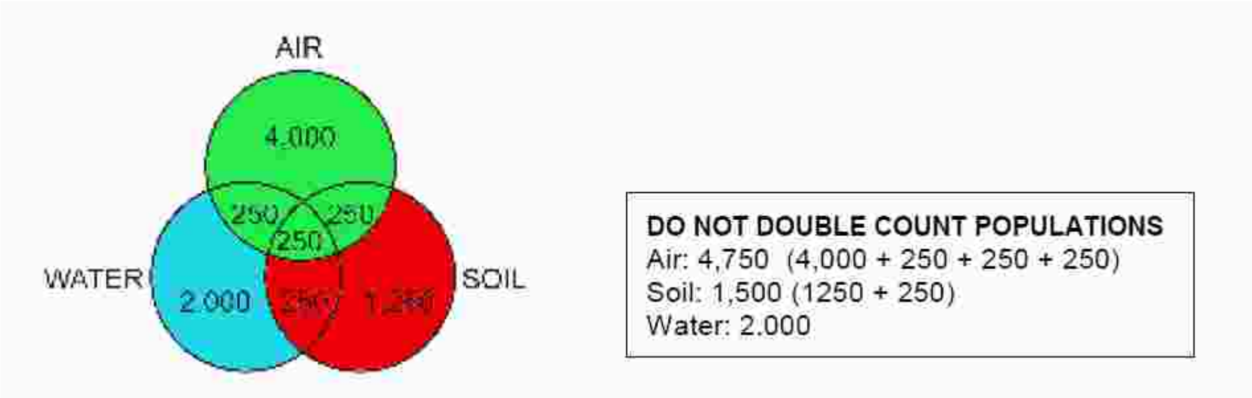
A worst case impacted population at risk estimate would include a larger number than the number of people who could be exposed to the toxic pollution. Examples might be:

- the total population in a 1 kilometre radius of a lead smelter or other air pollution source; or
- the entire population of a town in which a large industrial estate is located; or
- the entire population of an area relying on a contaminated aquifer or surface water source (as opposed to just the population relying on wells sampled and found to be contaminated).

Good professional judgment should be used in developing population estimates, using available information from maps, government sources (regarding such things as town population and water sources) and your own observations. An approximate estimate of the Population At Risk is OK. You may round off to the nearest thousand. For example, if 750 people are exposed, then round up to 1,000. Keep in mind that it is not uncommon to have exposed populations in the 10’s of thousands.

Please note that contaminant migration and pathways define the population at risk. Once a pollutant has been shown to be above the standard, consider the aerial extent of the contamination and how it gets inside of humans. Are people absorbing it by drinking it, breathing the air, inhaling or accidentally ingesting dust, eating food? This pathway will help you to ask the right questions and determine the population at risk. There are often multiple pathways at a given site. Soil that contains lead can contaminate barefoot children through dermal contact or ingestion, though it can also be inhaled as dust by local community members. Similarly, dust containing arsenic can be inhaled or ingested, and can also migrate to drinking water supplies and be ingested. Multiple pathways must be considered when reviewing a site. The total Population At Risk is therefore the total number of people when considering all pathways at a site.

Consider the chart below:



Note that a single person may be put at risk by more than one pathway, though they can only be counted once in the total Population At Risk. The box above illustrates that while multiple pathways can impact the same group, each group can only be counted once.

Finally, remember that you are only expected to estimate Population At Risk within a reasonable range. Make an educated guess by using your screening information and tools such as local maps or census data, or Google Earth to estimate the number of nearby housing units.

Appendix C Universal source categorisation (UBI) and tracers

UBI code

After more than 20 years of soil investigation and remediation in the Netherlands, a legislative change resulted in a more risk based remediation approach of contaminated sites. In line with these legislative changes, it was also concluded that the national remediation program should end within approximately 20 years. Given these changes there was a need for a national inventory to classify and prioritise contaminated sites and to assess the volume of the national remediation program. For this the UBI (Uniforme Bedrijfs Informatie) approach was developed.

The UBI approach consists of a UBI-code and a UBI-class. A long list of historical activities has been identified for the Dutch situation. The different identified activities have then been assigned a unique UBI-code. For all the unique activities, representative tracer components have been identified which are typically used in regard to the identified activity. The UBI-code can thus be used as a preliminary method to identify tracer components, which are regularly used for the identified activity. The tracer components can be seen as components of concern (CoC).

If there is existing information about contaminants from previous investigations, this information should be used to select tracers to be analysed. It has to be stated that not all the listed tracers necessarily has to be analysed at a site, but the list can be used as a starting point for the assessing analysis program at a specific site.

The UBI-codes has been used as a preliminary approach for assessing chemical tracers for various industry types. In an Indian context the HWR Schedule I “List of processes generating hazardous wastes” could probably be used, although it will require some effort to point out chemical tracers for the various processes (in total 36 overall processes). It is our recommendation that a similar approach for assessing tracer compounds should be developed based on the above HWR Schedule I. Until this is developed,we recommend using the below list of UBI-tracer.

Source Industry	UBI-code	UBI-description	UBI -tracers
Aluminium Smelting	2742	aluminium plant	copper (Cu)
			lead (Pb)
			Trichloroethane
			Trichloroethene
			Vinylchloride
			Xylene
			zinc (Zn)
Chemical Manufacturing	24	chemical industry	black box
Chemical works: Fertiliser manufacturing works	2415	fertilizer industry	Asbestos
			cadmium (Cd)
			Calciumfluoride
			chromium (Cr)
			copper (Cu)
			zinc (Zn)
Chemical works: Inorganic chemicals manufacturing works	2413	inorganic chemical raw material factory	Asbestos
			black box

Source Industry	UBI-code	UBI-description	UBI -tracers
Chemical works: Organic chemical manufacturing works	24142	organic chemical raw material factory	Asbestos
			black box
Chemical works: Pesticides manufacturing works	2420	agrochemical industry	1,3-dichloorpropeen
			3,4-dichlooralinine
			Asbestos
			DDT
			Dimethoaat
			Endosulfan
			Lindaan
			Mcpa
			Methylbromide
			Parathion
			Simazin
			Zineb
Chemical works: Pharmaceutical manufacturing works	2442	pharmaceutical products factory	Asbestos
			Chloroform
			Dichloromethane
			Toluene
			Trichloroethene
			Vinylchloride
Dye Industry	2412	paint and dye industry	Asbestos
			Benzene
			Benzidine
			chromium (Cr)
			Phenol
			lead (Pb)
			Toluene
			trichloroethene
			vinylchloride
			zinc (Zn)
Electrical & electronic equipment and clothing manufacturing works	2971	electrical household appliance factory	asbestos
			copper (Cu)
			lead (Pb)
			o-cresol
			tin (Sn)
			trichloroethane
			trichloroethene
			vinylchloride
	18	clothing industry	fluoranthene
			xylene
General manufacturing			black box
Heavy Industry (casting, rolling, stamping)	2710	pig iron and steel industry	cyanide
			fluoranthene
			copper (Cu)
			lead (Pb)
			trichloroethane
			zinc (Zn)
Heavy Industry (casting, rolling, stamping) i.e.	2710	pig iron and steel industry	cyanide
			fluoranthene
			copper (Cu)
			lead (Pb)
			trichloroethane
			zinc (Zn)
Industrial dumpsite	900038	dumpsite industrial waste on land	fill
			black box
Industrial/Municipal dumpsite	900038	dumpsite industrial waste on land	fill
			black box
	900052	dumpsite domestic waste	fill

Source Industry	UBI-code	UBI-description	UBI -tracers
		on land	
Lead smelting (with ingot production)	275407	plumbing factory	arsenic (As)
			asbestos
			cadmium (Cd)
			fluoranthene
			copper (Cu)
			lead (Pb)
			tin (Sn)
			zinc (Zn)
Lead-Battery Recycling	314002	accu recycling factory	antimony (Sb)
			asbestos
			cadmium (Cd)
			lead (Pb)
			nickel (Ni)
			pcb's
			Trichloroethane
Metal manufacturing: Iron and steelworks	27102	steel factory	Cyanide
			Fluoranthene
			copper (Cu)
			lead (Pb)
			Trichloroethane
			zinc (Zn)
Mining and Ore processing	631111	ore and mineral processing industry	arsenic (As)
			Asbestos
			copper (Cu)
			nickel (Ni)
			zinc (Zn)
Mixed (electronic, equipment, clothing industries)	2971	electrical household appliance factory	Asbestos
			copper (Cu)
			lead (Pb)
			o-cresol
			tin (Sn)
			Trichloroethane
			Trichloroethene
			Vinylchloride
	18	clothing industry	Fluoranthene
			Xylene
			black box
Oil refineries & bulk storage of crude oil and petroleum products	232	oil processing industry	Anthracene
			Asbestos
			Benzene
			benzo(a)pyrene
			Fluoranthene
			copper (Cu)
			n-decane
			n-octane
			o-cresol
			Toluene
			Xylene
			zinc (Zn)
Others			black box
Power Plant (coal or oil) & Tanneries	400021	power plant	arsenic (As)
			Asbestos
			benzo(a)pyrene
			Fluoranthene
			copper (Cu)

Source Industry	UBI-code	UBI-description	UBI -tracers
			lead (Pb)
			n-octane
			nickel (Ni)
			PCB's
			Xylene
			zinc (Zn)
Product Manufacturing (electronics, equipment, clothing)	2971	electrical household appliance factory	asbestos
			copper (Cu)
			lead (Pb)
			o-cresol
			tin (Sn)
			trichloroethane
			trichloroethene
			vinylchloride
	18	clothing industry	fluoranthene
			xylene
			black box
Pulp and paper manufacturing works	211	paper, pulp and cardboard industry	barium (Ba)
			dichloorbenzene
			pentachloorphenol
			trichloroethane
			trichloormethane
			zinc (Zn)
Tannery industry	1910	leather industry	3,4,5-trihydroxybenzoic acid
			arsenic (As)
			chromium (Cr)
			phenol
Vitamin C-Sorbitol manufacturing unit	2442	pharmaceutical products factory	asbestos
			chloroform
			dichloromethane
			toluene
			trichloroethene
			vinylchloride
No information obtained			black box
black box - no specific CoC can be determined, wide range analyses / screening is needed			

Appendix D Typology at contaminated sites

The typology of contaminated sites offers important elements when developing a site assessment strategy and remediation options in a manageable way. These elements are activities leading to contamination, geometry and type of contamination. Combined with site specific information on chemical substances and soil characteristics, this typology is useful to get an insight in realistic remediation options to facilitate the process of remediation option appraisal. The typology is described in The Guidance Document of the Development of Methodologies for NPRPS, Volume I and is attached in this Appendix D.

Annex to the Glossary

Explanation of Typology of contaminated sites

1 Introduction

The typology of contaminated sites offers important elements when developing a site assessment strategy and remediation options in a manageable way. These elements are activities leading to contamination, geometry and type of contamination. Combined with site specific information on chemical substances and soil characteristics this typology is useful to get insight in realistic remediation options to facilitate the process of remediation option appraisal.

2 Typology

Table T1 presents an overview of the typology, by showing all activities leading to contaminated soil and types of spreading. These activities are regardless of the party causing the contamination. E.g. liquid phase contaminations are not necessary focused only to industrial activities. On the other hand it is expected that most of this type of contaminations can be found in industrial areas. The following main types of contaminated sites are distinguished using this approach:

Source related:
- Type S1: Land bound solid phase contamination;
- Type S2: Water bound sediments solid phase contamination;
- Type L: Land bound liquid phase contamination. The source of this type of contaminations is connected to human activities or infrastructure.

Pathway related:
- Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids);
- Type P2: Groundwater contaminations.

Note 1: Although elements in the typology are based on the ‘source-pathway-receptor’ approach, it is not primary ‘receptor’ (risk) based. The typology is not based on risks (risks to human health, ecological risks, spreading or vaporizing). This is because site assessment and soil remediation options appraisal, for which this typology is developed, is not limited to the assessment of unacceptable risks, but needs to give insight in a contaminated site as a whole.

Note 2: depending on a specific situation:
- a combination of these types may be found on one site. Example: a land bound storage of Chromium containing hazardous waste (type S1), leaching Chromium to groundwater and leading to a contaminated groundwater plume (type P2). This combination of types on one single site could result in multiple site assessment strategies and multiple remedial options, each assessing the different types of contaminants (both the site assessment and remediation approach can be combined for practical reasons);
- multiple sites can form a cluster of contaminated sites of a specific type or combination of types. A combination of sites of a specific type in a single cluster or a combination of types on a single site can be recognized. These situations could be indicated as a “cluster-site” with a wide variety of scales. In general, the applicability of remediation techniques will not depend on this setting, but correct balancing of remediation techniques per type of site in a cluster will lead stakeholders to the best applicable remediation option.

Note 3: Both in type L as in type P1 liquid phase contaminants are involved. Type P1 is distinguished from type L by the specific type of contaminant, Non-Aqueous Phase Liquids (NAPL’s), which have a characteristic spreading pattern on or in the groundwater aquifer. This characteristic leads to different site assessment strategies, spreading mechanisms, risk profiles and remediation approaches for type P1 sites, as compared to type L sites. A type L site may, due to further spreading of the contaminant plume, develop over time into a type P1 site.

The main types listed above are based on normative characteristics, which play a role in determining the basics for remediation options. Side characteristics may do so as well, but their influence will in certain cases be restricted to the finer points (mostly technical details) in the selection of remediation options or to the planning or implementation of remediation actions. Thus subtypes come into perspective when remediation option appraisal is going into the second step of option appraisal, the detailed engineering phase. In this detailed engineering phase aspects have to be included related to contaminant specific specifications of remediation techniques, assessment of specific social aspects of the remediation actions or site use specific technical requirements.
Case example. The first step of a site specific remediation option appraisal, based on normative characteristics only, has shown that the remediation should be implemented within a period of less than two months and should result in a removal of all contaminants. In this case only then the site will meet the specific needs for planned reconstruction works. At this point it is already clear that only excavating techniques will be applicable, rendering the assessment of in situ techniques obsolete. This saves gathering and analysing detailed information on the performance of these techniques (e.g. contaminant related performance of in situ techniques) as this will not meet any purpose.

Subtypes can be distinguished based on the following secondary criteria:

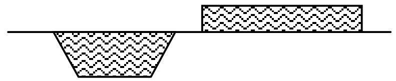
- **Type S1 and L** related subtypes are defined, based on the activity causing the contamination. HW-Schedule I (listing processes generating hazardous wastes) may help to focus on possible activities.
  In Table T1 these subtypes are coded ‘a’ through ‘f’ (type S) and ‘a’ through ‘d´ (type L).
  These subtypes are distinguished to support the site assessment.

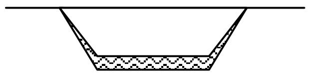
- **Type P1** related subtypes are defined, based on the bulk density of a NAPL (non aqueous phase liquids, dense and light).
  In Table T1 these subtypes are coded ‘a’ and ‘b’ (type P1).
  These subtypes are distinguished to support the site assessment.

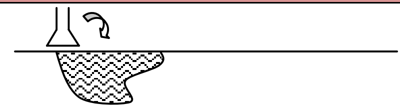
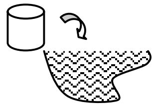
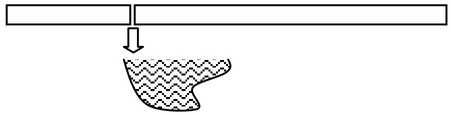
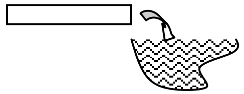
The typology is aimed to support the remediation options appraisal. Some examples to illustrate this point. A site assessment plan for a S1-f type contaminated site (deposition by flooding or washing) will focus on the boundaries of the flooded areas of a river system, easily recognizable on maps or areal pictures. Once the pattern of flooding is known an extensive sampling plan can be carried out to validate the flooding pattern and to validate the hypothesis on the spreading of the contamination with field data. By contrast, a site assessment plan for a S1-c type of contaminated site (storage of contaminated material) will focus on a relatively small area where human activities such as incineration have taken place.

The total volume of the removal of contaminated material, which accounts for the major part of remediation costs, will be smaller for a S1-e type of contaminated site (atmospheric deposition) than for a S1-a type (soil mixed with contaminated material). Therefore, it is more likely that the best applicable remediation option on a S1-e type site will be a complete removal of all contaminants, where for a S1-a type site a capping option is more likely to come into perspective.

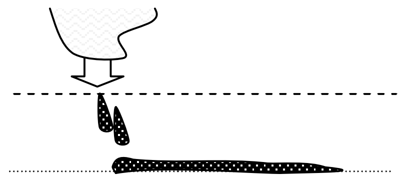
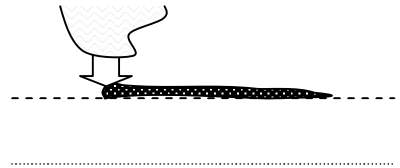
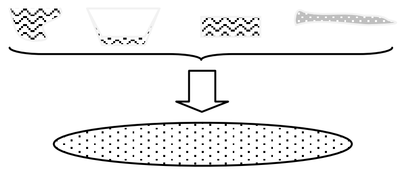
Table T1 Typology

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
S-1	Solid phase contamination (land bound site)		
S1-a *	Mixing the soil with contaminated material or materials containing contamination, not including agricultural activities.	Well defined body below surface level defined by boundaries of soil where soil is mixed with contaminants.	
S1-b **	Embankment, filling of pits or depressions, filling of surface waters with contaminated material or materials containing contamination.	Well defined body of non-mixed contaminants . E.g. storage of tailings.	
S1-c **	(Bulk) storage of contaminated material or materials containing contamination. (Industrial) activities in which contaminated solids are used. 'Leftovers' of incineration and burning of material.	Irregular shaped layer of contaminated material, recognizable as such. The shape of the contaminated site is related to the activity leading to the contamination	
S1-d *	Adding material containing contamination through agricultural activities (e.g. pesticides, fertilizers or additives to animal feed).	Agricultural site bound contaminations found up to a depth to which the soil is treated by ploughs and other agricultural tools.	
S1-e *	Atmospheric deposition (roads, railway, industries) of emissions or windblown dust.	Thin layered contaminations found over large areas with the highest concentrations close to the source following the prevailing wind direction.	
S1-f *	Deposition by flooding or washing.	Contaminations found in areas flooded by water systems or in downstream areas of flooding areas. The shape of the contaminated site is	

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
		determined by the flooding of flow of a water system.	
S-2	Solid phase contaminations (water bound site)		
S-2 **	Contaminated open water sediments.	Solid phase contaminants sedimented from surface water. The shape of the contaminates site corresponds to the shape of the water system itself. Contaminants may be bound to clay or organic compounds of sediments.	

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
L-1	Liquid phase contaminations		
L1-a *	(Business) activities involving fluids e.g. solvents, lubricants, paint, etc.	Liquid contamination in soil situated near a potential source of the contamination.	
L1-b *	Storage of liquids that contain contaminations in tanks or barrels (either storage on surface or subsurface).	Liquid contamination in soil situated at any place at a liquids storage site.	
L1-c *	Transfer and transport of fluids through linear infrastructure. Weak points are couplings, pressure regulators, valves, breakpoints and the passage through foundations / buildings.	Liquid contamination in soil situated at any place along a transport piping system or drains.	
L1-d	Spills or leaks of liquids. (either on surface or in rivers/lakes) *Note. Possibly leading to type S2 or P2.*	Liquid contamination in soil situated at the end of a transport piping or drain system.	

*) caused by multiple sources or situation where source cannot be attributed.

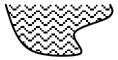
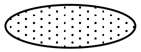
Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
P-1	Liquid phase related		
P1-a	Dense Non-Aqueous Phase Liquid (DNAPL [a])) in permeable soil. (bulk density > water)	Spreading of liquids due to gravity flow resulting in a characteristic spreading pattern. The DNAPL's laying of the botom of an aquiffer can result in a 'secondary source' of spreading of type P-2)	
P1-b	Light Non-Aqueous Phase Liquid (LNAPL [b])) in permeable soil. (bulk density < water)	Spreading of liquids in a characteristic spreading pattern of floating layers. The LNAPL's laying at the top of a water table can result in a 'secondary source' of spreading of type P-2)	
P-2	Leached or dissolved contaminants		
P-2	Groundwater contamination	Due to spreading of leachate or mobile dissolved contaminants in a permeable soil	

a) *A dense non-aqueous phase liquid or DNAPL is a liquid that is both denser than water and is immiscible in or does not dissolve in water. The term DNAPL is used primarily by environmental engineers and hydro geologists to describe contaminants in groundwater, surface water and sediments. DNAPLs tend to sink below the water table when spilled in significant quantities and only stop when they reach impermeable bedrock. Their penetration into an aquifer makes them difficult to locate and remediate. Examples of materials that are DNAPLs when spilled include chlorinated solvents or creosote.*

b) *Light Non-Aqueous Phase Liquid (LNAPL) is a groundwater contaminant that is not soluble and has a lower bulk density than water, which is the opposite of DNAPL. Once LNAPL infiltrates through the soil, it will stop at the water table. The effort to locate and remove*

LNAPL is relatively cheaper and easier than DNAPL because LNAPL will float on top of the water in the underground water table. Examples of LNAPLs are gasoline and other hydrocarbons.

Table T2 Key to icons in table T1

Icon	Key
	Solid waste or solid waste mixed with soil (all solid phase). Varying in shape, thickness and extent, depending on local conditions.
	Groundwater table Base of aquifer / top of impermeable layer.
	Liquid waste. Pure or mixed with soil.
	Leaching / spreading of contaminants to soil / groundwater. Depending on permeability of the soil.
	Contaminated groundwater plume. Depending on permeability of the soil.
	DNALP or LNAPL.
	Spill / leakage.
	Not soil related human activity / construction e.g. industrial process, storage, bulk transfer.

Appendix E SIP Form

MINISTRY OF ENVIRONMENT AND FORESTS

SITE INSPECTION FORM - TEMPLATE

ADDRESS COWI A/S
Parallelvej 2
2800 Kongens Lyngby
Denmark

TEL +45 56 40 00 00
FAX +45 56 40 99 99
WWW cowi.com

SITE ID:
SITE NAME:
STATE:
STATUS:

CONTENTS

PROJECT NO.	P-46909-D-15
DOCUMENT NO.	00
VERSION	04
DATE OF ISSUE	March 21, 2013, rev. July 8 2014, November 15 2014, 23 January 2015 (Final version)
PREPARED	B.v.d.Enden
CHECKED	Torben Jørgensen
APPROVED	Søren Viegand

1 Existing and general information (to be filled in before Site Inspection)

Data sheet no. #		
1.	**General Site Information**	
1.0	State Name	
1.1	ID number (State-district-xx)	
1.2	Site Name	
1.3	Address (Street, Street number, postal code)	
1.4	GPS coordinates /and elevation (x, y coordinates of the corners of perimeter) - (The coordinates should be written in Geographic latitude and longitude (North and East) for use in India throughout the report) (add more points if required)	Location of coordinates is shown on map in section 6
1.4.1/ 1.4.2	1	X: Y:
	2	X: Y:
	3	X: Y:
	4	X: Y:
1.4.3	Altitude (m above sea level)	
1.6.1	Who is the current owner (name and address)	
1.6.2	Who was the previous owner (name and address)	
1.6.3	What is the current status of contact with owner	1=Owner known and in communication with regulator; 2=Owner known but not available/communicating; 3=Owner not known
	Site Access (yes/no, any restrictions?). Will the Consultant have access to the site for field investigations	
	Contact person	
	Phone number	
	What are the available dates / hours to visit the site?	
	Are safety measures required by the owner of the site? If so, which safety measures? Are there any known dangers which a visitor should be aware of like unstable buildings and structures, toxic liquids, holes etc.).	
	Is there a permission to visit / investigate the whole site?	
1.10 + 1.11	**Historical review and overall Site description** Describe historical information about the site (industrial activities, including maps of features of these sites e.g., production area, storage area, underground storage tanks, information on reported spills/dumping etc. Give an overall description of the site including a clear description	

Data sheet no. #		
	of the type of site e.g.: i) is the site a point site with former or ongoing industrial activities on the site; ii) is the site an industrial area (with cluster of industries = Area Site) with no clear source of contamination); iii) is the site an area (e.g. waste land/water body/habitation area) where contamination has been spread via effluent or dumping of waste from an industry (or number of industries) which is placed outside the site boundary. Specify if there are any uncertainties with the Site Definition.	
1.16	Extend of data available (if any).	 A=Almost no information; B=Desk top study performed but no primary data; C=Site investigations performed an primary data available; D=Ongoing remediation; E=Other (specify).
1.17	Previous or ongoing remediation activities (if any)	
2.	**Source of contamination and waste characteristics**	
2.7.1	Give a brief summary of previous investigations performed at the site and in the vicinity (if any). Describe results of soil, air, groundwater and surface water on/off the site (if any). Analysis results should be included. For soil analysis max concentrations in should be reported if possible distinguish between top soil and deeper soil contamination. Depth must always be specified. For groundwater data depth of sample should be reported.	
2.7.2	Compare primary data with SSLs and Response Levels. Calculate the over standard ratio of the maximum concentration level compared to the screening value.	
3.	**Groundwater use and characteristics**	
3.1	Geology at the site. Give an overall description.	 Broad description of the typical stratigraphical sequences from topsoil to deepest aquifer. Based on earlier studies and / or general knowledge.
3.2.1	Hydrogeology - Overall description.	 Describe the depth of aquifers which is relevant for migration of contamination and drinking water/irrigation. The aquifers can be secondary/shallow aquifers and deeper aquifers (primary aquifers). Also, describe soil type of aquifers (sand, clay, bedrock, other) based on earlier studies and / or general knowledge.

Data sheet no. #		
3.2.2	Hydrogeology - Groundwater flow direction	Describe direction for each aquifer(if any information).
10.	**Overall Location and site description**	

#: refer to category in Data Sheet

2 Overall assessment of data and data gaps (assessed before Site Inspection based on desktop study)

Item	
Assessment of available data (e.g. analytical results). Can existing data be used to assess present contamination at the site?	
What are the Chemicals of Concern (CoCs)?	
What are the data gaps? (Description of site, location of site, etc.)	
Give an initial assessment of the samples to be taken (soil, groundwater, surface water, other?)	
What are the focus points during the Site inspection?	
Identify important stakeholders who should participate in the Site Inspection	

3 On site Reconnaissance

Date and time of site visit	...
Site investigation conducted by	... .
Spoken with	... ...
Weather conditions during visit	...

Data sheet no.				
1. #	**General site information**			
1.15	Operational status			
		1 = Active/ongoing; 2 = Closed; 3 = Abandoned; 4 = Other (specify)		
1.5.1	What is the current land use?	...		
1.5.2	What was the previous land use?	...		
1.5.3	What is the future land use (planned)	...		
		1 = Agricultural land; 2 = Waste land; 3 = Water bodies; 4 = Forests; 5 = Habitation settlement (Residential/School/Kindergarten); 6 = Commercial; 7 = Industrial, 8 = Mixed (to be specified for each case) and 9 = Other (to be specified in each case)		
1.7	Name(s) of polluter(s)			
		E.g. Name and address of industry, institution or person who caused the contamination		
1.8	Approximate area of site (m2)	...	m2	
	Built-up area (m2 or percentage of total)	...	%	
	Paved area (m2 or percentage of total)	...	%	
	Non-paved area (m2 or percentage of total)	...	%	

Data sheet no.			
1.9	Topography		
		1 = Water; 2 = Plains; 3 = Mountains; 4 = Hills; 5 = Any other (specify)	
1.10	Type of site		
		1 = “Point”site (single industry/dumpsite); 2 = ”Area”site(Industrial area or estate (cluster); 3 = Any other (specify)	
1.12	Industry type (which have caused contamination)	...	
		(select from Basetable 4 of the Data sheet in Annex F)	
1.13	Period of operation/contamination (year)	...	
		Enter period of operation (from – to) Period of contamination (from – to) based on available information	
1.14	Is the site classified before or after the development of HW rules in 1989 (Before / After)		
2.	**Source of contamination and waste characteristics**		
	Are there dump sites present? Describe	yes / no	....
2.1.1	Physically state of waste as deposited		
		1 = Solid, 2 = Sludge, 3 = Powder, 4 = Liquid, 5 = Gas, 6 = unknown, 7 = Any other (specify)	
2.1.2	Origin of the deposit		
		1 = dump, 2 = leakage, 3 = fluviatile deposit (sediment), 4 = areal deposit, 5 = storage, 6 = Effluent (wastewater) 7 = Any other (specify)	
2.1.3	Position in soil/effluent		
		1 = On the surface; 2 = In the soil; 3 = In effluent (wastewater); 4 = Any other (specify)	
2.1.4	Is there visual contamination		
		Describe visual contamination in soil; groundwater; surface water; effluent	
2.1.5	Is there vegetation stress		

Data sheet no.					
		Describe any sign of vegetation stress			
2.1.6	Area of contaminated soil				
		Area of the above source or area of HW deposited			
2.1.7	Volumen of contaminated soil				
		m3 / mt (source in soil or HW deposited)			
2.1.8	Is the source area delineated				
2.1.9	Area of contaminated groundwater				
		If plume is delineated assess the area of the plume (lengt (m), widht (m) area (m2)			
2.2	Type of contamination according to definition from MoeF				
		1 = Effluent; 2 = Air; 3 = Municipal Solid Waste; 4 = Bio-medical Waste; 5 = Hazardous Waste; 6 = Ship Break Waste; 7 = Any other (specify)			
2.3	"Industrial processes" which caused the contamination (According to Base table 5 of the Data sheet in Annex F)	...			
2.4	Type of hazardous waste				
		According to Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.) - select from Basetable 6 of the Data sheet in Annex F			
2.5	Hazardous Waste Constituents				
		According to Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.) - select from Basetable 7 4 of the Data sheet in Annex F			
2.6	What are the COC's? (use UBI Appendix C)	...			
	What potential sources of contamination are present? Quantify as much as possible (area and/or volume) Describe	....			
	Are there storage tanks present at the site? Specify number, sub surface or on	yes / no	... (number)	sub surface / on surface / both	content

Data sheet no.					
	surface, content (chemical) (If specification is available, please add)				
	Is there visible soil contamination present?	yes / no		Take 1 to 2 samples of most contaminated sites	
	What is the level (intensity) of visible soil contamination?	low / medium / high impact		Take photo	
	What is the scale of visible soil contamination? (percentage of total site size)	< 10% / 10 - 50% / >50%			
	Are the buildings visibly contaminated?	yes / no / NA			
	What is the level (intensity) of the building/ infrastructure visible contamination?	low / medium / high impact / NA		Take photo	
	What is the scale of the visible building/ infrastructure contamination? (percentage of total buildings/ infrastructure)	< 10% / 10 - 50% / >50% / NA			
	Are there materials present which might contain asbestos? (corrugated roofing panels				
	Is the present contamination local (hot spot) or diffuse?	hot spot / diffuse / both / none			
3.	**Groundwater use and characteristics**				
3.2.3	Hydrogeology - Depth to water table (m below subsurface, use wet season estimate).				
		Describe the depth to the water table for each aquifer. Based on local knowledge or information from Ground water Authorities or data from Site Inspection			
3.3	Current and future expected use of any aquifer for groundwater use				
		Describe current and future planned use of any aquifer			
3.4	Is the site within a groundwater recharge zone				
		1 = Area with special drinking water interest (i.e. major aquifer/potable water supply)			

Data sheet no.				
		2 = Areas with drinking water interest (aquifer with major aquifer potential) 3 = Areas with borderline drinking water interest (minor aquifer/ non potable water		
	Are there groundwater wells present on site? If so what use (consumption / domestic / industrial), what yield?	yes / no	consumption / domestic / industrial	**Take photo**
	Are there indications of groundwater pollution; e.g. smelling wells. If yes, what is the level (intensity) of groundwater contamination (if noticeable)?	yes / no / NA	...	**Take sample**
4.	**Surface water use and characteristics**			
4.1	Any drainage system (run off system) on site	... General description of (drain, trenches, streams) or streams at the site which can transport the contamination outside the premise to surface water bodies		
4.3	Type of Surface water Body	1 = Pond (less than 1 hectare), 2 = Small lake (1-10 hectares), 3 = Large lake (more than 10 hectares), 4 = Small river/stream, 5 = Large river, 6 = Wetland, 7 = Other (specify if possible)		
4.4	Any sensitive use of surface water	1 = Drinking Water, 2 = Irrigation, 3 = Use in commercial food production, 4 = Water recreational area (e.g. bathing, marina), 5 = Fishing, 6 = Other (specify if possible)		
4.6	Are there signs of flooding? Describe	yes / no	...	
	If so, what is the water table to the surrounding surface? (m below ssl)	... m - ssl		
	Is there any discharge to the surface water visible? Describe	yes / no / NA	...	**Take photo** **Take sample**
	Is the surface water visibly contaminated? Describe	yes / no / NA	...	**Take photo**

Data sheet no.				
5.	**Soil exposure characteristics**			
5.1.1	Access to the site from local communities			
		1 = Site secured and access controlled 2 = Site not secured but access limited 3 = Open site with regular public activity, 4 = Other (specify)		
5.1.2	Is there inhabitation on the site? If so how many people? How many children?	yes / no	... (number)	... (number)
5.1.3	How many workers are working on site? (Number)	...	Remarks: ..	
5.1.4	Specify other activities if any	...		
	Is there agricultural use at the site (crop growing / keeping of domestic stock)? Describe	yes / no	...	
6.	**Air exposure characteristics**			
6.1	What are the prevailing wind directions?	N / NE / E / SE / S / SW / W / NW / unknown		
	Is there a noticeable (smell) /bad air quality at the site? Dust visible? Describe	yes / no	...	

#: refer to category in Data Sheet

4 Off site Reconnaissance

Data sheet No #				
3.	**Groundwater use and characteristics**			
	Are there groundwater wells present? If so what use (consumption / domestic / industrial).	yes / no	consumption / domestic use / industrial	**Take photo** **Take sample if notice-able pollution is present**
3.5.1	Private wells (distances to nearest well and approximate number of wells within 1 km from the site)	... meters	... (number)	
3.5.2	Public wells (distances to nearest well and number of wells within 1 km from the site)	... meters	... (number)	
4.	**Surface water use and characteristics**			
4.1	Any drainage system (run off system) outside the site	... General description of (drain, trenches, streams) or streams at the site which can transport the contamination outside the premises to surface water bodies		
4.2	Name and distance to nearest surface water body (m)			
4.3	Type of Surface water Body	1 = Pond (less than 1 hectare), 2 = Small lake (1-10 hectares), 3 = Large lake (more than 10 hectares), 4 = Small river/stream, 5 = Large river, 6 = Wetland, 7 = Other (specify if possible)		
4.4	Any sensitive use of surface water	1 = Drinking Water, 2 = Irrigation, 3 = Use in commercial food production, 4 = Water recreational area (e.g. bathing, marina), 5 = Fishing, 6 = Other (specify if possible)		
	Is there surface water directly next to the site? If so, what type	yes / no	...	
	What distance is the water table to the surrounding surface? (m below ssl)	... m - ssl		
	Is there visible discharge from	yes / no / NA	...	**Take photo**

	the site visible? (Describe)			**Take sample**
	Is the surface water visibly contaminated? (Describe)	yes / no / NA	...	**Take photo and take sample**
4.5	What is the distance to sensitive environments and Wetlands (m)? (Describe)	... meters	...	
5.	**Soil exposure characteristics**			
5.2.1	What is the land use in the vicinity of the site?	1 = Agricultural land; 2 = Waste land; 3 = Water bodies; 4 = Forests; 5 = Habitation settlement (Residential/School/Kindergarten0; 6 = Commercial; 7 = Industrial, 8 = Mixed (to be specified for each case) and 9 = Other (to be specified in each case)		
	North	...		
	East	...		
	South	...		
	West	...		
	Are there crops grown next to the site? (Describe)	yes / no	...	**Take photo**
	Is there domestic stock present next to the site?	yes / no	...	**Take photo**
5.2.2	What is the distance to the nearest habitation? (Describe)	... meters	...	**Take photo**
	Approximate number of people living within 100 meter	... (number)		
5.2.3	Approximate number of people living within 1 km	... (number)		
5.2.4	What is the distance to other sensitive activities e.g. schools, nursery, allotments (m)? (Describe)	... meters	...	
7.	**Socio economic aspects**			
7.1	Describe general socio economic conditions			
		E.g. employment rate, in-come, rate woman/man, rate in age, population density, occupation,		

		alphabetise, religion, value of site/buildings, possibilities of temporary site clearance, social sensibility land user(s),
7.2	Drinking water source	…
		Describe drinking water source (e.g. public water supply based on groundwater) for the population in he vicinity of the site (within 1 km)

#: refer to category in Data Sheet

5 Miscellaneous

1.18	**Complaints**: List any other pending complaints, claims, liabilities, non-compliances, conversations with site personnel or neighbours and other relevant matters related to soil and groundwater pollution aspects
	Data gaps: List major (if any) data gaps or uncertainties which still occur after the conducted Site Inspections (e.g. insufficient information about geology/hydrogeology)
	Emergency response considerations: List observed conditions that may warrant immediate or emergency action (e.g. heavely contaminated groundwater/surface water used for drinking water, unrestricted public access to exposed hazardous substances etc.).

6 SITE map

Requested information on the site map. If necessary more than one maps can be shown in various scaling:

- Site boundary
- Point with GPS coordinates (with same ID as in section 1.4)
- Sampling location for **all** samples
- Land use (at the site and in the vicinity of the site)
- Location of observed "Source areas"
- Location of points of interests e.g. groundwater wells, surface water bodies
- Photos taken (if possible)
- Scale of map (use scaling bar)
- North arrow

7 Sampling

Site ID + number	soil / water	Date for sampling	Targeted or composite	Location (description and GPS coordinates if available)	Parameters analysed	Motivation of sampling *
1.						
2.						
3.						
4.						

*: Motivation (e.g. visible contamination, source area). Must also include information about landuse (only soil) and location of sample (inside/outside the site)

8 Draft Conceptual site model (CSM)

Based on the available information provide a sketch of the site's Conceptual Site Model:

9 Photographic Record

Number	Description	Location

10 Overview of analysis results from sampling

Soil samples (template – to be modified for the specific analysis programme)

Sample ID		xx	xx	xx	Detection Limit	Screening Level (soil)				Response level (soil)
						Agricul-tural	Residential /parkland	Commer-cial	Industrial	
Depth	m bgs									
Date for sampling (day-month-year)										
Arsenic	mg/kg					12	12	12	12	50
Cadmium	mg/kg					1,4	10	22	22	13 (22#)
Chromium (VI)	mg/kg					0,4	0,4	1,4	1,4	50
Chromium – total	mg/kg					64	64	87	87	180
Cyanide	mg/kg					0,9	0,9	8	8	50
Lead	mg/kg					70	140	260	600	530 (600#)
Mercury	mg/kg					6,6	6,6	24	50	36 (50#)
xx	mg/kg					xx	xx	xx	xx	xx

#: If Screening Level for the current land use exceeds the Response level then the Screening level should be used

Bold: Concentration exceeds Screening values for the current land use at the site

<u>Bold and underline</u>: Concentration exceeds Response Level

na: Not analyzed

Groundwater samples (template – to be modified for the specific analysis programme)

Sample ID		xx	xx	xx	Detection Limit	Drinking water standards		
						Indian Standard for Drinking Water ¤	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water
Depth of sample	m bgs							
Depth to water table	m bgs							
Date for sampling (day-month-year)								
Arsenic	mg/l					0,01		
Cadmium	mg/l					0,003		
Chromium (VI)	mg/l					0,05	-	-
Chromium – total	mg/l					-	0,05	0,05
Cyanide	mg/l					0,05		
Lead	mg/l					0,01		
Mercury	mg/l					0,001		
xx	mg/l					xx	xx	xx

¤: (IS: 10500:2012) Maximum acceptable concentration)

Bold: Concentration exceeds Drinking water standards

na: Not analyzed

Surface water samples (template – to be modified for the specific analysis programme)

Sample ID		xx	xx	Detection Limit	Surface water Quality Standards (Screening levels)					
					The Environment (Protection) Rules, 1986 Schedule VI. General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of Aquatic Life	Canadian Water Quality Guidelines for the protection of Agriculture
Date for sampling (day-month-year)					Inland surface water	Public sewers	Land for irregation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
Arsenic	mg/l				0,2	0,2	0,2	0,2	0,005	0,1/0,025
Cadmium	mg/l				2	1	-	2	Equation	0,0051/0,08
Chromium (VI)	mg/l				0,1	2	-	1	0,001	0,008/0,05
Chromium – total	mg/l				2	2	-	2	0,0089	0,0049/0,05
Cyanide	mg/l				0,2	2	0,2	0,2	0,005 (free CN)	-/-
Lead	mg/l				0,1	1	-	2	Equation	0,2/0,1
Mercury	mg/l				0,01	0,01	-	0,01	0,026	-/-
xx	mg/l				xx	xx	xx	xx	xx	xx
xx	mg/l				xx	xx	xx	xx	xx	xx

Bold: Concentration exceeds Surface Water Quality Standards

na: Not analyzed

11 Overall assessment of pathways, exposure, impacts and contamination, site classification

Data sheet No #		
8.	**Pathways, exposure impacts and risk from contamination**	
8.1	Potential/observed pathways for spreading of contaminants at the site	 1 = Groundwater pathway, 2 = Surface Water pathway, 3 = Soil exposure pathway, 4 = Air pathway 5 = Any other (specify)
8.2	Potential/observed exposure to contaminants	 1 = Direct human contact, 2 = Ingestion (soil, food) 3 = Groundwater use (Drinking water, Irrigation), 4 = Inhalation of polluted air/dust, 5 = Surface water use (drinking water, bathing, fishing), 6 = Sensitive environments, 7 = Other (specify)
8.3	Describe observed impacts (if any)	 E.g. observed impacts on humans, animals, flora, fauna
8.4	Estimation of population at risk (see Appendix B) <1000 1.000 – 5.000 5.000 – 10.000 10.000 – 20.000 20.000 – 50.000 50.000 – 100.000 100.000 – 200.000 200.000 – 500.000 >500.000	Specify

Data sheet No #		
9.1/ 9.2/ 9.3	Typology of contaminated site according to standard, see Appendix D (Note that more than one typology can be applicable): **S-1 Soil Phase contamination (land bound site):** (Subdivided into S1 – a; S1 – b; S1 – c; S1 – d; S1 – e; S1 – f) **S-2 (Solid Phase contaminations (water bound site)** **L-1 (Liquid phase contaminations)** (Subdivided into L1 – a; L1 – b; L1 – c; 1 – d) **P-1 Liquid phase related** (Subdivided into P1 – a; P1 – b) **P-2 Groundwater contamination** (Leached or dissolved contaminants) Specify overall typology, and if possible also subdivision of typology	
	Assessment of contamination from Site Inspection (based on analytical results from Site Inspection – see Section 10 and 12) (Specify most critical contaminants, specify if concentrations exceeds SSLs and Response Levels) If lack of data, include results from previous investigations (if any)	Soil: Groundwater: Surface water:
	Conclusion and recommendations: Assess whether or not the site meets the definition of contaminated site. Describe recommendation for the next step in the assessment and remediation process. If the information is to insufficient to draw a conclusion a recommendation for further investigation should be provided.	

#: refer to category in Data Sheet

12 Analytical Test Report

13 Field logbook from sampling

14 References

Appendix F Data sheet - template

Overall Topic	No	Topic		Explanation	Actual description
1. Generel site information	1.0	**State name**			
	1.1	**ID number** *(State-district-xx)*			
	1.2	**Site Name**			
	1.3	**Adress**		*Street, Street number, Postal code, City*	
	1.4.1	**GPS coordinates /and elevation**	Latitude (enter as decimal)	*X, Y and Z coordinates in center of the site)*	
	1.4.2		Longitude (enter as decimal)		
	1.4.3		Altitude (m above selevel)		
	1.5.1	**Land use**	*Current landuse*	*1 = Agriculture land, 2= Waste land, 3 = Water bodies, 4 = Forests, 5. Habitation settlement (Residential/School/Kindergarten), 6 = Commercial, 7 = Industrial, 8 = Mixed (to be specified for each case) and 9 =. Other (to be specified in each case)* ***(Basetable 1)***	
	1.5.3		*Future landuse (planned)*		
	1.6.1	**Owner**	*Current owner (name and adress)*		
	1.6.3		*Contact with owner*	*1 = Owner known and in communication with regulator 2 = Owner known but not available/communicating 3 = Owner not known*	
	1.7	**Name(s) of Polluter(s)**		*E.g. Name and adress of Industry, Institution or person who caused the contamination*	
	1.8	**Approximate area of site** *(m2)*			
	1.9	**Topography**		*1 = Water, 2 = Plains, 3 = Mountains, 4 = Hills, 5 = Any other (specify)*	
	1.10	**Type of Site ("Point" site or "Area" site)**		*1 = "Point" site (Single industrial site/dump site), 2 = "Area" site Industrial area or estate (cluster) 3 = Any other (specify)* ***(Basetable 2)***	
	1.11	**Historical review**		*Describe historical information about the site (Industrial activities, including maps of features of thes site e.g. production area, storage area, underground storage tanks, information about reported spills / dumping, etc.*	
	1.12	**Industry Type (which have caused contamnation)**		*Select from* ***Basetable 4*** *:* *The list is by no means exhaustive and is provided as a guide only. Where one or more of the activities on the list has been undertaken at the site, the site is not necessarily contaminated but there is an increased risk of contamination being present)*	
	1.13	**Period of operation/contaminating**		*Enter beginning year and end year e.g. 1988 - 1995*	
	1.14	**Is the site classified before or after the development of HW rules in 1989**			
	1.15	**Operational status**		*1 = Active/ongoing, 2 = Closed, 3 = Abandoned, 4 = Other*	
	1.16	**Extent of data avaliable**		*A = almost no informations, B = Desk top study performed but no primary data , C = Site investigations performed and primary data avaliable, D = Ongoing Remediation, E = Other (specify)*	
	1.17	**Previous or ongoing remediation activities (if any)**		*Specify activities and references*	
	1.18	**Any complaints regarding the contamination**		*Specify any complaints from e.g. site owner, neighbours, NGOs e.t.c.*	
2. Source of contamination and waste characteristics	2.1.1	**Source characteristic**	Physically state of waste as deposited	*1 = Solid, 2 = Sludge, 3 = Powder, 4 = Liquid, 5 = Gas, 6 = unknown, 7 = Any other (specify)*	
	2.1.2		Origin of the deposit	*1 = dump, 2 = leakage, 3 = fluviatile deposit (sediment), 4 = areal deposit, 5 = storage, 6 = Effluent (wastewater) 7 = Any other (specify)*	
	2.1.3		Position in soil/effluent	*1 = On the surface, 2 = In the soil, 3 = In effluent (wastewater), 4 = Any other (specify)*	
	2.1.4		Is there visual contamination	*Describe visual contamination in soil, groundwater, surface water, effluent*	
	2.1.5		Is there vegatation stress	*Describe any sign of vegatation stress*	
	2.1.6		Area of contaminated soil	*Area of the above source or area of HW deposited*	
	2.1.7		Volumen of contaminated soil	*m3 / mt (source in soil or HW deposited)*	
	2.1.8		Is the source area deliniated?		
	2.1.9		Area of contaminated groundwater	*If plume is deliniated assess the area of the plume (lengt (m), widht (m) area (m ^{2})*	
	2.2	**Type of contamination according to definition from MoeF**		*1 = Effluent, 2 = Air, 3 = Municipal Solid Waste, 4 = Bio-medical Waste, 5 = Hazardous Waste, 6 = Ship Break Waste, 7 = Any other (specify)* ***(Basetable 3)***	
	2.3	**"Industrial processes" which caused the contamination**		*According to schedule 1 - Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008) -* ***select from basetable 5***	
	2.4	**Type of hazardous waste**		*According to Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.) -* ***select from basetable 6***	
2. Source of contamination and waste characteristics	2.5	**Hazardous Waste Constituents**		*According to Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008.) -* ***select from basetable 7***	
	2.6	**Contaminants of concern - CoC - (chemical name(s)**		*Multiple contaminants can be selected). Select from* ***Basetable 8***	
	2.7.1	**Information on previous sampling and analysis (Primary data)**		*Give a brief* ***summary of previous investigations*** *performed at the site and in the vicunity (if any). Describe results in soil, air, groundwater and surfacewater on/off the site (if any). Analysis results should be included.*	
	2.7.2			*Primary data from the site should be compared to Screening Levels (SSLs) and Response Levels (RL) for the most critical chemical constituent (e.g. Cr(VI)*	

Overall Topic	No	Topic		Explanation	Actual description
3 Groundwater use and characteristic	3.1	**Geology at the site**	Overall description	*Broad description of the typical stratigraphical sequences from topsoil to deepest aquifer. Based on earlier studies and / or general knowledge).*	
	3.2.1	**Hydrogeology at the site**	Overall description	*Describe the depht of aquifers which is relevant for migration of contamination and drinking water/irregation. The aquifers can be secondary/shallow aquifers and deeper aquifers (primary aquifers).* *Also describe soil type of aquifers (sand, clay, bedrock, other) based on earlier studies and / or general knowledge)*	
	3.2.2		Groundwater flow direction	*Describe direction for each aquifer(if any information)*	
	3.2.3		Depth to water table *(m below subsurface).*	*Describe the depht to the water table for each aquifer. Based on local knowledge or information from Ground water Authorities or data from Site Inspection*	
	3.3	**Current and future expected use of any aquifer for groundwater use**		*Describe current and future planned use of any aquifer*	
	3.4	**Is the groundwater used for drinking water**		*1 = Major use of groundwater for drinking water purpose* *2 = Moderate use of groundwater for drinking water purpose* *3 = No use of groundwater for drinking water purpose* *4 = No information* *Select from **Basetable 9***	
	3.5.1	**Drinking water intakes**	Private wells	*Specify distances to nearest well and approximate number of wells within 1 km from the site)*	
	3.5.2		Public Wells	*Specify distances to nearest well and number of wells within 1 km from the site*	
4 Surface water use and characteristics	4.1	**Any drainage system (run off system) on/outside the site**		*Genereal description of (drain, trenches, streams) or streams at the site which can transport the contamination outsite the premice to surface water bodies*	
	4.2	**Name and distance to nearest surface water body (m)**			
	4.3	**Type of Surface water Body**		*1 = Pond (less than 1 hectare), 2 =* *Small lake (1-10 hectares), 3 = Large lake (more than 10 hectares), 4 = Small river/stream, 5 = Large river, 6 = Wetland, 7 = Other (specify if possible)* ***Select from Basetable 10***	
	4.4	**Any sensitive use of surface water**		*1 = Drinking Water. 2 = Irrigation, 3 = Use in commercial food production, 4 = Water recreational area (e.g. bathing, marina), 5 = Fishing, 6 = Other (specify if posible)* ***Select from Basetable 11***	
		Any sensitive use of surface water within 1 km		*1 = Major use of surface water for sensitive use (use for Drinking Water, Irrigation, Livestock, Commercial food production, Water recreational, Fishing* *2 = Moderate use for sensitive purpose* *3 = No use for sensitive purpose* *4 = No information **Pick from Base Table 12***	
	4.5	**Distance to Sensitive Ecological areas (m)**		*E.g. Reserves, wetland*	
	4.6	**Any flooding (yes/no)**		*If any flooding describe frequency and type*	
5 Soil Exposure Characteristics	5.1.1	**Current activities on the site/access**	Access to the site from local communities	*1 = Site secured and access controlled 2 = Site not secured but access limited 3 = Open site with regular public activity, 4 = Other (specify) **Select from Basetable 13***	
	5.1.2		*People living on the site (yes/no) (if yes how many people)*		
	5.1.3		*Workers on facility (yes/no) (if yes how many workers at the site)*		
	5.1.4		*Other Activities (if any)*		
	5.2.1	**Activity in the vicinity of the site**?	*Land use in the vicinity of the site*	*Use Land Use categorisation from section 1. Desribe any relevant Industrial faclitities close to the site which also may cause contamination*	
	5.2.2.		*Distance to nearest habitation*	*Distance in m*	
	5.2.3		*Approximate Population within 1 km from the site*		
	5.2.4		*Distance to other sensitive activities (m)*	*E.g. Schools, parkland, agriculture*	
6. Socio economic aspects	6.1	**Describe general socio economic conditions**		*E.g. employment rate, in-come, rate woman/man, rate in age, alphabetisme, religion, value of site/buildings, possibilities of temporary site clearence, social sensibility land user(s)*	

<table>
<tr><th>Overall Topic</th><th>No</th><th colspan="2">Topic</th><th>Explanation</th><th>Actual description</th></tr>
<tr><td rowspan="5">7. Pathways, exposure, impacts and risc from contamination</td><td>7.1</td><td colspan="2">Potential/observed pathways for spreading of contamination at the site</td><td>1 = Groundwater pathway, 2 = Surface Water pathway, 3 = Soil exposure pathway, 4 = Air pathway 5 = Any other (specify)</td><td></td></tr>
<tr><td>7.2</td><td colspan="2">Potential/observed exposure to contaminants</td><td>1 = Direct human contact, 2 = Ingestion (soil, food) 3 = Groundwater use (Drinking water, Irregation), 4 = Inhalation of polluted air/dust, 5 = Surface water use (drinking water, bathing, fishing), 6 = Sensitive environments, 7 = other (specify)</td><td></td></tr>
<tr><td>7.3</td><td colspan="2">Describe observed impacts (if any)</td><td>E.g. observed impacts on humans, animals, flora, fauna</td><td></td></tr>
<tr><td>7.4</td><td colspan="2">Total population at risk</td><td>According to approach describe din Site Inspection Protocol</td><td></td></tr>
<tr><td>7.5</td><td colspan="2">Risc Score from Blacksmit Insitute</td><td>Enter BI risc score (if included in the BI database)</td><td></td></tr>
<tr><td rowspan="3">8. Typology</td><td>8.1</td><td rowspan="3">Specify typology</td><td>Source Related:
Type S1 and Type S2</td><td rowspan="3">Select from note 6.
S1 = Solid phase contamination (land bound site)
S2 = Solid phase contaminations (water bound site)
L = Liquid phase contaminations
P1 = Liquid phase related
P2 = Leached or dissolved contaminants
Notice that a site may fit into more than one of these types). If possible specify subtypes as defined in Basetable 14</td><td></td></tr>
<tr><td>8.2</td><td>Source related: Type L</td><td></td></tr>
<tr><td>8.3</td><td>Pathway related:
Type P1 and Type P2</td><td></td></tr>
<tr><td>9. Overall description</td><td>9.1</td><td colspan="2">Overall Location and site description</td><td>For BI sites enter "Abstract" and part of "Location and site description" and/or "abstact". For other sites use summary from existing reports (if any)</td><td></td></tr>
<tr><td rowspan="5">10. Site Stakeholders and arguments for identifying the site as a probably contaminated site</td><td>10.1</td><td colspan="2">Site Stakeholders</td><td>(Specify contactperson for this partiular site: e.g. Goverment Environmental Agency, Municipal Authority, NGO/community Agency, Local Health Facility Director, Busines/Coorporate Agency, other Agencies)</td><td></td></tr>
<tr><td>10.2</td><td colspan="2">Name of institution which appointed the site as a "potentially" contaminated"</td><td>Based on our datacollection in Task 1. Point out Institution(s) (E.g. SPCBs, CPCB, BI, NGOs etc) and contact person</td><td></td></tr>
<tr><td>10.3</td><td colspan="2">Reasons on why the site has been appointed as contaminated /probably contaminated site</td><td></td><td></td></tr>
<tr><td>10.4</td><td colspan="2">Comments of SPCBs on the information that thes site is appointed as a probably contaminated site</td><td></td><td></td></tr>
<tr><td>10.5</td><td colspan="2">Confirmed by SPCB, CPCB as a probably contaminated sites or SI has been performed by COWI</td><td></td><td></td></tr>
<tr><td rowspan="2">11.Risc</td><td>11.1</td><td colspan="2">Total population at risc</td><td></td><td></td></tr>
<tr><td>10.6</td><td colspan="2">Blacksmith Institute Risc score</td><td></td><td></td></tr>
<tr><td rowspan="2">12. References</td><td>12.1</td><td colspan="2">Specify references that describe previous studies performed at the site</td><td>According to "List of references"</td><td></td></tr>
<tr><td>12.2</td><td colspan="2">Site ID from Blacksmith Institute</td><td>Enter BI site ID (if included in BI database)</td><td></td></tr>
</table>

Appendix G Draft Screening and Response Levels

The laboratory testing will result in a list of concentration levels for various parameters / substances. These concentration levels have to be compared with the Screening Levels and the Response Levels

A complete List of Screening Levels and Response Levels are shown in Appendix G.

Screening and Response Levels are important to assess the level of contamination.

- Screening Levels are generic concentrations of hazardous substances in soil, sediment, groundwater and surface water, at or below which, potential risks to human health or the environment are not likely to occur and where no further investigation and assessment is needed;

- Response Levels are generic concentrations of hazardous substances in soil and sediments, at or above which, it is very likely there is an imminent threat to human health or the environment. At or above this level some form of response is required to provide an adequate level of safety to protect public health and the environment.

Below, in Appendix Figure 1, the levels are schematically shown indicating the risk they represent and related actions to be taken.

Assessment	Level of risk / Actions to be taken
Hazardous substances exist at levels which may pose existing or imminent risk to human and environment	Unacceptable risk. Further site actions required (investigation, remediation or precautionary measures)
Response Level	
Hazardous substances exist at levels where existing or imminent risk to human and environment is not likely to occur (related to a certain type of land use)	Acceptable risk at current land use. Further investigation needed
Screening Level	
Hazardous substances have not been detected or exist at levels where risk for human and environment are likely to be negligible (related to a certain type of land use)	No risk at current land use. No action at current land use

Appendix Figure 1 Overview of Screening and Response Levels related to risk and actions

Risk levels versus site categorization according to the definition is schematically shown in the figure below. The relation between the definitions of (probably) contaminated sites and the determination of specific Screening/Response Levels can be deducted as follows:

Risk levels and site categorization

Screening Levels

Assessing soil contamination

In India, there are no specific levels for assessing soil contamination. The Canadian CCME Environmental Quality Guidelines will be used as preliminary screening levels in the Indian situation. Four categories of land use are distinguished:

- Agricultural
- Residential/Parkland
- Industrial
- Commercial.

In the table below, we show how to correlate the form of land use from the Canadian Environmental Quality Guidelines with the land uses referred to by the MoEF.

Land use India (Referred to by the MoEF)	Land use in the Canadian Environemtal Quality Guidelines
Agricultural land	Agricultural (including water quality guidelines for agriculture)
Waste land	Industrial
Water bodies	For soil depending on land use
Forests	Residential/Parkland
Habitation settlements	Residential/Parkland
Industrial	Industrial, commercial
Mixed	Choose the most vulnerable land use
Other	Choose the most vulnerable land use

Background levels

In most cases, Screening Levels are well above the natural background levels. The natural background levels of metals and other inorganic chemicals can vary widely, and this should be taken into account when applying the assessment levels. Where it can be demonstrated that *natural* background concentrations are elevated (e.g. heavy metal concentrations in mineralised areas), it would be appropriate to develop less stringent assessment criteria. However, care needs to be taken when establishing the level of the natural background and its natural variation, as the local background level may be influenced by historic mining and/or waste disposal activities. Note that for certain contaminants such as Persistent Organic Pollutants, no background values should be used, as there is no natural background for these substances.

Assessing groundwater contamination

For groundwater, first the intended use (at present or in future) of the groundwater has to be established. Is it to be used for drinking water for humans, for drinking water for animals, for irrigation of crops, or for water in industrial processes? Depending on this, different screening levels can be set up. In India, there are no specific standards for groundwater levels beneath contaminated sites. However, there are specified standards for e.g. drinking water and water used for irrigation.

Groundwater used for drinking water

As Screening Levels for groundwater used for drinking water, the Indian drinking water values considered are as per IS 10500:2012 - (Second Revision) will be used. For contaminants not listed in this document, suggested screening values are taken from Canadian Standards. Where Canadian values are also unavailable, those from WHO are used.

Groundwater used for irrigation

As Screening Levels for groundwater used for irrigation, the current Indian Standard: “The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants” will be used. If there are no Indian standards for a specific compound, the Canadian Water Quality Guidelines for the Protection of Agriculture will be used, see Appendix B.

Assessing surface water contamination

As Screening Levels for assessing surface water impact from contaminated sites discharging waste water to surface water bodies, the Indian standards: “The Environment (Protection) Rules, 1986 Schedule VI, General standards for discharge of environmental pollutants” will be used. The values are divided into 4 categories: 1) Inland/surface 2) Public sewers 3) Land for irrigation and 4) Marine coastal. In general, these values are very high compared to international standards e.g. the Canadian Water Quality Guidelines for the protection of Aquatic Life.

If there are no Indian standards for a specific compound, the Canadian Water Quality Guidelines for the Protection of Aquatic Life will be used as Screening Levels, see Appendix C.

Response Levels

India has no specific levels for assessing soil contamination. Because of that, the Dutch intervention values, which are widely accepted worldwide, is used as response levels. Compared to the Canadian soil screening levels, the Dutch standards are in general a factor 3-10 higher (for sensitive land use e.g. agricultural and residential). However, it can be seen from the list in Appendix G that for some chemical substances the Dutch intervention values are lower that the Canadian screening levels. This is especial true, when comparing with screening values for non-sensitive land use (e.g. Industrial and Commercial land use). To overcome this issue, the response levels should always be the highest specified level in Appendix E. In one important case, the Dutch Intervention Value is higher than the level in the Hazardous Waste Rules, namely for hexavalent Chromium, and in this case the Response Level will correspond to the level in the Hazardous Waste Rule (50 mg/kg).

Chemical Name	Chemical Groups	**Hazardous Waste** (levels Schedule II, HW Rules, 2008)[1]	**Soil (Screening and Response Levels)**					**Groundwater for drinking water (Screening levels)**			**Surface water Quality (Screening levels)**					
			Response levels (Dutch Intervention levels)[2]	**Screening leves** Soil Quality Guidelines for the Protection of Environmental and Human Health				Indian Standard for Drinking Water * (Maximum acceptable concentra-tion)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commer-cial	Industrial				Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
1,1,1-Trichloroethane (TCA)	Halogenated aliphatic compounds	5000	15	0,1	5	50	50	-	-	-					-	-
1,1,2,2- Tetrachloroethene (PCE)	Halogenated aliphatic compounds	5000	8,8	0,1	0,2	0,5	0,6	-	0.03	0,04	-	-	-	-	110	-
1,1,2,2-Tetrachlorethane	Halogenated aliphatic compounds	5000		0,1	5	50	50	-			-	-	-	-	-	-
1,1,2-Trichloroethane	Halogenated aliphatic compounds	5000	10	0,1	5	50	50	-	-		-	-	-	-	-	-
1,1,2-Trichloroethene (TCE)	Halogenated aliphatic compounds	5000	2,5	0,01	0,01	0,01	0,01	-	0.005	0,02	-	-	-	-	21	-/50
1,1-Dichloroethane	Halogenated aliphatic compounds	5000	15	0,1	5	50	50	-	-		-	-	-	-	-	-
1,1-Dichloroethene	Halogenated aliphatic compounds	5000	0,3	0,1	5	50	50	-	0.014		-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	Halogenated aromatic compounds	50	2,2	0,05	2	10	10	-	-		-	-	-	-	1,8	-
1,2,3,5-Tetrachlorobenzene	Halogenated aromatic compounds	50	2,2	0,05	2	10	10	-	-		-	-	-	-	-	-
1,2,3-Trichlorobenzene	Halogenated aromatic compounds	50	11	0,05	2	10	10	-	-		-	-	-	-	8	-
1,2,4,5-Tetrachlorobenzene	Halogenated aromatic compounds	50	2,2	0,05	2	10	10	-	-		-	-	-	-	-	-
1,2,4-Trichlorobenzene	Halogenated aromatic compounds	50	11	0,05	2	10	10	-	-		-	-	-	-	24	-
1,2-Dichlorobenzene	Halogenated aromatic compounds	50	19	0,1	1	10	10	-	-	1	-	-	-	-	0,7	-
1,2-Dichloroethane	Halogenated aliphatic compounds	5000	6,4	0,1	5	50	50	0,003	0.005	0,003	-	-	-	-	100	-/5
1,2-Dichloroethene	Halogenated aliphatic compounds	5000	1	0,1	5	50	50	-	-	0,05	-	-	-	-	-	-
1,2-Dichloropropane	Halogenated aliphatic compounds	5000	2	0,1	5	50	50	-	-	0,04	-	-	-	-	-	-
1,2-Dichloropropene (cis and trans)	Halogenated aliphatic compounds	5000		0,1	5	50	50	-	-		-	-	-	-	-	-
1,3,5-Trichlorobenzene	Halogenated aromatic compounds	50		0,05	2	10	10	-	-		-	-	-	-	-	-
1,3-Dichlorobenzene	Halogenated aromatic compounds	50		0,1	1	10	10	-	-		-	-	-	-	150	-
1,4-Dichlorobenzene	Halogenated aromatic compounds	50		0,1	1	10	10	-	0.005	0,3	-	-	-	-	26	-
1,4-Dioxane		-		-	-	-	-	-	-	0,05	-	-	-	-	-	-
2,3,4,6-Tetrachlorophenol	Halogenated aromatic compounds	50		0,05	0,5	5	5	-	0.1		-	-	-	-	-	-
2,4,6-Trichlorophenol	Halogenated aromatic compounds	50		0,05	0,5	5	5	-	0.005	0,2	-	-	-	-	-	-
2,4-Dichlorophenol	Halogenated aromatic compounds	50		0,05	0,5	5	5	-	0.9		-	-	-	-	-	-
2,4-Dichlorophenoxyacetic acid (2,4-D)	Pesticides (Phenoxy herbicide)	-		-	-	-	-	0,03	-	0,03	-	-	-	-	-	-
3-Iodo-2-propynyl butyl carbamate	Pesticides, Carbamate	-		-	-	-	-	-	-		-	-	-	-	1,9	-
Acenaphthene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤	-	-		-	-	-	-	5,8	-
Acenaphthylene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤	-	-		-	-	-	-	-	-
Acridine	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤	-	-		-	-	-	-	4,4	-
Aldicarb	Pesticides, Carbamate	-		-	-	-	-	-	0.009	0,01	-	-	-	-	1	54,9/11
Aldrin	Pesticides, Organochlorine	50	0,32	-	-	-	-	0.00003	0.0007	0,00003	-	-	-	-	0.004	-
Aliphatics nonchlorinated (each)	Non-halogenated aliphatic compounds	-		0,3	-	-	-	-	-		-	-	-	-	-	-
Aluminium	Metal	-		-	-	-	-	0.03	-		-	-	-	-	Variable	5000/5000
Ammonia (total)	Inorganic	20000		-	-	-	-	0,5	-		5			5	Table	-
Ammonia (un-ionized)	Inorganic	-		-	-	-	-		-		-	-	-	-	19	-
Aniline	Organic	-		-	-	-	-		-		-	-	-	-	2,2	-
Anthracene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,012	-
Antimony (metallic)	Inorganic	50	22	20	20	40	40		0.006	0,02	-	-	-	-	-	-
Arsenic	Metal	50	50 (76)!	12	12	12	12	0,01	0.01	0,01	0,2	0,2	0,2	0,2	5	100/25
Asbestos		5000	100	-	-	-	-		-		-	-	-	-		-
Atrazine	Pesticides, Triazine	-	0,71	-	-	-	-	0.002	0.005	0,002	-	-	-	-	1,8	10/5
Barium	Inorganic	20000	-	750	500	2000	2000	0.7	1.0	0,7	-	-	-	-	-	-
Benzene	Monocyclic aromatic compounds	50	1.1	0.05 ¤	0.5 ¤	5 ¤	5 ¤		0.005		0,01*	-	0,01*	0,01*	370	-
Benzo(a)anthracen	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,018	-

Chemical Name	Chemical Groups	**Hazardous Waste** (levels Schedule II, HW Rules, 2008)[1]	**Soil (Screening and Response Levels)**					**Groundwater for drinking water (Screening levels)**			**Surface water Quality (Screening levels)**					
			Response levels (Dutch Intervention levels)[2]	**Screening leves** Soil Quality Guidelines for the Protection of Environmental and Human Health				Indian Standard for Drinking Water * (Maximum acceptable concentration)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commer-cial	Industrial				Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
Benzo(a)pyrene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		0.00001		-	-	-	-	0,015	-
Benzo(b)fluoranthene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	-	-
Benzo(k)fluoranthene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	-	-
Beryllium	Inorganic	50		4	4	8	8		-		-	-	-	-	-	100/100
Boron	Inorganic	-		2	-	-	-	0,5	5.0		-	-	-	-	1.5mg/L	5000/5000
Bromacil	Pesticides	-		-	-	-	-		-		-	-	-	-	5	0,2/1100
Bromoxynil	Pesticides, Benzonitrile	-		-	-	-	-		0.005		-	-	-	-	5	0,33/11
Cadmium	Metal	50	13	1,4	10	22	22	0.003	0.005		2	1	-	2	Equation	5,1/80
Calcium	Inorganic	-		-	-	-	-	75	-		-	-	-	-	-	-/1000000
Captan	Pesticides	-		-	-	-	-		-		-	-	-	-	1,3	-/13
Carbaryl	Pesticides, Carbamate	-	0,45	-	-	-	-		-		0.01	-	0.01	0.01	0,2	-/1100
Carbofuran	Pesticides, Carbamate	-	0,017	-	-	-	-		0.09		-	-	-	-	1,8	-/45
Chlordane	Pesticides, Organochlorine	50	4	-	-	-	-		-		-	-	-	-	0.006	-/7
Chloride	Inorganic	-		-	-	-	-	250	-		-	-	-	-	or 120 mg/L	Variable/-
Chlorothalonil	Pesticides	-		-	-	-	-		-		-	-	-	-	0,18	crops)/170
Chlorpyrifos	Pesticides, Organophosphorus	5000		-	-	-	-	0,03	0.09	0,03	-	-	-	-	0,002	-/24
Chromium (total)	Metal	-	-	64	64	87	87		0.05	0,05	2	2	-	2	-	-
Chromium, hexavalent (Cr(VI))	Metal	50	50 (78)!	0,4	0,4	1,4	1,4	0.05	-		0,1	2	-	1	1	8/50
Chromium, trivalent (Cr(III))	Metal	5000	180	-	-	-	-		-		-	-	-	-	8,9	4,9/50
Chrysene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	-	-
Cobalt	Inorganic	5000	190	40	50	300	300		-		-	-	-	-	-	50/1000
Coliforms, fecal (Escherichia coli)	Biological	-		-	-	-	-		-		-	-	-	-	-	mL/-
Coliforms, total	Biological	-		-	-	-	-				-	-	-	-	-	mL
Colour	Physical	-		-	-	-	-	5 Hazen Units	-		-	-	-	-	Narrative	-
Conductivity	Physical	-		2 dS/m	2 dS/m	4 dS/m	4 dS/m		-		-	-	-	-	-	-
Copper	Metal	5000	190	63	63	91	91	0.05	-	2	3	3	-	3	Equation	Variable/variable
Cyanazine	Pesticides, Triazine	-		-	-	-	-		0.01	0,0006	-	-	-	-	2	0,5/10
Cyanide	Inorganic	50	50	0,9	0,9	8	8	0.05	0.2	0,07	0,2	2	0,2	0,2	5 (as free CN)	-/-
Cyanobacteria	Biological	-		-	-	-	-	-	0.0015		-	-	-	-	-	-/-
Debris	Physical	-		-	-	-	-	-	-		-	-	-	-	-	-/-
Deltamethrin	Pesticides	-		-	-	-	-	-	-		-	-	-	-	0,0004	-/2.5
Di(2-ethylhexyl) phthalate	Phthalate esters	-		-	-	-	-	-	-		-	-	-	-	16	-/-
Di-n-butyl phthalate	Phthalate esters	-		-	-	-	-	-	-		-	-	-	-	19	-/-
Di-n-octyl phthalate	Phthalate esters	-		-	-	-	-	-	-		-	-	-	-	-	-/-
Dibenz(a,h)anthracene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤	-	-		-	-	-	-	-	-/-
Dibromochloromethane	Halogenated methanes	5000		-	-	-	-	0.1	-		-	-	-	-	-	-/100
Dicamba	Pesticides, Aromatic Carboxylic Acid	-		-	-	-	-		-		-	-	-	-	10	0,006/122
DDT Total (Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane)	Pesticides, Organochlorine	50	1,7	0,7	0,7	12	12	0,001	-	0,001	10*)	-	10*)	10*)	0.001	-/30
DDD (Dichloro diphenyl dichloroethane, 2,2-Bis (p-chlorophenyl)-1,1-dichloroethane)	Pesticides, Organochlorine	50	34	-	-	-	-	0,001	-	0,001	-	-	-	-		-

Chemical Name	Chemical Groups	**Hazardous Waste** (levels Schedule II, HW Rules, 2008)[1]	**Response levels** (Dutch Interventi on levels)[2]	**Soil (Screening and Response Levels)** – **Screening leves** Soil Quality Guidelines for the Protection of Environmental and Human Health				**Groundwater for drinking water (Screening levels)**			**Surface water Quality (Screening levels)** – The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commer-cial	Industrial	Indian Standard for Drinking Water * (Maximum acceptable concentra-tion)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
DDE (Dichloro diphenyl ethylene, 1,1-Dichloro-2,2-bis(p-chlorophenyl)-ethene)	Pesticides, Organochlorine	50	2,3	-	-	-	-	0,001	-	0,001	-	-	-	-		-
DDT (Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane)	Pesticides, Organochlorine	50	1,7	-	-	-	-	0,001	-	0,001	-	-	-	-		-
Dichlorobromomethane	Halogenated methanes	5000		-	-	-	-	-	-		-	-	-	-	-	-/100
Dichloromethane (Methylene chloride)	Halogenated aliphatic compounds	5000	3,9	0,1	5	50	50	-	0.05	0,02	-	-	-	-	98,1	-/50
Dichlorophenols	Chlorinated phenols	50	22	0,05	0,5	5	5	-	0.9		-	-	-	-	0,2	
Diclofop-methyl	Pesticides	-		-	-	-	-	-	-		-	-	-	-	6,1	0,18/9
Didecyl dimethyl ammonium chloride	Pesticides	-		-	-	-	-	-	-		-	-	-	-	1,5	-
Dieldrin	Pesticides, Organochlorine	50	-	-	-	-	-	0.00003	-	0.00003	-	-	-	-		-
Diethylene glycol	Glycols	-		-	-	-	-	-	-		-	-	-	-	-	-
Diisopropanolamine	Organic	-		180	180	180	180	-	-		-	-	-	-	1600	2 000/-
Dimethoate	Pesticides, Organophosphorus	5000		-	-	-	-	-	-	0,006	-	-	-	-	6,2	-/3
Dinoseb	Pesticides	-		-	-	-	-	-	0.01		-	-	-	-	0,05	16/150
Dissolved gas supersaturation	Physical	-		-	-	-	-	-	-		-	-	-	-	Narrative	-
Dissolved oxygen	Inorganic	-		-	-	-	-		-		-	-	-	-	-	-
Endosulfan	Pesticides, Organochlorine	50	4	-	-	-	-	0.0004	-		10*)	-	10*)	10*)	0,003	-
Endrin	Pesticides, Organochlorine	50	-	-	-	-	-		-	0,0006	-	-	-	-	0.0023	-
Ethylbenzene	Monocyclic aromatic compounds	20000	110	0.1	5	50	50		-	0,3	-	-	-	-	90	-/2.4
Ethylene glycol	Glycols	-		960	960	960	960		-		-	-	-	-	192 000	-
Fluoranthene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,04	-
Fluorene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	3	-
Fluorine		5000		-	-	-	-		-		-	-	-	-		-
Fluoride	Inorganic	5000		200	400	2000	2000	1.0	1.5	1,5	2	15	-	15	120	1000/variable
Glyphosate	Pesticides, Organophosphorus	5000		-	-	-	-		0.28		-	-	-	-	800	-/280
Heptachlor	Pesticides, Organochlorine	50	4	-	-	-	-		-		-	-	-	-	0.01	-/3
Hexachlorobenzene	Halogenated aromatic compounds	50	2	0,05	2	10	10		-		-	-	-	-	-	-/0.52
Hexachlorobutadiene	Halogenated aliphatic compounds	5000		-	-	-	-		-		-	-	-	-	1,3	No data
Hexachlorocyclohexane (HCH)	Pesticides, Organochlorine	50	-	0,01	-	-	-		-		-	-	-	-	0,01	-/4
Hexachlorocyclohexane (alfa HCH)	Pesticides, Organochlorine	-	17	-	-	-	-		-		-	-	-	-		
Hexachlorocyclohexane (beta HCH)	Pesticides, Organochlorine	-	1,6	-	-	-	-		-		-	-	-	-		
Hexachlorocyclohexane (delta HCH)	Pesticides, Organochlorine	-		-	-	-	-		-		-	-	-	-		
Hydrazine(s)		5000							-		-	-	-	-		-
Imidacloprid		-		-	-	-	-		-		-	-	-	-	0,23	-
Indeno(1,2,3-c,d)pyrene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	No data	-
Iron	Inorganic	-		-	-	-	-	0.3			3	3	-	3	300	5000/'-
Lead	Metal	5000	530	70	140	260	600	0.01	0.01		0,1	1	-	2	Equation	200/100
Lindane (gamma HCH)	Pesticides, Organochlorine	50	1,2	-	-	-	-	0.002	-		-	-	-	-		
Linuron	Pesticides	-		-	-	-	-		-		-	-	-	-	7	0,071/-
Lithium	Inorganic	-		-	-	-	-		-		-	-	-	-	-	2500/-
Malathione	Pesticide, Organophosphorus	5000		-	-	-	-	0.19	0.19		10	-	10	10		-
Manganese	Inorganic	-		-	-	-	-	0.1			2	2	-	2	-	200/-

Chemical Name	Chemical Groups	**Hazardous Waste** (levels Schedule II, HW Rules, 2008)[1)]	**Soil (Screening and Response Levels)**					**Groundwater for drinking water (Screening levels)**			**Surface water Quality (Screening levels)**					
			Response levels (Dutch Intervention levels) [2)]	**Screening leves** Soil Quality Guidelines for the Protection of Environmental and Human Health				Indian Standard for Drinking Water * (Maximum acceptable concentration)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commer-cial	Industrial				Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
Mercury (inorganic)	Metal	50	36	6,6	6,6	24	50	0.001	0.001		0,01	0,01	-	0,01	0,026	-
Methoprene		-		-	-	-	-		-		-	-	-	-	Organism	-
Methyl tertiary-butyl ether (MTBE)	Aliphatic ether	-		-	-	-	-		-		-	-	-	-	10 000	-
MCPA (Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid)	Pesticides	-	4	-	-	-	-		0.1		-	-	-	-	2,6	0,025/25
Methylmercury	Organic	5000		-	-	-	-		-						0,004	-
Methylparathion	Pesticide, Organophosphorus	5000		-	-	-	-	0.0003	-		10	-	10	10		-
Metolachlor	Pesticide, Organophosphorus	50		-	-	-	-		0.05						7,8	28/50
Metribuzin	Pesticides, Triazine	-		-	-	-	-		0.08		-	-	-	-	1	0,5/80
Molybdenum	Inorganic	5000	190	5	10	40	40	0.07	.-	0,07	-	-	-	-	73	Narrative/500
Monobromomethane	Halogenated aliphatic compounds	5000		-	-	-	-		-		-	-	-	-	-	-
Monochlorobenzene	Halogenated aromatic compounds	50	15	0,1	1	10	10		0.08		-	-	-	-	1,3	-
Monochloromethane	Halogenated aliphatic compounds	5000		-	-	-	-		-		-	-	-	-	-	-
Monochlorophenols	Chlorinated phenols	50	5,4	0,05	0,5	5	5		-		-	-	-	-	7	-
Naphthalene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	1,1	-
Nickel	Metal	5000	100	50	50	50	50	0.02	-	0,07	3	3	-	5	Equation	200/1000
Nitrate	Inorganic nitrogen compounds	20000		-	-	-	-	45	45	50	10	-	-	20	13 mg/L	-
Nitrate + Nitrite	Inorganic nitrogen compounds	20000		-	-	-	-		-		-	-	-	-	-	NO3+NO2-N
Nitrite	Inorganic nitrogen compounds	5000		-	-	-	-		-	3	-	-	-	-	60 NO2-N	-/10 000 NO2-N
Nonylphenol and its ethoxylates	Nonylphenol and its ethoxylates	-		5,7	5,7	14	14		-		-	-	-	-	1	-
Nutrients		-		-	-	-	-		-		-	-	-	-	Framework	-
n-hexane	Aliphatic hydrocarbon	-		0.49/6.5 #	0.49/6.5 #	6.5/21 #	6.5/21 #		-		-	-	-	-	-	-
Parathione	Pesticide, Organophosphorus	5000							-		-	-	-	-		-
Pentachlorobenzene	Halogenated aromatic compounds	50	6,7	0,05	2	10	10		-		-	-	-	-	6	-
Pentachlorophenol	Halogenated aromatic compounds	50	12	7,6	7,6	7,6	7,6		0.06	0,009	-	-	-	-	0,5	-
Permethrin	Pesticides, Organochlorine compounds	50		-	-	-	-		-		-	-	-	-	0,004	-
Phenanthrene	Polycyclic aromatic hydrocarbons (PAH)	50		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,4	-
Phenolic compounds (as C6H5OH)	compounds	5000	14	0,1	1	10	10	0.001	-		1	5	-	5	-	-
Phenols (mono- & dihydric)	Aromatic hydroxy compounds	5000		3,8	3,8	3,8	3,8		-		-	-	-	-	4	-/2
Phenoxy herbicides	Pesticides	-		-	-	-	-		-		-	-	-	-	4	-/100
Phosphorus (as P)	Inorganic	20000		-	-	-	-		-		5	-	-	-	Framework	-
Phthalic acid esters (each)	Phthalate esters	-		30	-	-	-		-		-	-	-	-	-	-
Picloram	Pesticides	-		-	-	-	-		-		-	-	-	-	29	-/190
PCBs (Polychlorinated biphenyls)	Polychlorinated biphenyls	50	1	0,5	1,3	33	33	0.0005	-		-	-	-	-	0.001	-
Poly cyclic Hydrocarbon (PAH)	Polycyclic aromatic hydrocarbons (PAH)	-	40					0.0001	-		-	-	-	-	-	-
Polychlorinated dibenzo-p-dioxins/dibenzo furans	Polychlorinated dioxins and furans	-	0,00018	4 ng TEQ.kg-1	4 ng TEQ.kg-1	4 ng TEQ.kg-1	4 ng TEQ.kg-1		-		-	-	-	-	-	-
Propylene glycol	Glycols	-		-	-	-	-		-		-	-	-	-	500 000	-
Pyrene	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	0,025	-
pH	Inorganic Acidity, alkalinity and pH	-		6 to 8	6 to 8	6 to 8	6 to 8	6.5-8.5			5,5 - 9,0	5,5 - 9,0	5,5 - 9,0	5,5 - 9,0	6.5 to 9.0	-
Quinoline	Polycyclic aromatic hydrocarbons (PAH)	-		0.1 ¤	1 ¤	10 ¤	10 ¤		-		-	-	-	-	3,4	-
Reactive Chlorine Species	Inorganic Reactive chlorine compunds	-		-	-	-	-		-		-	-	-	-	0,5	-
Salinity	Physical	-		-	-	-	-		-		-	-	-	-	-	-

Chemical Name	Chemical Groups	Hazardous Waste (levels Schedule II, HW Rules, 2008)[1)]	Soil (Screening and Response Levels)					Groundwater for drinking water (Screening levels)			Surface water Quality (Screening levels)					
			Response levels (Dutch Intervention levels)[2)]	Screening leves Soil Quality Guidelines for the Protection of Environmental and Human Health				Indian Standard for Drinking Water * (Maximum acceptable concentration)	Guidelines for Canadian Drinking Water Quality	WHO guidelines for Drinking water	The Environment (Protection) Rules, 1986 Schedule VI General standards for discharge of environmental pollutants				Canadian Water Quality Guidelines for the Protection of **Aquatic Life**	Canadian Water Quality Guidelines for the Protection of **Agriculture**
				Agricultural	Residential/-parkland	Commer-cial	Industrial				Inland surface water	Public sewers	Land for irrigation	Marine coastal areas	Longterm in Freshwater	Irrigation/-Livestock
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/L	µg/L
Selenium	Inorganic	50		1	1	2,9	2,9	0.01	0.01	0,01	0,05	0,05	-	0,05	1	Variable/50
Silver	Inorganic	5000		20	20	40	40	0,1	-		-	-	-	-	0,1	-
Simazine	Pesticides, Triazine	-		-	-	-	-		0.01	0,002	-	-	-	-	10	0,5
Sodium adsorption ratio		-		5	5	12	12		-		-	-	-	-	-	-
Streambed substrate	solids Total particulate matter	-		-	-	-	-		-		-	-	-	-	Narrative	-
Styrene	Monocyclic aromatic compounds	20000	86	0,1	5	50	50		-	0,02	-	-	-	-	72	-
Sulfolane	Organic sulphur compound	-		0,8	0,8	0,8	0,8		-		-	-	-	-	50 000	500
Sulphate	Inorganic Inorganic sulphur compounds	-		-	-	-	-	200	-		-	-	-	-	-	No data
Sulphur (elemental)	Inorganic Inorganic sulphur compounds	50000		500	-	-	-		-		-	-	-	-	-	-
Suspended sediments	solids Total particulate matter	-		-	-	-	-		-		-	-	-	-	Narrative	-
Tebuthiuron	Pesticides	-		-	-	-	-		-		-	-	-	-	1,6	tame hays, and
Tellurium		50		-	-	-	-		-		-	-	-	-		-
Temperature	Physical Temperature	-		-	-	-	-		-		above				Narrative	-
Tetrachloromethane	Halogenated aliphatic compounds	5000	0,7	0,1	5	50	50		-		-	-	-	-	13,3	-/5
Tetrachlorophenols	Halogenated aromatic compounds	50	21	0,05	0,5	5	5		0.1		-	-	-	-	1	-
Thallium	Inorganic	50		1	1	1	1		-		-	-	-	-	0,8	-
Thiophene	Miscellaneous organic compound	-		0,1	-	-	-		-		-	-	-	-	-	-
Tin (inorganic)	Inorganic	5000		5	50	300	300		-		-	-	-	-	-	-
Tin (organic)		50		-	-	-	-		-		-	-	-	-	-	-
Toluene	Monocyclic aromatic compounds	20000	32	0.1	3	30	30		-	0,7	-	-	-	-	2	-/24
Total dissolved solids (TDS)	solids	-		-	-	-	-	500	-		100	600	200	100	-	00
Total hydrocarbons (TPH) (mineral oil)		50000	5000	-	-	-	-	0,5	-		10	20	10	20	-	-
Toxaphene	Pesticides, Organochlorine	50		-	-	-	-		-		-	-	-	-	0.008	-/5
Triallate	Pesticides, Carbamate	-		-	-	-	-		-		-	-	-	-	0,24	-/230
Tribromomethane	Halogenated aliphatic compounds	5000		-	-	-	-		-		-	-	-	-	-	-/100
Tributyltin	Organotin compounds	50		-	-	-	-		-		-	-	-	-	0,008	-/250
Trichlorfon		-		-	-	-	-		-		-	-	-	-	0,009	-
Trichloromethane (chloroform)	Halogenated aliphatic compounds	5000	0,7	0,1	5	50	50	0,2	-	0,3	-	-	-	-	1,8	-/100
Trichlorophenols	Halogenated aromatic compounds	50	22	0,05	0,5	5	5		0.005		-	-	-	-	18	-
Tricyclohexyltin	Organotin compounds	-		-	-	-	-		-		-	-	-	-	-	-/250
Trifluralin	Pesticides, Dinitroaniline	-		-	-	-	-		-	0,02	-	-	-	-	0,2	-/45
Triphenyltin	Organotin compounds	50		-	-	-	-		-		-	-	-	-	0,022	-/820
Turbidity	solids Total particulate matter	-		-	-	-	-	1 NTU	0.1-1.0 NTU		-	-	-	-	Narrative	-
Tungsten compounds		5000		-	-	-	-		-		-	-	-	-	-	-
Uranium	Inorganic	-		23	23	33	300		0.0s	0,015	-	-	-	-	15	10/200
Vinylchloride	Halogenated aliphatic compounds	5000	0,1	-	-	-	-		0.002	0,0003	-	-	-	-	-	-
Vanadium	Inorganic	5000		130	130	130	130		-		0,2	0,2	-	0,2	-	100/100
Xylene	Monocyclic aromatic compounds	20000	17	0.1	5	50	50		-	0,5	-	-	-	-	-	-
Zinc	Metal	20000	720	200	200	360	360	5	-		5	15	-	15	30	-/50000

NR: No relaxation

1): Schedule 2 of the Hazardous Waste Rules (2008); 2): Circulaire bodemsanering (Soil Remediation Circular, 2013)

¤: CCME (Canadian Council of Ministers of the Environment). 1991. Interim Canadian environmental quality criteria for contaminated sites. CCME, Winnipeg.

#: coarse/fine sediment

!: xx (yy): xx is value from HWR 2008; yy is Dutch Intervention values. In this case levels from HWR are used because these are lowest

*: IS: 10500:2012

Volume III

2.2-i Manual Conceptual Site Model and identifying the Source-Pathway-Receptor

Volume III-2.2-i
Manual Conceptual Site Model and identifying the Source-Pathway-Receptor

1 Introduction

This information is most relevant for Steps 2 (Task 2.2 Preliminary site investigation), 5 (Task 5.1 Detailed site investigation) and 6 (Remediation design, DPR).
This Section presents two internationally widely used concepts in site assessment, the Source-Pathway-Receptor (SPR) approach and the Conceptual Site Model (CSM). These two concepts are closely connected.

Using a CSM it is possible to characterize the physical, biological, and chemical systems existing at a site. The processes that determine contaminant releases, contaminant migration, and environmental receptor exposure to contaminants are described and integrated in a conceptual site model.
The conceptual site model should be used to enable experts from all disciplines to communicate effectively with one another, resolve issues concerning the site, and facilitate the decision-making process.

This section explains how to assist in the development of a CSM. At the end of this section reference is made to background information. Because the ASTM-1689-guideline provides clear information this guideline is mostly referred to in the below text.

2 The Source-Pathway-Receptor approach

The Source-Pathway-Receptor approach is used in site investigation and risk assessment to identify the source of any contamination, what the source may affect (receptor) and how the source may reach the receptor (pathway). The SPR concept is a fundamental and internationally widely accepted approach to assess contaminated sites and develop remediation options.

The three elements of this SPR concept are:

- Source (S): The cause or potential source of the contamination is identified and investigated. These sources might include all activities described in the Typology. Contaminants of concern as well as their concentrations in the various media on site require full characterization to understand the extent and potential for migration.
- Pathway (P): The pathway is the route by which the compounds of the contaminants are migrating from the source to the receptor. Pathways include air, water, soil, animals, vegetables and eco-systems. Potential migration pathways for the identified and characterized contaminants to receptors are then identified and evaluated to assess exposure risks. If direct contact of the Receptor with the source is present, the pathway is part of the source.
- Receptor (R): If contamination is to cause harm, it must reach a receptor. A receptor is a person, animal, plant, eco-system, property or a controlled (ground or surface) water. Each receptor must be identified and their sensitivity to the contaminant must be established. Consideration should be given to on-site as well

as off-site receptors. An example of an off-site receptor are individuals who receive exposure via consumption of drinking water which is obtained from a location down gradient of the contaminated source.

For one site several SPR-combinations can be applicable. Each SPR-combination can be subject to remediation. The risk assessment will define if remediation of a specific SPR-combination is needed. Without a SPR-combination, no risks can be identified, even if contaminations in soil, groundwater, surface water, sediment or air are present above certain levels. The analysis of the SPR-combination is therefore essential for the risk assessment.

3 The Conceptual Site Model (CSM)

Conceptual site models are commonly used to implement a structured and efficient investigation. Preparation and use of the conceptual site model is an iterative process throughout the lifecycle of the remediation project. It starts with the generic typology of the contaminated site during the preliminary investigation which will be extended with information of a specific site (see Glossary for an explanation on typology). As new data become available during the detailed site investigation and the risk assessment, the conceptual site model is modified to continually evaluate the connection between sources of contaminants, migration pathways, and receptors. Evaluation of these three components through the use of the conceptual site model in conjunction with initial preparation and subsequent revisions ensures receptors are identified and addressed. The CSM enables integration of all site information, identification of data needs and guiding of data collection activities. Possible uncertainties in the CSM should be mentioned clearly in order to decide if additional data should be collected.

Where the CSM is used to develop remediation options, the remediation techniques can be designed in such a way that the effects meet an optimum by balancing the intensity of a technique over the three elements of a specific site. The CSM can even be used during the site remediation when reporting on the results and on the achievement of the remediation objectives.

The site for which a CSM is developed should be able to be delineated clearly from other contaminated sites. If individual contaminated sites are in the proximity to one another and individual sources cannot be determined sites may be aggregated in that case and a conceptual model should then be developed for the aggregate.

Following activities have to be carried out in development of a CSM:

- Assembling Information by desk study and site visit: Assemble historical and current site-related information on topography, land use, hydrology and (hydro)geology from maps, aerial images, cross sections, environmental data, records, reports, studies, and other information sources. These activities are described in the Site Inspection Protocol (Volume III-2.1-i). This information should comprise the current and future use of the site.
- Identifying contaminating substances in the soil, groundwater, surface water, sediments, biota, and air. Provide description of the characteristics (a.o. density, solubility, volatility, biodegradability) and behavior in media.

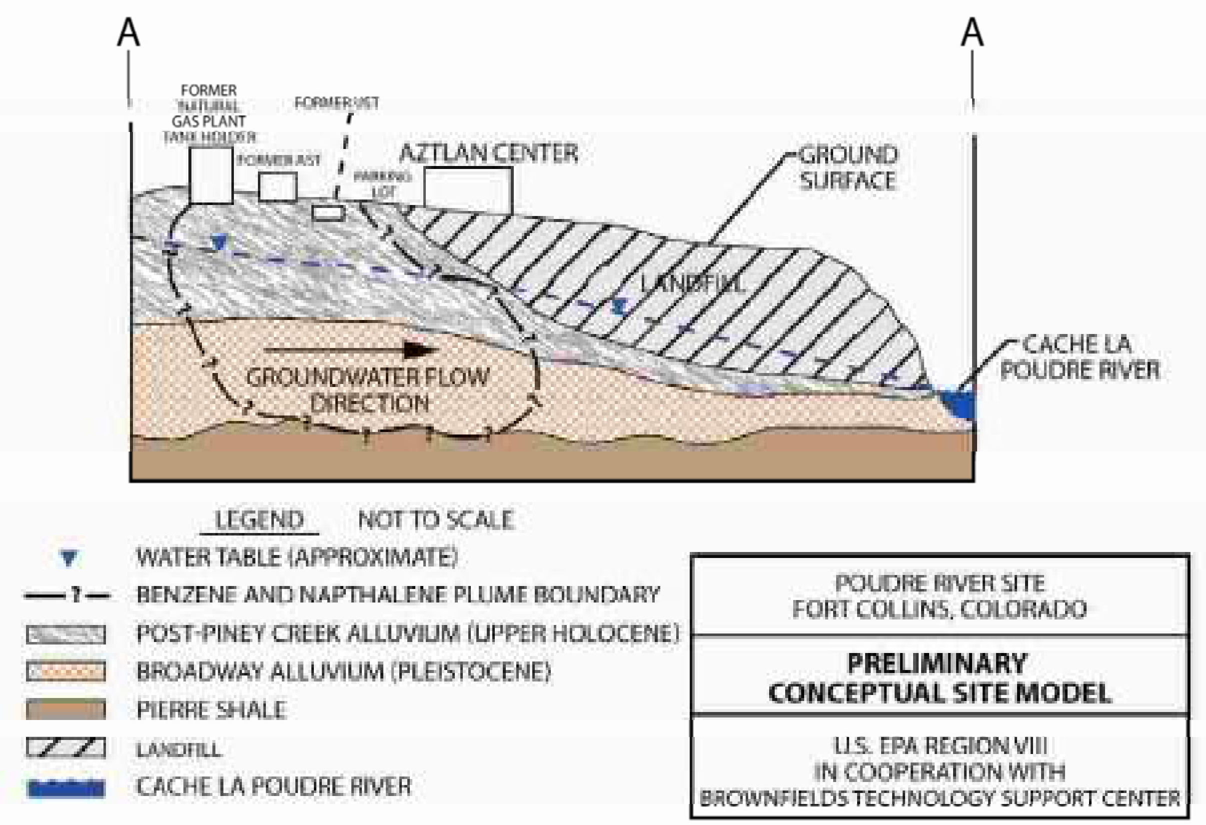
- Establishing Background Concentrations of Contaminants: This is important for the following reasons:
  a. to establish the range of concentrations of certain parameters present at the site due to natural occurrence;
  b. to help establish the extent to which contamination exceeds background levels and the area where this occurs.
- Identifying and characterizing Source: the following source characteristics should be measured or estimated for a site, the level of detail depends on the position in the process of assessment and remediation. During detailed site assessment these elements should be considered more detailed compared to the CSM during preliminary site assessment:
  - Source location(s), boundaries, and volume(s);
  - The potentially hazardous constituents and their concentrations in media at the source;
  - The time of initiation, duration, and rate of contaminant release from the source.
- Identifying Pathways: Potential migration pathways by which contaminants are migrating through groundwater, surface water, air, soils, sediments, and biota should be identi ed for each source. A diagram of exposure pathways for all source types at a site may help to structure and illustrate the collected information (see the description of task 5.2 in Volume I).
- Identifying Receptors: Identify receptors currently or potentially exposed to site contaminants. This includes humans and other organisms that are in direct contact with the source of contamination, potentially present along the migration pathways, or located in the vicinity of the site.

The results of the CSM can be described, summarized in a table and/or illustrated in 2D or 3D pictures. Some examples are provided below a.o. for the Ranipet site near Chennai, Tamil Nadu:

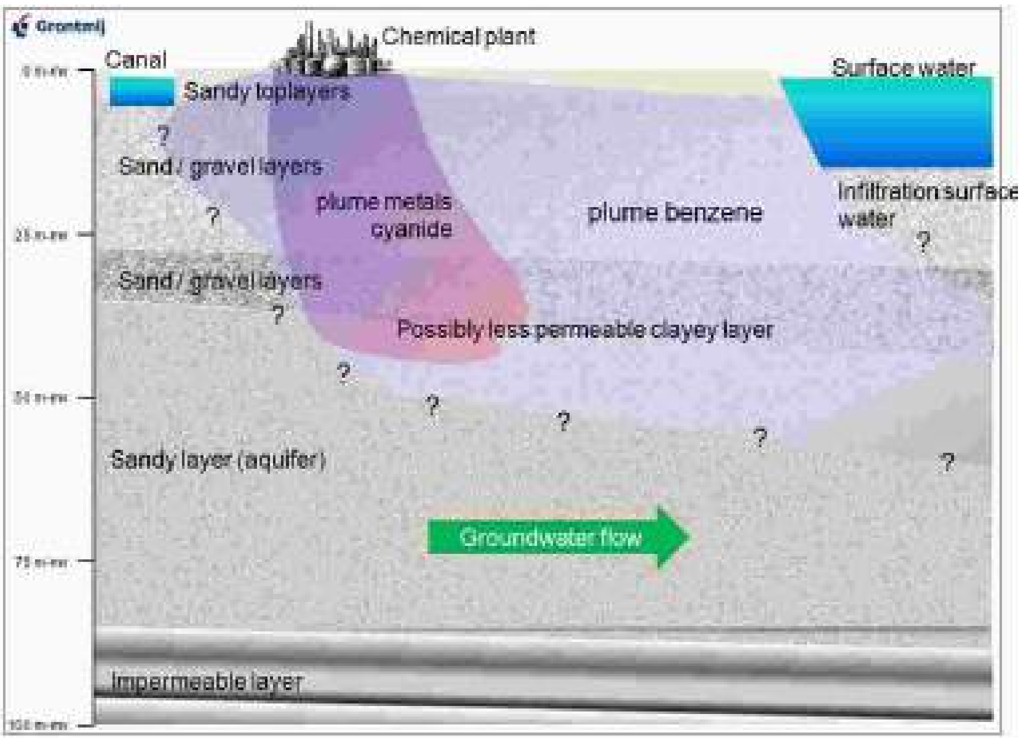
References to more detailed information on SPR and CSM

- Guide to Good Practice for the Development of Conceptual Models and the Selection and Application of Mathematical Models of Contaminant Transport Processes in the Subsurface: http://www.google.nl/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&cad=rja&ved=0CDEQFjAA&url=http%3A%2F%2Fwww.sepa.org.uk%2Fland%2Fidoc.ashx%3Fdocid%3D348518fc-6662-4699-8e7a-4b28d5cd64c9%26version%3D-1&ei=Sy7YUJa1LoLRhAfwuoGIBQ&usg=AFQjCNGbsmFOnTvTZBOPwZDfqS7t8HCxnA
- ASTM E1689 - 95(2008) Standard Guide for Developing Conceptual Site Models for Contaminated Sites: http://www.astm.org/Standards/E1689.htm (not freely accessible data).
- Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model: EPA 542-F-11-011 July 2011
- Public Health Assessment Guidance Manual, Agency for Toxic Substances and Disease Registry, January 2005, http://www.atsdr.cdc.gov/hac/PHAManual/PDFs/PHAGM_final1-27-05.pdf

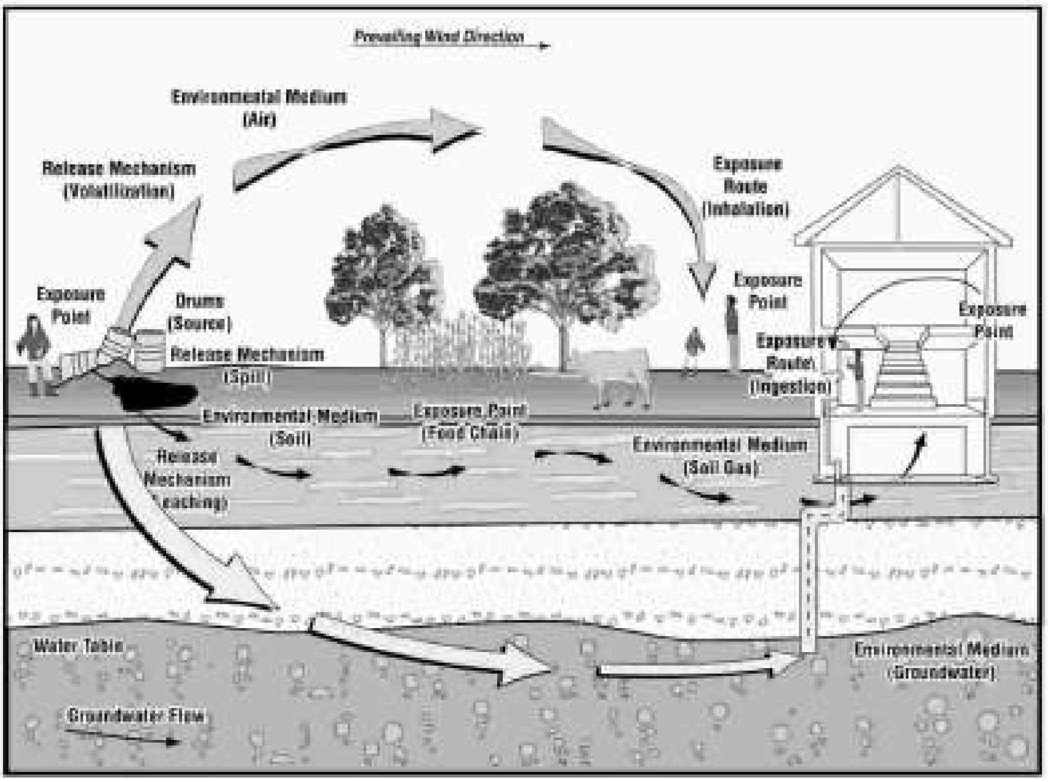
Example of Preliminary CSM Representation from US EPA July 2011



Example of 2-D Characterization CSM



Example of 2-D Characterization CSM



Example of a schematic exposure pathway in a Conceptual Site Model (source: Public Health Assessment Guidance Manual, Agency for Toxic Substances and Disease Registry, 2005)

Example of collection information and development of CSM w.r.t. Ranipet Site:

List of references for soil / subsurface data needed in site, risk and remediation option assessment					
Type of data needed	**Comments**	**Example elements in the site assessment the data is used for**	**Data sources available**	**Quality of data**	**Scale of data**
Soft soil subsurface					
Composition *)	e.g. clay, sand	spreading of contaminants: pathway layout risk assessment	General Soil Map India, 1:20.000.000, Indian Minister of Agriculture, 1998	Highly detailed study based on recent field measurements and laboratory analyses giving the standardized reference of soil quality and composition	Not applicable on site-scale but very useful for a general picture of the site and its surroundings
Alfisol : Haplustalfs, Paleustalfs, Rhodustalfs	reddish brown gravelly clay/sandy soil Riverine Land Form; Alluvium/Laterite (RECENT / PLEISTOCENE)	Spreading of Hexavalent Chromium from Chromium Ore Processing Residue to subsurface and leaching to ground water due during rains	Soil Map of India; Scale 1:6,000,000; Map Ref: INDI 5; All India Soil and Land Use Survey; Indiana Agricultural Research Institute; Govt. of India, 1971 and Soil Regions, Southern India Plate 203, National Atlas of India; Scale 1:2,000,000; Dept. of Science & Technology; Govt. of India, 1981 and Tamil Nadu Soils, Sheet 1 and 2; Scale 1:500,000; Survey of India Map; Govt. of India, 1996.	High Quality Maps of Govt. of India Map Reference is also given to: ISRIC, Wageningen, The Netherlands	Not applicable on site-scale but very useful for a general picture of the site and its surroundings
% organic matter *)		spreading of contaminants: adsorption of organic contaminants			

		capacity of NA			
% clay minerals *)		spreading of contaminants: retardation of heavy metal (adsorption)			
Permeability *)	if possible in m/day	spreading of contaminants: speed of spreading and assessment of pump and treat options			
High permeability					
Type of sedimentary deposition	e.g. river delta deposit, river plain deposit. If possible a detailed description.	spreading of contaminants: pathway layout design of in situ options			
Layering	Vertical variations in soil composition	spreading of contaminants: pathway layout design of in situ options			
Depth of soil/bedrock transition		spreading of contaminants: pathway layout			
1m			NGRI Report October 2008	High Quality	Applicable to site
Horizontal discontinuities	Horizontal variations in soil composition	spreading of contaminants: pathway layout			
Bedrock subsurface					
Type of rock		spreading of contaminants: pathway layout			
Achaean Granite with highly metamorphosed gneissic complex basement Alluvium, granite, gneisses and charnockite	Secondary structures like joints and fractures due to tectonic activity and intrusion of dolerite dykes and quartz Veins	Compacted Chromium upto 2m depth	NGRI Report October 2008 and DISTRICT GROUNDWATER BROCHURE VELLORE DISTRICT, TAMIL NADU- Technical Report Series, Central Ground Water Board, South Eastern Coastal Region, Chennai, January 2009	High Quality	Applicable to site and also very useful for a general picture of the site and its surroundings
Permeability		spreading of contaminants: pathway layout			
Highly		Chromium	NGRI Report	High Quality	Applicable to

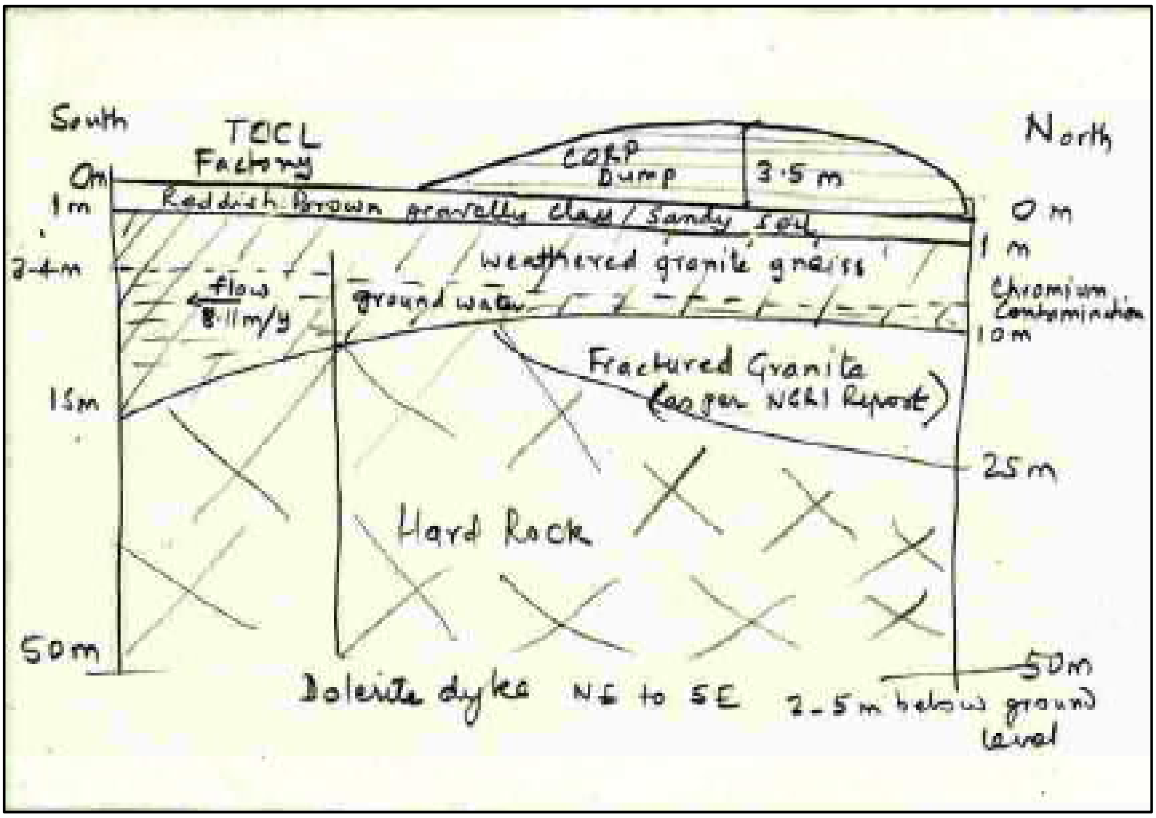
permeable		concentration decreases from average 200mg/kg at 1m depth to less than 50mg/kg at 5m depth	October 2008		site
Porosity		spreading of contaminants: pathway layout			
Weathering:					
thickness of weathered layer		spreading of contaminants: pathway layout			
10 to 15m	Weathered Granite gneiss	Chromium	NGRI Report October 2008	High Quality	Applicable to site
degree of weathering		spreading of contaminants: pathway layout			
22.50%	Weathered Granite gneiss		NGRI Report October 2008	High Quality	Applicable to site
Layering	Vertical variations in type of rock	spreading of contaminants: pathway layout			
Horizontal discontinuities	Horizontal variations in type of rock	spreading of contaminants: pathway layout			
Dolerite Dyke from 2 to 5m below ground level	NE to SE in the dumpsite	Subsurface barrier for groundwater movement and Chromium leaching	NGRI Report October 2008	High Quality	Applicable to site
Groundwater					
Head *)	Water table	risk assessment, pathway layout			
3 to 4 meter below ground level	Fracture granites, gneisses and charnockites		NGRI Report October 2008 and DISTRICT GROUNDWATER BROCHURE #)	High Quality	Applicable to site and also very useful for a general picture of the site and its surroundings
Groundwater flow *)					
Direction		spreading direction contaminants			
North to South	Follows topography		NGRI Report October 2008	High Quality	Applicable to site
Velocity		speed of spreading contaminants			
8.11m/year	Effective porosity value of 22.5%		NGRI Report October 2008	High Quality	Applicable to site

Chemical composition *)	general components like salts, O2 etc.	Risk assessment, capacity of NA of groundwater			
Total Hardness as $CaCO_3$ Chlorides Nitrates	More than permissible limit	Contamination of Chromium	DISTRICT GROUNDWATER BROCHURE #)	High Quality	Not applicable on site-scale but very useful for a general picture of the site and its surroundings
Pre Monsoon Water Level, m below ground level Post Monsoon Water Level, m below ground level Long Term Water Level Trend in 10 years, m/year	1.18 to 18.86 1 to 18.45 Annual Rise: min. 0.0025, max. 0.5264 Annual Fall: min. 0.0568, max. 2.3958		DISTRICT GROUNDWATER BROCHURE #)	High Quality	Not applicable on site-scale but very useful for a general picture of the site and its surroundings
Site use:					
Secured former industrial site	7.41 acres		Site visit 2012	High Quality	Applicable to site
To south:	500 m distance: small village and pasture with cattle; 4.5 m distance: river Palar				
North, West, East:	Industrial premises (still active)				
Pathways:					
Groundwater	Seepage of rain through waste material into underlying soil; transport of contamination through groundwater in horizontal direction to south;				
Surface water	runoff of rainfall with contaminated particles to				

	drainage ditches				
air	Possibly dust from not covered waste material				
Receptors:					
Residents village	Groundwater presently doesn't seem to be used		Site visit 2012		
Cattle related to community	Drinking surface water		Site visit 2012		
River Palar	Transport contaminated groundwater towards river		Report		
Plants and animals	Direct contact with contaminated soil, groundwater or surface water (outside industrial premises)		Site visit 2012		

Explanation:
*) if possible specified for each individual layer
#) DISTRICT GROUNDWATER BROCHURE, VELLORE DISTRICT, TAMIL NADU-Technical Report Series, Central Ground Water Board, South Eastern Coastal Region, Chennai, January 2009

Sketch of CSM from above data:



Volume III

2.2-ii Protocol investigation strategy preliminary site investigation

Volume III-2.2-ii
Protocol investigation strategy preliminary site investigation

1 Introduction

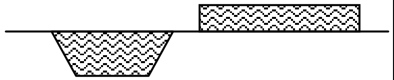
This information is most relevant for Task 2.2 preliminary site investigation.
The starting point for the preliminary site investigation is the typology of the contaminated site. For each type of contamination a different investigation strategy is recommended in order to achieve the investigation objective efficiently. The objective of a preliminary site investigation is to identify all sources of contamination and the relevant pathways to the receptors of concern.
When investigating a site a specific investigation protocol should be developed based on the typology. This site specific investigation protocol should pay attention to the following elements:

- Screening and sampling technical equipment;
- Sampling pattern and depth of samples, number of samples and use of composite samples;
- Analytical test parameters / determinants required;
- Quality Assurance / Quality Control procedures such as use of field blanks/trips blanks, procedures to avoid cross contamination by sampling equipment etc.

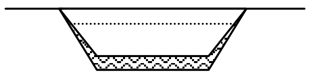
The table below provides a basis for the field investigation strategy including the sampling pattern based on the typology of the contamination and its field characteristics. In case more specific site information is available the general type can be made more site specific by using the Conceptual Site Model (CSM). Based on the CSM the investigation protocol may be specified to a greater detail, regarding assessment of the contamination levels of the source and the major pathways and receptors of concern.
General notes:

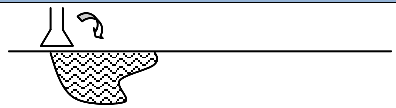
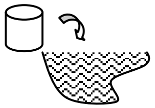
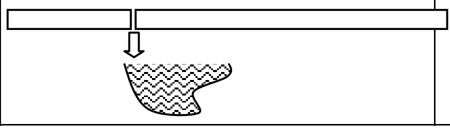
- At one contaminated site more than one type of contamination can occur. For each type of contamination and for each source a separate investigation strategy has to developed first but the investigation activities can be combined to result in an efficient investigation.
- There is always some uncertainty about the representativeness of the samples to actual site conditions due to variation in local conditions which can affect the vertical and lateral distribution of contaminants.
- Composite samples may enable a cost effective investigation of the average concentration levels in contaminated soil or sediment. Composite samples can be made up to a maximum of ten individual samples. The individual samples have to be taken from layers with comparable soil/sediment characteristics. In case individual samples have different olfactory characteristics, they should not be mixed in the composite sample but they should be tested in the laboratory individually. Composite sampling is not applied for groundwater or surface water nor in case of volatile contaminants.

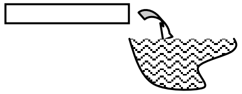
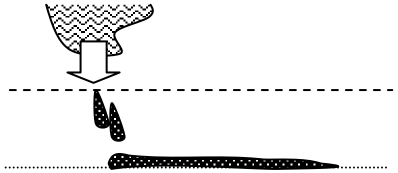
2 Field investigation strategy based on typology

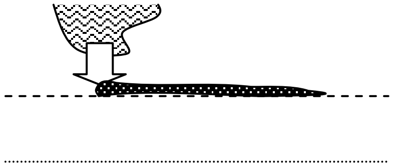
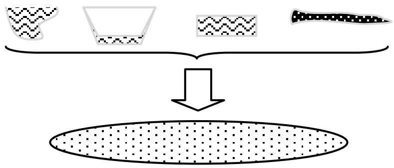
Type	Activity	Icon with typical field situation (cross-section)	Field characteristics	Field investigation strategy	Indication sampling pattern and number of samples
S1	Solid phase contamination (land bound)				
S1-a	Mixing the soil with contaminated material or materials containing contamination, not including agricultural activities.		• May be a thick layer of contaminated material. • Not always visually recognisable (possibly covered with natural soil material). • Relatively heterogeneous composition. • Shape depends on the mixing process.	• If location of source is not known screening methods can be first step for rough indication • If the composition is heterogeneous screening techniques may help to find the most contaminated spots where sampling should be carried out. • If location of source is roughly known sampling of soil and waste material is carried out. • If no spots are identified the samples are evenly distributed over the location of the expected source. This evenly distribution may be influenced by the accessibility of a sampling spot (rather sample of not-covered material in stead of a sample from material below a sealed surface (road, building). • Depth of samples at least to level of contaminated material (based on historical informatial, screening results or visual and olfactory evidence during sampling). • In case different layers of contaminated material within one source are expected for each layer a sample should be	• For non-lineair sources a sampling grid can be used. Rough indication for number of borings from which samples are obtained: 2-4 borings per acre, with a minimum of 2 per source. • Rough indication for number of samples to be tested: 0.25-1 per acre. • For linair sources a cross section of borings is carried out within certain distance intervals. Rough indication of intervals: 1 cross section per 20-50 meters with a minimum of 3 cross sections. Per cross section 3-5 borings and for each cross section 1 sample is obtained. • Composite samples made of a maximum of 10 samples before laboratory testing is possible to get indication of average concentration levels. Composite samples are only allowed for components with immobile and non-volatile character (heavy metals, PCB's, most PAH's and
S1-b	Embankment, filling of pits or depressions, filling of surface waters with contaminated material or materials containing contamination. E.g. a former dumpsite.		• May be a thick layer of contaminated material. • Not always visually recognisable (possibly covered with natural soil material). • Composition may either be homogeneous or heterogeneous. • Shape is determind by former or present topography, lineair as well as non-linair shaped source may occur.		

Type	Activity	Icon with typical field situation (cross-section)	Field characteristics	Field investigation strategy	Indication sampling pattern and number of samples
				collected. • In case the source of the contamination is expected at great depth below surface and the contaminants may dissolve relatively easy, a water sample from a groundwater well may be more efficient than sampling of soil at great depth.	pesticides).
S1-c	(Bulk) storage of contaminated material or materials containing contamination (leftovers after having removed the stored materials). (Industrial) activities in which contaminated solids are used. 'Leftovers' of incineration and burning of material. Demolition and construction of contaminant containing constructions (e.g. asbestos).		• Shallow layer of contaminated material. • Material present at the surface and visually recognisable. • Relatively homogeneous composition.	• Same applies as above. • With regard to depth of samples, maximum depth can be 0,5-1 meter depending on expected depth of source.	• Same applies as above. • With regard to number of borings and samples it is possible to use half of the average of borings mentioned above because of the relative homogenity of the material. Do however apply the minimum numbers as mentioned.
S1-d	Adding material containing contamination through agricultural activities (e.g. pesticides, fertilizers or		• Shallow layer of contaminated material. • Material present just below the surface. • Visually not recognisable. • Relatively homogeneous		

Type	Activity	Icon with typical field situation (cross-section)	Field characteristics	Field investigation strategy	Indication sampling pattern and number of samples
	additives to animal feed).		composition.		
S1-e	Atmospheric deposition (roads, railway, industries) of emissions or windblown dust.		• Shallow layer of contaminated material. • Material present at the surface. • Visually not well recognisable. • Relatively homogeneous composition.		
S1-f	Deposition by flooding or washing.		• Shallow layer of contaminated material. • Material present at the surface. • Visually sometimes recognisable. • Relatively homogeneous composition.		
	Solid phase contaminations (water bound)				
S2	Contaminated open water sediments.		• The material to be investigated consists of the soil/sediment and parent material beneath the surface water body. • Exact location of the source cannot be identified visually. • Lineair (canals, rivers, creeks) as well as non-lineair (lakes, ponds) shaped sources are common.	• Screening methods are not appropriate. • The site is divided in different investigation areas. Per unit area a number of samples are collected. • Samples are evenly distributed over the area. • Depth of samples is related to depth of the sediment layer. The result of the boring from which samples are obtained may provide a first indication of this depth, although during this step delineation is not primary	• For non-lineair sources a sediment sampling grid can be used. Rough indication of number of investigation unit areas: 0.5-1.5 per square root of the surface area (acre). Rough indication for number of borings: 6 borings per unit area, with a minimum of 2 per source. • Indication for number of samples to be tested: 1 composite sediment sample per unit area, for laboratory testing.

Type	Activity	Icon with typical field situation (cross-section)	Field characteristics	Field investigation strategy	Indication sampling pattern and number of samples
				objective. • The effect of contaminated sediment on the surface water quality can be checked by sampling of the surface water (taking into account background quality of the water).	• For linair sources a cross section of borings in the sediment is carried out within certain distance intervals. Rough indication of intervals: 1 cross section per 500-2,500 meters. Per cross section 3-5 borings and for each cross section 1 composite sample for laboratory testing.
	Liquid phase contaminations				
L1-a	(Business) activities involving fluids e.g. solvents, lubricants, paint, etc.		• Sometimes visually or olfactory recognisable point source. • Dispersion in shallow soil layers depends on soil characteristics, possibly at great depth.	• Identify core of the source, visually or olfactory or with help of screening methods. • Samples in the core or very near to the core. • Depth of sample is 0.5 m below level of core (maximum depth for this preliminary site investigation step: 5 meters below surface).	• Number of borings is 2-5 (related to a surface of 250-2,500 acres). • Per core 1 sample of apparently most contaminated material is tested in laboratory. • When olfactory observations indicate presence of contamination in groundwater, 1 groundwater sample per core mus be tested in laboratory.
L1-b	Storage of liquids that contain contaminations in tanks or barrels (either storage on surface or subsurface).		• Often not visually or olfactory recognisable point source because of subsurface release of products. • Dispersion in shallow soil layers depends on soil characteristics, possibly at great depth.		
L1-c	Transfer and transport of fluids through piping. Weak point are		• Often not visually recognisable point source because of subsurface release of products.		

Type	Activity	Icon with typical field situation (cross-section)	Field characteristics	Field investigation strategy	Indication sampling pattern and number of samples
	couplings, pressure regulators, valves, breakpoints and the passage through foundations / buildings.		• Dispersion in shallow soil layers depends on soil characteristics, possibly at great depth.		
L1-d	Spills or leaks of liquids. (either on surface or in rivers/lakes) Note. Possibly leading to type S2 or P2.		• Visually well recognisable point source. • Dispersion in soil and sediment as described for Types P2 and S2.		
	Liquid waste related				
P1-a	Dense Non-Aqueous Phase Liquid (DNAPL) in permeable soil. (bulk density > water)		• A liquid that is both denser than water and is immiscible in water or does not dissolve in water. • DNAPLs tend to sink below the water table when spilled in significant quantities and only stop when they reach less impermeable soil layer/impermeable bedrock. Their penetration into an aquifer makes them difficult to locate and remediate.	• Identify core of the source. • Samples in the core or very near in the direction of the groundwaterflow. • Depth of samples is to the level of a less permable layer. The depth of the less permeable layer may be determined using screening investigation techniques. • Visual or olfactory observations of drilled material 0.5 m below level of core (maximum depth for this preliminary site investigation step: 5 meters below surface). • Because of required depth of the samples necessary to investigate DNAPLs this investigation is may be too extensive for the preliminary site investigation. If the site already is regarded as contaminated site it is	• Sampling pattern and number of samples are customized, based on the Conceptual Site Model. • Deploy precautionary measures to prevent or mitigate penetration of less impermeable soil layers.

Type	Activity	Icon with typical field situation (cross-section)	Field characteristics	Field investigation strategy	Indication sampling pattern and number of samples
				recommended to investigate during the detailed site investigation.	
P1-b	Light non-aqueous phase liquid (LNAPL) in permeable soil. (bulk density < water)		• Groundwater contaminant that is not soluble and has a lower bulk density than water. • Once LNAPL infiltrates through the soil, it will stop at the water table.	• Identify core of the source. • Samples in the core or very near in the direction of the groundwaterflow. • Depth of boring is 0.5 m below groundwater level and filter of monitoring well has to be placed in such a way that is crosses the LNAPL layer. • In case of deep groundwater levels the necessity of this investigation during this stage of the assessment of the site has to be considered.	• Sampling pattern and number of samples are customized, based on the Conceptual Site Model. • Point of attention: the thickness of LNAPL measured in a monitoring well may be different from the actual LNAPL thinkness in the soil.
	Leached or dissolved contaminants				
P-2	Groundwater contamination due to spreading of leachate or dissolved contaminants in a permeable soil.		• The size, concentration and extension of the contamination are depending on many aspects: the area where the source of the contamination is present (e.g. a large area of the source will result in a large area of the plume), the chemical properties of the components of the	• Based on the field characteristics a hypothesis of the form and extension of the plume of contaminated groundwater is developed and from that a decision can be made how data of the contaminated groundwater should be collected. • Screening techniques may be used or samples can be obtained from e.g. monitoring wells.	• Depending on the form and length of the plume a pattern of groundwater sampling points may be developed. • For point sources with a clear core of the source (maximum surface is 0.25 acre) a number of 1 sample reaches • In case of larger sources of contamination a number of

Type	Activity	Icon with typical field situation (cross-section)	Field characteristics	Field investigation strategy	Indication sampling pattern and number of samples
			contamination (e.g. more mobile components will cause larger volume of the contaminated plume), the geological stratigraphy (e.g. vertical barriers may prevent spreading of groundwater or force it into a certain direction) and soil structure (e.g. high permeability will cause larger volume of the plume), the hydrogeological situation and the period the contamination is already present in the groundwater.	• Monitoring wells can be placed after carrying out borings (by hand) or drillings (motor driven) or using probes equipment.	0.25-1 per acre may be applied. • From each monitoring well a groundwater sample shall be tested in laboratory for the most relevant parameters.

3 Additional points of attention

3.1 Difference between waste and soil

Often samples of soil and sediment have to be taken by drilling through a layer of waste or rubble. If this is the case three issues should be addressed:

- During drilling contaminated material (which may be waste) from upper layers should not be taken into deeper layers;
- After the drilling the borehole has to be sealed properly to prevent future migration of contamination downwards into the borehole;
- In a situation where a protection layer has been applied under a layer of waste material it has to be prevented that this layer will be perforated by the drilling. Either that or it should be restored afterwards.

The fieldwork team is responsible for signalling of the presence of waste or rubble during sampling. An International Standard ISO/CD 25177 Soil quality – Field soil description, is presently under development. In the draft version of this standard a classification of soil layers or horizon aspects is provided. One of the criteria is related to special soil constituents, not being natural sediment like gravel, sand, loam, silt or clay grains, humus or peat (examples: brick, concrete, glass). In case the total volume percentage of these special soil constituents is more than 50% the layer has to be named after the dominating special soil constituent (e.g. brick layer).

During the fieldwork the team involved needs to accurately define the different layers of soil and other substances such as waste or rubble. Observation of the special soil constituents and reporting of it has to be done by fieldwork team.

3.2 Undisturbed sampling

In case it is known that contamination at a site may include volatile substances undisturbed sampling is recommended in order to ensure that substances will not evaporate before laboratory analysis has taken place. This undisturbed sampling can be carried out using thin-walled core samples. However, it is quite costly to sample every layer with thin walled sampling tubes. Therefore, it is suggested, in line with international best practice, that only relevant layers will be sampled using such tubes. If during fieldwork a contaminated layer is encountered (olfactory evidence of volatile material which often appears at or near groundwater level or in a sample with high moisture content) a separate drilling can be carried out next to the first drilling in order to take undisturbed samples using thin walled sampling tubes. For regular drilling and sampling it is recommended to take samples and put them in a jar immediately after excavation. If composite samples are required this should be done in the laboratory instead of composing samples in the field.

3.3 Determination of background values

Often it is important to determine the background values in a certain area in order to make a proper delineation of a contaminated site. These background values may be influenced by anthropogenic sources or may be related to geology of the area.
This determination is always site specific. However, there are some rules of thumb on how to define background values.
At first information from the desk study about the history of the site and its surroundings and information about the cause of the contamination is important to take into account. Maybe information on values of parameters in soil, sediment or groundwater in the area is already available.
If these values are not available samples have to be taken at points which have not been influenced by contamination at the site where the investigation is focussed on. For a first indication of background values at least 3 samples should be taken and testing results compared with those of the samples of the contaminated site.

In case of substantial consequences for investigation and remediation it may be important to provide a statistically underpinned background value. This may be applied during the detailed site investigation because of the efforts involved. In such a situation it is required to set up a database based on which statistical analysis can be made. This involves the following steps:

- determine for which area (with single item soil structure and use) the value will apply;
- make use of a suitable data set (sufficient quality (criteria), good spatial distribution across the area);
- remove extreme values and point source locations from the dataset that differ from the general area quality;
- complete the dataset if at parts of the area are not enough samples are available, there should be at least 20 samples per area;
- determine average, confidence interval and P80, P90 and P95-values;
- compare the values at the site with the applicable P-value.

Volume III

2.2-iii Overview of techniques for site investigation

Volume III-2.2-iii
Overview of techniques for site investigation

1 Introduction
This Section is most relevant for Task 2.2, Preliminary site investigation, and Task 5.1, Detailed site investigation.

This Section provides a first overview of techniques, which are widely used. Screening techniques (Section 2) as well as sampling collection techniques (Section 3) are described.
For more detailed information on sample collection, extraction and testing site investigation tools the user may refer to more detailed data such as:
- Field Sampling and Analysis Technologies Matrix and Reference Guide, Prepared by the Naval Facilities Engineering Command and the U.S. Environmental Protection Agency: http://www.frtr.gov/site/toc.html
- Dutch directive on restoration and management of soil, groundwater and sediment, provides information on 130 techniques for investigation: http://www.bodemrichtlijn.nl/Tools/bodemonderzoekstechnieken/applicatie-zoeken-naar-onderzoekstechnieken (English translation is provided on this internet page)

Depending on the situation the field investigation team must use personnel protection equipment. Basic equipment includes: boots, protective clothing, dust masks, goggles or safety glasses and gloves.

2 Technical screening equipment
This Section shows an overview of technical screening equipment for preliminary site investigation (see table III-2.2-iii-1). These techniques are typically used in a first step in a Preliminary site investigation, in cases where the location of the source or the pathway or both is not known. These techniques provide a *'quick and dirty'* approach to assess a rough delineation of the source or pathway or both, needed to make a next step in the preliminary site investigation, which involves sampling and testing.

The table is to be used as a first overview to all techniques. For more detailed information on sample collection, extraction and testing site investigation tools reference may be made to the above mentioned websites.

Some of the techniques show accurate on site contaminant concentration levels. The techniques are described for typical situations based on best practices and expert judgment.

The selection of techniques should be well considered to avoid inefficiency. For example, seismic methods can be used to determine the groundwater table. This information is regarded as 'secondary data' gained from this technique as the technique is primarily used for stratigraphy assessment. Therefore, if only the groundwater table has to be measured seismic techniques are not recommended.

Some techniques are indicated to be able to measure contaminations. Depending on the technique this can be either quantitatively of qualitatively. The XRF for instance is able to provide parameter specific ppm data while magnetic field methods will provide quantitative spatial information, e.g. the outlines of a dump site. The latter techniques provide the opportunity to distinguish between pristine soil layers and layers possibly contaminated.

Table III-2.2-iii-1 only shows categories of techniques. A wide variety of subtechniques is available. These techniques either are commercially linked to one specific supplier or are generic techniques available, regardless of the supplier (e.g. auger sampler or cone penetration test).

For each technique spatial representation is indicated with ‘point/line/3D’, indicating if data is collected on a discrete point, along a vertical or horizontal line or gives a 3D image of the matrix. Some notes should be made to this point:

- Multiple points can build up to line data and multiple lines can build up to a 3D image;
- Some techniques may give point information but the data generated may represent a large volume of soil, sediment or air. For example, a gas detection reading is based on a volume of air which is pumped through the tube. The spatial representation of this measurement depends on the volume of air and area where it is extracted from.

Table III-2.2-iii-1: preliminary site investigation survey techniques for quick screening of sites: basic characteristics and typical application

	Electro magnetic methods	Geo-electric and Self Potential methods	Magnetic field measurement	Ground penetrating radar (GPR)	Radiometric measurement	Seismics (sonar)	Penetration test cones	XRF X-Ray Fluorescence	NIR Near IR luminescence	PID Photo-Ionisation Detector	Gas detection tubes
Basic characteristics											
Parameter	Electrical soil resistivity	Electrical soil resistivity	Magnetic susceptibility	Dielectric constant	Gamma ray radiation	Acoustic impedance	Various	Concentration (heavy metals)	Concentration (heavy metals / some organic compounds)	Concentration of contaminations in the air	Concentration (parameter sensitive reagent)
Unit	Ω/m	Ω/m	Gauss	F/m	Bequerel	ms or kgm^2	Various	ppm	ppm	ppm	ppm
Property of investigation	Electro magnetic induction	Galvanic resistivity	Magnetic field	Reflection/refraction electro-magnetic field	Radio active radiation	Reflection/refraction of sound waves	Various	wavelengths of the emitted X-Rays	Near IR luminescence	Ionisation of charged molecules	Speed of chemical reaction
Typical field specification											
Range of depth	0 – 25 m	0 – 100 m	0 – 10	0 – 25	0.1 m (in situ) > 0.1 m (samples)	1 – 100 m	0 – 50 m	0.1 m (in situ) > 0.1 m (samples)	0.1 m (in situ) > 0.1 m (samples)	NA > 0.1 m (samples)	NA > 0.1 m (samples)
Soil/water/air/ sediment	Soil/sediment	Soil	Soil/sediment	Soil	Soil/water/air/ sediment	Soil/sediment	Soil/sediment	Soil/water/air/ sediment	Soil/sediment	Air (sample)	Air (sample)
Resolution	1 – 25 m	1 – 100 m	1 – 5 m	0.5 – 2.5 m	0.1 m	0.5 – 5 m	0.1 m	0.1 m	0.1 m	1 m	1 m
Point/line/3D	point	point	point	line	point	line/3D	line (vertical)	point	point	point	point
Survey type (Survey technique is (+) highly suitable; (0) suitable with restrictions; (-) not suitable)											
Stratigraphy	+	+	0	+	0	+	+	-	-	-	-
Contamination	+	+	0	0	+	-	+	+	+	+	+
Objects	0	-	+	+	-	0	0	-	-	-	-
Groundwater level	0	0	-	+	-	+	+	-	-	-	-

	Electro magnetic methods	Geo-electric and Self Potential methods	Magnetic field measurement	Ground penetrating radar (GPR)	Radiometric measurement	Seismics (sonar)	Penetration test cones	XRF X-Ray Fluorescence	NIR Near IR luminescence	PID Photo-Ionisation Detector	Gas detection tubes
Practical aspects											
Field personnel (# of field operators)											
	1-2	1-2	1	1	1	>2	1	1	1	1	1
Investigation time needed ((+) quick survey technique; (0) moderate time consuming technique; (-)time consuming survey technique)											
	+	0	+	+	+	-	0	+	0	+	+
Costs (Survey technique is (+) expensive; (0) moderately expensive; (-) low cost)											
	+	0	+	+	+	-	0	+	+	+	+
Much used (Survey technique is (+) used on daily basis; (0) now and then used; (-) seldom used)											
	+	+	0	+	+	-	+	+	-	+	+
Typical type of field survey	Groundwater plume and source recon-naissance / delineation	Groundwater plume and source recon-naissance / delineation	Source and object (drums) reconnaissan-ce / delineation	Stratigraphy, source and object recon-naissance / delineation	Source recon-naissance / delineation	Stratigraphy	Stratigraphy and plume re-connaissance / delineation	Source recon-naissance / delineation	Source and pathway recon-naissance / delineation	Source and pathway recon-naissance / delineation	Source and pathway recon-naissance / delineation

Pictures of some of the screening techniques described in Table III-2.2-iii.1

Figure III-2.2-iii.1a and 1b: Example of Ground Penetrating Radar

Figure III-2.2-iii.2: Example of PID Photo-Ionisation Detector

Figure III-2.2-iii.3: Example of XRF X-Ray Fluorescence

3. Sampling techniques

3.1 Soil sampling collection tools

For the sampling of soil material different types of drills can be used depending on the soil type and type and level of contaminating substances. Some widely used types of drills are described below:

- Hand held techniques:
  - Scoops, spoons, and shovels
  - Augers
  - Tube
  - Gouge
  - Thin-walled core samplers
  - Hand pulse

- Power driven drill techniques
  - Screw drilling system: hollow auger drill
  - Screw drilling system: auger drill
  - Displacement drilling system
  - Cased auger/pulse drill

<u>Hand held techniques</u>

Scoops, spoons, and shovels
Hand-held scoops (10- to 100-gram capacity), spoons (typically 300- to 2,000-gram capacity), and shovels are used for exploratory holes, test pits and sampling near surface soils.
Accurate, representative samples can be collected depending on the care and precision demonstrated by the sample team member. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required. Care should be exercised to avoid use of devices plated with chrome or other materials. Volatiles may be lost during sample collection.

Figure III-2.2-iii.4a Example of soil sampling with shovel

Figure III-2.2-iii.4b Example of trial pit excavated with shovel

Augers

Augers are commonly used to collect near surface samples and, in combination with tube samplers, to collect undisturbed samples. Examples of augers: Edelman-drill, “riverside” drill, gravel drill.

This auger is used for drilling up boreholes to the groundwater level. It can also be used in cohesive soils. Smearing can be prevented by using an increasingly smaller diameter or by using a (lost) casing. The “riverside” and gravel drill have more disturbed samples than the Edelman-drill, but samples never cover more than 10 to 15 cm in height.

Figure III-2.2-iii.5a Example of augers (left) and handles (right)

Figure III-2.2-iii.5b Example of augers. From left to right: Riverside (gravel, debris), auger (sand), Edelman auger

Figure III-2.2-iii.5c and 5d: Examples of soil sampling with Edelman auger

Tube

Tube drills are used in (relatively) cohesive soils to obtain almost undisturbed samples. They provide fast and simple information on the (shallow) soil structure. Samples have a small volume but are useful for profile descriptions. The maximum reach depth is between 5 and 10 m below ground surface level. Like augers, tubes can utilize a variety of tips depending on soil type. Tubes are considered better than augers for sampling VOCs. Tubes are similar to augers except that a tube with a cutting tip is attached to the drill rod. Instead of being rotated, the tube is pushed into the soil.

Figure III-2.2-iii.1. Example of soil sampling with tube

Often augers are used to drill the hole and tubes are used to collect the sample. Tubes are not suitable for rocky, dry, loose, or granular material or very wet soil. A variety of tube samplers are available. Some tubes can be driven into the soil by a demolition hammer. This system is often used when debris in the subsurface occurs. There are also fully closed tubes/gouges with liners or with a foil in which the sample is entered.

Gouge

Similarly to tubes, gouge drills are used to collect undisturbed samples generally from soft and wet soils. Gouges are long, semi cylindrical chambers made of tapered stainless steel, that are pushed into the soil, twisted and recovered to display a full profile of the soil. Gouges are usually used to collect small samples, e.g. to determine soil water content by mass.

Figure III-2.2-iii.2 Example of soil sampling using gouge

Thin-walled core samplers
Thin-walled core samplers are most commonly used for collection of undisturbed core samples in cohesive soils, silt, and sand above the water table. Sample collection procedures are similar to split-spoon sampling except that the tube is pushed into the soil, using the weight of the drill rig, rather than driven (Shelby tube or Continuous tube).

Figure III-2.2-i.3a Examples of thin-walled core samplers

Figure III-2.2-iii.8b Example of sampling with thin-walled core samplers

To avoid volatile components to disappear from the soil samples after excavation a method has been developed to prevent this evaporation. A small tube is filled with soil material and methanol is added in the same amount.

Figure III-2.2-iii.8c and 8d Illustration of adding methanol to soil sampling material

Hand pulse
The hand pulse drill is used in non- or little-cohesive soils, below the water table. The borehole will be protected against collapsing by a casing made of steel or plastic. The soil material just below the casing is loosened with the help of the pulse and removed. Mechanical pulse installations are used for drilling from 10 m below ground surface level. When a hard clay layer or a strongly contaminated zone (for example a layer of purely contaminated substance) is penetrated, an additional casing with a smaller diameter is used.

Figure III-2.2-iii.9a Example of hand pulsing, using tripod and steel casing

Figure III-2.2-iii.9b Example of hand pulsing

Power driven drill techniques

Screw drilling system: hollow auger drill
Consists of a hollow central shaft with a removable sheet or valve structure at the bottom end. Due to the unfavorable spiral width diameter ratio the soil material is strongly displaced and hard to interpret, because it is smeared. Two types of hollow auger drills: in the simple system the soil is sampled without disturbing it parallelly, and in the more complex system a non-rotating sampling tube is pressed down and collects the sample in the hollow central part, while the surrounding soil is being drilled up through the space surrounding the central part.

Figure III-2.2-iii 4. Hollow auger drill

Screw drilling system: auger drill
With an auger, cohesive soils can be drilled up to 30 m below ground surface level above the water table. The jacked ground is mixed, which increases with depth. Indicative sampling or profile description is only possible when the drill is screwed into the soil like a corkscrew (lowering speed is equal to the rate of the windings) and then not turned when it is pulled up.

Figure III-2.2-iii.11a Auger drill

Figure III-2.2-iii.11b Machine driven auger drill

Displacement drilling system

There are two ways to take samples with this method. First method is a relatively thin tube provided with a lost point that is pressed into the soil to the desired depth. Inside this tube a very thin monitoring well is lowered. Then the casing is pulled up after which the filter remains. Second method is a sounding tube with an integrated filter that is pressed down until the desired depth is reached. Then the groundwater samples are taken immediately.

Figure III-2.2-iii.12a and 12b: Examples of power driven displacement drilling system

Figure III-2.2-iii.12c and 12d: Examples of sonic displacement drilling system

Cased auger/pulse drill

The auger is used to drill to the wet sand layer. With contaminated soil the casing can be inserted through rotation to limit smearing when it is pulled up. After this it can be pulsed. Within or below the casing samples may be taken. In this method, there is a minimum of smearing and wells with a large diameter are applied.

Figure III-2.2-iii.13a, 13b and 13c: Examples of cased auger/pulse drill

In case of rock or paving, material has to be crushed when drilling bore holes, special equipment has to be used.

Figure III-2.2-iii.13d-h: Examples of cased auger/pulse drill required for Hard ground and rock drilling

3.2 Groundwater sampling collection tools

Groundwater samples can be collected through several types of pumps depending on the groundwater level, the sampling of volatile compounds, etc.

The following widely used types of pumps are described below as well as filtering of groundwater samples is described:

- suction lift pump
- pressure pump
- bailer sampler
- ball valve pump

Suction lift pump

These peristaltic pumps are frequently used for shallow ground water sampling. Suction lift pumps apply a vacuum to either the well casing or to tubing that runs from the pump to the desired sampling depth. Most are easily controlled to provide continuous and variable flow rate. Peristaltic pumps utilize a self priming or power operated vacuum pump. This pump can be used to a maximum groundwater level of 9,5 m below ground surface level. It can be used for the sampling of groundwater for chemical testing of volatile compounds, provided the suction height is not over 6 m.
For each sample a disposable filter should be used. Filtering the water before bringing it into the sampling bottle is required.

Figure III-2.2-iii.14. Suction lift pump

Pressure pump
This pump, also known as Submersible centrifugal pump, is used for well purging and ground water sample collection. This pump is universally applicable for sampling for chemical testing of volatile compounds, provided the speed of the pump is variable to sampling rate. Submersible centrifugal pumps use an electrically-driven rotating impeller that accelerates inside the pump body, building up pressure and forcing the sample up the discharge line. Commonly constructed of stainless steel, teflon, rubber, and brass, most can also provide a continuous and variable flow rate. Small diameter submersible centrifugal pumps are available that can be used in 2-inch diameter wells and can be operated at both high flow rates for purging and low flow rates for sampling. Maximum depth for sampling is about 70 m below ground surface level. The risk of contamination is very large, so much attention should be paid to the materials and the cleaning of the pump.

Figure III-2.2-iii.15a and 15b: Examples of pressure pump

Bailer sampler
Bailer samplers are the most widely used sampling method, due to their low cost. However, other devices like bladder, helical-rotor, and gear pumps generally provide better results when sensitive constituents such as VOCs are present. A bailer is a hollow tube with a check valve at the base (open bailer) or a double valve (point source bailer). The bailer is attached to a line (generally either a polypropylene or nylon rope, or stainless steel or Teflon coated wire) and lowered into the water. The bailer is pulled up when the desired depth is reached, with the weight of the water closing the check valve. Open bailers provide an integrated sample of the water column. Point source bailers use: (1) balls or (2) valves (operated by cables from the surface) to prevent additional water from entering the bailer so that a sample can be collected at a specific point. Maximum depth for sampling is about 70 m below ground surface level.

Ball valve pump

The ball valve pump is used to push water upward. The pump is connected to the end of a sampling hose or tube. By moving the tube and pump down, the ball is moving up and it will let water enter into the tube. By pushing the tube and pump up, the ball is closing, so the water goes up with the tube and pump. The moving can be done by hand or by a machine. It uses the gravity and slowness of the mass of the water column. The ball valve pump is available in different diameters for different tube sizes. The pump is small, relatively cheap and it can be used to clean a monitoring well by pumping water and sediment after placement, as well as for sampling monitoring wells.

Figure III-2.2-iii.16a and 16b: Examples of ball valve pump

Filtering of groundwater samples

If testing of a groundwater sample on heavy metals is required, the turbidity in the sample should be as low as possible. Therefore, the sampled groundwater needs to be filtered through a 0,45 µm filter to remove the sediment that causes the turbidity. There are two types of filters for this:

- Filtering by “in line” filtration: the disposable filter is placed directly in between the monitoring well and the sampling bottle. The filter can also be placed at the end of the discharge of a anaerobic acting pump like a peristaltic pump (e.g. ball valve pump). The materials that have contact with the sample should be made from physically and chemically inert material. For every well a new filter must be used.
- Filter machine for pressure filtration under a vacuous gas: this machine should be completely removable to clean it. In case it is expected that the filter clogged because of the presence of floating materials, a double filter is used. In the first filter holder the prefilter is placed. This method requires use of gas tanks, quite a lot of detergent and demineralised water to clean the filter holders in between the sampling of different wells. It also requires more skills from the person executing the sampling and filtering, compared to the filtering process described above.

Figure III-2.2-iii.17a and 17b: Examples of filtering groundwater samples

3.3 Sediment sampling collection tools

For the sampling of sediment material different types of drills can be used. Some widely used types of drills are described below:

- Piston drill
- Sediment core-sampler
- Grabbers

Piston drill

The piston consists of drilling a through tube, normally made of stainless steel, to which extension rods can be attached. The insert tube is pressed into the sediment with the rod system, while the piston is kept at a constant depth with respect to the sediment. This piston maintains a negative pressure, causing the sample over the full cutting depth to be recorded into the penetration tube. The maximum cutting depth of the piston sampler is 2 m. There is no visual inspection if the sample also includes the upper surface. Coarse sand or very watery material drops during the acceleration of the piston bore. There is no provision, other than the vacuum of the piston, to keep it down in the tube.

Figure III-2.2-iii.18: Transparent material piston drill

Sediment core sampler

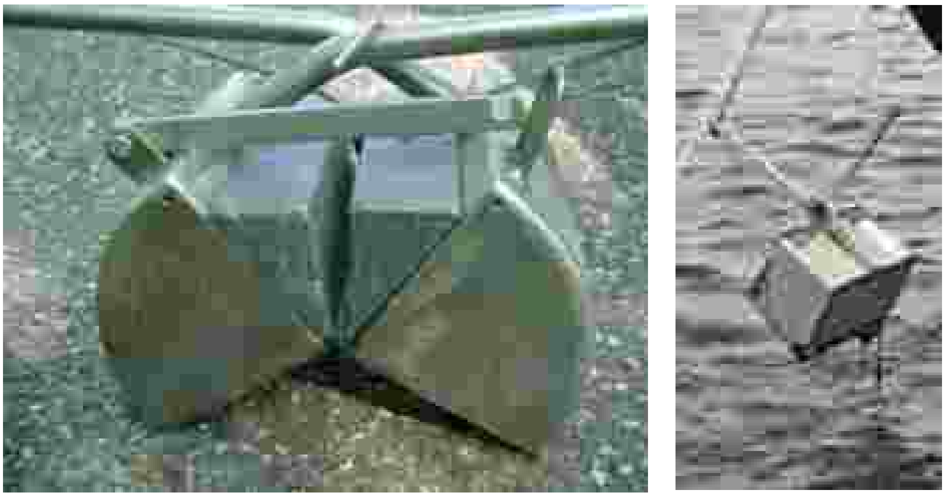
The sediment core sampler (in this case of the so called Beeker type) consists of a cutting head with an attached transparent penetration tube of polyvinyl chloride, which is presses or hammers the extension rods into the soil. A piston down tube creates a vacuum, which enables sampling of the best stitch length down tube (sample tube). Once the penetration tube arrives at the correct depth, a rubber bellow can be inflated in the cutting head so that the bottom of the sample tube can be closed. The sampling unit can then be retrieved. Subsequently, the sample can be judged visually and expressed in sample pots or a gutter. The maximum stitch length of a Beeker sediment plug is 2 m, with a diameter of 63 mm. In stagnant water it can be applied to 10 m depth.

Figure III-2.2-iii.19 Example of sediment core sampler

Grabbers

The so called Van Veen grabber, the example of a grabber described here, is a grabber with a cable or rope lowered to the bottom. When hitting the bottom of the suspension cable an unlocking mechanism is set into motion. By subsequently pulling up the cable the sample is snapped out of the sediment. The device collapses weak sludges, and collects, depending on the size, only a shallow sample. It can be applied in non or hardly flowing water to all depths.

Figure III-2.2-iii.20a and 20b: Examples of grabbers

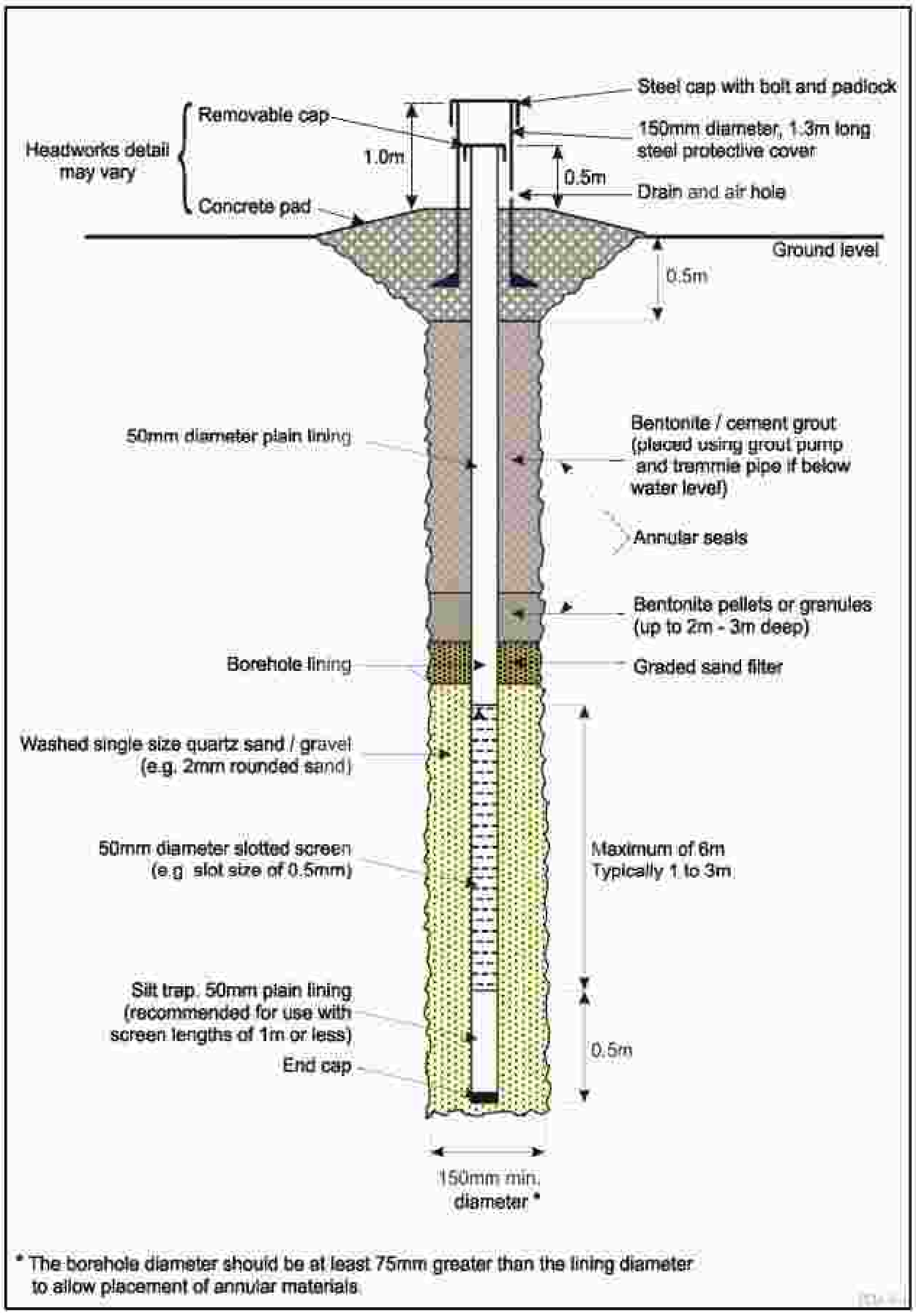


3.4 Other materials required for drilling and sampling

Piezometers and monitoring wells

For measuring groundwater level and for sampling groundwater monitoring well pipes may be installed in boreholes to create piezometers and monitoring wells. These pipes are normally made of plastic which is inert and does not influence the quality of the groundwater. The pipes have slits through which the groundwater can flow into the pipe where it is extracted for sampling. After installing the pipe a cap with lock should be applied to be able to prevent disturbance of the wells.

Figure III-2.2-iii.21: Example of generic groundwater well design

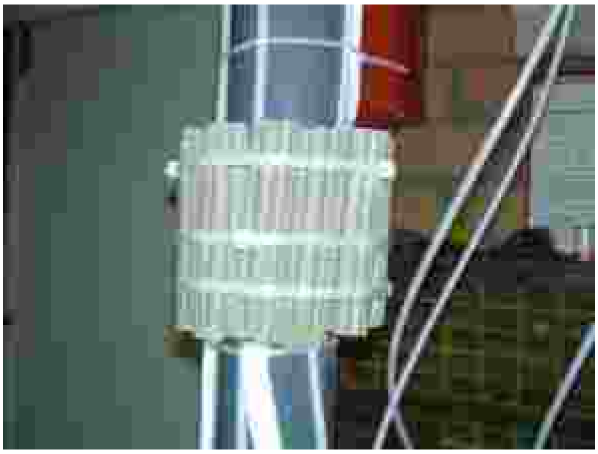


Swelling clay

Groundwater may be differentiated by the stratigraphic layers in soil. Drilling can cause leakages between these layers which may lead to unintentional intrusion of contaminated substances into a layer of fresh and undisturbed groundwater. To prevent groundwater flow between different soil layers swelling clay must always be used. This clay can be added as pellets or as plugs, as shown in the figures III-2.2-iii.22 a and b respectively.

Figure III-2.2-iii.22a: Bentonite pellets

Figure III-2.2-iii.22b: Bentonite plug



Filter sand or gravel

After drilling a borehole a monitoring filter may be placed in the hole. For the filling of the space between the filter and the borehole sand or gravel should be applied, at least for the length of the filter, to enable groundwater flow through the filter. Filter sand is not required in case of very coarse and well drained soil layers. Examples of filter sand are shown in figures III-2.2-a and b.

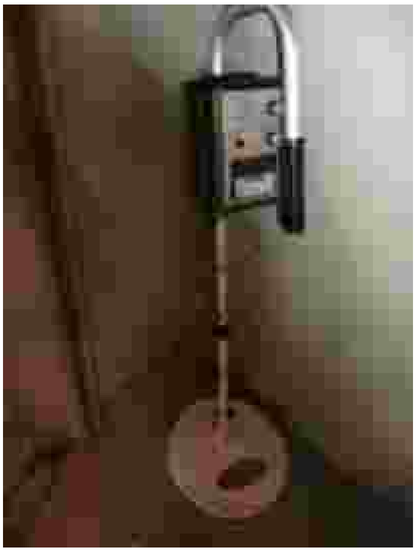
Figure III-2.2-iii.23a and 23b: Filter sand

Groundwater level measuring device
Many tools are available to detect the groundwater level in a monitoring well. Some of these are illustrated in figure III-2.2-iii.24a-d below.

Figure III-2.2-iii.24a-d: Examples of groundwater level measuring tools

Metal detector
A metal detector may be used to detect the presence of hidden objects of metallic origin below the surface, such as tanks, barrels and cables. In case such objects are expected at a site it should be considered to excavate a hole by hand before performing mechanical drilling.

Figure III-2.2-iii.25 Example of metal detector



Oil water observation tool
To detect if there are floating contaminating compounds in soil or groundwater a tool may be used for rapid on site observation. This tool does not provide information on the exact substances and concentrations.

Figure III-2.2-iii.26a and 26b: Examples of oil-water observation tool / oil detection pan

Sediment level measuring device
A method to roughly assess the thickness of a sediment layer is to use a hand held tool, as illustrated in figure III-2.2-iii.25a and b below.

Figure III-2.2-iii.27a and 27b: Example of tool to detect sediment level

Samples coolers
Laboratories provide information about maximum holding time for samples before analysis is carried out. Samples of contaminated material should, as much as possible, be kept under conditions which will not influence the contaminants before arriving at the testing laboratory. Often, this involves cooling, especially when samples are to be tested for volatile compounds.

Figure III-2.2-iii.28a and 28b: Examples of sample cooling methods

Volume III

5.1-i Example investigation strategy detailed site investigation

Volume III-5.1-i
Example investigation strategy detailed site investigation

1 Introduction

This information is most relevant for Task 5.1 Detailed site investigation.
A detailed site investigation is always a site specific exercise for which a site specific investigation protocol should be developed. An example of the development of an investigation strategy is provided below.

2 Example investigation strategy detailed site investigation

The following example explains how an investigation strategy should be tailor made to specific situations. The examples refer to a situation of a contaminated top layer (S-1 type: solid phase contamination, land bound site) caused by elevating the ground level by using contaminated material and mixing it with the soil underneath.

Available project information
Site inspection provided information that the contaminated top layer occurs to a depth of approximately 0.8 m. The groundwater is about 1.5 meters below ground. The area is approximately 3000 m². The concentrations of copper, lead, zinc and PAHs in the top layer are in excess of the Response levels. From the results of the analysis of the groundwater it concludes that the contamination is immobile: no relevant groundwater contamination was found. Future use of the site is residential.

Define scope
In respect to the sensitive future land use remediation of all contaminated material at the site is considered. The remediation may be carried out by removing the contaminated top layer and replace it by a clean soil layer of about 1 m.

Establish required information
Based on the scope of the investigation of the investigation the required information is established. In this case the sort of information that has to be collected and the required level of detail of this information, is closely dependent on the remediation option to be carried out. The information to be collected is required in order to:
- delineate the contaminations because it is expected that the contaminated material will be fully removed;
- determine the treatment possibilities of the contaminated material representative levels of contaminants including organic matter and clay content, and quantities of debris and large waste particles;
- determine the remediation costs.

The required level of detail for the investigation is determined by what is sufficient enough to determine the depth of the contaminated material. The level of detail required is determined per soil layer as follows:

- 0.0 to approximately 0.8 m below: to be excavated;
- approximately 0.8 to approximately 1.3 m below: vertical demarcation size determination.

Developing a conceptual site model (CSM) of the situation
Based on the available data, a conceptual site model is developed, in which particular attention is being paid to [i] the data that has to be collected and [ii] the possible remediation option which will likely to be executed.

Conceptual model in table

Situation of the contaminated multiplication layer:	The site is part of the larger area where these kind of contaminated layers are expected. At the location the multiplication layer extends to 0.8 meters depth. Within the boundaries of the location the intention is to fully remove the contamination.
Groundwater quality and household:	Not significantly contaminated groundwater, groundwater level is at a depth of 1.5 m below ground level.
Possible remediation variant:	Soil top layer may be completely excavated down to 0.8 meters below ground level. The excavated area will be supplemented with clean soil.
Party-division and size:	from 0 to 0.4 m depth: about 120 m³ polluted ground, including asbestos and admixtures of debris from 0.4 to 0.8 m depth: 120 m³ contaminated soil, asbestos is not suspected, soil admixtures of foreign material. Volume weight is unknown so the calculation from m³ to tons is uncertain, which determines the remediation costs.
Treatment possibilities material:	Transport and disposal or sifting of debris and extractive cleaning, representative concentrations of contaminants and other relevant parameters (humus, clay, grading curve) for treatment possibilities of both parties are lacking. It is unclear if the soil underneath the contaminated layer has been contaminated by leaching as well.
Risks of working with contaminated ground:	PAHs, lead and asbestos is present, representative concentrations and soil moisture content is not known.

Note: the above conceptual model is later included in the report of the detailed site investigation. In the conclusion of the report it is addressed in particular the investigation questions that were answered during the investigation.

Formulation of specific required information:

- What is the average concentration of the expected chemical substances, clay content, organic matter in the layer of approximately 0.0 to 0.8 meters deep? What is the grain-size distribution of the soil particles?
- What is the average concentration of chemical substances in the layer of approximately 0.8 to 1.3 meters deep?
- What is the required excavation depth?
- What is the volume weight of both to be discharged parties?
- What is the percentage of the debris and large waste particles in the top layer?

Investigation protocol

- Inspection holes or test pits should be excavated in the top layer. Visual inspection of the surface and the excavated material is important. Samples will be taken from the individual recognizable layers.
- The inspection holes are spatially distributed in the backyard: 5 inspection holes dug from 0.3 to 0.3 meters wide and 0.5 meters deep. All inspection holes are 12 cm by hand drill put to approximately 1.3 meters.

When the soil is sampled, a distinction is made in the following two layers in below table:

Layer	Sampling contaminated material	Sampling volume weight
Toplayer	*per test pit / drilling 1 sample-pot, dilution processes at laboratory*	*1 undisturbed sample using tube*
Non-suspected subsurface layer below top layer	*Per drilling one sample-pot, dilution processes at laboratory*	*None*

Volume III

5.2-i Tools for risk assessment

Volume III-5.2-i
Tools for risk assessment

1 Introduction

This information is most relevant for Task 5.2, Risk Assessment. During the risk assessment tools may be used to support the qualitative or quantitative assessment. First, the use of a diagram to establish the relevant exposure routes is explained. Subsequently, information is provided on the internationally favoured risk assessment models.

2 Diagram for establishment of exposure routes

A diagram (refer Figure III-5.2-i.1) may be used to illustrate how exposure routes depend on source, land use and detailed site establishment. This is the qualitative phase in the risk assessment process, as described in Volume I under Activity 2. In the quantitative phase of the risk assessment process (as described in Volume I under Activity 3 and 4) attention should be paid only to the identified potential exposure routes, which are shown in the diagram.

An indication of the exposure routes relevant for a specific site can be established by applying the following steps:

1) Identify the contaminants of concern in the source. This information is obtained from the previous Tasks 2.2, Preliminary site investigation, and 5.1, Detailed site investigation;
2) Determine the pathways through which the contaminants are migrating to the possible receptors. More detailed information on the pathways is provided in Box III.5.2.1 below;
3) Indicate land use (on-site and off-site). Generic forms of land use are mentioned in Box III.5.2.2 below;
4) In addition to these generic forms of land use information on the detailed situation at the contaminated site should be collected. This can be done for example from a plan, from a map or from interviews with local people. Examples are provided in Box III.5.2.2 below;
5) Identify the receptors currently or potentially exposed to site contaminants. This includes humans and other organisms that are in direct contact with the source of contamination, or are potentially present along the migration pathways, or are located in the vicinity of the site. Maps indicating the contaminated sources, pathways and receptors may support the identification. For ecological receptors terrestrial and aquatic habitats for plants and animals within and around the study area or associated with the source(s) or migration pathways are important to identify.

Box III.5.2.1 Identification of pathways (exposure routes)

Potential migration pathways by which contaminants are migrating through groundwater, surface water, air, soils, sediments, and biota should be identified for each source. Based on the ASTM-1689 guideline for Conceptual Site Models the following pathways are mentioned that may be involved:

Ground Water Pathway:
This pathway should be considered when hazardous solids or liquids have or may have come into contact with the surface or subsurface soil or rock. The following should be considered further in that case:

- vertical distance to the saturated zone;
- movement through the unsaturated zone;
- subsurface ow rates;
- presence and proximity of downgradient seeps, springs, or caves;
- fractures or other preferred ow paths;
- artesian conditions;
- presence of wells, especially those for irrigation or drinking water; and
- in general, the underlying geology and hydrology of the site. Other fate and transport phenomena that should be considered include hydrodynamic dispersion, interphase transfers of contaminants, and retardation.

Surface Water and Sediment Pathway:
This pathway should always be investigated in the following situations:

- A water body (river, lake, continuous stream, drainage ditch, etc.) is in direct contact with, or is potentially contaminated by a source or contaminated area,
- an uninterrupted pathway exists from a source or contaminated area to the surface water,
- sampling and analysis of the surface water body or sediments indicate contaminant concentrations substantially above background,
- contaminated groundwater or surface water runoff is known or suspected to discharge to a surface water body, and
- under arid conditions in which ephemeral drainage may convey contaminants to downstream points of exposure.

Air Pathway:
Contaminant transport through the air pathway should be evaluated for contaminants in the surface soil, subsurface soil, surface water, or other media capable of releasing gasses or particulate matter to the air. The migration of contaminants from air to other environmental compartments should be considered, for example, deposition of particulates resulting from incineration onto surface waters and soil or from dust due to wind over dry surfaces.

Soil Contact Pathway:
Contaminated soils that may come into direct contact with human or ecological receptors should be investigated. This includes direct contact with chemicals through dermal absorption. There is a potential for human and ecological receptors to be exposed to contaminants at different soil depths (for example, humans may be exposed to only surface and subsurface soils, whereas plants and animals may encounter contaminants that are buried more deeply).

Biotic Pathway:
Bioconcentration and bioaccumulation in organisms and the resulting potential for transfer and biomagni cation along food chains and environmental transport by animal movements should be considered. For example, many organic, lipophilic contaminants found in soils or sediments can bioaccumulate and bioconcentrate in organisms such as plankton, worms, or herbivores and biomagnify in organisms such as carnivorous sh and mammals or birds. The movement of contaminated biota can transport contaminants.

Examples of source-pathway-receptor combinations are presented in the 'Diagram for identification exposure routes'.

Box III.5.2.2 Land use and detailed site establishment

The following generic forms of land use can be distinguished:

- Agricultural land;
- Kitchen gardens;
- Forests and other natural area;
- Habitation settlement/residential or school or playground or garden/park;
- Commercial;
- Industrial;
- Infrastructure (roads, parking, railway, subsurface cables and pipes);
- Waste land;
- Water bodies;
- Mixed land use (to be specified for each case);
- Other land use (to be specified for each case).

In addition to these generic forms of land use examples of additional information on the detailed establishment of the contaminated site are:

- are there buildings / houses at the site? At which location exactly?
- are there roads, paths, parking? Which is the material of the pavement?
- are there consumption crops grown?
- is groundwater abstracted for drinking water or other purposes?
- is surface water used for fishery?
- Is access to the site restricted, e.g. a secured industrial site which is accessible only by industrial workers?

Figure III-5.2-i.1: Diagram for identification exposure routes, filled in as an example

Diagram for identification exposure routes

				land use										detailed site establishment								exposure routes and receptors					
														not-sensitive				sensitive				human					eco
	source contamination	pathway		Agriculture land	Kitchen garden	Forests and other natural area	Habitation settlement/Residential	School or Playground or recreational park	Commercial	Industrial	Infrastructure (e.g. roads, parking, railway)	Water bodies	Mixed and other land use	contamination sealed by buildings	contamination sealed by pavement	contamination sealed with clean soil	contamination sealed by other material	water used for fishery	ground water abstracted for drinking water	crops grown	contamination in top layer, not sealed	direct contact	ingestion of crops	ingestion of fish	ingestion of drinking water	inhalation of indoor air	exposure ecology
		soil																									
		groundwater																									
		surface water & sediment																									
		air																									
		biotic																									
example 1	heavy metals	soil	X				X														X	X					
		groundwater	X																X						X		
		surface water & sediment	X																								
		air	X																			X					
		biotic	X																								
example 2	volatile aromatics	soil																									
		groundwater	X				X				X			X	X											X	
		surface water & sediment																									
		air																									
		biotic																									

3 Risk assessment models

Internationally, a multitude of models for the quantitative assessment of risks for human health and water resources is in use. Examples of the most widely used of these models are presented in this Section.

Most of the approaches to risk assessment promote increasing (or tiered) levels of investigation, separated by decision steps. These steps evaluate the need for further investigation regarding the costs of remediation, the assessed risks to human health or to the environment, the costs of further investigation, and the regulatory obligations.

For the derivation of critical exposure values a threshold approach or a non-threshold approach is applied. Threshold effects are assumed to exist for all toxic effects except genotoxicity (direct effect on DNA, which is linked to carcenogenity). In the threshold approach the Tolerable Daily Intake (TDI, see Box III.5.2.3 below) is used.

Box III.5.2.3 Tolerable Daily Intake (TDI)

A TDI is an estimate of the amount of a substance in air, food or drinking water which represents the daily intake over a lifetime without appreciable health risk. TDIs are based on laboratory toxicity data to which uncertainty factors are applied.

For most kinds of toxicity, it is generally believed that there is a dose below which no adverse effect will occur. For chemicals that give rise to such toxic effects, a tolerable daily intake (TDI) should be derived as follows, using the most sensitive endpoint in the most relevant study, preferably in drinking water:

TDI = (NOAEL or LOAEL) / UF

Where:
NOAEL = no-observed-adverse-effect-level, which represents the highest tested dose or concentration of a substance at which no adverse effects is found in exposed test organisms, where higher doses or concentration resulted in an adverse effect.
LOAEL = lowest-observed-adverse-effect-level.
UF = Uncertainty factor, which is a safety factor (100 is mostly used) to account for differences between test animals and human.

As TDIs are regarded as representing a tolerable intake for a lifetime, they are not so precise that they cannot be exceeded for short periods of time. Short-term exposure to levels exceeding the TDI is not a cause for concern, provided the individuals intake averaged over longer periods of time does not appreciably exceeds the level set. The large uncertainty factors generally involved in establishing a TDI serve to provide assurance that exposure exceeding the TDI for short periods is unlikely to have any deleterious effects upon health. However, consideration should be given to any potential acute effects that may occur if the TDI is substantially exceeded for short periods of time.

Source: drinking water – derivation of chemical guideline values (FAO/WHO)

The non-threshold approach applies to chemicals for which any exposure has the potential to cause adverse effects. For these contaminants (e.g. genotoxic carcenogens) an estimation extra lifetime cancer risk can be calculated using a ‘potency’ or ‘slope’ factor. The result can be compared to a level for acceptable cancer risks, internationally varying between about 1 in 10,000 to 1 in 1,000,000. If the calculated risk estimates are less than an acceptable level, it is regarded to be an acceptable situation.

A variety of software models are available to assess risk that contaminated land may pose to Human Health and water resources. The following internationally widely used models are presented and discussed below:
- CLEA
- RBCA
- RISC5
- CSOIL
- MODFLOW
- ConSim
- Remedial Targets Methodology

CLEA
CLEA v1.06 is the most recent release of the Contaminated Land Exposure Assessment (CLEA) Model produced by the Environment Agency. It is fully compliant with the UK technical guidance (SR2-report, Human health toxicological assessment of contaminants in soil, Environment Agency, 2009 and SR3-report, Updated technical background to the CLEA model, Environment Agency, 2009). The model is deterministic.

The CLEA v1.06 model is the software that the Environment Agency has used to derive Soil Guideline Values. It may be used to:
- derive generic assessment criteria (GAC) (basic mode);
- derive site specific assessment criteria (SSAC) (advanced mode) and
- calculate average daily exposure /heath criteria ratios (requires representative media contaminant concentrations).

It offers the following exposure pathways:
- ingestion of soil and soil derived dust
- consumption of homegrown produce (vegetables and fruit)
- consumption of soil attached to homegrown produce (indirect)
- dermal contact with soil and soil derived dust;
- inhalation of soil derived dust (indoors and outdoors) and
- inhalation of soil derived vapours (indoors and outdoors).

The following land-use scenarios, with standard assumptions from SR3 are already present within the model:
- residential with consumption of homegrown produce;
- (Residential without the consumption of homegrown produce);
- allotments and
- commercial.

There is also a series of standard building types and soil types. Users may adapt the land-use scenarios, building types and soil types already present, or may add their own to the database.

The CLEA v1.06 model has a chemical database which contains all the physical-chemical data present with the SR7 report and all the toxicological data within individual published TOX reports (contaminants in soil: updated collation of toxicological data and intake values for humans, Environment Agency) published since 2008. Users may add their own contaminants to the database.

The CLEA v1.06 model does not incorporate sub-surface water pathways. The model output will flag when a saturation limit (either solubility or within the vapour phase) is reached, but does not limit the assessment criteria at the saturation limit. Only on-site users are considered. The CLEA v1.06 model allows a user to incorporate bioaccessibility considerations, but not to include biodegradation. It is possible to incorporate media concentrations, such as those in soil vapour, indoor air or homegrown produce. It cannot model behaviour of free product.

RBCA

The most recent version of the RBCA Toolkit for Chemical Releases produced by GSI Environmental (a US-organization) is v2.6. It has been designed to meet the requirements of the ASTM Standard Guide for Risk-Based Corrective action (E-2081). The model is deterministic and has been designed to:

- calculate baseline risk levels and
- derive “risk based cleanup standards” (assessment criteria).

Theoretically, the model can be used at both Tier 1 (i.e. generic risk assessment) and Tier 2 (detailed quantitative risk assessment) however, because Tier 1 incorporates a range of US assumptions and is not compliant with SR2 or SR3,therefore in the UK users will need to use Tier 2.

The RBCA Toolkit v2.6 incorporates the following pathways:

- groundwater ingestion;
- surface water recreational contact and fish consumption
- incidental ingestion of surface soils;
- dermal absorption of surface soils;
- inhalation of particulates from surface soils;
- inhalation of vapours from surface soils (outdoors and indoors);
- inhalation of vapours from subsurface soil sources (outdoors and indoors) and
- inhalation of vapours from subsurface water sources (outdoors and indoors).

The following standard land-use scenarios, incorporating default ASTM assumption are already present within the model:

- residential and
- commercial.

These can be adapted and, in addition, it is possible to create a user-defined receptor. Both on-site and off-site receptors can be considered. Users can adapt the default buildings and soil parameters.

The chemical database of RBCA Toolkit for Chemical Releases v2.6 is based on the database published by the Texas Commission of Environmental Quality along with Dutch and UK databases. However, the model is able to operate with multiple database files, rather than just by adapting the default database, so that users can select the one they need that complies with technical guidance in the country in which they are operating.

The RBCA Toolkit limits assessment criteria at the saturation limit and indicates where this is the case. The model allows the user to incorporate soil and subsurface water source depletion. It is not readily possible to incorporate concentrations in media other than soil and groundwater. It cannot model behaviour of free product.

RISC 5

RISC5 is the most recently released version of the model which was formerly RISC Workbench, and prior to that BP RISC. The model can be used either deterministically or probabilistically.

It can be used to:

- estimate human health risk from exposure to contaminated media (soil, groundwater, vegetables, sediment) and
- estimate risk-based clean-up levels in various media.

It can be used in a tiered manner, depending on whether default assumptions are altered or not.

It incorporates the following pathways:

- ingestion of soil;
- dermal contact with soil;
- ingestion of subsurface water;
- dermal contact with subsurface water;
- inhalation in the shower;
- inhalation of vapours in outdoor air;
- inhalation of vapour in indoor air;
- inhalation of dusts;
- inhalation of surface water (swimming);
- dermal contact with surface water (swimming);
- dermal contact with sediment;
- ingestion of sediment;
- irrigation pathways (ingestion, inhalation, dermal contact);
- consumption of vegetables grown in contaminated soil and
- ingestion of vegetables irrigated with contaminated groundwater.

There are a number of receptor profiles incorporated, including adult residents and workers and child residents. An additive receptor, which considers a receptor exposed as both a child and an adult is also included. Users can create new receptor profiles.

There are a number of default soil types present within the model and users may both adapt these and create new soil types. Building parameters can be edited. There is a chemical database which users can edit. The default toxicological parameters are USEPA values.

Media concentrations can be entered directly into the model. The model incorporates a number of different models for source depletion, including biodegradation during transport through the unsaturated zone. There are different fate and transport models, depending on whether or not free product is present.

CSOIL

The Dutch CSOIL exposure model for human risk assessment of soil contamination was developed in 1994 and updated in 2000 to determine the Dutch intervention values, to be used for assessment of the need for remediation. CSOIL calculates the risks that humans are exposed to if they come into contact with soil contamination. Humans can be exposed to contaminated soil via different exposure routes (soil, air, water and crops). The soil use, such as a vegetable garden, determines the measure of exposure. Physical-chemical properties of the contaminant in soil air, soil particles and groundwater also have an influence on the exposure. CSOIL 2000 also calculates the maximum concentration of a contaminant in the soil at which it is still safe for humans. This maximum concentration influences the level of the intervention value. In soil contamination the intervention value differentiates between slightly and seriously contaminated soils. The urgency of remediation is therefore determined by the level at which soil contamination exceeds the intervention value. For further information: National Institute of Public Health and the Environment, The Netherlands, RIVM report 711701054/2007

The model incorporates the following pathways:

- direct ingestion of soil and soil derived dust;
- consumption of vegetables that have taken up contamination from soil;
- inhalation of soil vapours outside;
- inhalation of soil vapours inside;
- dermal contact with soil outside;
- dermal contact with soil derived dust inside;
- inhalation of soil-derived dust outside;
- inhalation of soil-derived dust inside;
- inhalation of subsurface water vapours outside and inside;
- ingestion of contaminated groundwater both directly and through permeation of plastic pipes;
- inhalation of vapours during showering;
- dermal contact during showering;

The default land-use scenario is a residential small-holding, but a new land use scenario can be created by altering pathways, receptor and exposure factors. Users can adapt the default soil and building parameters.
The default toxicological database is based on the physical-chemical and toxicological parameters used within CSOIL to derive the Dutch Intervention Values. It is possible to insert measured concentrations for all media. It is not possible to include incorporate degradation rates or bioaccessibility. It can model behaviour of free product.

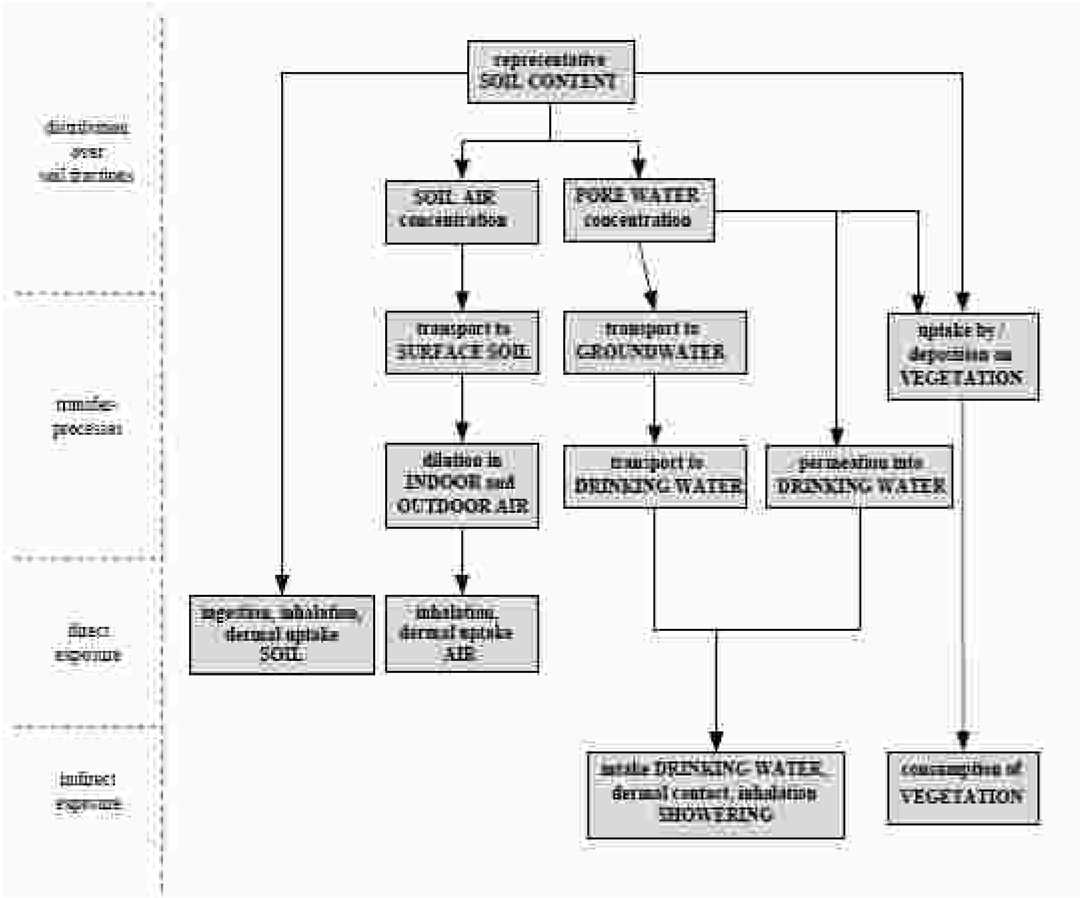


Diagram showing the exposure routes of the model, CSOIL 2000 (RIVM, 2007).

Groundwater and transport models

For the understanding of transport of contaminants in the subsoil, and therefore also of the distribution of a contamination in the soil, groundwater movement and transport of substances can be modelled. The model should be appropriate regarding the required information in the specific situation and the quality of the data of the site. If the soil profile and the spatial variation therein are only partly known, a simple model may provide insight into average linear transport. In case this is not providing sufficient information, more data of the subsoil should be collected before a more complicated modelling can be applied.

Groundwater models describe the groundwater flow and transport processes using mathematical equations based on certain simplifying assumptions. These assumptions typically involve the direction of flow, geometry of the aquifer, the heterogeneity or anisotropy of sediments or bedrock within the aquifer, the contaminant transport mechanisms and chemical reactions. Because of the simplifying assumptions embedded in the mathematical equations and the many uncertainties in the values of data required by the model, a model must be regarded as an approximation and not an exact duplication of field conditions.

Before selecting any of the assessment models or tools, it is vital to have a sound conceptual model of the site. It is also important to have a sound dataset before starting the modelling. It is essential to use the appropriate tool and to interpret the results with a clear understanding of the applicability, accuracy, precision and relevance of its inputs and outputs.

Below three models are illustrated: CONSIM and Remedial Targets Methodology by UK Environment Agency and MODFLOW by USGS.

MODFLOW

MODFLOW is a widely used groundwater flow model for simulating and predicting groundwater conditions and groundwater/surface-water interactions. The most widely used numerical groundwater flow model is MODFLOW which is a three-dimensional model, originally developed by the U.S. Geological Survey (McDonald and Harbaugh, 1988).

Originally developed and released solely as a groundwater-flow simulation code later on many codes were added including for simulation of contaminant transport. The group of MODFLOW-related programs now includes capabilities to simulate coupled groundwater/surface-water systems, solute transport, variable-density flow (including saltwater), aquifer-system compaction and land subsidence, parameter estimation, and groundwater management.

CONSIM

ConSim is a probabilistic model that uses the Monte Carlo simulation technique to select values randomly from each parameter range for use in the calculations. Repeating the calculations many times gives a range of output values, the distribution of which reflects the uncertainty inherent in the input values. This enables you to determine the likelihood of the estimated output values being realised.

CONSIM uses a tiered approach to the assessment of risk to groundwater which predicts contaminant concentrations at several stages along the pathway between the source and the receptor and allows a comparison with appropriate water quality standards. ConSim follows a tiered approach, based on that outlined by the R&D 20 (Environment Agency 1999). The tiers in ConSim are not directly equivalent to those described in R&D 20, and they have therefore been termed 'levels' to avoid confusion. The levels may be summarised as follows:

Level 1. Contaminant Source Assessment.

Level 1 is the simplest stage in a ConSim assessment, which produces contaminant concentrations in porewater within the contaminated soil. The assessment directly incorporates the results of leachate testing, or predicts porewater concentrations based on the results of soil concentration analyses and solid/liquid/gaseous partitioning effects. Level 1 assumes no dilution or attenuation of the contamination and is thus the most conservative of the three assessments.

Level 2. Unsaturated Zone Transport, Aquifer Dilution.

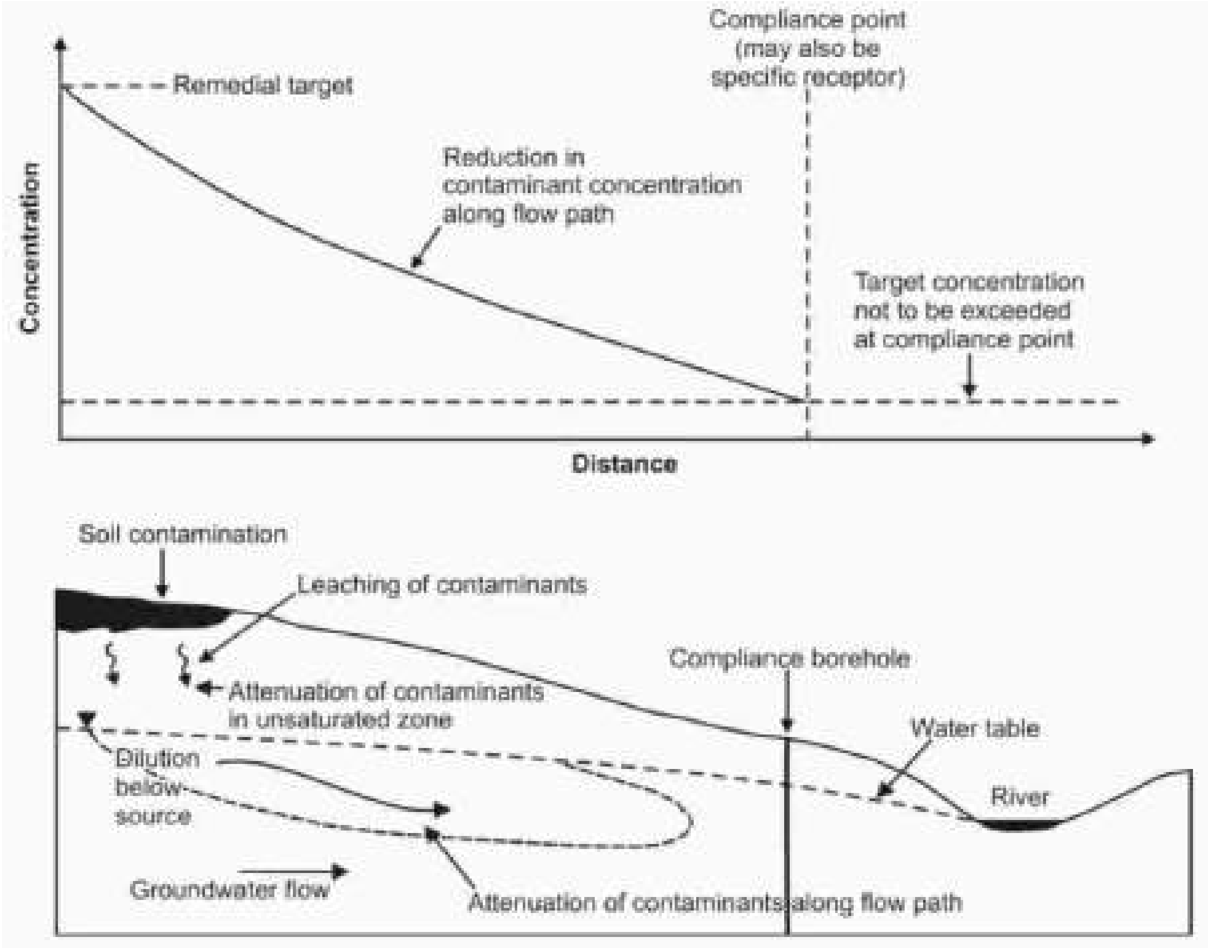
A Level 2 assessment includes a Level 1 assessment, and there are three additional parts; an assessment of the time required for contaminants to migrate from the contaminated soil to the base of every unsaturated pathway, an assessment of the concentration of contaminants at the base of every unsaturated pathway, and a preliminary assessment of the concentration of contaminants at the point of maximum dilution in the aquifer, if sufficient data are available. The effects of biodegradation/decay and retardation can be included if you wish, and both fractured and porous unsaturated zones may be considered. A Level 2 analysis can be completed with a soakaway to allow intense recharge to be simulated. As Level 2 allows for the effects of retardation, degradation and dilution, the results are less conservative than those which are generated by a Level 1 assessment.

Level 3. Saturated Zone Transport.
A Level 3 assessment includes Level 1 and 2 plus an assessment of the time for contaminants to reach a receptor at some distance from the site and the concentrations of contaminants to be expected. You can include the attenuating effects of biodegradation/decay, retardation and dispersion.
At each stage, the calculated contaminant concentrations may be compared with selected water quality standards to indicate the magnitude of the risk posed to groundwater.

Level 3a
The Level 3a module allows the user to omit the unsaturated zone and directly input groundwater concentrations. This option can be used to simulate the movement of contaminants that have passed through the soil zone (e.g. an underground storage tank beneath the water table, or where the soil source has been removed). Level 3a is equivalent to a Tier 3 groundwater analysis in R&D Publication 20 (Environment Agency, 1999).

Level 4
ConSim performs the necessary calculations using Laplace transforms to solve the groundwater flow and contaminant transport equations. The fourth tier described by The Environment Agency (1999) comprises detailed numerical groundwater flow and contaminant transport modelling. This type of calculation is outside the intended application of ConSim, but it may be necessary to carry out further, more detailed, modelling if the hydrogeological regime is complex, or if the sensitivity of the receptor warrants additional expenditure.

Remedial Targets Methodology
The Environment Agency Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination guidance document and accompanying spreadsheet allow the derivation of remedial target concentrations for contaminants in soils and groundwater. These target concentrations should not be exceeded at compliance points which have to be determined along the contaminant pathway (refer to below picture which illustrates the compliance point relationship with Remedial Targets Methodology (source: Groundwater protection, Principles and Practice, UK-Environment Agency, 2013).



The methodology was developed to derive site-specific remedial objective for contaminated soils and/or groundwater and to protect the aquatic environment. It is based on a phased approach to risk assessment and management as set out in UK government guidance. The approach is underpinned by progressive data collection and analysis, structured decision making and cost benefit assessment.

The methodology applies to soils and groundwater that is already contaminated, where the original surface source of the contamination has ceased and consists of up to four assessment levels which progressively follow the pathway from the contaminant source through to the receptor. A remedial target is derived at each level, but this likely to be less stringent at the next level as additional processes such dilution attenuation are taken into account.

At level one the assessor considers the initial conceptual site model and evidence of pollutant linkages. The assessor then evaluates whether contaminant concentrations in pore water in contaminant soil are sufficient to impact the receptor but ignores dilution, dispersion, and attenuation along the pathway.

At level two the assessor considers the possible effect of attenuation processes in the soil and unsaturated zone, and predicts the effects of dilution by groundwater flow beneath the site.

At level three, the assessor considers the effects of attenuation between the site and a downgradient receptor and can include such processes as:

- dilution;
- dispersion;
- retardation;
- degradation by biotic of abiotic processes and
- other attenuation processes.

Finally, at level four, the assessor can consider whether it is appropriate to take account of dilution in the receiving watercourse or abstraction.

4 More information

More detailed information on risk assessment methodologies is available via specialized websites of governmental organizations and research institutes:

- http://www.neeri.res.in/
  National Environmental Engineering Research Institute (NEERI), Nagpur

- http://www.nih.ernet.in/
  National Institue of Hydrology, Roorkee
  Providing for learning package for hydrology:
  http://www.nih.ernet.in/rbis/learning.htm#Groundwater

- http://ngri.org.in/
  National Geophysical Research Institute (NGRI), Hyderabad

- Concepts and Modeling of Groundwater System, C.P. Kumar, S. Singh, National Institute of Hydrology, in International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 2, February 2015

- https://www.gov.uk/government/collections/land-contamination-technical-guidance
  Link to information and examples UK

- http://publications.gc.ca/site/archivee-archived.html?url=http://publications.gc.ca/collections/collection_2014/ec/En163-1-16-eng.pdf
  link to Technical Assistance Bulletin nr 16 on Risk Assessment-Exposure Model, Toxicity analysis and Evaluation, Canada

- http://esrd.alberta.ca/lands-forests/land-industrial/inspections-and-compliance/alberta-soil-and-groundwater-remediation-guidelines.aspx
  Alberta Environment and Parks government, links to Tier 1 and Tier 2 Soil and Groundwater Remediation Guidelines.

- http://www.epa.gov/risk_assessment/guidance.htm
  link to information and examples of US-EPA risk assessment

- http://www.epa.gov/land-research/models-tools-and-databases-land-and-waste-management-research
  link to information and examples of US-EPA Models, Tools, and Databases for Land and Waste Management Research

- http://water.usgs.gov/software/lists/groundwater/#var-saturated
  link to information and examples of USGS Water Resources Groundwater Software such as MODFLOW

- https://clu-in.org/docs/embed.cfm?link=%2Fpublications%2Fdb%2Fdb%5Fsearch%2Ecgi%3Ftitle%3D1%26cat1%3D1%26submit%5Fsearch%3D1
  website of the US-EPA Contaminated Site Clean-Up Information, section characterization and monitoring

- http://www.unido.org/what-we-do/environment/implementation-of-multilateral-environmental-agreements/o591190100/e-learning/unido-contaminated-site-investigation-and-management-toolkit.html
  link to toolkit UNIDO

  PERSISTENT ORGANIC POLLUTANTS: CONTAMINATED SITE INVESTIGATION AND MANAGEMENT TOOLKIT, UNIDO
  A contaminated site investigation and management toolkit for Persistent Organic Pollutants has been developed by UNIDO. Module 3 of this Toolkit report provides guidelines for assessing the human health risks. It outlines how to conduct a generic Tier 1 approach, in which the information collected during the site investigation is used to compare contaminant concentrations against the recommended values for soil and groundwater.
  Tier 1 is a set of generic guidelines that provide simple tabular values that were developed based on conservative scientific assumptions about soil and groundwater characteristics. Two of the three risk assessment components, receptors and pathways, are already built into a Tier 1 assessment; therefore only the contaminants need to be considered.

  This module also presents the basis steps of a Site-specific Risk Assessment, identifying a site’s contaminants, exposure pathways and receptors. This can be used as the basis for developing a risk management process in situations when complete remediation is not a viable option for a contaminated site.

Volume III

5.4-i Overview remediation techniques and menu of options

Volume III-5.4-i
Overview remediation techniques and menu of options

1 Introduction

This information is most relevant for Task 5.4, Development of remediation options. This sections presents information and tools applicable when performing site remediation investigation. First the driving principles of remediation techniques are presented (section 2). Then an overview is presented of available remediation techniques and their applicability (section 3). Section 4 provides information on remediation techniques and for each technique descriptions, specific characteristics and SWOT[1]-analysis is provided. Finally section 5 provides a menu of prioritized remediation options for all types of contaminated sites.

2 Remediation techniques – driving principles

There are five major driving principles behind remediation techniques:

- Extraction: removal of the unaltered contaminant from the ground/sediment or groundwater in which it is located (for treatment elsewhere);
- Transformation: the destruction or alteration of the contaminant into a less or non-harmful product;
- Immobilization: stopping of the migration of the contaminant in its pathway;
- Containment: capturing the contaminant within non penetrable physical boundaries;
- Temporary safety measures: shielding the receptor itself from contact with the contaminant.

Table III-5.4.1 presents these five driving principles, together with some examples of their incorporation into remediation techniques and approaches.

[1] Strengths, Weaknesses, Opportunities & Threats

Table III-5.4.1 Driving principles of remediation techniques and examples

Principles	**Localisation**	**Type**	**Examples of techniques**
Extraction	On site Soil treatment off-site	Physical	Excavation SVE – Soil vapor extraction SVE – Soil vapor extraction MPE – Multi phase extraction
	On site Soil treatment on-site	Physical / Biological / Chemical	Biological treatment / Biopiles On site soil processing with mobile soil washer plant and reuse of treated soil
Transformation	In-situ	Chemical	In-situ chemical oxidation (ISCO) Air-sparging
	In-situ	Biological	In-situ bioremediation, natural attenuation
Immobilization	In situ	Physical	Chemical immobilisation Vitrification
Containment	In-situ	Physical	Vertical wall Capping layer Geohydrological control
Temporary safety measures	On-site	Physical Social Legal	Alternative water supply, treatment of pumped groundwater Fencing/signage Land access restrictions Notification and administrative obligations

3 Available remediation techniques and their applicability

This information is most relevant for Task 5.4 Development of remediation options. This Section presents, in table III-5.4.2 below, a brief overview of available remediation techniques and their applicability towards source/pathway/receptor and types of contaminating substances. In certain cases a combination of techniques has to be applied to reach the intended remediation objective.

Table III-5.4.2 Overview of remediation techniques and their applicability

✓ Remediation option is potentially applicable to a specific media-contaminant combination
X Remediation option is not applicable to a specific media-contaminant combination
? A pre-treatment step or pilot may be necessary prior to the method being suitable or case study information is inconclusive regarding applicability
S Soils, made ground en sediments
W Groundwater and surface water

Principle	***Technique***	***Section***	***Point of entry (SPR)***				***Applicability substances***									
			Source	***Pathway***	***Receptor***	***Applicable media***	***VOC's (volatile organic components)***	***Halogenated Hydrocarbons***	***Non-halogenated Hydrocarbons***	***PAHs (polycyclic aromatic hydrocarbons)***	***PCBs (polychlorinated biphenyl/s)***	***Dioxins and furans***	***Pesticides and herbicides***	***Heavy metals***	***Asbestos***	***Cyanides***
Extraction	*Excavation, followed by:*	*4.1*	*X*	*X*	*X*	*S*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	- Biological treatment / biopile	*4.1.1*	*X*	*X*	*X*	*S*	✓	X	✓	✓	X	X	✓	X	X	X
	- Soil washing	*4.1.2*	*X*	*X*	*X*	*S*	X	✓	✓	✓	✓	X	✓	✓	X	✓
	- Thermal treatment	*4.1.3*	*X*	*X*	*X*	*S*	✓	✓	✓	✓	✓	✓	✓	X	X	✓
	- Physical separation	*4.1.4*	*X*	*X*	*X*	*S*	X	X	X	X	X	X	X	X	✓	X
	- Disposal in landfill	*4.1.5*	*X*	*X*	*X*	*S*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Groundwater abstraction (pump & treat)	*4.2*	*X*	*X*		*W*	✓	✓	✓	✓	✓	✓	✓	✓	X	X
	SVE – Soil vapor extraction	*4.3*	*X*	*X*	*X*	*S*	✓	✓	✓	X	X	X	X	X	X	X
	MPE – Multi phase extraction	*4.4*	*X*	*(X)*	*X*	*S,W*	✓	✓	✓	?	X	X	X	X	X	X
Transformation	*Air-sparging*	*4.5*	*X*	*X*		*W*	✓	✓	✓	?	X	X	X	X	X	X
	Soil Heating	*4.6*	*X*			*W*	✓	✓	✓	✓	?	X	X	X	X	?
	Elektrokinetics	*4.7*	*X*	*(X)*		*S, W*	✓	✓	✓	✓	?	?	?	✓	X	✓
	In-situ chemical oxidation (ISCO)	*4.8*	*X*	*(X)*		*S, W*	✓	✓	✓	✓	X	X	✓	X	X	?
	Permeable reactive barriers (PRB)	*4.9*		*X*		*W*	✓	✓	✓	✓	✓	✓	✓	✓	X	✓
	In-situ bioremediation	*4.10*	*X*	*X*		*S, W*	✓	✓	✓	✓	X	X	✓	X	X	X
	Phyto remediation	*4.11*	*X*	*X*		*S, W*	✓	✓	✓	✓	X	X	✓	✓	X	?
	Natural attenuation	*4.12*	*X*	*X*		*W*	✓	✓	✓	✓	X	X	✓	X	X	X
Immobilization	*Vitrification*	*4.13*	*X*			*S*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	In-situ grouting	*4.14*	*X*	*X*		*S*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Containment	*Vertical wall*	*4.15*		*X*		*S, W*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Capping layer	*4.16*		*X*		*S, W*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Geohydrological control	*4.17*		*X*		*W*	✓	✓	✓	✓	✓	✓	?	✓	✓	?
Temporary safety measures	*Land use restrictions*	*4.18*			*X*	*S, W*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Relocation and safety measures	*4.19*			*X*	*S, W*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Drinking water treatment	*4.20*			*X*	*W*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Additional sections are added for:

- *Water treatment technologies (section 4.21)*
- *Off gas air treatment technologies (section 4.22)*
- *Recovery of material from remediation activities (section 4.23)*
- *Remediation of sediments (section 4.24)*

4 Remediation techniques – Descriptions, specific characteristics and SWOT[2]-analysis

This information is most relevant for Tasks 5.4 Development of remediation options and 5.5 Selection remediation option.

This Section presents descriptions of the available remediation techniques mentioned in 4.2 and offers their specific characteristics and a SWOT-analysis. These remediation techniques have provided good results internationally and are likely to be applicable in India as well.

Were relevant, *more information* internet links have been created. The purpose of the internet links is to provide more information on the basics of a technology. Application of a technology must always be a site specific consideration.

Following internet sources provide generic information about remediation techniques and examples of cases where techniques have been applied:

- CLU-IN website of US-Environmental Protection Agency providing information about innovative treatment and site characterization technologies: http://www.clu-in.org/
- Federal Remediation Technologies Roundtable website providing information about technologies for assessment and remediation of contaminated sites: http://www.frtr.gov/
- A good overview on standings for in-situ treatments is provided in: http://www.frtr.gov/pdf/meetings/jun08/madalinski_presentation.pdf
- Soilection website providing information and case descriptions of practical in-situ remediation experiences in The Netherlands and Belgium: http://www.soilection.eu
- Dutch directive on restoration and management of soil, groundwater and sediment, provides information on remediation techniques: http://www.bodemrichtlijn.nl/Bibliotheek/bodemsaneringstechnieken (English translation is provided on this internet page)

4.1 Excavation

Excavation is based on the driving remediation principle of extraction. The contaminated soil is extracted by means of excavation. This is an ex-situ technique by localisation. The physically extracted soil has to be treated further to further reduce the risk related to the contaminant. Various techniques for soil treatment exist and some of them can be implemented both on-site and off-site.

Remediation level

In general excavation enables a high degree of contaminant removal paired with a high degree of control and accuracy. In particular for shallow contamination, removal of all contaminant is technically feasible.

[2] Strengths, Weaknesses, Opportunities & Threats

Technical risks
Soil excavation can be a very robust technique. The technical risks of soil excavation are related to the presence of buildings, foundations or other objects above or below ground. A good insight in the presence of all these objects before start of the excavation can significantly reduce the technical risks. The risks increase with increasing depth of excavation and excavation below the natural groundwater level.
Many remediation projects where excavation is applied exceed financial budgets. This is related to the excavation of larger volumes of contaminated soil than estimated. To control this risk, excavation requires a well defined CSM[3] and proper delineation of the contamination.

Costs
The costs of an excavation are directly linked to the volume of soil to be excavated and treated. In particular the treatment of the excavated soil and the transport of the excavated soil to a treatment facility are determinant for the costs of this technique. Refilling of the excavation pit with suitable quality soil can also be a major factor in costs.

Sustainability
Excavation equipment and trucks for transportation of the excavated soil are energy consuming and produce significant amounts of CO_2. Sustainability is also influenced by the treatment for the excavated soil.

Time
Excavation by itself is a relatively fast technique, delivering tangible results with each bucket of contaminated soil that is excavated.

Post remedial use
Given total removal of the contamination and backfilling with suitable quality soil, a site can be restored to full multifunctional use.
The post remedial use of a site that has been remediated by excavation can be limited when contamination has been left behind in soil and/or groundwater and on the quality of the soil applied for filling the excavation.

Social criteria
During a remediation by excavation the site is generally off bounds to other uses. The function of the site is temporarily lost.

Excavation equipment and trucks may cause local nuisance (noise, dust, smell, traffic, vibrations).

Lowering the groundwater table during excavation may cause consolidation of soil and lead to damage to neighbouring buildings.

The application of vertical walls (sheet piling) to enable excavation may cause vibrations (nuisance and/or damage to neighbouring buildings).

[3] Conceptual Site Model

SWOT: Strengths
Remediation by excavation can deliver robust results and can be completed in a short time. Remediation up to full multifunctional restoration can be possible.

SWOT: Weaknesses
During excavation the site is unavailable for other uses. Soil logistics (excavation, transportation) have significant energy consumption. Costs are strongly related to the volume of soil to be excavated, transported and treated.

SWOT: Opportunities
Excavation can offer a fast and final solution for relatively small and shallow contaminations.
Excavation is a prime candidate as remediation technique for dynamic sites in an urban setting which require fast results.
Remediation by excavation can be combined with other civil works, if the remediation dig has been considered in the civil design (example: the space created by the excavation becomes part of the underground parking space/tunnel).

SWOT: Threats
In populated areas nuisance issues and risk for neighbouring buildings and objects are to be carefully taken into account.
Lack of working space can seriously hinder the logistics of excavation, increasing the costs and the risk of longer remediation duration. Lack of working space is typical of excavating in urban areas, where time is also of the essence.

More information
http://www.frtr.gov/matrix2/section4/4-29.html

http://www.egr.msu.edu/tosc/dutchboy/factsheets/what%20is%20excavation.pdf

http://www.abdk.nl/html/media/documenten/CO%20Folder%20Corporate%20Engels%202008.pdf

4.1.1 Excavation: soil treatment by biological treatment / biopiles

Biological treatment and biopiles are both based on the driving remediation principle of transformation. On-site biological treatment is generally indicated with the term landfarming. It should be emphasized that landfarming as remediation technique is not allowed in India due to agricultural policy. However we will use this term in the text below because of the generic use of this technique internationally. In both techniques, the contaminants in the soil are biologically transformed into less or non-harmful products. Biopiles are basically a more engineered form of landfarming. Both techniques share many characteristics.

Landfarming consists of cultivating the contaminated soil in lined bed in layers of 0.5 up to 1 meter thick. The beds are periodically turned over to improve the oxygen supply and the structure of the soil.

Biopiles are a more engineered version of landfarming in which the contaminated soil is places in mounds between 0.5 and 3 m in heights. Oxygen can be actively supplied by air injection or extraction. Generally the soil in a biopile is also supplied with nutrients and moisture. If needed, soil structure can be improved (for example with fine gravel), pH can be buffered (for example with lime) and temperature within the biopile can be regulated.

Remediation level
Landfarming/biopiles are applicable to biodegradable organic contaminants. Total removal of the biologically available fraction of the contamination is the expected result. For volatile, mobile compounds this generally implies near total removal. For heavier organic contaminants a certain amount of biologically unavailable residual contamination has to be taken into consideration.

Technical risks
Heavier organic compounds are more difficult to degrade. This can result in a longer remediation time and higher remediation level. Contamination levels that exceed microbial growth inhibition levels will severely hamper degradation.

Conditions within the bed/pile must be maintained favourably towards aerobic degradation by micro organisms. In particular temperature, oxygen, moisture, nutrients, soil structure, temperature and pH are of importance.

Care has to be taken to prevent unwanted cross contamination of the underlying soil, this includes mixing as well as (rain-) water seepage.

Costs
The costs of landfarming/biopiles consist of two elements:
- installation costs (lining, aeration equipment, space);
- operational costs (piling, periodic turning over of beds, aeration, monitoring, nutrients).

The installation costs are linked to the volume of soil to be treated and the degree of engineering of the system. The operational costs are determined by the amount of handling and the volume of the soil. The amount of handling is linked to the biodegradability of the contamination.

Sustainability
Landfarming/biopiles are generally considered to be sustainable soil treatment techniques, especially when the treated soil is reused for backfill the site instead of backfilling with pristine soil.

Time
The duration of soil treatment by landfarming/biopiles depends largely on achieving the suitable conditions for degradation. Under optimal conditions, the treatment generally has a duration between 3 to 9 months. In a temperate climate, landfarms and biopiles are generally considered to be inactive during late fall, winter and early spring, causing landfarms/biopiles to have a duration measured in one or two summers rather than in months.

Post remedial use
It is likely that a degree of residual contamination has to be taken into consideration after using landfarming/biopiles.
Soil treated by landfarming/biopiles retains its biological functions. Any biological functions this soil had before treatment will be preserved.

Social criteria
The site of the landfarming/biopiles is generally off bounds to other uses. The function of the site is temporarily lost.

Excavation equipment and trucks for transportation may cause local nuisance (noise, dust, smell, traffic, vibrations).

SWOT: Strengths
Given the right climatic circumstances and soil composition, landfarming/biopiles are very efficient at treating organic pollutants, while requiring relatively little effort.

SWOT: Weaknesses
Landfarm/biopiles take time and use space. The optimum result (backfilling with the treated soil) implies delayed backfilling. Planning ahead is vital.

SWOT: Opportunities
Having the landfarm/biopile on site, and using the treated soil to backfill the excavations, removes the need to obtain suitably reusable soil from other parties and eliminates much of the cross media effects caused otherwise by transportation and treatment in specialized installations elsewhere.

SWOT: Threats
A landfarm/biopile will emit a part of the volatile fraction of its contaminants to the outside air. These volatile organics can be potentially harmful, but more often they are also odorous. It is recommended to operate a landfarm/biopile on a suitable distance from populated areas.

More information
http://www.epa.gov/oust/cat/biopiles.htm

http://www.frtr.gov/matrix2/section4/4_11.html

4.1.2 Excavation: soil treatment by soil washing

Soil washing is based on the driving remediation principle of extraction. In soil washing, the majority of the contamination is separated from the bulk soil by consecutive separation steps, using separation on size, washing with water, optionally washing with water enhanced with acids/alkalis/complexants and/or surfactants and gravitational separation. The process employs standard mineral processing equipment like screens, scrubbers, hydrocyclones, flotation cells and/or dewatering filters.

The fraction of fine silt and clay particles that contains most of the residual contamination has to be disposed at a hazardous waste landfill or be treated further by chemical, thermal or biological processes.

Remediation level
The clean sandy fraction is typically of suitable quality to be reused on site or be reused elsewhere for less sensitive uses like infrastructural works.

Technical risks
The fine content (silt and clay, typically specified as particles smaller than 63 µm) retaining the contamination has to be exposed of by expensive means, so it is vital to keep this content as low as possible without cross contaminating the treated sand fraction.

Clay, silt and peat will generally result in more fine content than treated sand fraction and are therefore unsuitable soil compositions for soil washing.

Costs
The fine content determines much of the total costs of treatment by soil washing Depending on local economics, anywhere from above 20% to 40% by weight of particles smaller than 63 µm is considered not to be economically treated by soil washing.

Soil washing water will likely have to be processed before it can be reused or discharged. This represents additional costs.

Sustainability
Soil washing is not a typically sustainable soil treatment technique. The main reason being soil washing does not actually remove contamination; rather it concentrates and transfers it into a lesser fraction of the original soil. Another factor can be transportation, if the soil washing installation is not available on-site.

Time
Soil washing is a relatively fast treatment process.

Post remedial use
Soil treated by soil washing has lost much if not all of its fine content. It will have lost most of its contaminants but often some residual contamination remains. The treated sand fraction typically is reusable in less sensitive uses like infrastructural works and land levelling for non-residential and non-agricultural uses.

Social criteria
Excavation equipment, trucks for transportation and mineral processing equipment for soil washing may cause local nuisance (noise, dust, smell, traffic, vibrations).

SWOT: Strengths
The strength of soil washing is its ability to treat most organic compound as well as heavy metals and cyanides in sandy soils.

SWOT: Weaknesses
Soil washing is not suitable for soils with a fine content of more than 20 to 40 % by weight.

SWOT: Opportunities
Soil washing installations are typically relatively small in size, enabling mobile versions of the installation. Given a large enough volume of soil to be treated, a mobile soil washer can considerably cut costs, especially if the treated sand fraction is reused for backfilling the excavation.

SWOT: Threats
Permanent soil washing installations may not be available or may be at considerable distance from the remediation site.

More information
http://www.frtr.gov/matrix2/section4/4-19.html

http://chemeng.queensu.ca/courses/CHEE484/documents/FortuneMelanie_SoilWashing.pdf

4.1.3 Excavation: soil treatment by thermal treatment

Thermal treatment is based on the driving remediation principle of transformation. Typically thermal treatment is employed in a rotary kiln and operated at high temperatures of anywhere between 90 to 600 °C (mostly thermal desorption/evaporation) to as high as 1.300 °C (mostly thermal destruction). The process results in thermal desorption and/or thermal destruction of the contamination, depending on the temperature of operation. Using thermal treatment most organic contaminants can be removed from a wide range of soil compositions including silt, clay and mineral-rich peat. Also a degree of removal of volatile metals can be achieved, depending on temperature of operation.

Remediation level
Using thermal treatment, high and reliable levels of removal up to total removal of contaminants, can be achieved.

Technical risks
The contaminated soil may need pre-treatment to remove clumps and oversize material.

Thermal treatment of mineral-poor peat can lead to uncontrollable thermal processes and is not recommended.

In particular by thermal desorption processes incomplete combustion products can be formed, such as dioxins/furans. The possible emission of these compounds as well as dust and particulates requires careful air emission control and proper off gas treatment.

Costs
Costs for thermal treatment are typically high, as the process requires large amounts of fossil fuel for heating the kiln. Also the costs are determined by transportation, pre-treatment and off-gas treatment.

Sustainability
Thermal treatment is not a typically sustainable soil treatment technique. The main reasons being the energy consumption and the loss of most of the biological function of soil treated at the higher temperature ranges (above 300 °C). It can however be the only alternative to disposal at a hazardous waste landfill and therefore still be the preferred method.

Time
Thermal treatment is a relatively fast treatment process in itself. The throughput of a thermal treatment plant depends mostly on equipment capacity and soil moisture content. Typically thermal soil treatment plants will bulk up such amounts of treatable soil as to keep their process running continuously over longer times, and prevent relatively costly start-ups and shut-downs as much as possible.

Post remedial use
Thermally treated soil typically is reusable in less sensitive uses like infrastructural works and land levelling for non-residential and non-agricultural uses.

Thermally treated soil at temperatures above 300 °C will have lost most of its biological function due to loss of structure and (partly or totally) organic matter. Such treated soil is a distinctively dark grey to black coloured, ashy granular substance. This limits reuse to uses that do not require any biological function of the soil nor have high soil structure demands.

Social criteria
Excavation equipment, trucks for transportation and thermal treatment equipment for soil washing may cause local nuisance (noise, dust, smell, traffic, vibrations).

Possible emissions of incomplete combustion products as dioxins and furans may cause local concerns over air quality.

SWOT: Strengths
The strength of thermal treatment is its ability to treat most organic compound as well as some heavy metals to some extent in silt and clay and mineral-rich peat containing soils.

SWOT: Weaknesses
Thermal treatment is expensive with high energy costs. Reuse of the treated soil may be limited because of loss of structure and (part of) organic matter, depending on temperature of operation.

SWOT: Opportunities
Soil thermal treatment installations are also available in mobile versions. Given a large enough volume of soil to be treated, a mobile soil treatment plant can considerably cut costs, especially if the treated soil can be reused for backfilling the excavation.

SWOT: Threats
Permanent soil thermal treatment installations may not be available or may be at considerable distance from the remediation site, depending on the economic circumstances.

Mobile soil thermal treatment installations may cause local concerns over emission of incomplete combustion products such as dioxins/furans.

More information
http://www.clu-in.org/download/Citizens/a_citizens_guide_to_thermal_desorption.pdf

http://www.epa.vic.gov.au/~/media/publications/1402.pdf

4.1.4 Excavation: soil treatment by physical separation

Physical separation is based on the driving remediation principle of separation. The particulate matter containing the contamination is, after excavation removed from the bulk soil by physical separation or size and handpicking. The process employs standard mineral processing equipment like screens and conveyor belts, water spraying units, and specialized equipment like (contained) asbestos picking stations and asbestos scrubbers.

This technique is most often used for the removal of asbestos containing materials from the soil. After removal from the soil, the asbestos and asbestos containing fine fractions have to be properly sealed before transport and subsequently disposed at a hazardous waste landfill.

The technique of physical separation is also widely used to separate rubble from soil or to prepare selected soil particle sizes. If contamination is related to rubble or a specific particle size, the technique can be used to remove contaminations from the excavated soil.

Remediation level
Asbestos can be near-totally removed from soil, provided the soil is suitably for screening. Remediation levels for other substances are very much dependent on the specifics of the materials to be processed.

Technical risks
Fine content (silt and clay, typically specified as particles smaller than 63 µm) containing soil is unsuitable for asbestos removal by screening.

Emissions to air of asbestos fibres during storage and transport have to be taken into consideration and may require soil moisture content control and/or sealing.

Emissions to air of asbestos fibres and particulates during treatment have to be taken into consideration and may require contained treatment units with air filtration equipment.

Costs
The operational costs of the equipment and the disposal costs of the asbestos determine much of the total costs of asbestos treatment by physical separation. Additional costs can be caused by asbestos exposure control, in particular when treating non matrix-bound asbestos containing materials which have a higher potential of fibre release.

Sustainability
Physical separation of asbestos is not a typically sustainable soil treatment technique. The main reason being the asbestos is not actually removed; rather transferred to a hazardous waste disposal.

Time
Physical separation of asbestos from soil is a relatively fast treatment process.

Post remedial use
Soil treated by physical separation is typically reusable in less sensitive uses like infrastructural works and land levelling for non-residential and non-agricultural uses.

Social criteria
Excavation equipment, trucks for transportation and mineral processing equipment for soil washing may cause local nuisance (noise, dust, smell, traffic, vibrations).

Possible emissions of asbestos fibres may cause local concerns over exposure to airborne asbestos.

SWOT: Strengths
The strength of physical separation is its ability to remove asbestos from sandy soils using a standard technology.

SWOT: Weaknesses
Physical separation by screens is not applicable to silt/clay containing soils. Technologies to remove asbestos from these types of soil are becoming available.

SWOT: Opportunities
Mechanical soil screens are particularly mobile and start to be effective already at relatively small volumes of soil to be treated.

SWOT: Threats
Having to operate in containment, due to nearby sensitive uses or the potential to emit fibres from the asbestos (e.g. asbestos pulp), will increase costs.

Treated soil that still contains the slightest bit of asbestos can remain controversial for reuse, despite reaching sufficient removal of asbestos.

More information
http://www.frtr.gov/matrix2/section4/4-18.html

4.1.5 Excavation: soil treatment by disposal in landfill

Disposal of contaminated soil is based on the driving remediation principle of containment. The contaminated soil is permanently contained in a controlled landfill.

Remediation level
The remediation level for a subject site is complete. However, no remediation levels are achieved for the soil in the landfill.

Technical risks
A controlled landfill should be well designed so that all risks for the environment are controlled. This implies a proper bottom liner, control of infiltration of rainwater into the landfill material, treatment of landfill gas, and capping of the landfill after closure.

Emissions to air of contaminated dust and volatile components have to be taken into consideration during land filling and may require soil moisture content control and/or sealing.

Costs
The operational costs of the landfill, transportation to the landfill and taxes determine much of the total costs of disposal to a landfill.

Sustainability
Disposal to a landfill is not considered to be a sustainable remediation technique. Landfills use up land, make the land unsuitable for any other uses.

Time
Disposal of contaminated soil in a landfill is a fast treatment process.

Post remedial use
Soil disposed in a landfill is not reusable. Within the landfill the soil can be used to improve the property of the landfill body.

Social criteria
A landfill can result in many nuisances for its surroundings. Excavation equipment, trucks for transportation and compactors for land filling may cause local nuisance (noise, dust, smell, traffic, vibrations).

SWOT: Strengths
The strength of disposal to a landfill is the ability of the landfill to store all types of contaminated soil directly.

SWOT: Weaknesses
Disposal to a landfill is not a definitive solution. A landfill consumes valuable land.

SWOT: Opportunities
Landfills can be relative simple operations that can store wide varieties of waste including contaminated soil.

SWOT: Threats
The use of landfill in general does not encourage recycling and final solutions for contaminated soil.

4.2 Groundwater abstraction
Groundwater abstraction (*pump & treat*) is based on the driving remediation principle of extraction. The contaminated groundwater is extracted acted by means of abstraction. This is an in-situ technique by localisation. The extracted groundwater has to be treated further depending on the levels of contamination and the risk related to the contaminant. Various techniques for water treatment exist and most of them can be implemented on-site.

Remediation level
The remediation level is very much depended on local conditions and contaminations. Under optimal circumstances, groundwater abstraction can accomplish complete removal of contaminations. In most cases groundwater abstraction can stop the spreading of contamination.

Technical risks
Groundwater abstraction is a proven technology. The permeability of the water bearing layer is critical for the success of groundwater abstraction. The well design for the groundwater abstraction should be based on the permeability, soil conditions and contaminant behaviour

During operation of the abstraction, the effects of well clogging (mechanical and biological) should be monitored.

Costs
The operational costs of groundwater abstraction are determined by the need for additional groundwater treatment.

Sustainability
Groundwater abstraction can be a sustainable technique if the extracted water is after treatment reintroduced in the water bearing layer.

Time
The time involved for groundwater abstraction is fully dependent on the contamination type and related retardation factor of the contamination.

Post remedial use
If properly remediated and treated, both the water in the water bearing layer and the treated water can be reused.

Social criteria
Groundwater abstraction can result in nuisances for its surroundings due to lowering of the groundwater table and related geotechnical consequences (soil settling).

SWOT: Strengths
The strength of groundwater abstraction is the ability to stop spreading of multiple contaminations in water bearing layers directly.

SWOT: Weaknesses
In most situations groundwater abstraction has to be combined with extensive and expensive water treatment installations.

SWOT: Opportunities
The abstracted and treated groundwater can be used locally for various purposes.

SWOT: Threats
The use of groundwater abstraction can result in the loss of valuable water and depletion of water bearing layers.

More information
http://www.clu-in.org/download/citizens/a_citizens_guide_to_pump_and_treat.pdf

http://www.frtr.gov/matrix2/section4/4-48.html

http://www.soilection.eu/index.php?option=com_technics&Itemid=26

4.3 Soil vapor extraction (SVE)

Soil vapor extraction is based on the driving remediation principle of extraction. SVE creates an under pressure in unsaturated zone of the soil creating a flow of soil air to extraction wells. In this process the volatile contaminations in the unsaturated zone are transported aboveground. The extracted air has to be treated further depending on the levels of contamination and the risk related to the contaminant. Various techniques for air treatment exist and most of them can be implemented on-site.

Remediation level
The remediation level is very much depended on local conditions and contaminations. Under optimal circumstances, SVE can accomplish complete removal of contaminations. In most cases SVE can stop spreading of contamination to the underlying groundwater.

Technical risks
The permeability of unsaturated soil and the volatility of the contaminants are critical for the success of SVE. The risks can be very easy be controlled by implementing a pilot before deciding on the full scale application of SVE.

Costs
Operational costs of SVE are relatively low. Significant additional costs can be endured by the need for off gas treatment.

Sustainability
SVE is not a typically sustainable soil treatment technique. The main reason is the energy consumption of the technique.

Time
The time involved for SVE will always be in the range of months - year.

Post remedial use
Soil treated by SVE is typically reusable in less sensitive uses as non-residential and non-agricultural uses.

Social criteria
A SVE system results in little nuisances for its surroundings due to compact nature of the equipment. To minimize nuisance and odour issues, off gas treatment has to be applied if levels require so.

SWOT: Strengths
The strength of SVE is the ability to stop spreading of contamination to the underlying groundwater. SVE also stimulates the aerobic degradation in the unsaturated zone. and allows for additional techniques such as air-sparging, to be applied with little extra costs.

SWOT: Weaknesses
The application of SVE is limited to a very specific, limited range of contaminants. In most situations SVE has to be combined with extensive and expensive air treatment installations.

SWOT: Opportunities
The implementation of SVE allows for additional techniques such as air-sparging, to be applied with little extra costs.

SWOT: Threats
The proper operation and monitoring of SVE requires specific training and skills.

More information
http://www.frtr.gov/matrix2/section4/4-7.html

http://www.clu-in.org/download/remed/epa542r05028.pdf

http://www.soilection.eu/index.php?option=com_technics&Itemid=26

4.4 Multi phase extraction (MPE)

Multi phase extraction is based on the driving remediation principle of extraction. MPE creates a near vacuum in the soil creating a flow of air, water and product layers to extraction wells. Wells for the MPE are installed just below the groundwater table. The extracted air and fluids have to be treated further depending on the levels of contamination and the risk related to the contaminants. Various techniques for air and water treatment exist and most of them can be implemented on-site.

Remediation level
The remediation level is very much depended on local conditions and contaminations. MPE should not be considered as a technique for the complete removal of contaminations or achieving low levels of residual contamination. In most cases MPE can successfully remove source areas of contaminations.

Technical risks
The permeability of the soil and the correct placement of MPE extraction wells in relation to the groundwater table are critical for the success of MPE. The risks can be very easy be controlled by implementing a pilot before deciding on the full scale application of MPE.

Costs
Operational costs of MPE are relatively low. Significant additional costs can be endured by the need for off gas, water and product treatment.

Sustainability
MPE is not a typically sustainable soil treatment technique. The main reason is the energy consumption of the technique.

Time
The time involved for MPE will always be in the range of ½ year - year.

Post remedial use
Soil treated by MPE is typically reusable in less sensitive uses as non-residential and non-agricultural uses.

Social criteria
A MPE system results in little nuisances for its surroundings due to compact nature of the equipment. To minimize nuisance and odour issues, off gas treatment has to be applied if levels require so.

SWOT: Strengths
The strength of MPE is the ability to remove source areas of contamination in both the unsaturated and saturated zones of the soil. It also is successful in removal of product layers. MPE also stimulates the aerobic degradation in the unsaturated and saturated zone through the introduction of air. It also allows for additional techniques such as air-sparging, to be applied with little extra costs.

SWOT: Weaknesses
The application of MPE is limited to a small area of the soil. In most situations MPE has to be combined with extensive and expensive air and water treatment installations.

SWOT: Opportunities
The implementation of MPE allows for additional techniques such as air-sparging, to be applied with little extra costs.

SWOT: Threats
The proper operation and monitoring of MPE requires specific training and skills.

More information
http://clu-in.org/download/remed/mpe2.pdf

http://www.clu-in.org/download/remed/epa542r05028.pdf

http://www.soilection.eu/index.php?option=com_technics&Itemid=26

4.5 Air sparging

Air sparging is based on the driving remediation principle of transformation
Air sparging involves the injection of atmospheric air beneath the groundwater table. The air volatilises the contamination from the groundwater and the soil. The air with the contamination subsequently rises up to the unsaturated zone where it is collected by a Soil Vapour Extraction system.

Air sparging can also be used as a technique to increase oxygen levels in the groundwater, the purpose being to enhance the aerobic degradation of contaminations. This application is referred to as bio-sparging.

Remediation level
The remediation level is very much depended on local conditions and contaminations and additional remediation systems. Air sparging is mostly combined with other techniques (Soil Vapour Extraction, groundwater abstraction).

Technical risks
The permeability of the saturated soil and the correct placement of air sparging injection wells in relation to the groundwater contamination are critical for the success of air sparging.

Costs
Operational costs of air sparging are relatively low.

Sustainability
Air sparging is not a typically sustainable soil treatment technique. The main reason is the energy consumption of the technique.

Time
The time involved for air sparging will mostly be limited to ½ year- year. Bio-sparging often requires a longer time due to the speed of the biological processes underlying the working of this technique.

Post remedial use
Soil treated by air sparging is typically reusable in less sensitive uses as non-residential and non-agricultural uses.

Social criteria
An air sparging system results in little nuisances for its surroundings due to compact nature of the equipment.

SWOT: Strengths
The strength of air sparging is the ability of the technique to improve the performance of techniques as groundwater abstraction and soil vapour extraction.

SWOT: Weaknesses
Air sparging is not a standalone technique. In most situations additional techniques such as groundwater abstraction or Multi Phase Extraction have to be used during the remediation. An exception can be bio-sparging which can be used as a sole technique for the aerobic degradation for groundwater contamination.

SWOT: Opportunities
If properly designed, an air sparging can be easily transferred into a bio-sparging system. This enables the transfer to a bioremediation of the groundwater for organic components that are biodegradable under aerobic conditions.

SWOT: Threats
The operation of air sparging without proper monitoring of the technique can result in uncontrolled spreading of contamination.

More information
http://www.clu-in.org/download/citizens/a_citizens_guide_to_soil_vapor_extraction_and_air_sparging.pdf

http://dec.alaska.gov/spar/csp/guidance/guide_vapor.pdf *http://www2.bren.ucsb.edu/~keller/courses/esm223/SuthersanCh04AirSparge.pdf*

http://www.soilection.eu/index.php?option=com_technics&Itemid=26

4.6 Soil heating

Soil heating is based on the driving remediation principle of transformation. The technique operates under the principal that electrical current passing through a resistive component, such as soil, will generate heat. Another option is to inject steam in the soil matrix. As a result the temperature of the soil will increase. This influences the mobility of many contaminants so that recovering them from the soil is made much easier.
Due to the temperature increase, the biodegradation of contaminants in the soil will also be enhanced. Soil heating allows for temperature increase from 20 to 100 Celsius.

Remediation level
The remediation level is very much depended on local conditions and contaminations and additional remediation systems for recovery. Soil heating can achieve high remediation levels for the saturated soil under optimal conditions. However it should be considered as a technique that can successfully remove source areas of contaminations.

Technical risks
The conductivity of the soil for electrical currents is critical for the temperature increase that can be achieved by soil heating. Also the free transfer of contaminants to extraction systems for recovery has to be determined in an early stage.

Costs
Operational costs of soil heating are relatively high.

Sustainability
Soil heating is not a typically sustainable soil treatment technique. The main reason is the energy consumption of the technique.

Time
The time involved for soil heating will mostly be limited to a month - ½ year. Additional techniques for the extraction of the contaminants will be required a longer time.

Post remedial use
Soil treated by soil heating is typically reusable in less sensitive uses as non-residential and non-agricultural uses.

Social criteria
Soil heating systems result in little nuisances for its surroundings due to compact nature of the equipment.

SWOT: Strengths
The strength of soil heating is the ability of the technique to improve the properties of the soil and contaminants so that the performance of techniques as groundwater abstraction and soil vapour extraction are improved significantly.

SWOT: Weaknesses
Soil heating is not a standalone technique. In most situations additional techniques such as groundwater abstraction or soil vapour extraction have to be used during the remediation.

SWOT: Opportunities
Soil heating is very suitable for enhancing biodegradation.

SWOT: Threats
The operation of soil heating without proper assessment of its application beforehand can result in uncontrolled processes in the soil and high cost levels.

More information
http://www.epa.gov/superfund/remedytech/tsp/download/heatenh.pdf

http://www.clu-in.org/download/remed/sveenhmt.pdf

http://www.frtr.gov/pdf/in_situ_thermal_trtmnt.pdf

http://www.soilection.eu/index.php?option=com_technics&Itemid=26

4.7 Elektrokinetics

Elektrokinetics remediation is an in-situ technique in which an electrical field is created in a soil matrix by applying a low-voltage direct current (DC) to electrodes placed in the soil. As a result of the application of this electric field, heavy metal contaminants may be mobilized and concentrated at the electrodes, and extracted from the soil. The application of the electric field has several effects on the soil, water, and contaminants. Cations (positively charged ions) tend to migrate towards the negatively charged cathode, and anions (negatively charged ions) migrate towards the positively charged anode. The application of the technique is focussed at heavy metals contaminations and some organic contaminations.

Remediation level
The remediation level is very much depended on local conditions and the type of contaminant.

Technical risks
The conductivity of the soil for electrical currents is critical

Costs
Operational costs of elektrokinetics are relatively high.

Sustainability
Elektrokinetics is not a typically sustainable soil treatment technique. The main reason is the energy consumption of the technique.

Time
The time involved for elektrokinetics will mostly be limited to ½ year – year.

Post remedial use
Soil treated by elektrokinetics is typically reusable in less sensitive uses as non-residential and non-agricultural uses.

Social criteria
Elektrokinetics systems result in little nuisances for its surroundings due to compact nature of the equipment.

SWOT: Strengths
The strength of elektrokinetics is that this technique is able to in-situ remediate heavy metals.

SWOT: Weaknesses
Elektrokinetics is most often limited to small areas/volumes of contamination. Its application should be well evaluated beforehand as local conditions strongly influence the success of a full scale application.

SWOT: Opportunities
Elektrokinetics is very suitable for a target remediation of small, isolated heavy metal contaminations.

SWOT: Threats
The operation of elektrokinetics without proper assessment of its application beforehand can result in uncontrolled processes in the soil and high cost levels.

More information

http://www.frtr.gov/matrix2/section4/4-4.html

http://www.epa.gov/tio/download/remed/electro.pdf

http://www.epa.gov/superfund/remedytech/tsp/download/heatenh.pdf

4.8 In-situ chemical oxidation (ISCO)

ISCO involves the introduction of a chemical oxidant into the soil for transforming groundwater or soil contaminants in the saturated zone into less harmful chemical components. There is a variety of oxidants which can be used for ISCO, all possessing specific qualities for the remediation of a wide variety of contaminants.

Remediation level
The remediation level is very much depended on local conditions and the type of contaminant. ISCO is most suited to remediated source areas.

Technical risks
Oxidation chemicals are often non selective towards contaminants. Reactions with other organic components in the soil will compete with the oxidation of the contaminants. The selection of the appropriate oxidant is a very important step in minimizing risks.

Costs
Operational costs of ISCO are related to the amount and type of oxidizing agent required. In general, the costs are considered to be low.

Sustainability
Oxidation is not a typically sustainable soil treatment technique. The main reason is the energy consumption for the preparation of the oxidants.

Time
The time involved for ISCO is limited to 1 month - ½ year.

Post remedial use
Soil treated by ISCO is typically reusable in less sensitive uses as non-residential and non-agricultural uses.

Social criteria
ISCO systems result in little nuisances for its surroundings due to compact nature of the equipment.

SWOT: Strengths
The strength of ISCO is the wide variety of contaminants that can be remediated.

SWOT: Weaknesses
ISCO is a non selective remediation process. The oxidizing agent will also react to non-hazardous components in the soil.

SWOT: Opportunities
ISCO is suitable for remediating source areas and plume areas of contaminations.

SWOT: Threats
The application of oxidants for ISCO is often based on overkill. Too much oxidant is applied resulting in unexpected and unwanted reactions.

More information

http://info.ngwa.org/gwol/pdf/101184365.pdf

http://www.epa.gov/ada/gw/isco.html

http://citychlor.eu/sites/default/files/code_of_good_practice_isco.pdf

http://www.soilpedia.nl/Bikiwiki%20documenten/SKB%20Cahiers/ISCO%20-%20In%20situ%20chemische%20oxidatie%20(Engels).pdf

http://www.epa.gov/superfund/remedytech/tsp/download/heatenh.pdf

4.9 Permeable Reactive Barriers (PRB)

A Permeable Reactive Barrier (PRB) is an engineered treatment zone of reactive material(s) that is placed in the soil in order to remediate contaminated groundwater as it flows through it. PRBs can be designed to treat a variety of groundwater contaminations and are most often used to remediate contaminated groundwater within aquifers. The reactive media used in PRBs enhances the chemical or biological transformation of the contaminant, or retards its migration by sorption or immobilisation of the contaminant onto the reactive media.

Remediation level
PRB's can achieve high remediation levels for the contaminants in the groundwater. Please note that when a source area of contaminations is present, the PRB this not influence the levels in this source area.

Technical risks
PRB's are dependent on the flow of groundwater through the barrier to accomplish the remediation. During the design of the barrier a thorough knowhow of the hydrological conditions is required. Also the resistance of the reactive material used in the barrier is critical for a good operation of the PRB. The selection of the appropriate reactive material is a very important step in minimizing risks.

Costs
The costs are governed by the installation of the PRB system. The depth and the size of the barrier and the fill material determine the costs. Operational costs of PRB's are low.

Sustainability
PRB's are considered to be a sustainable remediation technology. The energy consumption is very low (sometimes required for producing the reactive material). However, a PRB does not provide a definitive solution for a source area of contamination.

Time
The time involved for PRB installation is mostly limited to one month. The operational remediation time is dependent on extend of the groundwater contamination. The average time lies between 10- 20 years.

Post remedial use
Groundwater treated by PRB's is typically reusable.

Social criteria
The installation of a PRB can result in nuisances for its surroundings. During the operation of the PRB, very little nuisance is encountered.

SWOT: Strengths
The strength of a PRB's is the high remediation levels that can be achieved, the very low operational costs and the long term working of the system. PRB's can remediate a wide variety of contaminants.

SWOT: Weaknesses
PRB's require solid know how on hydrological conditions of the area. These conditions can change during the life time of the PRB. PRB's do not provide a permanent remediation solution for a source area of a contamination.

SWOT: Opportunities
PRB's are a sustainable alternative to pump & treat for aquifer contaminations.

SWOT: Threats
PRB's require a high quality monitoring of the system and the surrounding areas. During the long term a PRB is in operation, changes in hydrological conditions can occur.

More information

http://www.epa.gov/ada/gw/prb.html

http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/scho0902bitm-e-e.pdf

http://www.clu-in.org/download/citizens/a_citizens_guide_to_permeable_reactive_barriers.pdf

http://clu-in.org/download/rtdf/prb/reactbar.pdf

http://www.itrcweb.org/GuidanceDocuments/PRB-5-1.pdf

http://www.frtr.gov/matrix2/section4/4-53.html

http://www.frtr.gov/pdf/2-prb_performance.pdf

http://www.soilection.eu/index.php?option=com_technics&Itemid=26

4.10 In-situ bioremediation

Organic contaminations are subject to biological degradation. Over time, levels of these contaminations will decrease. However, the rates in which the levels decrease are often very slow and not useful when considering remediation options. Bioremediation is aimed at accelerating biological processes. Key in

bioremediation is the identification and removal of the limiting factors for biological processes.
There is a large range of bioremediation techniques. They all have in common the use of biological processes for the degradation of contaminants. This is done by methods ranging from injecting nutrients to introducing suitable bacteria for the required degradation process.
Biological processes can thrive is saturated areas of the soil as biological processes need moisture to develop. Application of bioremediation is therefore most suitable for the saturated zone of the soil.

Remediation level
Bioremediation can achieve very low remediation levels. However this requires a very long period of time and homogeneous types of contamination. In general, bioremediation can eliminate risks related to contaminants.

Technical risks
Bioremediation requires a thorough understanding of all aspects influencing the biological degradation of a specific contaminant on a site. Apart from knowledge on contaminations, information on hydrological conditions, macro chemical composition of the groundwater and indigenous bacteria populations is required. Use of laboratory experiments to design full scale remediation for a specific site will result in disappointing remediation results.

Costs
The operational costs of bioremediation in general are low.

Sustainability
Bioremediation is considered to be a sustainable remediation technology. The energy consumption is very low.

Time
The time involved for bioremediation is typically between 1 and 5 years.

Post remedial use
Groundwater treated by bioremediation is typically reusable in less sensitive uses as non-residential and non-agricultural uses.

Social criteria
Bioremediation techniques can result in nuisances for its surroundings during installation of nutrients etc. During the operation of the bioremediation, very little nuisance is encountered.

SWOT: Strengths
Bioremediation is a technique which uses the natural process of degradation for remediation purposes. Bioremediation can remediate a wide variety of organic contaminants.

SWOT: Weaknesses
Bioremediation requires a lot of specific investigations on items not common within the soil investigation and soil remediation. Also, remediation contractors are patenting various nutrient compositions limiting their use.

SWOT: Opportunities
Bioremediation is very suitable for contaminated sites where there are no time restrictions.

SWOT: Threats
Bioremediation requires a high quality of investigation data and monitoring.

More information
http://www.epa.gov/superfund/remedytech/tsp/download/issue11a.pdf

http://hazenlab.utk.edu/files/pdf/2009Hazen_HHLM_In_situ_groundwater_bioremediation.pdf

http://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3065.pdf

4.11 Phyto remediation

Phyto remediation uses the property of some plants to absorb and store large amounts of mainly heavy metals in their roots and shoots. The technique involves selecting and cultivating plants that are suitable for the local soil and climate in which a contaminated site is located. After completion of a growth cycle or the remediation, the plants roots and shoots should be removed and properly be disposed.
Phyto remediation can be used for several purposes, ranging from the extraction of the heavy metals from the soil to preventing erosion and dispersion of the contaminated soil. Phyto remediation is generally limited to the immediate zone of influence of the roots. It is also possible to use phyto remediation to reduce levels of contaminants in the groundwater which are influenced by the root system of the plants.

Remediation level
Phyto remediation is not only targeted for extraction of contaminants from the soil. Often it is used to immobilize or contain a contamination. As such it is difficult to refer to a specific remediation level.

Technical risks
Phyto remediation requires a long preparation time in order to decide on the most suitable type of plant for the site and the contaminants. If this information is not available and/or not used for the design of the remediation, it is unlikely that phyto remediation will be successful.

Costs
The operational costs of phyto remediation in general are low.

Sustainability
Phyto remediation is considered to be a sustainable remediation technology.

Time
The remediation time is strongly related to the purpose of the phyto remediation. When applied for containment, the phyto remediation will be in operation for several decades. The time involved for phyto extraction is typically between 3 and 15 years.

Post remedial use
Sites treated by phyto remediation are typically reusable in less sensitive uses as non-residential and non-agricultural uses.

Social criteria
Phyto remediation often requires the remediation site to be closed off. As the remediation process will last a significant time, this can pose a significant hinder. During the operation of the phyto remediation, very little nuisance is encountered.

SWOT: Strengths
Phyto remediation is very well suited to remediate large areas impacted with shallow contaminations. The plants used for phyto remediation enhance the green appearance of a site, making a remediation less disturbing. If well designed, phyto remediation can remediate a wide variety of contaminants.

SWOT: Weaknesses
Phyto remediation requires a lot of specific investigations on items not common within the soil investigation and soil remediation (climate, plant growth). Also, the remediation time for the process is significant.

SWOT: Opportunities
Phyto remediation is very suitable for contaminated sites where there are no time restrictions on remediation and no urgent land use. Future genetic engineering will likely further improve the efficiency of the process.

SWOT: Threats
Phyto remediation requires a high quality of investigation data before starting the actual remediation. The uncontrolled disposal or use of plants which are used for phyto remediation, poses a serious risk.

More information
http://www.clu-in.org/download/citizens/a_citizens_guide_to_phytoremediation.pdf

http://www.nature.com/scitable/knowledge/library/phytoremediation-17359669 http://www.ecolotree.com/pdf/introphyto.pdf

4.12 Natural attenuation (NA)

Organic contaminations in groundwater are subject to processes such as biological degradation, dilution and diffusion. Over time these processes will result in a decrease of contamination levels or a halt to spreading of the contamination. Natural attenuation (NA) or Monitored natural attenuation uses these processes in a controlled manner for remediation purposes.

Natural attenuation is most often applied as an approach for managing residual contaminations in the groundwater.

Essential for the implementation of NA is a complete understanding of the contamination. Delineation of the contamination and modelling of future spreading all should be completed before starting NA. For most sites, NA can only be implemented after the source of the contamination is removed. Proper monitoring of the process and contaminant behaviour is an essential aspect of NA.

Remediation level
Natural attenuation can achieve low remediation levels. However this requires a very long period of time. The focus of natural attenuation is most often the control of risks related to spreading of a contaminant in the groundwater.

Technical risks
Natural attenuation requires a thorough understanding of all aspects influencing the behaviour of a specific contaminant on a site. Apart from knowledge on the contaminant, information on hydrological conditions, macro chemical composition of the groundwater and indigenous bacteria populations is required. A major contribution in reducing the risks is the use of conceptual site models (CMS) to assess risk related to the contamination. To predict future behaviour of the contaminant, hydrological models are valuable tools.

Costs
The operational costs of natural attenuation in general are very low. In the designing process, significant costs can be endured as a result of the thorough research that is required.

Sustainability
Natural attenuation is considered to be a sustainable remediation technology.

Time
The time involved for natural attenuation is typically between 10 and 25 years.

Post remedial use
Groundwater managed by natural attenuation is typically reusable in less sensitive uses as non-residential and non-agricultural uses.

Social criteria
Natural attenuation can result in nuisances for its surroundings due to the long time a contaminated site or the contaminated groundwater is not available for other uses. Natural attenuation itself consists mainly of monitoring which results in very little nuisance.

SWOT: Strengths
Natural attenuation is a technique which uses the natural processes occurring in the soil for remediation purposes. As such it is a very robust approach.

SWOT: Weaknesses
Natural attenuation requires a long time. The quality of project management and monitoring tends to suffer over this long time.

SWOT: Opportunities
Natural attenuation is very suitable for contaminated sites where there are no time restrictions. It is a very easy to adopt as part of a remediation scheme where source areas are removed.

SWOT: Threats
Natural attenuation requires a high quality of investigation well in advance of implementing the process. Restrictions on site use or groundwater use are sometimes difficult to enforce over the long period of time natural attenuation requires.

More information
http://www.clu-in.org/download/Citizens/a_citizens_guide_to_monitored_natural_attenuation.pdf

http://www.clu-in.org/download/remed/chl-solv.pdf

http://www.clu-in.org/download/remed/pet-hyd.pdf

http://www.nj.gov/dep/srp/guidance/srra/mna_guidance_v_1_0.pdf

http://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3065.pdf

http://www.soilection.eu/index.php?option=com_technics&Itemid=26

4.13 Immobilization by in-situ vitrification

In-situ vitrification is a technique which focuses on the immobilization of contaminants. Vitrification is the process to make glass out of something, in relation to contaminated soil, to turn the soil containing the pollutant into a large block of glass. After the vitrification, the contaminant can then be left in place indefinitely encased inside of the glass without any risk of emissions.

Contaminants react in different ways to this remediation technique. Organic pollutants are pyrolyzed and are generally reduced into gasses. The gasses rise to the surface where they are collected by a gas hood over the subject site. The gases are then transported to an off-gas treatment system. The inorganic pollutants or heavy metals are encased in the glass formed by the vitrification process. Radioactive materials are also encased in the glass and the glass formed by the soil also helps to limit the radiation leakage. During the molten phase of the process almost all of the void spaces in the soil are removed and therefore there is a volume reduction of 20-50% of the original soil volume. The end result is a very dense block of glass.

Remediation level
As such no remediation levels are reached. However, all contaminants are encapsulated and no risks related to the original contamination endure.

Technical risks
Key in assessing the possibilities for vitrification is the composition of the soil. Good insight is required in percentage of organic constitutes of the soil. A to high percentage poses a high risk for vitrification. Also the amount of combustible contaminants should be well established beforehand otherwise uncontrolled explosions can result from the heating process.

Costs
The operational costs of vitrification are high. The costs are mainly related to the expensive equipment for the vitrification process and energy costs for the operation of the process.

Sustainability
Vitrification is not considered to be a sustainable remediation technology due to its high energy consumption. Also it renders the treated soil useless for any natural use.

Time
The time involved for in-situ vitrification is limited to 1-4 weeks, depending on the volume of soil to be remediated.

Post remedial use
Soil treated by vitrification in general possesses no qualities associated with natural soil.

Social criteria
Vitrification can result in significant nuisances for its surroundings due to the fact that the treated soil cannot fulfil any natural functions.

SWOT: Strengths
Vitrification can remediate specific contaminations that cannot be remediated by any other technique. As such it is a unique technology.

SWOT: Weaknesses
Vitrification will always be limited to a very specific group of contaminations. It is only feasible for the remediation of limited amounts of soil.

SWOT: Opportunities
Vitrification is very suitable for a target remediation of small, specific contaminations.

SWOT: Threats
Vitrification requires a high quality of investigation, staff and equipment. Restrictions on soil use after completion are significant.

More information

http://www.clu-in.org/download/contaminantfocus/dnapl/Treatment_Technologies/engineering_bulletin.pdf

http://www.wmsym.org/archives/2003/pdfs/460.pdf

4.14 Immobilization by in-situ grouting

In-situ grouting is a technique which focuses on the immobilization of contaminants. To achieve this, the contaminated soil is mixed or injected with an immobilizing component (the 'grout'). The injecting or mixing is carried out by vertical methods, mainly special drilling or injecting equipment. The grouting material used is depended on the site, the required immobilizing properties for the contamination and the soil conditions. Most often a type of cement or clay is used.

Remediation level
As such no remediation levels are reached. However, all contaminants are immobilized and no risks related to the original contamination endure.

Technical risks
Key in assessing the possibilities for in-situ grouting is the composition of the soil and contamination type. Application of grouting in low permeability soils is problematic as the grout material will not penetrate sufficient in the soil to immobilize all contaminants. For soils with a very high permeability, the grout material has to be amended with filler.
Certain types of grout can result in significant changes of soil volume.

Costs
The operational costs of in-situ grouting differ according to depth and size of the site to be treated. Also the specifics of the grouting material are of major influence to the costs.

Sustainability
In-situ grouting is considered to be a less sustainable remediation technology mainly due to the fact that it renders the treated soil useless for any natural use.

Time
The time involved for in-situ grouting is limited to a few weeks, depending on the volume of soil to be treated.

Post remedial use
Soil treated by in-situ grouting in general possesses no qualities associated with natural soil.

Social criteria
In-situ grouting can result in significant nuisances for its surroundings due to the fact that the treated soil cannot fulfil any natural functions.

SWOT: Strengths
The strength of in-situ grouting is the ability to stop all the leaching from contaminants. The technique can be applied to an extensive range of contaminants by changing the grout material qualities.

SWOT: Weaknesses
In-situ grouting will always be limited to a very specific group of contaminations and site locations. It is only feasible for the remediation of limited amounts of soil.

SWOT: Opportunities
In-situ grouting is very suitable for a target remediation of small, specific contaminations.

SWOT: Threats
In-situ grouting requires a high quality of investigation, staff and equipment. The assessment of the type grout required is an essential step. Restrictions on soil use after completion are significant.

More information
http://web.engr.oregonstate.edu/~hambydm/papers/remedrev.pdf

http://www.inl.gov/technicalpublications/Documents/3314427.pdf

http://www.frtr.gov/matrix2/section4/4-8.html

4.15 Vertical wall

The instalment and maintaining of a vertical wall is a technique which is aimed at control or containment of contaminated soil. The wall has impermeable qualities to prevent the spreading of contaminants or exposure to contaminants. The wall also prevents the inflow from clean water into the contaminated soil. Often, the vertical wall is combined with measures which prevent infiltration rainwater in the contaminated soil.
Vertical walls are systems widely used for general construction purposes. Their application for soil remediation requires however a specific quality focusing much more on retaining the contamination. Basic examples of vertical wall

include steel sheet piling and slurry walls. The most effective application of the vertical wall for site remediation is to base the wall into a low permeability layer such as clay or bedrock.

Remediation level
As such no remediation levels are reached. However, all contaminants are contained and no risks related to the contamination endure.

Technical risks
A vertical wall should contain the contaminants under all circumstances. Key in assessing the possibilities for a vertical wall is knowledge on the composition of the contaminants and their chemical properties which may affect the material of the wall and the hydrological conditions of a site. A solution can be to select a wall consisting of two materials such as betonite slurry in combination with a HDPE liner.
A major risk is the permeability of the wall. The material and the construction of the wall have to be guaranteed for a long time.

Costs
The costs of vertical walls are decided by the depth and the total length of the wall. Significant additional costs can be involved in the hydrological control (no infiltration on the soil) of the contained soil.

Sustainability
Vertical walls are considered to be a less sustainable remediation technology mainly due to the fact that it provides no definitive solutions for the contaminated soil.

Time
The time involved for the instalment of a vertical wall is fully dependent on the size of the wall. A good indication of required time is 1-6 months. After instalment the proper functioning of the wall have to be verified indefinitely.

Post remedial use
Soil contained by and vertical wall in general possesses no qualities associated with natural soil or with normal soil use. Under certain conditions the top layer of the soil contained by the wall, can be restored and used for basic, low sensitive purposes such as car parks, recreational areas or city parks.

Social criteria
The instalment of vertical walls results in significant nuisances for its surroundings. If the top layer of the site is not restored, the site cannot fulfil any functions for the area and is likely to become an unattractive area.

SWOT: Strengths
The strength of a vertical wall is the ability to stop all the leaching from contaminants to the surrounding area. The technique can be applied to an extensive range of contaminants and soil types.

SWOT: Weaknesses
Vertical walls require indefinitely control and management on the quality of the system.

SWOT: Opportunities
If well constructed and social needs are well integrated into the design process, vertical wall can contribute to the restoration of an area. Good examples include the construction of city parks on top of sites contained by vertical walls.

SWOT: Threats
The most significant threat to vertical walls is the long term functioning of the system. If no proper quality management is carried out during installation and maintenance, leakages from contamination through the wall are likely. Most important reason for leakage is infiltration of water into the site due to precipitation. The increase in water level and associated pressure to the wall is major threat.

More information
http://www.frtr.gov/matrix2/section4/4-53.html

4.16 Capping layer

The instalment and maintaining of a capping layer is a technique which is aimed at control or containment of contaminated soil or waste material. Capping layers form a barrier between waste or contaminated soil and the environment.
Capping layers also prevent the migration of contaminants from the site. This migration can be caused by rainwater or surface water moving over or vertically through the site, or by the wind blowing over the site.
Capping layers are generally constructed of clean sediment, sand, or gravel. A more complex layer can include geotextiles, liners, and other permeable or impermeable materials in multiple layers. Layers can also include additions of organic carbon or other in systems which control the movement of contaminants through the layer.
Capping layers can be applied for contaminated land but also for contaminated sludge or sediments in aqueous environments.

Remediation level
As such no remediation levels are reached. However, all contact and exposure to the contaminants is prevented by the layer.

Technical risks
A capping layer must protect the environment form the contaminants, must also be easy to be maintained and should last very long. To achieve all these functions, all issues that influence these qualities must be known before construction. Most common risks include the permeability of the cap, unexpected settling and consolidation of the soil which tears the cap.

Costs
The costs of capping layers are decided by the complexity of the structure and the area to be covered. Significant additional costs will be endured if active extraction systems (for gas and / or water) are required.

Sustainability
Capping layers are considered to be a less sustainable remediation technology mainly due to the fact that it provides no definitive solutions for the contaminated soil.

Time
The time involved for the instalment of a vertical wall is fully dependent on the area to be covered and the complexity of the system. A good indication of required time for simple application is time is 2 months. Complex capping layers can require 1 month/hectare area covered.
After instalment the proper functioning of the capping layer has to be verified indefinitely.

Post remedial use
Soil contained under the capping layer in general possesses no qualities associated with natural soil or with normal soil use. For capping layers used in an aqueous environment, the soul used for the capping layer often can support basic aquatic life.

Under certain conditions the capping layer can be an integral part of a new development and area used for basic, low sensitive purposes such as car parks, recreational uses or city parks.

Social criteria
The instalment of a capping layer results in significant nuisances for its surroundings. If no further development of the capping layer is undertaken, the site cannot fulfil any functions for the area and is likely to become an unattractive area.

SWOT: Strengths
The strength of a capping layer is the ability to stop all infiltration of precipitation or weathering of the contaminants thus preventing spreading. Capping layers also prevent any exposure to the contaminated soil.
The technique can be applied to an extensive range of contaminants, soil and waste types.

SWOT: Weaknesses
Capping layers require indefinitely control and management on the quality of the system.

SWOT: Opportunities
If well constructed and social needs are well integrated into the design process, capping layers can contribute to the restoration of an area. Good examples

include the construction of city parks on top of former waste dumps, indoor ski centres etc.

SWOT: Threats
The most significant threat to capping layers is the long term functioning of the system. If no proper quality management is carried out during installation and maintenance, damage of the capping layer is likely.

More information
http://www.clu-in.org/contaminantfocus/default.focus/sec/sediments/cat/Remediation/p/1/

4.17 Geohydrological control

The instalment and operation of a geohydrological control system is a technique which is aimed to control the spreading of contaminated groundwater.
The system prevents the migration of contaminants from the site. This migration is mostly caused by natural hydrological conditions. For most sites the systems requires various methods for the abstraction of groundwater and systems for the treatment of the groundwater. In some selected sites, plants can perform abstraction of the groundwater. This application of phyto remediation is sustainable alternative to abstraction for a geohydrological control system.

The technical approach for a geohydrological control system has a lot off similarities with a ground water abstraction – water treatment system ('pump & treat').

Remediation level
As such no remediation levels are reached. However, all spreading by the natural groundwater flow is prevented by the system. Risks related to spreading are stopped.

Technical risks
When considering a geohydrological control system, a thorough knowhow on the hydrological conditions on the site is essential. A misunderstanding of these conditions is the paramount risk when designing and operating a geohydrological control system. It can result in placement of abstractions systems in the wrong locations or systems which do not have the required capacity.

Costs
The costs of a geohydrological control are almost fully decided by the requirement to have a water treatment system. If a water treatment is required, costs are likely to be high. If this requirement does not exist, costs are low and mainly related to power costs for pumps and overall maintenance.

Sustainability
A geohydrological control system is considered to be a less sustainable remediation technology mainly due to the fact that it provides no definitive solutions for the contaminated soil. Also the abstraction of large quantities of

groundwater from the soil is not considered to be sustainable. Improvements can be made if the abstracted groundwater can, after treatment, be used for other purposes.

Time
The time involved for the instalment of a geohydrological control system is on average a few months. After start up, the system has to be operated indefinitely including monitoring of the hydrological conditions in the soil.

Post remedial use
Groundwater controlled by the system in general possesses no qualities associated with natural or normal use.

Social criteria
The instalment of a geohydrological control system results in little nuisance for its surroundings. Groundwater abstractions in general can result in nuisances for its surroundings due to lowering of the groundwater table and related geotechnical consequences (soil settling).

SWOT: Strengths
A geohydrological control system provides a fast solution for uncontrolled spreading of groundwater contamination. The basics of the system are simple and, if well designed, are not prone to technical difficulties.

SWOT: Weaknesses
Geohydrological control systems require indefinitely control and management on the quality of the system and the hydrological conditions on the site.

SWOT: Opportunities
The abstracted and treated groundwater can be used locally for various purposes.

SWOT: Threats
The use of groundwater abstraction can result in the loss of valuable water and depletion of water bearing layers.

More information
http://www.clu-in.org/download/citizens/a_citizens_guide_to_pump_and_treat.pdf

http://www2.bren.ucsb.edu/~keller/courses/esm223/SuthersanCh11Pump&Treat.pdf

4.18 Land use restrictions

Land use and activity restrictions for a site are implemented to eliminate exposure pathways for, or reduce potential exposures to contaminated land. Land use restrictions are temporary safety measures in preparation for more definitive remediation measures.

First step in considering land use restrictions is the identification of all activities which should not occur on the site unless further evaluation and remedial action is undertaken. These activities and uses may result in the exposure of persons or ecological receptors to the contamination.
After these steps are identified, the implementation of land use restriction is both technical and administrative. Technical implementation is very simple and can be sometimes limited to the installation of a fence to prevent people entering the site.

Remediation level
As such no remediation levels are reached. However, exposure to contaminants is prevented.

Technical risks
Land use restrictions are very simple techniques and measurements. The basis is understandings of the area were the restrictions should be applied and which restrictions are relevant. To make these decisions a good understanding of the contaminants and the exposure pathways is required.

Costs
The costs of the technical implementation of land use restrictions are low. Fencing and proper signalling in combination with regular monitoring and maintenance make up the technical costs. If the site is occupied and used by people it may be necessary to find alternative accommodation, resulting in significant additional costs.

Sustainability
Land use restrictions cannot be considered to be sustainable remediation technology mainly due to the fact that it provides no definitive solutions for the contaminated soil.

Time
The time involved for installing proper fencing etc. is limited. After the restrictions are implemented they have to be maintained and monitored until a definitive remediation is carried out.

Post remedial use
Land use restrictions seldom result in post remedial use of a site. If there are differentiations in restrictions, some uses may be allowed. However, they rarely have qualities associated with natural or normal use of the soil.

Social criteria
The instalment of land use restrictions can result in significant nuisance for people as they are likely not allowed to enter or use the site.

SWOT: Strengths
Land use restrictions are a fast solution for uncontrolled exposure to all types of contaminants. The basics of the system are simple and have low maintenance costs.

SWOT: Weaknesses
Land use restrictions can be very intrusive as the prevent persons from entering a specific site or area. The restrictions require indefinitely control and monitoring.

SWOT: Opportunities
Land use restrictions can have unexpected benefits for biodiversity as the site is not accessible by people.

SWOT: Threats
Land use restrictions can generate desolate areas which can negatively affect communities.

4.19 Relocation and safety measures

Relocations and safety measures are drastic methods for gaining control over risks related to contaminations. This approach is considered for large scale environmental problems affecting large areas. This method is applied when time is required to find definitive solutions for the contaminations; however it is likely that this will take decades. Examples of the application of this approach are former mining areas and radioactive contaminated areas.
The practical implication of relocations and safety measures implies removing all people from the affected area. Alternative housing has to be provided for those relocated. For the affected area, safety measures have to be enforced. They include access restrictions to the area and monitoring of most relevant spreading routes of the contamination.

Remediation level
As such no remediation levels are reached. However, human exposure to contaminants is prevented.

Technical risks
Relocations and safety measures are very simple techniques and measurements. The basis is understandings of the area were relocation has to be enforced and which type of safety measures is relevant. To make these decisions a good understanding of the contaminants and the exposure pathways is required.
It is without doubt that the social impact of the measures and possible resistance to the relocation is the most significant risk.

Costs
The costs of the technical implementation of land use restrictions are low. However, other costs will be significant. Relocation, finding alternative housing, compensation for those affected will result in very high costs.

Sustainability
Relocations and safety measures cannot be considered to be a sustainable remediation technology mainly due to the fact that it provides no definitive solutions for the contaminated soil.

Time
The time involved for the technical issues such as installing proper fencing etc. is limited. However, relocation of people and finding alternative living quarters for them will take a significant period. After relocation is implemented, safety measures have to be maintained and monitored until a definitive remediation is carried out. This is likely to be several decades.

Post remedial use
Relocations and safety measures seldom result in post remedial use of a site.

Social criteria
The relocations of people from an area will result in significant nuisance and is likely to encounter resistance from inhabitants of the area.

SWOT: Strengths
Relocations and safety measures are a drastic but working solution for the prevention of exposure to contaminants. The technical basics of the system are simple and have low maintenance costs.

SWOT: Weaknesses
Relocations and safety measures are very intrusive as it removes people from the area were they have their livelihood. The safety measures require indefinitely control and monitoring.

SWOT: Opportunities
Relocations and safety measures for an area can have unexpected benefits for biodiversity as the area is not accessible by people.

SWOT: Threats
Relocations can generate desolate areas which will negatively affect communities.

4.20 Drinking water treatment

Drinking water attained trough wells, surface water and piping can become contaminated. The processes that result in the contamination can be very different. Direct emissions of pollutants into surface waters, contamination of water bearing layers and penetration of contamination through piping are all known causes for affecting drinking water. As drinking water is an essential resource for life, the contamination of water will result in direct health problems. Drinking water treatment is focussed on providing alternatives for the contaminated resources. It can be implemented in various manners, ranging from drinking water delivery by trucks, to small treatment plants. In combination with these provisions for clean drinking water, the contaminated resources have to be shut off.

Remediation level
As such no remediation levels are reached. However, exposure to contaminated drinking water is prevented.

Technical risks
To provide alternative drinking water can be a very simple technique.
Without doubt the social impact of the measures is the most significant risk.

Costs
The costs for providing alternative drinking water can be high depending on site specific conditions and the presence of good alternatives.

Sustainability
Drinking water treatment cannot be considered to be a sustainable remediation technology. It is only meant to provide safe drinking water and does not in any way contribute to a definitive solution for the contaminated soil.

Time
The time involved for the installing alternatives for drinking water can be very short. After installing an alternative drinking water provision, the operation has to be maintained until a definitive restoration of the original drinking water resources has been completed.

Post remedial use
Drinking water treatment does not affect or enhance the post remedial use of a contaminated site.

Social criteria
Installing alternative drinking water treatment for an area can result in social tensions. People are shut off from their known sources of drinking water and will feel insecure.

SWOT: Strengths
The strength of this measure is that it immediately stops the exposure to contaminated water. The technical basics for alternative drinking water systems can be simple.

SWOT: Weaknesses
Installing alternative drinking water resources is very intrusive for people living in the area. It can only be considered as a measurement preceding a definitive remediation.

SWOT: Opportunities
Installing alternative drinking water resources can be the start of revising or implementing modern drinking water systems for an area.

SWOT: Threats
Drinking water is an essential resource. It is likely that a poor control on the alternative provision of drinking water can result in tensions.

4.21 Water treatment technologies

Water treatment technologies used for contaminated water flows are all related to existing industrial treatment technologies and water treatment plants.

Following treatment technologies are most common for application on remediation sites.

Activated Carbon
Activated carbon is widely used in water treatment plants. The principle of activated carbon is the absorption of the contaminant on the carbon. Activated carbon is mostly used for the treatment of VOC. However, other types of contamination can include some heavy metals. Activated carbon is a simple technology which can achieve high levels of treatment efficiency (90%).
At soil remediation sites activated carbon is mostly used for small water flows or as a second treatment step after air stripping.

Air Stripping – Shallow tray aeration treatment
Air stripping is the most widely used technology for water treatment for sites contaminated wit VOC. The contaminated water is generally pumped into a collection vessel where it pumped into spraying nozzles located in the top of the air stripping column. The water encounters ambient air from outside the stripper unit blown into the water with sufficient pressure to push the air up.
As the air flows upward through the water, contamination is transferred to the air flow. The stripped off gas air continues upward and is blown out the top of the air stripper unit for discharge to an additional post treatment (if required).

The shallow tray aeration treatment uses the same basic technology. Ambient air is blown through hundreds of holes in the bottom of the trays to generate a froth of bubbles. This results in a large mass transfer surface area where the contaminants are volatilized. The stripped off gas air is blown out the top of the unit for discharge to an additional post treatment (if required). The big advantage of a shallow tray system is the compact size.

Separation
Most widely used at soil remediation sites is the oil – water separator. It is a simple technique which separates oil from water. The basic principle is based on the difference in density. Water has a higher density then most hydrocarbons. In a settling vessel the oil will migrate to the top, forming a layer that can be separated from the water. The oil layer can be removed for separate treatment. Particles heavier then water will settle on the bottom allowing them also to be removed. This type of separation is mostly used to reduce levels of oil and remove floating particles from the water. This type of separation is very simple to operate.

A more completed method of separation is membrane filtration. This technology removes contaminants from water by passing the water trough a semi permeable barrier or membrane. The membrane allows some constituents to pass while it blocks others. This type of treatment can be used to remove heavy metals from water flows.

Precipitation
For this technique, chemicals are added to the water to transform the dissolved contaminants into insoluble solids or on which the dissolved contaminants will

be adsorbed. The insoluble solids are then removed from the water flow using clarification or filtrations. This type of treatment is often used to remove heavy metals from water flows.

Biological treatment
This type of technology is widely used in the treatment of waste water. It now forms the basis of wastewater treatment worldwide. It simply involves confining naturally occurring bacteria at very much higher concentrations in tanks. These bacteria, together with some protozoa and other microbes, are collectively referred to as ‘activated sludge’. The concept of treatment is very simple. The bacteria remove small organic carbon molecules by ‘eating’ them. As a result, the bacteria grow, and the wastewater is cleansed. Whilst the concept is very simple, the control of the treatment process is very complex, because of the large number of variables that can affect it. These include changes in the composition of the bacterial flora of the treatment tanks, and changes in the sewage passing into the plant. The influent can show variations in flow rate, in chemical composition and pH, and temperature.
Biological treatment is seldom used on-site at soil remediations. However, water emitted to the sewer system will be treated by this system is a waste water treatment plant is in operation.

Oxidation
Oxidation processes are an emerging technology that can be used for specific goals in wastewater treatment. Oxidation utilizes the very strong oxidizing power of hydroxyl radicals to oxidize organic compounds to the preferred end products of carbon dioxide and water. The type of oxidant has to be selected based on the contaminants to be treated. For water treatment, UV has fast becoming a very much used method for oxidation. This method is capable in handling almost all organic contaminants.

4.22 Off gas air treatment technologies

Various remediation technologies create contaminated gasses. Examples are soil vapor extraction and multi phase extraction. For the on-site treatment of these gasses, existing industrial technologies for off gas treatment are applied.

Following treatment technologies are most common for application on remediation sites.

Activated Carbon
Activated carbon is used in many industrial processes and consumer applications. The use in remediation technologies is not limited to off gas air treatment. It is also used in water treatment plants (water phase).
The principle of activated carbon is the absorption of the volatile contaminant on the carbon. Activated carbon is mostly used for the treatment of VOC’s.
The treatment efficiency is very high (>99%) for good quality activated carbon.

Bio filtration
Bio filtration is a method of transforming mainly hydrocarbons with the use of bacteria. The bacteria are specifically designed to digest the unwanted

hydrocarbon. These bacteria may be designed to work in conjunction with an activated carbon system. Bio filtration is suitable for low-medium high gas levels. If well designed and maintained, the treatment efficiency can reach 95%. The major benefit of a bio filtration system is the reduction in operating costs such as electricity and adsorption media. The maintenance is reduced due to fewer operating parts.

Thermal oxidation
Thermal oxidation is most often used to convert organic hydrocarbons into carbon dioxide and water. The principle is based on increasing the thermal temperature of the gas, breaking of the hydrogen-carbon bonds. This process allows new bonds to be created such as CO_2 and H_2O. As can be expected, these types of systems consume large amounts of energy. However, they can be interesting for off gas treatment of large, industrial type flows.

Catalytic Oxidizers
Catalytic oxidizers are alternatives to thermal oxidizers. These systems oxidize waste gas into CO_2 and H_2O. Their successful operation is limited to a more controlled range of applications and components than other thermal oxidizers. They are most suitable for hydrocarbons. Catalytic oxidizing systems have considerably lower fuel consumption, operating costs and lower CO and NO_x emissions.

4.23 Recovery of material from remediation activities

Contaminated sites possibly contain materials that may be valuable for reuse. So efforts can be justified to find out if these materials may be retrieved from these sites.

An important hindrance for reuse results from the mixing of the materials in soil. Due to this mixing, the materials are often difficult to extract from the soil matrix. In the soil matrix, potentially reusable materials have been mixed with other materials. So, is can be very difficult to produce pure materials from a remediation site. Because of this it is hard to find a useful industrial reuse purpose for the retrieved materials.

If these hindrances can be overcome, the recovery of materials can be a positive contribution to a remediation.

For (former) landfill sites many studies have been carried out on the possibilities for ‘waste mining’.
Recycling waste in many cases is technically achievable. Legal and financial aspects can be found to be restrictive for implementation of these techniques. However if the recovery of material can be part of a remediation strategy to remove the contaminated material and to redevelop the area it might be a cost efficient approach to consider.

In 2003 a paper on landfill mining in India was published (*Studies on landfill mining at solid waste dumpsites in India, J. Kurian et. al., article in the Proceedings Sardinia 2003, Ninth International Waste Management and Landfill Symposium*). Conclusion of this paper was that the concept of waste mining and related technology merits serious consideration in the rehabilitation of dumpsites. Site-specific conditions will determine whether or not landfill mining and reclamation is feasible for a given location. The key conditions to be considered include composition of the waste initially put in place in the landfill, historic operating procedures, extent of degradation of the waste, types of markets and uses for the recovered materials. The heavy metal content and other characteristics of the recovered soil fraction indicate that the fraction can be suitable for landfill cover material. The compost standards are met for most parameters in the soil fraction of most studies.

4.24 Remediation of contaminated sediments

For sediment remediation following basic principles apply:

- A contaminated sediment problem nearly always deals with huge volumes. So, the costs of appropriate treatment technologies are an important factor.
- Since sediments tend to be very heterogeneous, a selected treatment technology must able to cope with this aspect. This means that the technology has a low sensitivity to variations: if (slight) deviations in the presumed physical-chemical composition occur the treatment still does not fail.
- Mineral materials are basically appropriate as a building material. The utilization of treated sediments may contribute to the reduction of raw materials such as sand, rock and so on. Possible applications are dependent on the treatment technology used. Some applications include foundation material under roads and parking’s, construction material in sound barriers and so on.

There are two generic ways to remediate contaminated sediments in surface water: contaminated sediments may be dredged and the material is treated of disposed of or the contaminated compounds in the sediments may be immobilized in-situ.

Dredging
In general terms, dredging technologies can be divided into three groups on the basis of their principle of operation: mechanical dredging technologies, hydraulic dredging technologies and technologies for work under special conditions. All dredging technologies for the removal of contaminated sediments should achieve a high level of accuracy and a minimum of spillage and turbidity. In addition efforts should be made to pick up as little water from the surroundings as possible. For this reason, much emphasis is placed on achieving as high a density mixture as possible in hydraulic dredging, and the highest feasible filling level of the excavator bucket in mechanical excavation. When designing the dredging operation, following elements need to be taken into consideration: type of surface water and water depth; current and waves; soil properties; type and amount of contamination; possible obstacles.

Treatment of dredged material
For treatment of dredged sediments, following techniques will be explained:

- Separation in sedimentation basins;
- Physical separation;

- Ripening;
- Biological decontamination;
- Immobilization;
- Dewatering and storage of sludge in tube made of geotextile;
- In-situ treatment of contaminated sediments.

Separation of dredged sediments in sedimentation basins
After the dredging the sediments are injected as slurry into the sedimentation basin. The slurry flows from the injection point to the effluent side, where the excess water and any suspended particles are removed from the basin. The coarse, sandy fraction is thus separated from the more contaminated mud fraction, using the differences in sedimentation behavior of the coarse heavy (sand) particles and fine light (clay) particles and of the fact that the contaminants generally attach themselves to the clay fraction.
A relatively clean sand fraction is produced by separating the coarse and fine particles from each other.

Physical separation
Sediment separation is based on physical properties. Particles are separated with the objective to obtain a large volume of “clean” material (which can be put to reuse) and a small concentrated amount of highly contaminated material which must be disposed of or will be treated further.

Most available technologies are capable of processing sediment which contains a sufficient amount of sand. The sandy fraction is generally not contaminated and can easily be purified further, if so desired. The contaminated residue can either be stored in a smaller space than the one claimed by the original integrated sediment, or be treated further.

Ripening of dredged sediment
Ripening is a natural process with physical, chemical and biological processes, in which the predominantly anaerobic dredging mud is converted into a more compact, better aerated, more permeable material by evaporation and oxidation. This process slowly converts the dredging mud from a wet slurry into a solid clayey soil. The volume of material is, depending on its initial dry-matter content and physical composition, reduced by 30-50%. Ripening is an irreversible process, i.e. the material does not revert back into its original state after re-wetting. The dredging mud is ripened to obtain an environmentally acceptable product that can be used for civil engineering works such as construction of dykes and roads.

Biological decontamination of dredging mud
The objective of the biological techniques is the removal of organic contaminants using bacterial degradation. Microorganisms (bacteria and fungi) can use certain organic contaminants for their growth and/or metabolic processes. However not all types of contaminants can be degraded, e.g. heavy metals. Based on the manner in which oxygen is introduced into the process, four biotechnological concepts can be distinguished: decontamination in-situ, in depots, in land farms and in reactors. Landfarming however is not a suitable technique in India due to agricultural policy.

Immobilization
Immobilization is here defined as the technical treatment to change the physical and / or chemical properties, to minimize spreading of contamination by leaching, erosion or drifting. The aim of immobilization (also called: solidification or stabilization technologies) is a stronger fixation of contaminants to reduce the emission rate to the biosphere and to retard exchange processes. Most of the stabilization technologies aimed for the immobilization of metal-containing wastes are based on additions of cement, water glass (alkali silicate), coal fly ash, lime or gypsum. Generally, maintenance of a pH of neutrality or slightly beyond favors adsorption or precipitation of soluble metals. Recently, the technology provides a better immobilization for organic contaminants.

Immobilization may be applied to the whole sediment or to the fines produced by the sediment separation. The source material is (highly) contaminated and the main parameter that has to be controlled is the leaching factor. Binders and additives are used to control the leaching. Often cement is used as a binder but some companies also use self developed secondary binders made from by-products of the industry. Depending on the type of contaminant additives are chosen. The “recipe” for these additions is dependent on the characteristics of the sediment.
The result of the immobilization will be a product that can be used as foundation material for road construction, parking lots etc.

Dewatering and storage of sludge in tubes made of geotextile
Dewatering of dredged material by using tubes made of geotextile is a method to reduce the amount of water in sludge. To improve the dewatering process specific chemicals may be added to bind the solid. After the water has been removed from the sludge the tube can be removed. Due to the fact that the volume has reduced the costs for further treatment are much lower than for the original volume. If the level of the contamination of the dewatered sludge is low and monitoring is applied the tubes may be used for civil engineering constructions.

In-situ treatment of contaminated sediments
The general purpose of this technique is to introduce substances in or on top of the sediments which result in limiting the availability of contaminants into the biosphere. A good example is the introduction of activated carbon in the top layer of the sediments. The activated carbon absorbs the contaminants and so prevents them from entering the biosphere.
A major disadvantage of in-situ treatment is the lack of control on the process. It is very difficult to assess if the technique achieves its goal. Also, the application the technique is limited to water bodies with little natural flow and traffic.

5 Menu of prioritized remediation options for (sub)types of contaminated sites

This Section presents a menu of most likely ('prioritized') options for remediation of (sub)types of sites (refer to Glossary). This Menu of remediation options provides a first indication of potential remediation options that may be suitable for the situation at hand. For small and simple sites one or more best practice methods included in the menu may directly apply. In more complex situations the best practice overview will help the performing agent to make the first steps in the development of options.

Table III-5.4.3 Overview of remediation options and their applicability to types of sites

Explanation example of how to read the table: a site of both S1 and P2 type, i.e. a site with both land bound solid phase contamination as well as groundwater contamination is described in the first and third line in the table. In case the site is in an industrial setting in an urban area you may refer to remediation option 3 in figure III-5.4.1.

Nr.*)	**Type **)**					**Subtype**				
	S1	**S2**	**L**	**P1**	**P2**	**Land use (present)**				**Remark**
Option						**Ur-ban**	**Indu stry**	**Nature**	**Agricul-ture / rural**	
1	X				X	X				
2	X(d)				X			X	X	
3	X				X	X	X			
4		X				X	X	X	X	
5	X(def)								X	
6	X							X		
7	X					X				
8	X						X			
9			X							
10				X			X			Type P1-a
11				X			X			Type P1-b
Additional options based on *clustering* of specific types										
12	X									'Cluster sites'
13			X		X					Area oriented groundwater approach

Explanation:

X Types of sites for which a blueprint of options is presented in this Section

**) Number referring to remediation options presented in this Section:*

1. Type S1 + P2: Land bound solid phase contamination and groundwater contamination
2. Type S1-d + P2: Land bound solid phase contamination and groundwater contamination
3. Type S1 + P2: Land bound solid phase contamination and groundwater contamination
4. Type S2: Solid phase contamination (water bound site, open water sediments)
5. Type S1-d-e-f: Land bound solid phase contamination
6. Type S1: Land bound solid phase contamination
7. Type S1: Solid phase contamination (land bound site)
8. Type S1: Land bound solid phase contamination
9. Type L: Liquid phase contamination, both NLAPL and DNAPL
10. Type P1-a: Dense Non-Aqueous Phase Liquid (DNAPL) in permeable soil (bulk density > water)
11. Type P1-b: Light Non-Aqueous Phase Liquid (LNAPL) in permeable soil (bulk density < water)
12. Type S1-a/b: Cluster of land bound solid phase contamination
13. Type L1: Cluster of liquid phase contamination (multiple/overlapping plumes)

***) Type of contaminated sites(see Glossary)*

S1	Solid phase land bound contaminations
S2	Solid phase water bound contaminations
L	Liquid phase contaminations
P1	Liquid phase related DNAPL / LNAPL contaminations
P2	Leached or dissolved contaminants

In figure III-5.4.1 (see next pages) each of the 13 remediation options mentioned in the table above is discussed. We present every option in the same format, one option to a page, each divided into four headings:

- Site and setting summary
  This heading presents a brief summary of the main site characteristics, i.e. type of contamination, setting and site use, most prolific risks and most common contaminants, always illustrated by a schematic cross-section.

- Most likely remediation objectives
  This heading presents recommendations for cleanup levels. Where applicable, examples are given of sensitive land use that may require additional evaluation as to whether remediation to the generic level for the corresponding land use will provide sufficient level of protection. In general, fit for use levels based on the corresponding type of land use are recommended. Setting generic levels as remediation goal may not always result in an economically or technically feasible remediation. In such cases remediation to a concentration level meeting a site specific level based on site specific risk assessment can be considered.

- Most likely remediation measures
  This heading lists the most likely remediation measures according to the targeted point of operation (source, pathway or receptor). It must be stressed that this heading should not be used as the only reference in the design process of remediation option. We refer to Chapter 5 for more information.

- Specific conditions or alternative approaches
  This heading describes specific conditions that may prove pivotal for cost efficient remediation design. Also listed are some alternative remediation options that may come into perspective in case the costs of full scale remediation to generic levels are not in balance with the required level of risk reduction. In specific cases alternative remediation options can be acceptable and viable, e.g. in case the costs render a full scale remediation not feasible, or in case these options are used as a temporary safety measure, or in case the Indian soil remediation policy offers opportunities for a decreased (site-specific) level of risk reduction.

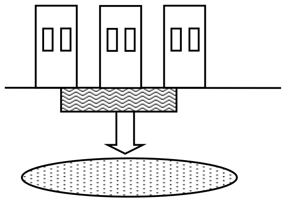
It should be noted that feedback from the Client and end users is crucial to determine whether or not to include the more creative remediation options in the Guidance document.

Figure III-5.4.1 Blueprint of options: most likely remediation measures per type of site (13 pages with figures)

Option 1: Remediation of land bound solid phase contamination including groundwater contamination in urban areas

Site and setting summary

Type S1 + P2: Land bound solid phase contamination including groundwater contamination
Setting: Urban area
Risks: Direct contact, exposure to polluted drinking water
Most common contaminant: heavy metals



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
• Top soil: fit for use based on generic levels for residential areas
• Groundwater: fit for use based on generic levels for residential areas

Examples of sensitive uses that may require site-specific remediation goals:
• Use of soil as kitchen garden or playground
• Use of groundwater as drinking water

Most likely remediation measures

Source
• Excavation of soil to a concentration level meeting the remediation objective
• Cover with pavement or layer of clean soil
• Reduction of leaching by partial source excavation, sealing or drainage

Pathway (plume):
• Removal to a concentration level meeting the remediation objective by pump & treat
• Vertical wall or geohydraulical containment
• Natural or stimulated precipitation/sorption

Receptor:
• Treatment of well water to meet drinking water standards or alternative water source
• Imposed limits to site use (e.g. no unauthorized digging, no wells)

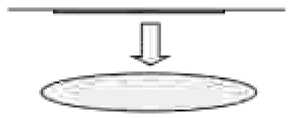
Specific conditions or alternative approaches

• Excavation is more efficient as part of a redevelopment project that involves excavating anyway
• Removal of contamination in pathway (plume) by pump & treat is more efficient if the leaching process has been reduced
• Soil surface elevation can be considered to avoid large volumes of excavated soil
• An alternative option to reduce contact risk and/or leaching may be chemical immobilisation or physical immobilisation (grouting)
• In-situ strategies towards hexavalent chromium are mostly based on reduction to the less toxic and less mobile trivalent chromium by chemical or microbiological means. These techniques are mostly in a laboratory or pilot phase of development

Option 2: Remediation of land bound solid phase contamination including groundwater contamination in agricultural and other rural areas

Site and setting summary

Type S1-d + P2: Land bound solid phase contamination including groundwater contamination
Setting: Agricultural or other rural area
Risks: Direct human contact, exposure to polluted drinking water, ingestion of contaminated crops
Most common contaminants: heavy metals, pesticides



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
• Top soil: fit for use based on generic levels for agricultural or other rural areas
• Groundwater: fit for use based on generic levels for agricultural or other rural areas

Examples of sensitive uses that may require site-specific remediation goals:
• Specific toxicity of copper to sheep
• Specific uptake of contaminants by crops
• Use of groundwater for irrigation purposes

Most likely remediation measures

Source
• Phytoremediation
• Excavation of soil to a concentration level meeting the remediation objective, on-site treatment (landfarming) and optional backfilling with soil of suitable quality

Pathway (plume):
• Removal to a concentration level meeting the remediation objective by pump & treat
• Geohydraulical containment

Receptor:
• Treatment of well water to meet drinking water standards or alternative water source
• Alternative crops with less uptake of contaminants in edible parts
• Imposed limits to site use (e.g. no unauthorized digging, no wells)

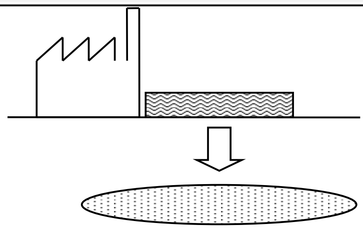
Specific conditions or alternative approaches

• Profile reversion can be considered as alternative approach
• Aggressive treatments like chemical treatments deteriorate the biology of the ground
• The cultivation method and climatic circumstances should also be taken into consideration when evaluating potential risk, cleanup levels and remediation, e.g.:
  • Erosion by wind and/or precipitation
  • Intensified contact with soil due to cultivation by manpower
  • Increased biodegradation rate due to tropical conditions
  • Promotion of anaerobic processes due to submerged cultivation methods
  • Cyclical changes in soil physical, macrochemical and biological properties due to slash and burn agricultural methods

Option 3: Remediation of land bound solid phase contamination including groundwater contamination in industrial areas

Site and setting summary

Type S1 + P2: Land bound solid phase contamination including groundwater contamination
Setting: Industrial area
Risks: Direct human contact, exposure to polluted drinking water
Most common contaminant: heavy metals



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
• Top soil: fit for use based on generic levels for industrial areas
• Groundwater: fit for use based on generic levels for industrial areas

Examples of sensitive uses that may require site-specific remediation goals:
• Use of groundwater as drinking water
• Use of groundwater as process water

Most likely remediation measures

Source
• Excavation of soil to a concentration level meeting the remediation objective
• Capping with pavement
• Combined with redevelopment: isolation under new buildings or constructions

Pathway (plume):
• Removal to a concentration level meeting the remediation objective by pump & treat
• Vertical wall or geohydraulical containment
• Natural or stimulated precipitation/sorption

Receptor:
• Treatment of well water to meet drinking water standards or alternative water source
• Imposed limits to site use (e.g. no digging, no wells)

Specific conditions or alternative approaches

• Removal of contamination in pathway (plume) by pump & treat is more efficient if the leaching process has been reduced
• Removal of contamination in pathway (plume) by pump & treat is more efficient if the treated water can be used as process water by the industry or when performed in combination with storage of thermal energy in soil
• Chemical or biological barriers can be considered on sites neighbouring more sensitive (e.g. urban) areas as alternative to full plume treatment
• Treatment of the actual cause of the pollution (industrial activity), if still present, should be performed before starting remedial action

Option 4: Remediation of solid phase contamination in a water bound site
(contaminated open water sediments)

Site and setting summary

Type S2: Solid phase contamination (water bound site) (open water sediments)
Setting: Urban, nature or industrial area
Risks: Direct human contact, ecological risks
Most common contaminant: heavy metals, effluents

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels
• Sediment: fit for use based on generic level corresponding with type of site use

Examples of sensitive uses that may require site-specific remediation goals:
• Use of open water for swimming or bathing
• Use of surface water for consumption or agricultural purposes

Most likely remediation measures

Source
• Dredging
• Excavation (in times of drought)
• Capping layer with clean sediment

Pathway (plume): n.a.

Receptor:
• Government imposed limits to site use (e.g. fencing, no bathing or swimming)

Specific conditions or alternative approaches

• Capping is only technically feasible for relatively static water systems (lake, pond)
• Dredging or excavation typically involves large volumes for which adequate (temporary) storage has to be provided, also depending on method of treatment (on-site treatment/off-site treatment/sanitary landfill)

Option 5. Remediation of land bound solid phase contamination in agricultural areas or open water shores

Site and setting summary

Type S1-d-e-f: Land bound solid phase contamination
Setting: Agricultural area, open water shores
Risks: Direct human contact, ingestion of crops, risk of spreading
Most common contaminant: heavy metals, pesticides

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for agricultural areas

Examples of sensitive uses that may require site-specific remediation goals:
- Specific toxicity of copper to sheep
- Specific uptake of contaminants by crops

Most likely remediation measures

Source
- Phytoremediation
- Excavation and reuse in levees (open water shore settings) or big bags (fitted into the landscape)

Pathway (plume): n.a.

Receptor
- Alternative crops with less uptake of contaminants in edible parts

Specific conditions or alternative approaches

- Profile reversion can be considered as alternative approach
- Aggressive treatments like chemical treatments deteriorate the biology of the ground
- Specific excavation of hotspots can be considered as alternative approach, but requires detailed site assessment
- The cultivation method and climatic circumstances should also be taken into consideration when evaluating possible risk, cleanup levels and remediation, e.g.:
  - Erosion by wind and/or precipitation
  - Intensified contact with soil due to cultivation by manpower
  - Increased biodegradation rate due to tropical conditions
  - Promotion of anaerobic processes due to submerged cultivation methods
  - Cyclical changes in soil physical, macrochemical and biological properties due to slash and burn agricultural methods

Option 6. Remediation of land bound solid phase contamination in nature areas

Site and setting summary

Type S1 - Land bound solid phase contamination
Setting: Nature area
Risks: Ecological risks, direct human contact
Most common contaminant: heavy metals

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels
• Top soil: fit for use based on generic levels for nature areas

Examples of sensitive uses that may require site-specific remediation goals:
• Intensive recreational use

Most likely remediation measures

Source
• Capping to reduce exposure by direct contact and vegetation consumption
• Phytoremediation to reduce concentration levels
• Excavation of hotspots

Pathway (plume): n.a.

Receptor:
• Goverment imposed limits to site use (e.g. fencing, no unauthorized access)

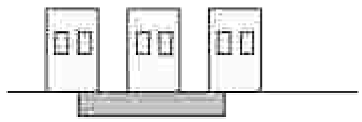
Specific conditions or alternative approaches

• Specific excavation of hotspots requires detailed site assessment
• To reduce the quantity of soil in excavation of hotspots, site-specific remediation levels higher than the generic levels for nature areas can be developed to obtain acceptable risk levels for a particular site under particular circumstances
• Capping can be combined with nature development (landscaping) to both increase environmental quality and biodiversity

Option 7: Remediation of land bound solid phase contamination in urban areas

Site and setting summary

Type S1: Land bound solid phase contamination
Setting: Urban area
Risks: Direct contact
Most common contaminant: heavy metals, PAH



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels
• Top soil: fit for use based on generic levels for residential areas

Examples of sensitive uses that may require site-specific remediation goals:
• Use of soil as kitchen garden
• Use of soil as playground, potential exposure of children to lead

Most likely remediation measures

Source
• Excavation of soil to a concentration level meeting the remediation objective
• Covering by pavement or layer of clean soil

Pathway (plume): n.a.

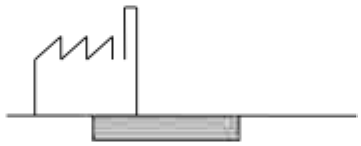
Receptor:
• Imposed limits to site use (e.g. no unauthorized digging)

Specific conditions or alternative approaches

• Excavation is more efficient as part of a redevelopment project that involves excavating anyway
• While redeveloping, soil surface elevation can be considered to avoid large volumes of excavated soil
• An alternative option to reduce contact risk may be chemical immobilisation or physical immobilisation (grouting)
• In-situ strategies towards hexavalent chromium are mostly based on reduction to the less toxic and less mobile trivalent chromium by chemical or microbiological means. These techniques are mostly in a laboratory or pilot phase of development

Option 8: Remediation of land bound solid phase contamination in industrial areas

Site and setting summary

Type S1 : Land bound solid phase contamination *Setting*: Industrial area *Risks*: Direct human contact *Most common contaminant*: heavy metals, PAH	 *Draft sketch of typical field situation*

Most likely remediation objectives

Recommendations for cleanup standards and levels
- Top soil: fit for use based on generic levels for industrial areas

Examples of sensitive uses that may require site-specific remediation goals:
- Unpaved sites sensitive to spreading by dust

Most likely remediation measures

Source
- Excavation of soil to a concentration level meeting the remediation objective
- Capping with pavement
- Combined with redevelopment: isolation under new building

Pathway (plume): n.a.

Receptor:
- Imposed limits to site use (e.g. no unauthorized digging)

Specific conditions or alternative approaches

- Specific excavation of hotspots can be considered as alternative approach, but requires detailed site assessment
- An alternative option to reduce contact risk may be chemical immobilisation or physical immobilisation (grouting)
- In-situ strategies towards hexavalent chromium are mostly based on reduction to the less toxic and less mobile trivalent chromium by chemical or microbiological means . These techniques are mostly in a laboratory or pilot phase of development
- Treatment of the actual cause of the pollution (industrial activity), if still present, should be performed before starting remedial action

Option 9: Remediation of liquid phase contamination

Site and setting summary

Type L: Liquid phase contamination *Setting*: all site uses *Risks*: Direct human contact *Most common contaminant*: industrial effluents	 *Draft sketch of typical field situation*

Most likely remediation objectives

Recommendations for cleanup standards and levels
• Top soil: fit for use based on generic levels corresponding with site use
• Subsoil and groundwater: steady end state and removal of risks

Examples of sensitive uses that may require site-specific remediation goals
• Habitation (soil vapour intrusion)

Most likely remediation measures

Source
• Excavation (above groundwater)
• Soil vapour extraction

Pathway (plume):
• Pump & Treat (combined with excavation)
• Multi Phase Extraction (combined with excavation)
• Bioremediation (combined with excavation)
• ISCO (combined with excavation)

Receptor
• Forced ventilation of basement/crawl space, sealing of floors (soil vapour intrusion)
• Imposed limits to site use (e.g. no unauthorized digging)

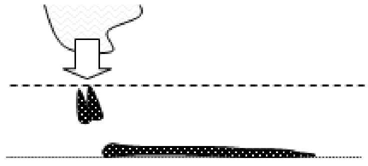
Specific conditions or alternative approaches

• Remediation of source and plume are often combined to obtain the most (cost) efficient remediation
• Several combinations of techniques for source and path remediation are possible, depending on site circumstances and project boundary conditions (timeframe, setting)
• Steady state is a situation, not a concentration level, therefore target concentration levels are not applicable. Proof of steady state is gathered by periodic sampling, condition for steady state is sufficient source load removal (e.g. 80% load removal)
• Typically, steady state does not require complete removal, but only removal of the mobile fraction of the contamination
• Inner air sampling is required to determine actual soil vapour risks; models will overestimate

Option 10: Dense Non-Aqueous Phase Liquid (DNAPL)

Site and setting summary

Type P1-a: Dense Non-Aqueous Phase Liquid in permeable soil (often found in combination with a P2 type)
Setting: Industrial site
Risks: inhalation (if no ground water present), spreading to groundwater
Most common contaminant: VOC, tar/heavy oil related contaminants, PCB



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- inhalation risk reduction (soil vapour)
- spreading risk reduction by:
    - mass removal as far as needed to reach a steady state plume
    - mass control (containment)

Most likely remediation measures

Exposure risk removal
- Soil vapour extraction and air sparging
- Vapour proof sealing in building floor

Spreading risk removal by mass removal
- Excavation
- Multi phase extraction
- Shock load bioremediation

Spreading risk reduction by mass control
- Physical/Hydraulic barriers
- Permeable reactive barriers

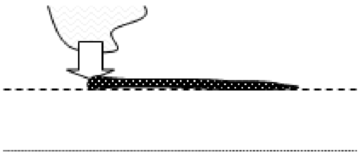
Specific conditions or alternative approaches

- DNAPL characterisation difficult due to irregular spreading pathways and specialized soil investigation techniques.
- Risk of unintentional DNAPL vertical transport by faulty monitoring wells or drillings.
- Specialized (and thus expensive) in-situ techniques may be worth considering if a high degree of source removal in needed a very short time frame. Example techniques are: chemical oxidation, surfactant-enhanced subsurface remediation, cosolvent flushing, steam/hot air injection and three/six-phase electrical resistance heating.
- Pump and treat is generally not recommended for DNAPL removal due to long lasting rebound of contaminations to groundwater.

Option 11: Light Non-Aqueous Phase Liquid (LNAPL)

Site and setting summary

Type P1-b: Light Non-Aqueous Phase Liquid (LNAPL) in permeable soil (often found in combination with a P2 type)
Setting: Industrial site
Risks: explosion, exposure, spreading to groundwater/surface water
Most common contaminant: VOC and light/medium fraction mineral oil



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Exposure/Explosion risk reduction
- Spreading risk reduction:
    - Mass removal as far as technique is cost effective. If
    - Mass control (containment)

Most likely remediation measures

In case of acute risks requiring immediate action
- Excavation
- Vapour proof sealing in building floor

In absence of acute risks
- Mass recovery: excavation, skimming, dual pump extraction
- Mass recovery by phase change: soil vapour extraction, air sparging, bio slurping
- Mass control: subsurface barrier, trench, wells

In case of low risk profile
- Long-term stewardship
- Natural source zone depletion

Specific conditions or alternative approaches

- The assessment of LNAPL spreading potential and the fitting remediation objectives requires specialist soil characterisation expertise.
- If chosen the right technique, the implementation of this technique to a point it is effective will typically lead to an acceptable risk reduction.
- Specialized (and thus expensive) in-situ techniques may be worth considering if a high degree of source removal in needed a very short time frame. Example techniques are: in-situ chemical oxidation, surfactant-enhanced subsurface remediation, co solvent flushing, steam/hot air injection, radio-frequency heating and three/six-phase electrical resistance heating.
- Pump and treat is generally not recommended for LNAPL removal due to long lasting rebound of contaminations to groundwater.

Option 12: Remediation of cluster of land bound solid phase contamination

Site and setting summary

Type S1-a/b: Cluster of land bound solid phase contamination
Setting: Multiple sites and site usages
Risks: Direct human contact, ecological risks (depending on site use)
Most common contaminant: heavy metals, PAH, pesticides

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:

- Top soil: fit for use based on generic level corresponding with site use
- Gradual improvement of soil quality over time towards a acceptable risk level and a minimal of site use restrictions

Most likely remediation measures

Technical aspects of the remediation can be found in the description of options for the non-clustered sites of the same type. The cluster approach differs from this sitewise approach regarding the management and coordination of the remediation of all the sites in the cluster area. Examples of aspects in dealing with cluster sites are:

- Remediation strategy and target levels established for the whole area
- Logistical solution for subsequent remediation of individual sites, such as a single sanitary landfill or central mobile soil treatment plant
- A single tender procedure
- A single generic remediation plan to be fine-tuned for individual sites, taking into account site specific conditions and site use
- A single organization dealing with post-remediation procedures
- A single generic plan for soil management (use, reuse and interchange between individual contaminated sites)

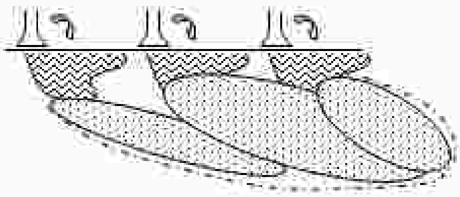
Specific conditions or alternative approaches

- Awareness of local aberrations in contamination situation required
- Generic remediation plans need updating every couple of years to remain aligned with developments in policy, state of the art in remediation approaches and changes in site use

Option 13: Remediation of cluster of liquid phase contamination

Site and setting summary

Type L1: Cluster of liquid phase contamination
Setting: multiple sites and site usages, urban area
Risks: Direct human contact, exposure to polluted drinking water, spreading
Most common contaminant: mobile organic compounds



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: site-specific levels for risk removal or risk reduction
- Subsoil and groundwater: steady end state and removal or reduction of risks over entire system area to be reached over longer timeframe (typically 30 to 40 years)
- Target levels for load removal for individual plumes, based on their contribution to the total plume volume and spreading
- Custom signal and action levels to evaluate spreading (towards receptors).

Most likely remediation measures

Principle: area oriented approach of groundwater remediation

Technical aspects:
- The approaches as listed under the description of the option for P2
- MNA – monitored natural attenuation
- Stimulation of biodegradation of the contaminants
- Monitoring of the groundwater quality to protect receptors

Strategic instruments:
- Remediation strategy and warning or action levels to be developed for the entire area
- Generic remediation plan for the entire area and underlying site specific remediation plans to assess hot spots (leaching) and establish load removal
- A single organization dealing with post-remediation procedures

Specific conditions or alternative approaches

- The area oriented approach is only used in cases where assessment of individual plumes is not technically feasible because remedial action applied to one plume will affect other plumes
- Active, immediate remediation (topsoil, source, plume, receptor) is only applied in case of actual risks
- Signal level: level of contamination at which additional attention is required, e.g. more intense sampling over time or space
- Action level: level of contamination at which additional active measures are required
- Low intensity remediation techniques (vertical biological or chemical barrier) can be considered if active prevention of spreading out of the area towards receptors is required

Volume III

5.5-i Examples of methods for remediation option evaluation

Volume III-5.5-i
Examples of methods for remediation option evaluation

1 Introduction

This Section presents examples of different methods for remediation option evaluation which is most relevant for Step 5.5 Selection remediation option. Following methods will be explained:

- descriptive methods;
- qualitative overview methods;
- quantitative overview methods.

2 Descriptive methods

Descriptive methods lead to a ‘text only’ description of the criteria. These methods are favoured in relatively simple situations, with few and simple remediation options. The results will provide a basis for remediation option appraisal. Descriptive methods are straightforward without any restrictive rules, but the results typically do not present a clear overview of the differences among the remediation options. A set of criteria is presented in the *Checklist Criteria for comparison and approval of remediation options, Volume II-5.5-a.* This checklist includes following criteria:

- Generic criteria: Risk reduction potential, Technical success potential, Cost and benefits, Sustainability;
- Site specific criteria: Time, Post remediation site use, Social criteria.

3 Qualitative overview method

In qualitative overview methods, the remediation options are subjected to qualitative judgment with respect to costs, burdens and benefits. These methods are favoured in relatively complex situations, with a wide variety of remediation options. Aspects that are comparatively similar in the different remediation options are eliminated, resulting in a clear identification of the criteria that really make the difference. The eventual selection of the most applicable remediation option can then be based on just these critical aspects. The results of these methods are typically presented in a table showing the pros and cons of the remediation options

An advantage of qualitative overview methods is that the results will present a clear overview of the most characteristic differences among the remediation options. Furthermore, they support constructive stakeholder involvement. On the other hand, these methods require a certain effort to perform, and the results may not provide enough information to finalise the selection of the most applicable remediation option.

Figure III-5.5-i-1 shows an example of a table presenting the results of a Costs Benefits Analysis. The results of such analysis are presented in a table showing burdens and benefits for each appraised remediation option. This particular example is based on the ROSA guideline (Guideline for decision making when dealing with mobile soil contaminants), used in The Netherlands.

Figure III-5.5-i-1 Example of a table presenting results of Costs Benefits Analysis

Criteria	**Option 1**	**Option 2**	**Option 3**
Burden			
Costs	1.000.000	500.000	350.000
Duration of remediation and post remediation	4 years, no post remediation (short)	2 years	
Failure risk	Average to high	Average	Average
Effects on other environment and surroundings	Large	Small	Small
Benefits			
Risk reduction	<MTR	<MTR	<MTR
Site recovery potential	Complete	Limited	None
Groundwater plume behaviour	Decreasing within 4 years	Decreasing within 15 years	Decreasing within 30 years
Removed contamination load	90%	80-90%	60-80%
Liability reduction	Large	Average	Small

While not guaranteeing an easy decision, this table does present a transparent overview of critical criteria, clearly showing the differences among the remediation options. This renders it a useful tool towards the eventual selection of the most applicable remediation option.

4 Quantitative overview method

The quantitative method is a Multi Criteria Analysis (MCA), based on the ranking of a series of criteria for each remediation option. Users may change criteria and arrange categories depending on individual approaches. Each criterion is assessed with a score ranging from 1 to 9 (where 9 stands for the highest impact). Each criterion can be weighted with a factor, reflecting the importance of the criterion compared to others. The scores are then added into subtotal scores and a total score. The highest scoring remediation option theoretically is the most applicable.

Results are typically presented in a weighting table. Bar or line charts may help to get a clear overview of the results.

Figure III-5.5-i.2 shows an example of a Multiple Criteria Analysis (MCA) weighting table, which illustrates the concept of MCA. This particular example is based on the Surf-UK/Surf-US programmes.
Figure III-5.5-i.3 shows an example visualisations of a MCA weighting table.

An advantage of quantitative overview methods is that it facilitates the selection by clearly showing one or two preferential options. However, while the translation of remediation option characteristics into a score is easy to do, it can also lead to a pseudo accuracy not always in accordance with reality. The use of mathematical decision techniques like Multi Criteria Analysis (MCA) may strengthen this effect. To prevent irrational decision making one should always keep an eye on reality while using these methods.

Figure III-5.5-i.2 Example of a MCA weighting table

Aspects (categories)	**Weighting-factor**	**Options 1**	**2**	**...**
Environmental				
Impacts on air (including climate change)	3	2	5	…
Impacts on soil	2	5	1	…
Impacts on water	2	3	1	…
Impacts on ecology	1	4	3	…
Use of natural resources and generation of wastes	3	1	2	…
Intrusiveness	1	2	4	…
Weighted group subtotal	***12***	***31***	***32***	…
Economic				
Direct economic costs and benefits	1	5	5	…
Indirect economic costs and benefits	1	4	2	…
Employment and capital gain	2	2	4	…
Gearing	2	4	1	…
Life-span and 'project risks'	1	1	3	…
Project flexibility	3	3	3	…
Weighted group subtotal	***10***	***37***	***40***	…
Social				
Impacts on human health and safety	3	2	4	…
Ethical and equity considerations	2	2	4	…
Impacts on neighbourhoods or regions	1	5	3	…
Community involvement and satisfaction	1	5	2	…
Compliance with policy objectives and strategies	2	4	5	…
Uncertainty and evidence	1	3	1	…
Weighted group subtotal	***10***	***40***	***44***	…
Total	**32**	**108**	**116**	**...**

Options. Number of options is typically 3 to 6, depending on the complexity of the remediation.

Weighting factors: important criteria are assigned more weight.

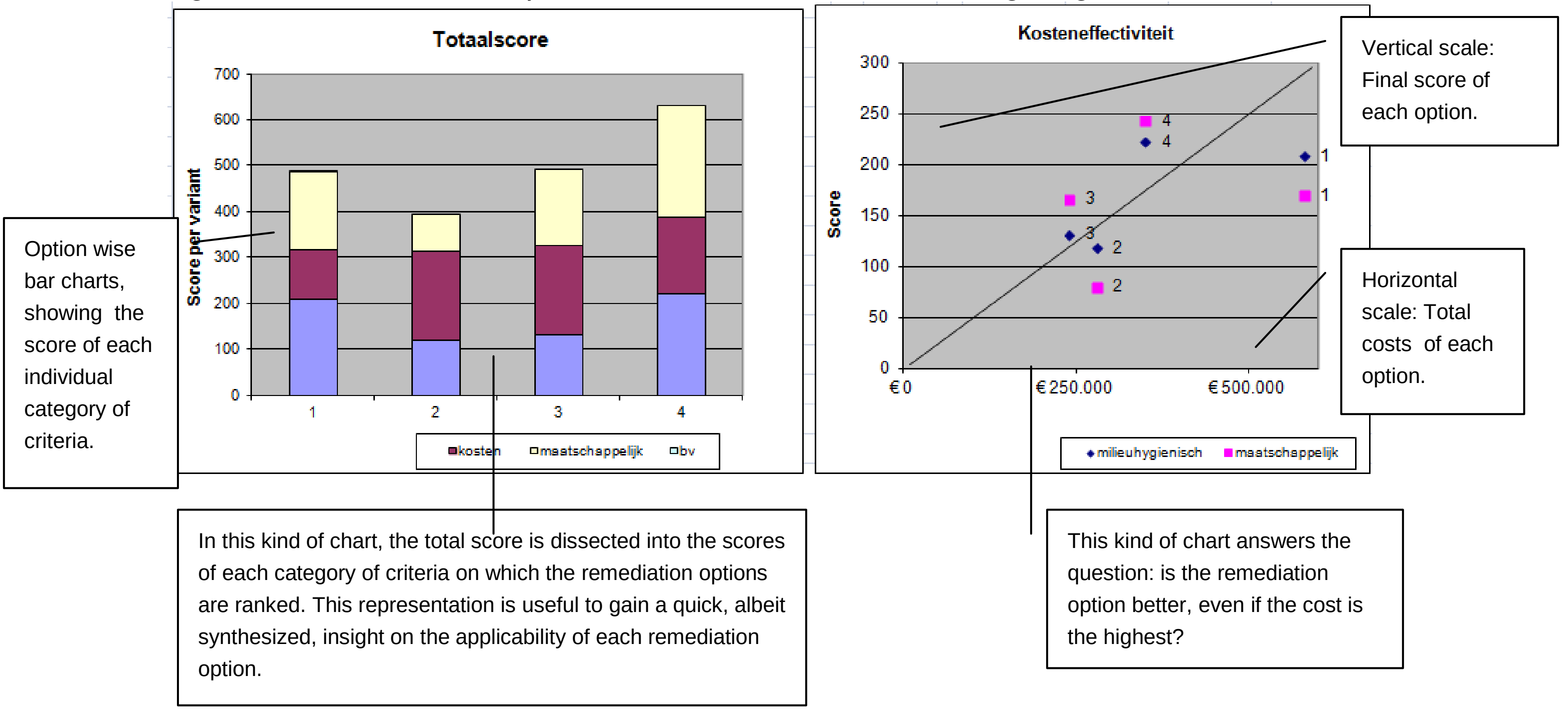
Description of aspects to be ranked.

Score of each criterion in each alternative.

Subtotals enable to see which alternative has a better consideration of each individual category.

Totals of each option. The highest score theoretically is the most applicable option.

Figure III-5.5-i.3 Example of visualisations of a MCA weighting table



5 Sustainable Costs-Benefits Analysis

Principle

A Sustainable Costs-Benefits Analysis Another can be made using a formula[1] allowing to see the balance between the costs and benefits and to see whether the benefits of the preferred remediation option exceed the costs associated with implementing the remedial option. This method implies to monetize costs and benefits for each of the used categories.

$$SR = \sum ((Benefit_{[illegible]} - Cost_{[illegible]}) + (Benefit_{[illegible]} - Cost_{[illegible]}) + (Benefit_{[illegible]} - Cost_{[illegible]}))$$

- SR is the 'sustainable remediation score' for each of the n remedial options that can achieve the agreed remedial objectives;
- Benefit x is the benefit associated with each factor (environment, society or economy) for each remedial option; and
- Cost x is the cost associated with each factor (environment, society or economy) for each remedial option.

The optimum remedial option achieves:

- SR ≥ 0;
- SR is the maximum for the feasible remedial options 1 to n; and
- A fair distribution of the costs and benefits amongst the affected parties

Pros and Cons

This method gives easily one or two preferential options and facilitates the decision making.

However, the translation of option characteristics into a score might work easily in a technical way but gives a pseudo accuracy not always meeting reality. The use of mathematical decision techniques like Multi Criteria Analyses (MCA) might even strengthen this effect.

[1] A Framework for Assessing the Sustainability of Soil and Groundwater Remediation, www.claire.co.uk/index.php?option=com_content&view=article&id=182&Itemid=78&limitstart=7, CL:AIRE.

Volume III

6-i Manual for environmental and social impact assessment for remediation of contaminated sites

Volume III-6-i
Manual for Environmental and Social Impact Assessment for remediation of contaminated sites

1 Introduction

This section provides the aspects relevant for development of an Environmental and Social Impact Assessment for remediation of contaminated sites. The Environmental Impact Assessment is an existing regulatory instrument since 1994 especially used in case of industrial manufacturing activity and building construction projects. The remediation of contaminated sites can be added to the scope of this instrument with following remarks. An Environmental Impact Assessment is aimed to evaluate the possible negative effects of the intended activities which includes almost always a permanent change of the situation. The remediation of a contaminated site has different characteristics. First of all the intention for remediation is to eliminate or at least reduce the risks caused by existing contaminated material. The activities in this way are especially meant to have a positive environmental impact. Secondly the remediation activities often are temporary activities.

Nevertheless it has to be stated that remediation activities itself can have negative impact on the environment e.g. noise, dust, use of energy and water. Because of that it is required to carry out an Environmental Impact Assessment.

Section 2 provides the elements relevant for Environmental Impact Assessment. In section 2.1 the below tables (I), (II) and (III) provide a checklist helpful for reporting. In table (II) some of the elements that are not preliminary related to remediation of contaminated sites have been marked with ‘N’ in the column Yes/No. Section 2.2 provides more descriptive information regarding the important elements for and EIA.

Section 3 provides the aspects relevant for Social Impact Assessment.

For more detail information on Environmental Impact Assessment reference is made to EIA notification S.O.1533(E) dated 14 09 2006, Sr. No. 16 under:
http://envfor.nic.in/environmental_clearancegeneral
And for EIA specific manuals we refer to:
http://envfor.nic.in/essential-links/eia-specific-manuals

2 Elements of Environmental Impact Assessment

2.1 Tables

(I) Basic Information	
Name of the Project:	
Location / site alternatives under consideration:	
Size of the Project:	
Expected cost of the project:	
Contact Information:	
Screening Category:	

(II) Activity			
1. Construction, operation or decommissioning of the Project involving actions, which will cause physical changes in the locality (topography, land use, changes in water bodies, etc.)			
S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities /rates, wherever possible) with source of information data**
1.1	Permanent or temporary change in land use, land cover or topography including increase in intensity of land use (with respect to local land use plan)		
1.2	Clearance of existing land, vegetation and buildings?		
1.3	Creation of new land uses?		
1.4	Pre-construction investigations e.g. bore houses, soil testing?		
1.5	Construction works?		
1.6	Demolition works?		
1.7	Temporary sites used for construction works or housing of construction workers?		
1.8	Above ground buildings, structures or earthworks including linear structures, cut and fill or excavations		
1.9	Underground works including mining or tunnelling?		
1.10	Reclamation works?		
1.11	Dredging?		
1.12	Offshore structures?	N	
1.13	Production and manufacturing processes?	N	
1.14	Facilities for storage of goods or materials?		
1.15	Facilities for treatment or disposal of solid waste or liquid effluents?		
1.16	Facilities for long term housing of operational workers?		
1.17	New road, rail or sea traffic during construction or operation?		
1.18	New road, rail, air waterborne or other transport infrastructure including new or altered routes and stations, ports, airports etc.?	N	
1.19	Closure or diversion of existing transport routes or infrastructure leading to changes in traffic movements?	N	
1.20	New or diverted transmission lines or pipelines?	N	
1.21	Impoundment, damming, culverting, realignment or other changes to the hydrology of watercourses or aquifers?		
1.22	Stream crossings?	N	

1.23	Abstraction or transfers of water from ground or surface waters?		
1.24	Changes in water bodies or the land surface affecting drainage or run-off?		
1.25	Transport of personnel or materials for construction, operation or decommissioning?		
1.26	Long-term dismantling or decommissioning or restoration works?		
1.27	Ongoing activity during decommissioning which could have an impact on the environment?		
1.28	Influx of people to an area in either temporarily or permanently?		
1.29	Introduction of alien species?	N	
1.30	Loss of native species or genetic diversity?	N	
1.31	Any other actions?		

Explanation: N means this that from the possible activities during a remediation this activity will surely not apply to a contaminated site remediation project.

2. Use of Natural resources for construction or operation of the Project (such as land, water, materials or energy, especially any resources which are non-renewable or in short supply):

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
2.1	Land especially undeveloped or agricultural land (ha)		
2.2	Water (expected source & competing users) unit: KLD		
2.3	Minerals (MT)	N	
2.4	Construction material – stone, aggregates, sand / soil (expected source – MT)		
2.5	Forests and timber (source – MT)	N	
2.6	Energy including electricity and fuels (source, competing users) Unit: fuel (MT), energy (MW)		
2.7	Any other natural resources (use appropriate standard units)		

3. Use, storage, transport, handling or production of substances or materials, which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health.

S.No.	Information/Checklist confirmation	Yes/No	Details thereof (with approximate quantities /rates, wherever possible) with source of information data
3.1	Use of substances or materials, which are hazardous (as per MSIHC rules) to human health or the environment (flora, fauna, and water supplies)		
3.2	Changes in occurrence of disease or affect disease vectors (e.g. insect or water borne diseases)	N	
3.3	Affect the welfare of people e.g. by changing living conditions?		
3.4	Vulnerable groups of people who could be affected by the project e.g. hospital patients, children, the elderly etc.,		
3.5	Any other causes		

4. Production of solid wastes during construction or operation or decommissioning (MT/month).			
S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities /rates, wherever possible) with source of information data**
4.1	Spoil, overburden or mine wastes	N	
4.2	Municipal waste (domestic and or commercial wastes)		
4.3	Hazardous wastes (as per Hazardous Waste Management Rules)		
4.4	Other industrial process wastes	N	
4.5	Surplus product		
4.6	Sewage sludge or other sludge from effluent treatment		
4.7	Construction or demolition wastes		
4.8	Redundant machinery or equipment	N	
4.9	Contaminated soils or other materials		
4.10	Agricultural wastes	N	
4.11	Other solid wastes		

5. Release of pollutants or any hazardous, toxic or noxious substances to air (Kg/hr).			
S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities /rates, wherever possible) with source of information data**
5.1	Emissions from combustion of fossil fuels from stationary or mobile sources		
5.2	Emissions from production processes	N	
5.3	Emissions from materials handling including storage or transport		
5.4	Emissions from construction activities including plant and equipment		
5.5	Dust or odours from handling of materials including construction materials, sewage and waste		
5.6	Emissions from incineration of waste		
5.7	Emissions from burning of waste in open air (e.g. slash materials, construction debris)		
5.8	Emissions from any other sources		

6. Generation of Noise and Vibration, and Emissions of Light and Heat.			
S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities /rates, wherever possible) with source of information data**
6.1	From operation of equipment e.g. engines, ventilation plant, crushers		
6.2	From industrial or similar processes		
6.3	From construction or demolition		
6.4	From blasting or piling		
6.5	From construction or operational traffic		
6.6	From lighting or cooling systems		
6.7	From any other sources		

7. Risks of contamination of land or water from releases of pollutants into the ground or into sewers, surface waters, groundwater, coastal waters or the sea.			
S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities /rates, wherever possible) with source of information data**
7.1	From handling, storage, use or spillage of hazardous materials		
7.2	From discharge of sewage or other effluents to water or the land (expected mode and place of discharge)		
7.3	By deposition of pollutants emitted to air into the land or into water		
7.4	From any other sources		
7.5	Is there a risk of long term build up of pollutants in the environment from these sources?		

8. Risk of accidents during construction or operation of the Project, which could affect human health or the environment.			
S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities /rates, wherever possible) with source of information data**
8.1	From explosions, spillages, fires etc. from storage, handling, use or production of hazardous substances	N	
8.2	From any other causes		
8.3	Could the project be affected by natural disasters causing environmental damage (e.g. floods, earthquakes, landslides, cloudburst etc.)?		

9. Factors which should be considered (such as consequential development) which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality.			
S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities /rates, wherever possible) with source of information data**
9.1	Lead to development of supporting facilities, ancillary development or development stimulated by the project which could have impact on the environment e.g.: • Supporting infrastructure (roads, power supply, waste or waste water treatment, etc.) • housing development • extractive industries • supply industries • other	N	
9.2	Lead to after-use of the site, which could have an impact on the environment	N	
9.3	Set a precedent for later developments		
9.4	Have cumulative effects due to proximity to other existing or planned projects with similar effects	N	

(III) Environmental Sensitivity			
S.No.	**Information/Checklist confirmation**	**Yes/No**	**Details thereof (with approximate quantities /rates, wherever possible) with source of information data**
1	Areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value		
2	Areas which are important or sensitive for ecological reasons - Wetlands, watercourses or other water bodies, coastal zone, biospheres, mountains, forests		
3	Areas used by protected, important or sensitive species of flora or fauna for breeding, nesting, foraging, resting, over wintering, migration		
4	Inland, coastal, marine or underground waters		
5	State, National boundaries		
6	Routes or facilities used by the public for access to recreation or other tourist, pilgrim areas		
7	Defence installations		
8	Densely populated or built-up area		
9	Areas occupied by sensitive man-made land uses *(hospitals, schools, places of worship, community facilities)*		
10	Areas containing important, high quality or scarce resources *(ground water resources, surface resources, forestry, agriculture, fisheries, tourism, minerals)*		
11	Areas already subjected to pollution or environmental damage. *(those where existing legal environmental standards are exceeded)*		
12	Areas susceptible to natural hazard which could cause the project to present environmental problems (*earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions*)		

2.2 Additional information

For Construction projects there is a separate checklist of environmental impacts. This checklist provides more descriptive information and are in this way additional to the elements mentioned in the above tables (I), (II) and (III).

CHECKLIST OF ENVIRONMENTAL IMPACTS for Construction Project
(Project proponents are required to provide full information and wherever necessary attach explanatory notes with the Form and submit along with proposed environmental management plan & monitoring programme)

1. LAND ENVIRONMENT

1.1. Will the existing landuse get significantly altered from the project that is not consistent with the surroundings? (Proposed landuse must conform to the approved Master Plan / Development Plan of the area. Change of landuse if any and the statutory approval from the competent authority be submitted). Attach Maps of (i) site location, (ii) surrounding features of the proposed site (within 500 meters) and (iii)the site (indicating levels & contours) to appropriate scales. If not available attach only conceptual plans.

1.2. List out all the major project requirements in terms of the land area, built up area, water consumption, power requirement, connectivity, community facilities, parking needs etc.

1.3. What are the likely impacts of the proposed activity on the existing facilities adjacent to the proposed site? (Such as open spaces, community facilities, details of the existing landuse, disturbance to the local ecology).

1.4. Will there be any significant land disturbance resulting in erosion, subsidence & instability? (Details of soil type, slope analysis, vulnerability to subsidence, seismicity etc. may be given).

1.5. Will the proposal involve alteration of natural drainage systems? (Give details on a contour map showing the natural drainage near the proposed project site)

1.6. What are the quantities of earthwork involved in the construction activity-cutting, filling, reclamation etc. (Give details of the quantities of earthwork involved, transport of fill materials from outside the site etc.)

1.7. Give details regarding water supply, waste handling etc. during the construction period.

1.8. Will the low lying areas & wetlands get altered? (Provide details of how low lying and wetlands are getting modified from the proposed activity)

1.9. Whether construction debris & waste during construction cause health hazard? (Give quantities of various types of wastes generated during construction including the construction labor and the means of disposal)

2. WATER ENVIRONMENT

2.1. Give the total quantity of water requirement for the proposed project with the breakup of requirements for various uses. How will the water requirement met? State the sources & quantities and furnish a water balance statement.

2.2. What is the capacity (dependable flow or yield) of the proposed source of water?

2.3. What is the quality of water required, in case, the supply is not from a municipal source? (Provide physical, chemical, biological characteristics with class of water quality)

2.4. How much of the water requirement can be met from the recycling of treated wastewater? (Give the details of quantities, sources and usage)

2.5. Will there be diversion of water from other users? (Please assess the impacts of the project on other existing uses and quantities of consumption)

2.6. What is the incremental pollution load from wastewater generated from the proposed activity? (Give details of the quantities and composition of wastewater generated from the proposed activity)

2.7. Give details of the water requirements met from water harvesting? Furnish details of the facilities created.

2.8. What would be the impact of the land use changes occurring due to the proposed project on the runoff characteristics (quantitative as well as qualitative) of the area in the post construction phase on a long term basis? Would it aggravate the problems of flooding or water logging in any way?

2.9. What are the impacts of the proposal on the ground water? (Will there be tapping of ground water; give the details of ground water table, recharging capacity, and approvals obtained from competent authority, if any)

2.10. What precautions/measures are taken to prevent the run-off from construction activities polluting land & aquifers? (Give details of quantities and the measures taken to avoid the adverse impacts)

2.11. How is the storm water from within the site managed?(State the provisions made to avoid flooding of the area, details of the drainage facilities provided along with a site layout indication contour levels)

2.12. Will the deployment of construction labourers particularly in the peak period lead to unsanitary conditions around the project site (Justify with proper explanation)

2.13. What on-site facilities are provided for the collection, treatment & safe disposal of sewage? (Give details of the quantities of wastewater generation, treatment capacities with technology & facilities for recycling and disposal)

2.14. Give details of dual plumbing system if treated waste used is used for flushing of toilets or any other use.

3. VEGETATION

3.1. Is there any threat of the project to the biodiversity? (Give a description of the local ecosystem with it's unique features, if any)

3.2. Will the construction involve extensive clearing or modification of vegetation? (Provide a detailed account of the trees & vegetation affected by the project)

3.3. What are the measures proposed to be taken to minimize the likely impacts on important site features (Give details of proposal for tree plantation, landscaping, creation of water bodies etc. along with a layout plan to an appropriate scale)

4. FAUNA

4.1. Is there likely to be any displacement of fauna- both terrestrial and aquatic or creation of barriers for their movement? Provide the details.

4.2. Any direct or indirect impacts on the avifauna of the area? Provide details.

4.3. Prescribe measures such as corridors, fish ladders etc. to mitigate adverse impacts on fauna

5. AIR ENVIRONMENT

5.1. Will the project increase atmospheric concentration of gases & result in heat islands? (Give details of background air quality levels with predicted values based on dispersion models taking into account the increased traffic generation as a result of the proposed constructions)

5.2. What are the impacts on generation of dust, smoke, odorous fumes or other hazardous gases? Give details in relation to all the meteorological parameters.

5.3. Will the proposal create shortage of parking space for vehicles? Furnish details of the present level of transport infrastructure and measures proposed for improvement including the traffic management at the entry & exit to the project site.

5.4. Provide details of the movement patterns with internal roads, bicycle tracks, pedestrian pathways, footpaths etc., with areas under each category.

5.5. Will there be significant increase in traffic noise & vibrations? Give details of the sources and the measures proposed for mitigation of the above.

5.6. What will be the impact of DG sets & other equipment on noise levels & vibration in & ambient air quality around the project site? Provide details.

6. AESTHETICS

6.1. Will the proposed constructions in any way result in the obstruction of a view, scenic amenity or landscapes? Are these considerations taken into account by the proponents?

6.2. Will there be any adverse impacts from new constructions on the existing structures? What are the considerations taken into account?

6.3. Whether there are any local considerations of urban form & urban design influencing the design criteria? They may be explicitly spelt out.

6.4. Are there any anthropological or archaeological sites or artifacts nearby? State if any other significant features in the vicinity of the proposed site have been considered.

7. SOCIO-ECONOMIC ASPECTS

7.1. Will the proposal result in any changes to the demographic structure of local population? Provide the details.

7.2. Give details of the existing social infrastructure around the proposed project.

7.3. Will the project cause adverse effects on local communities, disturbance to sacred sites or other cultural values? What are the safeguards proposed?

8. BUILDING MATERIALS

8.1. May involve the use of building materials with high-embodied energy. Are the construction materials produced with energy efficient processes? (Give details of energy conservation measures in the selection of building materials and their energy efficiency)

8.2. Transport and handling of materials during construction may result in pollution, noise & public nuisance. What measures are taken to minimize the impacts?

8.3. Are recycled materials used in roads and structures? State the extent of savings achieved?

8.4. Give details of the methods of collection, segregation & disposal of the garbage generated during the operation phases of the project.

9. ENERGY CONSERVATION

9.1. Give details of the power requirements, source of supply, backup source etc. What is the energy consumption assumed per square foot of built-up area? How have you tried to minimize energy consumption?

9.2. What type of, and capacity of, power back-up to you plan to provide?

9.3. What are the characteristics of the glass you plan to use? Provide specifications of its characteristics related to both short wave and long wave radiation?

9.4. What passive solar architectural features are being used in the building? Illustrate the applications made in the proposed project.

9.5. Does the layout of streets & buildings maximise the potential for solar energy devices? Have you considered the use of street lighting, emergency lighting and solar hot water systems for use in the building complex? Substantiate with details.

9.6. Is shading effectively used to reduce cooling/heating loads? What principles have been used to maximize the shading of Walls on the East and the West and the Roof? How much energy saving has been effected?

9.7. Do the structures use energy-efficient space conditioning, lighting and mechanical systems? Provide technical details. Provide details of the transformers and motor efficiencies, lighting intensity and air-conditioning load assumptions? Are you using CFC and HCFC free chillers? Provide specifications.

9.8. What are the likely effects of the building activity in altering the micro-climates? Provide a self assessment on the likely impacts of the proposed construction on creation of heat island & inversion effects?

9.9. What are the thermal characteristics of the building envelope? (a) roof; (b) external walls; and (c) fenestration? Give details of the material used and the U-values or the R values of the individual components.

9.10. What precautions & safety measures are proposed against fire hazards? Furnish details of emergency plans.

9.11. If you are using glass as wall material provides details and specifications including emissivity and thermal characteristics.

9.12. What is the rate of air infiltration into the building? Provide details of how you are mitigating the effects of infiltration.

9.13. To what extent the non-conventional energy technologies are utilised in the overall energy consumption? Provide details of the renewable energy technologies used.

10. Environment Management Plan

The Environment Management Plan would consist of all mitigation measures for each item wise activity to be undertaken during the construction, operation and the entire life cycle to minimize adverse environmental impacts as a result of the activities of the project. It would also delineate the environmental monitoring plan for compliance of various environmental regulations. It will state the steps to be taken in case of emergency such as accidents at the site including fire.

3. Elements for Social Impact Assessment

The scope and depth of Social Impact Assessment (SIA) should be determined by the complexity and importance of issues studied, taking into account the skills and resources available. SIA should include studies related to involuntary resettlement, compulsory land acquisition, impact of imported workforces, job losses among local people, damage to sites of cultural, historic or scientific interest, impact on minority or vulnerable groups, child or bonded labor, use of armed security guards. However, SIA may primarily include the following:

Description of the socio-economic, cultural and institutional profile

Conduct a rapid review of available sources of information to describe the socioeconomic, cultural and institutional interface in which the project operates.

Socio-economic and cultural profile: Describe the most significant social, economic and cultural features that differentiate social groups in the project area. Describe their different interests in the project, and their levels of influence. Explain any specific effects, the project may have on the poor and underprivileged. Identify any known conflicts among groups that may affect project implementation.

Institutional profile: Describe the institutional environment; consider both the presence and function of public, private and civil society institutions relevant to the operation. Are there important constraints within existing institutions *e.g.* disconnect between institutional responsibilities and the interests and behaviors of personnel within those institutions? Or are there opportunities to utilize the potential of existing institutions, *e.g.* private or civil society institutions, to strengthen implementation capacity.

Legislative and regulatory considerations

To review laws and regulations governing the project's implementation and access of poor and excluded groups to goods, services and opportunities provided by the project. In addition, review the enabling environment for public participation and development planning. SIA should build on strong aspects of legal and regulatory systems to facilitate program implementation and identify weak aspects while recommending alternative arrangements.

Key social issues

SIA provides baseline information for designing social development strategy. The analysis should determine the key social and Institutional issues which affect the project objectives; identify the key stakeholder groups in this context and determine how relationships between stakeholder groups will affect or be affected by the project; and identify expected social development outcomes and actions proposed to achieve those outcomes.

Data collection and methodology

Describe the design and methodology for social analysis. In this regard:

* build on existing data;
* clarify the units of analysis for social assessment: intra-household, household level, as well as communities/settlements and other relevant social aggregations on which data is available or will be collected for analysis;

* choose appropriate data collection and analytical tools and methods, employing mixed methods wherever possible; mixed methods include a mix of quantitative and qualitative methods.

Strategy to achieve social development outcomes

Identify the likely social development outcomes of the project and propose a social development strategy, including recommendations for institutional arrangements to achieve them, based on the findings of the social assessment. The social development strategy could include measures that:

* strengthen social inclusion by ensuring inclusion of both poor and excluded groups and intended beneficiaries in the benefit stream; offer access to opportunities created by the project
* empower stakeholders through their participation in design and implementation of the project, their access to information, and their increased voice and accountability (*i.e*. a participation framework); and · that enhance security by minimizing and managing likely social risks and increasing the resilience of intended beneficiaries and affected persons to socio-economic shocks

Implications for analysis of alternatives

Review proposed approaches for the project, and compare them in terms of their relative impacts and social development outcomes. Consider what implications the findings of social assessment might have on those approaches. Should some new components be added to the approach, or other components be reconsidered or modified?

If SIA and consultation processes indicate that alternative approaches may to have better development outcomes, such alternatives should be described and considered, along with the likely budgetary and administrative effects these changes might have.

Recommendations for project design and implementation arrangements

Provide guidance to project management and other stakeholders on how to integrate social development issues into project design and implementation arrangements. As much as possible, suggest specific action plans or implementation mechanisms to address relevant social issues and potential impacts. These can be developed as integrated or separate action plans, for example, as Resettlement Action Plans, Indigenous Peoples Development Plans, Community Development Plans, *etc*.

Developing a monitoring plan

Through SIA process, a framework for monitoring and evaluation should be developed.

To the extent possible, this should be done in consultation with key stakeholders, especially beneficiaries and affected people.

The framework shall identify expected social development indicators, establish benchmarks, and design systems and mechanisms for measuring progress and results related to social development objectives. The framework shall identify organizational responsibilities in terms of monitoring, supervision, and evaluation procedures. Wherever possible, participatory monitoring mechanisms shall be incorporated. The framework should establish:

* a set of monitoring indicators to track the progress achieved. The benchmarks and indicators should be limited in number, and should combine both quantitative and qualitative types of data. The indicators should include outputs to be achieved by the social development strategy; indicators to monitor the process of stakeholder participation, implementation and institutional reform;
* indicators to monitor social risk and social development outcomes; and indicators to
* monitor impacts of the project's social development strategy. It is important to suggest mechanisms through which lessons learnt from monitoring and stakeholder feedback can result in changes to improve operation of the project. Indicators should be of such nature that results and impacts can be disaggregated by gender and other relevant social groups;
* Define transparent evaluation procedures. Depending on context, these may include a combination of methods, such as participant observation, key informant interviews, focus group discussions, census and socio-economic surveys, gender analysis, Participatory Rural Appraisal (PRA), Participatory Poverty Assessment (PPA) methodologies, and other tools. Such procedures should be tailored to the special conditions of the project and to the different groups living in the project area;

Estimate resource and budget requirements for monitoring and evaluation activities, and a description of other inputs (such as institutional strengthening and capacity building) needs to be carried out.

Capacity Building requirements
Key output Report Task 5

Development of Methodologies for National
Programme for Rehabilitation of Polluted Sites
in India

Final, rev. 2

Ministry of Environment, Forest and Climate Change
Government of India

Authorisation

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Management summary

General
This report presents the key output of the activities carried out under Task 5 (Capacity Building requirements) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

Objective and report content
The objective of this Task 5 is to identify the capacity requirements for various levels of stakeholders (stakeholder agencies) involved in design, implementation and monitoring of remediation plans, including technical capacity of staff, sampling and laboratory equipment for sample testing, training and capacity building requirements.

The objective of this report is to present the above, but also to demonstrate its development, thereby providing the results with a sound basis. By contrast to the Guidance Document (the product of our Task 4), which is aimed at the organisations responsible for the implementation of NPRPS, this report is targeted primarily at those who need a deeper understanding of the technical backgrounds.

Results
This report presents the following results:
- An evaluation of the key roles involved in the implementation of the fourteen Steps in the site assessment and remediation process, including an inventory of the activities that need to be implemented by the stakeholder agencies responsible for each role (Chapter 2);
- An assessment of the capacities each of the key roles requires for effective implementation of the activities assigned to that role, including human resources (expertise, experience and skills), equipment and materials. Also included is a brief evaluation of best international practices in national and semi-national quality assurance and quality control structures, and recommendations for India (Chapter 3);
- A methodology for calculation of the required capacities for effective implementation of NPRPS. The methodology presented can be used to calculate the required capacities per role and, from there, the total capacities required for effective implementation of NPRPS (Chapter 4).

Conclusions
This report presents the following conclusions, based on the results described above:

- **Six key roles** need to be involved for effective implementation of the fourteen Steps in the site assessment and remediation process. These are the roles of:
  - Advisor;
  - Site investigator;
  - Laboratory;
  - Remediation Contractor;
  - Programme management Authority;
  - Site related programme implementation Authority.

  While the Site investigator, Laboratory and the Remediation Contractor have clearly defined involvement in a limited number of Steps, the other roles are involved in most of the Steps. The Programme management Authority even has involvement in all Steps. In addition to the roles in Programme management and in Site related Programme implementation the Authority may have a third role where project management for an 'orphan site' is required;
- Effective site assessment and remediation involves **a broad range of knowledge fields**, ranging from chemical and civil engineering through fields like hydrogeology to social sciences. This means that effective implementation of NPRPS requires expertise in a considerable number of fields. Significant experience and skills are also required, to be able to properly approach the substantial variety in site specific circumstances;
- The roles of Site investigator, Laboratory and Remediation Contractor in particular require **specialised reusable equipment**, ranging from small hand operated devices to large vehicles and machinery. In addition to that, both Site investigator roles also require a significant amount of **not reusable materials** for an effective implementation of their activities;
- A number of countries around the world have implemented **quality assurance and quality control structure**s in relation to national site assessment and remediation programmes. Each of these are structured in a different way, leading to a number of decisions that may be anticipated on this topic. First of all, a fundamental decision is needed on whether or not to implement a structure on quality assurance and control. In case it is decided to do so, a decision will be needed on how to set up that structure. At the time that decision is faced, a more in depth study of international best practices may be carried out in support of that decision, even though it may be decided to initially develop a more basic structure. An example of a structure which relatively small capacity for quality assurance on the public side does exist (the Netherlands). As in other sectors, it is international consensus that laboratories work under accreditation according to international standards;
- At the time of writing of this report, hands on experience with site assessment and remediation in India is still limited. International best practices do not offer a methodology for determination of capacity building requirements that can be implemented in India without considerable adaptation. Therefore, this report presents a tailor made **methodology for the calculation of capacities** required for effective implementation of NPRPS. The methodology presented:

- includes the costs for the effective implementation of all fourteen Steps of the site assessment and remediation process as described in the Guidance document;
  - includes all types of sites in the Typology developed for NPRPS (Task 1 of this Assignment);
  - anticipates the best practice remediation options (Task 3 of this Assignment);
  - uses the relevant parameters provided by the database developed in Assignment 1;
  - meets Indian market conditions;
  - can be used to calculate capacities required, both per role and in totals, for effective implementation of NPRPS, based on the input of data from the database developed in Assignment 1. This calculation can be adjusted whenever new data become available;
  - consists of a basic method for the generic calculation of required capacities to deal with a Reference contaminated site, and a method to refine the results through the definition of correction factors;
  - cannot be used for the calculation of capacities required to effectively deal with an individual contaminated site. This is because that needs methodologies providing room for more detailed site specific data.
- The **use of the methodology is demonstrated** through the performance of example calculations, using data on virtual sites, with the methodology. These data are based on international experience, and converted to the Indian situation by application of a number of assumptions;
- By far the **largest part of the cost is needed for remediation** and, if applicable, post remediation. This means that calculation or estimation of the costs for these Steps (8 and 11) are key;
- **Opportunities for effective cost management** are available, most notably the spreading of costs over a prolonged period of time in case of long running remediation or post remediation activities.

Table of contents

1 Introduction

1.1 General

This report presents the key output of the activities carried out under Task 5 (Capacity Building requirements) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.
The report presents the results of the steps implemented under Task 5.

1.2 Objectives of Task 5

The capacity needed to adequately deal with contaminated sites can be very significant. Recognising this is crucial to effectively implement the NPRPS programme. The objective of this Task 5 is therefore to “identify the capacity requirements for various levels of stakeholders (stakeholder agencies) involved in design, implementation and monitoring of remedial plans. This shall include technical capacity of staff, sampling and laboratory equipment for sample testing, training and capacity building requirements, etc.” (quotation from the Terms of Reference for this Assignment).

1.3 Scope of Task 5

The scope of Task 5 is primarily aimed at the technical capacity requirements of the fourteen step sequence described in the Guidance Document. This sequence, summarized in Annexure 3 to this report, describes the entire process of site assessment and remediation in fourteen steps, from Identification of a probably contaminated site via steps like Preliminary Site Assessment and Implementation remediation right up to Site reuse. For non-technical capacity requirements such as administrative, procedural and legal aspects, we refer to the report of Task-4 National Programme for Remediation of Polluted Sites, December 2015) as developed in Assignment 3.

In view of the above, the scope of Task 5 comprises an evaluation of the following elements of capacities required for implementation of the NPRPS:

- The relevant organisations;
- The activities the relevant organisations are required to perform;
- The instruments the relevant organisations require;
- The requirements to set the quality standards.

Also within the scope of Task 5 is a synthesis of these elements, resulting, through model calculations, in an estimate of the required resources quantities.

Stakeholder agencies within the scope of Task 5 include those directly involved in performing one or more Steps in the fourteen step sequence, i.e. stakeholder

agencies involved in design, implementation and monitoring of site assessment or remediation plans. This includes third party consultants, site investigators (fieldwork), laboratories, remediation contractors and subcontractors, as well as the competent authorities.
The identification of capacity requirements includes all specifications like technical capacity and instruments, conditional requirements like management skills and staff capacity required for an effective implementation of the NPRPS.

Capacity requirements for stakeholders who are not directly involved in the fourteen steps are not discussed in this report. Examples of these are capacity requirements for site owners, the potentially affected community, and those involved in related processes like spatial planning.

1.4 Output and practical applicability

The information on capacity requirements in this report is used in Chapter 4, which presents a methodology to estimate the quantities of resources required for effective implementation of the NPRPS. It should be noted that this methodology is applicable only on a generic level, i.e. the NPRPS. It cannot be applied to estimate capacity requirements for individual sites. This is because such estimates typically require more detailed information, most notably on site specific conditions. If a basic set of data on contaminated sites is available in a nationwide database, this methodology can be used to assess the required investments for the assessment of all sites in the database and for the remediation of those sites for which, based on their assessment, it is decided that they need to be remediated.

Implementation of the NPRPS will include the assessment and remediation of individual sites. These activities will yield new data and improve expertise and skills of those involved. The estimate of capacity requirements (time, efforts and costs involved) can be adjusted at any time by introducing new data into the methodology. The specific capacity requirements for implementation of the capacity building programme, e.g. training of staff, are not calculated by the methodology. This is because these specific capacities are determined by too many specific factors, e.g. how the capacity building programme is shaped, the duration of the implementation period and geographical spreading.

1.5 Data sources and assumptions

Roles and activities

An inventory is made of organisations relevant to NPRPS and the roles they are likely to be assigned. Secondly, the activities each of these organisations will have to perform to fulfil its role are evaluated. The roles and the activities related to the roles have been compiled from the Task 4 report of Assignment 3 (December 2015) and the Guidance Document developed as Task 4 in this Assignment (December 2015).

Required resources
An inventory is made of the resources each of the organisations relevant to NPRPS needs to effectively fulfil its role. The main source for the summary of resources required for effective implementation of the activities in NPRPS is the Guidance Document. This summary includes for example the required expertise, experience and skills the performing organisations require. For evaluation of these capacity requirements, these activities are listed and illustrated in this report. Input for activities implemented by authorities is presented in the Assignment 3 Task 4 report. If applicable, best practice input is presented to illustrate these activities with practical information.

Quality standards
In various countries around the world national structures for quality assurance and quality control of site assessment and remediation are in effect. A number of these are discussed.

Required resources quantities
Quantitative data are gathered from the available international best practices in the US, UK and in the Netherlands. For the quantitative assessment of capacity building requirements on a national level basic unit cost prices are introduced. We derive basic unit cost prices from available relevant international sources and the international experience of senior soil remediation specialists within and close to the project team.
Finally, the best practices on quantities of resources identified in this way are adapted to the specific situation in India. This is done by identifying basic cost elements and then converting each element to the specific Indian situation. The results of this are verified based on available local data of known contaminated site projects.

1.6 Reading guide

We have carried out the steps in Task 5 as described in the Contract for Consultants' Services (26/03/2012) and the report discusses these steps and their results. We present the discussion in a sequence different from the sequence of steps, as this results in a logical flow of reasoning:

First we discuss the relevant organisations for NPRPS and the roles they can take on in the site assessment and remediation process. This is done in Chapter 2, Roles and activities. This represents Step 5.1 (Relevant organisations) as described in the Contract.

When the roles are defined, an inventory of activities required for implementation of NPRPS can be made. This inventory is also discussed in Chapter 2, Roles and activities. This represents part of Step 5.4 (Inventory of activities and model calculations) as described in the Contract.

Next, the resources required for implementation of NPRPS can be derived from the required activities. These resources are discussed in Chapter 3, Required resources. This represents part of Step 5.2 (Analysis of investments for steps in remediation process) as described in the Contract.

For effective implementation of NPRPS the available resources need to be deployed in such a way that certain quality standards are met. This issue is also discussed in Chapter 3, Required resources. This represents the remaining part of Step 5.2 (Analysis of investments for steps in remediation process) as well as Step 5.3 (Analysis per category of hazardous waste sites) as described in the Contract.

Finally, all of the preceding steps are evaluated to develop a model for the calculation of resources required for effective implementation of NPRPS. This model is discussed in Chapter 4, Methodology for calculation of required capacities. This represents the remaining part of Step 5.4 (Inventory of activities and model calculations) as described in the Contract.

2 Roles and Activities

2.1 Introduction

In the process of investigation, remediation and evaluation of contaminated land a variety of stakeholders is involved, each of them performing a different role. The next Section 2.2 presents the roles of the stakeholders involved in the assessment and remediation of contaminated sites. Section 2.3 lists the activities the stakeholders need to perform for the implementation of the NPRPS. This overview is based on the fourteen steps in the site assessment and remediation process and the involvement of the relevant roles in this process. The activities listed in Section 2.3 refer to the technical activities mentioned in the reports of Task-4 (Guidance document for assessment and remediation of contaminated sites in India, December 2015) of this Assignment and Task-4 (National Programme for Remediation of Polluted Sites, December 2015) of Assignment 3.

Roles, activities and stakeholders are closely interlinked, and the three terms can easily be used incorrectly. For clarity, we have developed a definition for each of these terms, that applies within the context of this report.
A **role** is an interlinked set of performed activities.
An **activity** is defined as an action performed at some point in the site assessment and remediation process.
A **stakeholder** is an entity, public or private, with an interest in the site assessment and remediation process. In this report, only stakeholders performing activities in this process are taken into account.

2.2 Roles

Key roles
Based on information from the Guidance document for assessment and remediation of contaminated sites in India (draft Task-4 report of this Assignment) and the National Programme for remediation of Polluted Sites (draft Task-4 report of Assignment 3), the following roles are key to the performance of the most important activities in the assessment and remediation process:

- Advisor;
- Site investigator;
- Laboratory;
- Remediation contractor;
- Programme management Authority;
- Site related programme implementation Authority.

Depending on the site situation and legal and financial aspects, the authority might have a third role in the procurement of the investigation and remediation activities. This particular role is relevant for orphan sites.

Roles and stakeholders are closely related. However, the roles described above are not always linked to a specific stakeholder. For example, the Advisor may be a third party private engineering consultancy, but certain activities within this role, e.g. the design of the fieldwork, the interpretation and reporting of the site assessment results, or the appointment of the remediation contractor, may be carried out by public institutes or specialist teams in a public organization. Often, the roles of Site investigator and Advisor are performed by the same consulting company. Nevertheless, both roles are described separately here, because the two generate different types of activity.

Please note that the role of responsible party is not addressed as a separate role in this report. This is because the group performing this role is not usually addressed in capacity building programmes.

Table 2.1 below shows the involvement of the relevant roles at different stages in the site assessment and remediation process. For example, for Preliminary investigation (Step 2), the stakeholders responsible for the roles of Advisor, Site investigator and Laboratory should be involved. And for approval of DPR (Step 7), the stakeholder performing the role of Site related programme implementation Authority should be involved, while there is likely to be some involvement by the Programme management Authority.

Table 2.1 Roles required in a typical site assessment and remediation process (for activities to be performed re. Section 2.3)

Steps in the remediation process		**Relevant roles**					
		Advisor	**Site investigator**	**Laboratory**	**Remediation contractor**	**Programme management Authority**	**Site related programme implementation Authority**
1	Identification of probably contaminated sites					✓	
2	Preliminary investigation	✓	✓	✓		✓	✓
3	Notification of polluted site					✓	
4	Priority list addition					+	
5	Remediation investigation						
5.1	Detailed site assessment	✓	✓	✓		+	✓
5.2	Risk assessment	✓				+	✓
5.3	Setting remediation objectives and requirements	✓				+	✓
5.4	Development of remediation options	✓				+	✓
5.5	Selection remediation option	✓				+	✓
6	Remediation design, DPR	✓				+	
7	DPR approval and funding					+	✓
8	Implementation of remediation						
8.1	Preparation and authorisation	✓				+	
8.2	Contracting	✓				+	✓

Steps in the remediation process		Relevant roles					
		Advisor	Site investigator	Laboratory	Remediation contractor	Programme management Authority	Site related programme implementation Authority
8.3	Execution, supervision and verification of remediation results	✓	✓	✓	✓	+	✓
9	Approval of remediation completion					+	✓
10	Post remediation Plan	✓				+	✓
11	Post remediation Action	✓	✓	✓	✓	+	✓
12	Cost recovery					✓	
13	Priority list deletion					✓	
14	Site reuse					✓	

Key
✓ Role required in a typical site assessment and remediation process
\+ Some involvement of role of Programme management Authority required

Other roles
Apart from the key roles presented above, other organisations or persons will typically have interests or concerns in the site assessment and remediation process. Usually, this will translate into them voicing their demands at some point during the process, in most cases on the site assessment, the decision making process on the remediation objective or the implementation phase. The concerns raised by these stakeholders are not necessarily focused on the technical scope of the remediation, but rather on social issues like safety and nuisance, or economic ones like site use restrictions or land use.

The international consensus is that these demands should always be given careful consideration. After all, their demands may be just as important as the primary technical demands. Preferably, the stakeholders voicing these demands should, in one way or another, be actively involved in the process, at least during the Steps that are most relevant to them. This approach is likely to support a notably smoother run through the process. In many cases, involvement of these stakeholders has led to creative solutions with more benefits for all that would otherwise not have been considered. The Guidance document (developed as Task 4 in this Assignment, December 2015) presents guidelines on how and when to involve these stakeholders in the site assessment and remediation process.

In recent years, structured incorporation into the process of social and economic concerns has developed considerably through developments in sustainable remediation. We have touched on this subject in our Task 2 report (May 2014). The most practical documents and guidelines on this subject are published in the UK, the US and in Australia.
In the UK, documents on sustainable remediation are published by SuRF-UK and available through the CL:AIRE website (www.claire.co.uk). Their road map distinguishes Framework and guidance documents, documents to support execution of sustainable remediation and otherwise supporting materials like case

studies and reports. Up to date, documents are available in all categories, e.g. on planning a sustainability assessment.
In the US, the Sustainable Remediation Forum, internationally known as SuRF-US, has published a considerable number of documents to support the application of sustainable remediation, all available through www.sustainableremediation.org. The White Paper[1] contains general thoughts on the incorporation of sustainable remediation principles in remediation decision making. A set of three documents, all published in 2011, are aimed at practical application of these principles: a Framework for Integrating Sustainability into Remediation Projects[2], Metrics for Integrating Sustainability Evaluations into Remediation Projects[3], and Guidance for Performing Footprint Analyses and LCAs for the Remediation Industry[4].
Australia has published a number of practical documents on sustainable remediation, most notably the Framework for Sustainable Remediation[5], available through www.surfanz.com.au.

Stakeholders that are often involved in the site assessment and remediation process include land owners, site users, community workers, residents of or near the site, media or press, NGO's and public authorities for urban planning, water or infrastructure.

2.3 Activities

This Section summarizes the activities to be performed by the involved organisations, per Step. For a more detailed description of these activities re. the Guidance Document (Task 4 report of this Assignment, December 2015).

2.3.1 Advisor

The role of Advisor typically covers all technical engineering activities during the site assessment and remediation process. Examples of these activities are the implementation of the site assessment, risk analysis, site investigation, remediation option appraisal, and consultancy during the implementation of the remediation. For each of the Steps where the Advisor role is most relevant the activities related to technical aspects are summarized below.

Step 2: Preliminary investigation, Task 2.1: Preliminary site assessment, and Task 2.2: Preliminary site investigation

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[1] Sustainable Remediation Forum (SURF), "Integrating sustainable principles, practices, and metrics into remediation projects", Remediation Journal, 19(3), pp 5 - 114, editors P. Hadley and D. Ellis, Summer 2009
[2] Holland, K.S., R.E. Lewis, K. Tipton, S. Karnis, C. Dona, E. Petrovskis, L.P. Bull, D. Teage and C. Hook, 2011 – Framework for Integrating Sustainability Into Remediation Projects. Remediation, Summer 2011, pp. 7- 38.
[3] Brandt Butler, P., L. Larsen-Hallock, R. Lewis, C. Glenn and R. Armstead – Metrics for Integrating Sustainable Evaluations Into Remediation Projects. Remediation. Summer 2011, pp. 81-87.
[4] Favara, P.J., T.M. Krieger, B. Boughton, A.S. Fisher and M. Bhargava – Guidance for Performing Footprint Analyses and Life-Cycle Assessments for the Remediation Industry. Remediation, Summer 2011, pp. 39-79.
[5] Blount, A., M. Herrmann, S. Wood, J. Prentice, J. Fox, C. Brumley and J. Meaklim – Framework. Working Group report, March 2013.

- Assessment of data on the site available in reports and petitions through a desk study, including taking stock of new data;
- Inspection of the site to verify the desk study data;
- Preparation of fieldwork and laboratory testing plan;
- Management of fieldwork and laboratory testing;
- Drawing of conclusion on whether or not the site should be regarded as a contaminated site. Along with this conclusion, drafting of recommendations on the necessity to carry out more detailed site assessment, including drafting of objectives of that assessment;
- Reporting of results of the preliminary site assessment and preliminary site investigation.

Step 5: Remediation investigation, Task 5.1: Detailed Site Assessment

- Definition of site assessment scope and strategy;
- Management of fieldwork and laboratory testing;
- Evaluation and interpretation of data from fieldwork and laboratory testing;
- Reporting of detailed site assessment.

Step 5: Remediation investigation, Task 5.2: Risk Assessment

- Assessment of contaminant concentration levels;
- Identification of applicable source-pathway-receptor-combinations for human health;
- Implementation of a generic quantitative risk assessment for human health;
- If necessary, implementation of a more detailed quantitative risk assessment for human health;
- If necessary, implementation of a risk assessment for the environment.

Step 5: Remediation investigation, Task 5.3: Setting remediation objectives and requirements

- Drafting proposed remediation objectives;
- Drafting proposed remediation requirements.

Step 5: Remediation investigation, Task 5.4: Development of remediation options

- Assessment of remediation objectives and requirements;
- Identification of constraints to remediation;
- Identification of applicable remediation techniques;
- Appraisal of the proposed remediation options.

Step 5: Remediation investigation, Task 5.5: Selection remediation option

- Comparison and appraisal of proposed remediation options;
- Consultation with relevant stakeholders;
- Preparation of remediation investigation report, including stakeholder views, and recommendations on the selection of the remediation option.

Step 6: Remediation design, DPR

- Design of the technical system for the remediation, including detailed descriptions and drawings of the remediation activities;
- Costing of each of the remediation activities, based on volumes, amounts and unit prices;

- Planning of remediation activities, indicating the time involved for each of the activities.
- Consultation of stakeholders and assessment of environmental, economic and social impact of the remediation activities.

Step 8: Implementation of remediation, Task 8.1: Preparation and authorisation
- Identification of required permits;
- Application for the required permits.

Step 8: Implementation of remediation, Task 8.2: Contracting
- Preparation of procurement documents;
- Supporting the Authority in selection and appointment of the remediation contractor.

Step 8: Implementation of remediation, Task 8.3: Execution, supervision and verification of remediation measures
- Supervision and verification of preparatory activities for remediation against contract and specifications;
- Supervision and verification of remediation activities against contract and specifications;
- Reporting of verification results in a Remediation evaluation report. In a remediation that runs for a prolonged period of time this will be done both periodically as well as after completion of the remediation activities.

Step 10: Post remediation plan
- Preparation of post remediation plan:

Step 11: Post remediation activities
- Prepare Post Remediation Implementation Programme:
  - Design of the technical system for the post remediation, including detailed descriptions and drawings of the post remediation activities;
  - Costing of each of the post remediation activities, based on volumes, amounts and unit prices;
  - Planning of post remediation activities, indicating the time involved for each of the activities.
  - Consultation of stakeholders and assessment of environmental, economic and social impact of the post remediation activities.
- Outsource implementation of post remediation activities:
  - Preparation of procurement documents;
  - Supporting the Authority in selection and appointment of the post remediation contractor.
- Supervision and verification of post remediation activities;
- Reporting of verification results in a periodical and, if applicable, final post remediation status report.

2.3.2 Site investigator

The role of Site investigator, typically covers all on-site activities for site assessment. Typically, on-site activities during site assessment include land survey, drilling, by hand as well as (if necessary) mechanically, installation of monitoring wells and sampling of soil and groundwater and, if applicable, sediment, waste and surface water. In addition to this, also qualitative on-site screening techniques like XRF, field operable chromatography testing and geophysical survey techniques may be applied. Internationally, the application of these screening techniques is increasing. It is doubted whether these techniques will ever completely replace the classical method of taking samples and having these tested in a laboratory. It is generally accepted that, in the current situation, laboratory testing is needed for the validation or verification of results of an on-site screening technique.

Aside from during site assessment, a substantial part of the on-site fieldwork activities is performed during the implementation of remediation. The scope of these activities is to monitor the progress of the remediation and to establish the actual boundary of lateral or vertical removal of contaminated soil, to establish the quality of removed soil and waste material and, in relation to the latter, to establish the potential destinations of soil batches of different quality (Sanitary LandFill (SLF), soil treatment plant, reuse on-site or reuse elsewhere). Alternatively, the scope of fieldwork activities comprises the monitoring of the operation, maintenance and adjustment of a groundwater treatment plant.

For each of the steps where the Site investigator role is most relevant the activities are summarized below.

Step 2: Preliminary investigation, Task 2.1: Preliminary site assessment, and Task 2.2: Preliminary site investigation

- Land survey;
- Sampling, applied in a structured and planned manner, aimed at cost effective location of sources of contamination and relevant pathways to potentially affected receptors;
- In addition to sampling, site screening techniques may be applied to gain a general impression of the distribution of contaminating agents on the site;
- Reporting of field data, including geographical presentation on a site map that shows at least the site topography and the location of the boreholes and monitoring wells.

Step 5: Remediation investigation, Task 5.1: Detailed Site Assessment

- Sampling, specifically aimed at the points on site where sources of contamination and relevant pathways to potentially affected receptors are anticipated.
- Reporting of field data, including geographical presentation on a site map that shows at least the site topography and the location of the boreholes and monitoring wells.

Step 8: Implementation of remediation, Task 8.3: Execution, supervision and verification of remediation measures

- Sampling, specifically aimed at the verification of remediation results;
- Reporting of field data, including geographical presentation on a site map that shows at least the site topography and the location of the boreholes and monitoring wells.

Step 11: Post remediation activities
- Sampling, specifically aimed at the verification of post remediation results;
- Reporting of field data, including geographical presentation on a site map that shows at least the site topography and the location of the boreholes and monitoring wells.

2.3.3 Laboratory
The role of Laboratory, covers all laboratory activities during the site assessment and remediation process. Typical activities within this role are the provision of sample containers to the fieldwork team, the distribution and collection of the same from the fieldwork team, the installation and maintenance of a climate controlled sample depot, preparation and testing of samples, quality assurance and quality control and reporting of the results of sample testing results. Additional activities may include consultancy on the interpretation of the results of sample testing.

For each of the steps where the Laboratory role is most relevant the activities are summarized below. From the point of view of a laboratory the activities are the same, regardless of the Step for which they are performed.

Step 2: Preliminary investigation, Task 2.1: Preliminary site assessment, and Task 2.2: Preliminary site investigation
Step 5: Remediation investigation, Task 5.1: Detailed Site Assessment
Step 8: Implementation of remediation, Task 8.3: Execution, supervision and verification of remediation measures
Step 11: Post remediation activities
- Providing logistics concerning the sample containers between the fieldwork site and the laboratory;
- Preparation and testing of samples of soil material, groundwater, and if applicable, also sediment, waste and surface water;
- Reporting of sample testing results.

The vast majority of samples analysed in the site assessment and remediation process involve soil, groundwater and sediment samples. In particular cases, depending on the relevant polluted linkages, other sample types such as waste, air, surface water or dust, may be subject to laboratory testing within the context of the site assessment and remediation process.

Contaminants that may be expected
The type of analyses (parameters) and testing will vary depending on the contaminating substances expected at the site. The provisional version of the database of contaminated sites available at the time of developing the draft version of this report (Assignment 1, database version 13-12-2012, presenting 106 sites with expected contaminations) has been consulted. Validation of this consultation against the version of the database presented in the final Task 3 report of Assignment 1 (January 2015) resulted in no significant changes in the results. Table 2.2 below lists the contaminants that may be expected at the sites in the database, based on this consultation.

Table 2.2 Contaminants that may be expected at the sites in the database

Contaminant group	**% of sites where con-taminant group may be present**	**Examples of contaminants in group**
Heavy metals	84%	e.g. As, Cd, Pb, Cr(different valences), Cu, Mn Hg, Zn, Hg
Anorganic	7%	e.g. CN, Fluoride, S, Na, NH_4
Pesticides	7%	e.g. Various Pesticides, DDT, BHC Isomers, PCB, Endosul-fan,
Hydrocarbons	3%	e.g. PAH, aliphatic compounds
Other parameters	3%	e.g. Rare earth, V, Thiozole
Organic	2%	e.g. 'organic waste', phenol
Asbestos	1%	

Notes
Percentages should be regarded as provisional, as the database will be expanded with additional data as the NPRPS is implemented.
At least 10% of the evaluated sites is expected to be contaminated with two or more types of parameters, which explains why the percentages add up to more than 100%.

Realistic sample testing plan, suited to assessment objective
The number of existing chemical components is without bounds. In much the same way, the number of potential contaminants is theoretically endless. It is therefore internationally accepted that it is impossible to develop a complete assessment of all potential contaminants at any given site. As a result, the objective of any assessment of contaminants at a site is to develop as complete a picture of the contaminant situation as is reasonably possible. Aside from technical considerations, economic ones do play a role in the optimisation of the plan for laboratory testing.

At the vast majority of contaminated sites the contamination consists of more than a single contaminant. This is because contaminants typically are associated with other contaminants. For example: in chromium ore tailings the primary contaminant, Chromium, is typically accompanied by Mg, Co, Zn, Ni or Cu, albeit in lower concentrations. Organic parameters are typically accompanied by their compounds after biodegradation. Preliminary site assessment will therefore, in addition to testing of the primary contaminant, include testing of the contaminants that may be expected in association with the primary one. In the case of chromium ore tailings, the laboratory will therefore be requested to analyse samples for Chromium, as well as for Mg, Co, Zn, Ni and Cu.

At the outset, a preliminary site assessment is often geared to developing a quick and rather broad picture of the contaminant situation and its perimeter. In those cases, the laboratory may be requested to analyse the first batches of samples for only the primary contaminant or a very limited number of contaminants. In many other cases, the information available prior to the start of the preliminary site assessment is very limited. In those cases, the most widely used option to optimize the site assessment strategy while minimising costs is to request the testing of samples on standard sets of contaminants. Over the years, international laboratories have developed competitively priced standard set packages for testing, e.g. a set of eight heavy metals or a set including the most common heavy metals, PAH, volatile aromatic compounds and mineral oil.

In later stages in the site assessment, laboratory testing will be used as part of the development of a risk assessment or to assess the options for treatment of contaminated soil material. This kind of activity requires a more comprehensive characterisation of the contamination, resulting in more comprehensive lists of contaminants for laboratory testing.

2.3.4 Remediation Contractor

The role of Remediation Contractor covers the implementation of remediation and post remediation activities. The scope of these activities depends on the remediation technique that has been selected. In case of excavation the Remediation Contractor will typically excavate and separate the soil material in batches in accordance with the instructions from the supervisor (See Section 2.3.1). Also in accordance with these instructions the Remediation Contractor will arrange the transportation of the soil material batches to the appropriate destination. The destination depends on the quality of the soil material batch in question (Sanitary LandFill (SLF), soil treatment plant, reuse on-site or reuse elsewhere).

In case an in-situ remediation technique has been selected the Remediation Contractor will typically install the instruments, usually including a pumping system and measurement units, and be responsible for their maintenance throughout the remediation or post remediation. In the great majority of post remediation operations an in-situ technique is applied.

Irrespective of the remediation technique, the Remediation Contractor will usually also provide the equipment and materials for an effective implementation of the remediation or post remediation activities.

For each of the steps where the Remediation Contractor role is most relevant the activities are summarized below.

Step 8: Implementation of remediation, Task 8.3: Execution, supervision and verification of remediation measures
- Preparation of remediation activities;
- Execution and management of remediation activities;

Step 11: Post remediation activities
- Preparation of post remediation activities;
- Execution and management of post remediation activities;

The Remediation Contractor may also perform activities for reconstruction of the site. Combining reconstruction and remediation may be complex, but can result in an efficient integrated working programme at a site.

Often, a Remediation Contractor introduces subcontractors, either to cover for capacity that he cannot provide himself, or for specialised activities. The first may occur on very large sites where the Remediation Contractor is likely to need more excavators than he has readily available within his own company. Examples of a specialised activity often performed by a specially engaged sub-contractor are specific techniques for the drilling of wells, e.g. for an in situ re-mediation. For the client and the authorities it is important to know which party is responsible for execution of the remediation activities.

2.3.5 Programme management Authority

The roles of Programme management and of Site related programme imple-mentation are always assigned to public authorities. The difference between the two is that the role of Programme management covers the activities on a pro-gramme level, i.e. the public activities pertaining to multiple sites, while the role of Site related programme implementation includes the public activities in the assessment and remediation at individual sites. The role of Programme man-agement is described in this Section, the role of Site related programme imple-mentation in the next Section. The activities related to technical aspects of the NPRPS are summarized from combining information in the Task-4 report of As-signment 3 (December 2015) with project team expertise.

The key assumption based on this information is that MoEF will delegate the central management of NPRPS to a central Remediation of Polluted Sites (RPS) Authority. In the current plans, outlined in the Task 4 report of Assign-ment 3 (December 2015), this authority is to be involved in Programme man-agement as well as in Site related programme implementation. This authority is to be supported by CPCB, where the latter will be responsible for the infor-mation management, including the management of the polluted site registry and the coordination of the SPCB's. The SPCB's, in turn, will provide CPCB with data on the identified polluted sites, each within their own jurisdiction.

It should be stressed that programme management is required during all Steps in the process of site assessment and remediation, in order to schedule and register results of activities at sites within the NPRPS programme.

For a comprehensive list of activities that may be assigned to a RPS Authority, CPCB and SPCB's we refer to the Task 4 report of Assignment 3 (December 2015, pages 30 and 31). The role of Programme management Authority in-cludes a wide range of generic activities for which technical knowledge and ex-pertise is needed.

For each of the Steps where the Programme Management Authority role is most relevant the activities related to technical aspects are summarized below.

Step 1 Identification of probably contaminated sites
- Identification of sites that may fit the definition of probably polluted sites;
- Collection of data on probably contaminated sites, including any existing site investigation reports, regulatory records, petitions and complaints;
- Reviewing and assessment of the data obtained. This may also require a site visit.

Step 3: Notification of polluted site
- Delineation of the polluted or probably polluted site;

- Imposition of site use restrictions and temporary safety measures;
- Recommend notification of the site, site use restrictions and temporary safety measures to the State Government.

Step 4: Priority list addition
- Assessment of available data on the site;
- Application of prioritisation algorithm to obtain priority score;
- Keeping of updated inventory of sites in the site registry maintained by the Central Pollution Control Board;
- Recommendation of priority of remediation to State Government.

Step 12: Cost recovery
- Preparation of cost overview of executed assessment, remediation and post remediation activities;
- Identification of responsible persons and recommendation of assignment of liability for costs to the State Government.

Step 13: Priority list deletion
- Assessment and recording of site use restrictions;
- Recommendation of closure of the remediation process and consequent change of registration status of the site in the database to the State Government.

Step 14: Site reuse
- If necessary, recommendation of site use restrictions and temporary safety measures to the State Government.

2.3.6 Site related programme implementation Authority

The role of the Site related programme implementation Authority covers several generic activities for which technical knowledge and expertise is needed:
- Appraisal and recommendation for approval or rejection of site investigation reports, detailed project reports, costs of remediation and voluntary remediation;
- Appraisal of site investigators and advisors, including legal and financial advisors, and, based on that appraisal, approval or rejection of appointment of the same. In case of appointment: review, monitoring, supervision and verification of their activities;

At ‘orphan’ sites, i.e. sites where no private person or organisation can be forced to start remediation activities: appointment of remediation activities and project management. This includes encouragement of, implementation of and participation in site assessment and remediation and research on all matters connected with the site.

Below for each of the steps where the Site related programme implementation Authority role is most relevant the activities related to technical aspects are summarized:

Step 2: Preliminary investigation, Task 2.1: Preliminary site assessment, and Task 2.2: Preliminary site investigation

- Review of the reports of the preliminary investigation and, based on the results of this review, approval or rejection of the same.

Step 5: Remediation investigation, Task 5.1: Detailed site assessment
- Review of the report on the detailed site assessment and, based on the results of this review, approval or rejection of the same.

Step 5: Remediation investigation, Task 5.2: Risk assessment
- Review of the report on the risk assessment and, based on the results of this review, approval or rejection of the same. Often, the report on the risk assessment will be integrated in the report on the detailed site assessment. In such a case the Authority can subject both parts of this report to an integrated review.

Step 5: Remediation investigation, Task 5.3: Setting remediation objectives and requirements
- Review of the proposed remediation objectives and requirements and, based on the results of this review, approval or rejection of the same.

Step 5: Remediation investigation, Task 5.4: Development of remediation options
- Review of the developed remediation options and, based on the results of this review, approval or rejection of the same.

Step 5: Remediation investigation, Task 5.5: Selection of remediation option
- Selection of the most appropriate remediation option. This selection may also be based on recommendations by the Advisor.

Step 7: DPR approval and funding
- Review of DPR and, based on the results of this review, approval or rejection of the same.

Step 8: Implementation of remediation, Task 8.2: Contracting
- Appraisal of Remediation Contractors and, based on that appraisal, approval or rejection of appointment of the same.

Step 8: Implementation of remediation, Task 8.3: Execution, supervision and verification of remediation results
- Enforcement of remediation activities according to the applicable regulations and the terms of the contract;
- Appraisal of variations to the DPR proposed or applied during the remediation activities and, based on that appraisal, approval or rejection of the same;
- Appraisal of periodic remediation reports submitted and, based on that appraisal, approval or rejection of the same.

Step 9: Approval of remediation completion
- Appraisal of final remediation evaluation report submitted and, based on that appraisal, approval or rejection of the same.

Step 10: Post remediation plan

- Review of Post remediation plan and, based on the results of this review, approval or rejection of the same.

Step 11: Post remediation activities

- Appraisal of post remediation contractors and, based on that appraisal, approval or rejection of appointment of the same;
- Enforcement of post remediation activities according to the applicable regulations and the terms of the contract;
- Appraisal of variations to the post remediation plan proposed or applied during the remediation activities and, based on that appraisal, approval or rejection of the same;
- Appraisal of periodical post remediation status reports submitted and, based on that appraisal, approval or rejection of the same;
- If applicable: appraisal of final post remediation report submitted and, based on that appraisal, approval or rejection of the same.

3 Required capacities

3.1 Introduction

This Chapter presents an overview of capacities required to effectively implement the activities described in Chapter 2, related to the technical aspects of the site assessment and remediation process. This Chapter is based on information in Volumes II and III of the Guidance Document, developed in Task-4 in this Assignment (December 2015), and the Task-4 report of Assignment 3 (December 2015).

The required capacities include human resources (expertise, experience and skills), equipment and materials. This Chapter also includes a discussion on quality assurance and quality control.

As is shown earlier, the fourteen steps in the site assessment and remediation process include a broad range of activities, from technical consultancy via programme management, financial management, legal consultancy and procurement to project management. While the activities will be performed by different roles, it is clear that the human factor is crucial in most activities. Staff involved in the activities needs to meet certain standards in expertise, usually expressed in educational requirements, experience, typically expressed in a number of years of relevant professional experience, as well as skills.

A variety of technical equipment or technical tools is required to implement the various activities during all Steps in the site assessment and remediation process. Equipment consists of tools that can be reused multiple times at different sites and should be considered as a standard technical toolbox, e.g. for site assessment, site remediation or monitoring the progress of site remediation. Examples include digging machinery and measurement devices.

In addition to the above, a variety of materials is required to effectively implement the various activities during all Steps in the site assessment and remediation process. Materials differ from equipment in that materials are typically used only once on a single site. Examples include sample containers and paper filters. Which materials are used largely depends on the selected remediation option involved. A broad range of materials does exist and many materials can be delivered by local providers.

In determining which capacities are needed at a particular point in time, it should be noted that the following timeline is expected to be included in the NPRPS legal and regulatory framework (Task 4 report of Assignment 3, December 2015):

- Any site in the inventory is assessed and preliminarily investigated within 3 months of the date of identification of a petition received. This refers to the performance of Step 2 in the site assessment and remediation process;
- A polluted site is notified and accorded appropriate priority for remediation within 6 months from the date of determination that such site is a polluted site (Steps 3 and 4);
- A polluted site is scheduled for commencement of remediation within 12 months of such polluted site being included in the priority list of sites for remediation (Steps 5 and 6). It should be noted however that, for large complicated sites, where trend analyses needs to be part of the assessment phase, this may prove ambitious, as such analyses may take one to three years to complete.

A timeline for Remediation and Post remediation (from Step 8 onwards) is not provided, as planning can vary widely depending on the local situation.

In the next Sections, capacities are described per key role, in alignment with the structure followed in Chapter 2.

3.2 Advisor

3.2.1 Human resources

The expertise, experience and skills required of the Advisor for an effective performance of the technical engineering activities during site assessment and remediation are summarized from information by CPCB and expert judgement. As stated in Section 2.4.1 these activities are the implementation of the site assessment, risk analysis, site investigation, remediation option appraisal, and consultancy during the implementation of the remediation. Table 3.1 presents the generic human resources required for an effective performance of these activities at a relatively complex contaminated site, including social issues. The table is organised around a typical team composition for such a site. It should be noted here that team composition as well as required standards vary, depending on the specific situation at the site at hand.

Table 3.1 Generic human resources required for effective performance by Advisor at a relatively complex contaminated site

Key Position	Required expertise	Required experience
Remediation expert (assessment and / or remediation expert)	Post Graduate in Environmental / Civil/Chemical Engineering /Hydrogeology/Science or relevant discipline	At least 7 years' experience in assessment and planning for remediation of contaminated sites, including risk assessment, priority setting, management of hazardous wastes and characterization.
Engineering Design Specialist (Remediation works)	Graduate/Post Graduate in Environmental / Civil/Chemical Engineering / relevant discipline	At least 5 years' experience in designing remediation works including. Experience in designing landfills, extraction wells, impermeable barriers, liners, capping etc.
Social Development expert	Master Degree in Social Sciences / Sociology / Planning	At least 3 years' experience in social development sector and social impacts

In addition to these positions other specialists may be required, for example a geohydrological expert or a field work supervisor.

In addition to these generic capacity requirements, the effective performance of every activity in the site assessment and remediation process requires specific capacities. It should be noted that these requirements do not need to be united within a single person, but the Advisor's team as a whole should possess them all. It should also be noted that situations can arise for which commissioning of external expertise may be necessary. In particularly complicated situations it may be considered to compose a special team dedicated to dealing with that situation.

The requirements for effective performance of the Advisor's activities are presented below:

- Expertise:
  - Environmental fate, transport and degradation characteristics of contaminants (e.g. mobility, biodegradability) (for Steps 2, 5, 6, 8, 10 and 11);
  - Risk assessment (for Step 5);
  - Remediation and post-remediation techniques and their physical, chemical, hydrological and social impacts (for Step 5, 6, 8, 10 and 11);
  - Spatial planning, for effective interpretation of the intended future site use (for Steps 5 and 6);
  - Local legal and environmental requirements (For Steps 2, 5, 6, 8, 10 and 11);
  - The NPRPS framework and the State and local environmental policy (for Steps 5, 6, 8, 10 and 11);
  - Staff and equipment costing (for Steps 6 and 10).
- Experience with:
  - Assessment and remediation at other sites in comparable situations, for an effective establishment of realistic remediation objectives (for Steps 5, 6 and 10);
  - Interaction with Authorities and communication with stakeholders on conditions for remediation at the site (for Steps 6 and 10);
  - The selection of a remediation option, as this is a delicate balance of multiple aspects like site use and site use restrictions, risks and costs, which may have a long lasting impact on the community and individual stakeholders (for Steps 5, 6 and 10);
  - Translation of remediation measures as described in the DPR into detailed practical solutions for the technical activities (for Step 6);
  - Translation of information on the technical system into conclusions on the required permits, licenses and consents (for Steps 6 and 10);
  - Costing and planning of remediation and post remediation measures, also in the specific regional or local situation, to reach a realistic budget (for Steps 6 and 10);
  - Verification and reporting of remediation and post remediation activities (Steps 8 and 11);
  - Processing of procurement procedures and development of bid documents (for Steps 8 and 10);

- Skills:

- ◦ Ability to interpret topographical and geological maps and to interpret information of history of sites to indicate potential sources of contamination (Steps 2 and 5);
- ◦ Ability to balance technical, regulatory, financial and community requirements (for Step 5);
- ◦ Ability to include knowledge of regional and local regulations (for Steps 6 and 10);
- ◦ Ability to cooperate with the involved stakeholders: site owner, competent authorities, remediation contractor or with other roles (for Step 8);
- ◦ Ability to take decisions when the implementation of the remediation deviates from the plan (for Step 8).

To further illustrate the capabilities needed Annexure 1 presents elements that Terms of Reference for site assessment activities will typically include.

3.2.2 Equipment
The Guidance Document (Task-4 report of this Assignment, December 2015) provides relevant checklists and tools such as manuals and models for site assessment, risk assessment and development of remediation option.
Equipment for registration and monitoring and post remediation activities typically includes data loggers, automated samplers, instrument and reading panel for controlling a pump and treat system.
Regular hardware and relevant software are required for reporting, calculations and modelling.

3.2.3 Materials
No specific materials are required.

3.3 Site investigator
3.3.1 Human resources
The expertise, experience and skills required for fieldwork teams of site investigators are comprehensively described in Dutch protocols and are accepted in many countries worldwide. We have evaluated these against expert judgement.

As stated in Section 2.4.2, the fieldwork team of a site investigator is involved in the steps of the assessment and remediation process where retrieving site information is essential to evaluate the characteristics of the site and confirm the presence or absence of contaminated material. Table 3.2 presents the generic human resources required for an effective performance of these activities at a relatively complex contaminated site. The table is organised around a typical team composition for such a site. It should be noted here that team composition as well as required standards vary, depending on the specific situation at the site at hand.

Table 3.2 Generic human resources required for effective performance by Site Investigator at a relatively complex contaminated site

Key Position	Required expertise	Required experience
Team Leader	Intermediate technical and vocational education and training in Environmental / Civil/Chemical Engineering or other relevant discipline.	Minimum 2 years' experience in fieldwork on contaminated sites and waste characterization. Knowledge of fieldwork protocols/manuals and safety measures.
Member of fieldwork team	Training in fieldwork.	At least 2 months experience in fieldwork on contaminated sites and waste characterization.

In addition to these positions, other supporting staff may be required, for example for logistical aspects.

In addition to these generic capacity requirements, the effective performance of every activity in the site assessment and remediation process requires specific capacities. It should be noted that these requirements do not need to be united within a single person, but the Site investigator as a whole should possess them all. The requirements for effective performance of the Site investigator/Fieldwork's activities are presented below. These requirements are relevant for Steps 2, 5, 8 and 11.

- Expertise:
  - Knowledge of fieldwork manuals;
  - Knowledge of (mechanical) equipment;
- Experience with:
  - Application of strategies for fieldwork during site assessment and verification of remediation and post remediation activities;
  - Use of mechanical equipment and hand-operated equipment;
- Skills:
  - Ability to communicate with Advisor and ability to take decisions in the field when effective implementation of a fieldwork strategy may necessitate deviation from the plan;
  - Ability to register and report results of fieldwork;
  - Ability to communicate with local population and owners and inhabitants.

3.3.2 Equipment

Fieldwork equipment typically includes tools for drilling, site localization, sampling, monitoring, sample transport and for processing results. The Guidance Document (Task-4 report) goes into more detail, particularly in the Site Inspection Protocol, and in Volume III-2.2-ii.

In the lists below numbers are per field team, unless otherwise indicated.

General equipment (all fieldwork):

- 1 pH and EC monitoring tool and thermometer;
- 1 Groundwater table measuring tool;
- 1 Tape-measure, 25 or 50 meters in length;

- 1 Motorized or hand-operated equipment to transport samples and equipment;
- 1 Site localization equipment: maps, GPS, compass, land surveying equipment;
- (# as required to obtain sufficient capacity for expected number of samples) Cooler or refrigerator for storing samples during transport;
- 1 Mallet, 1 Graver, 1 Spatula and 1 Drill stool of 0,75 meters in height;
- 1 (per person) bucket and clean brush;
- 1 broom;
- 1 water tank or cans of at least 120 liters, filled with clean water;
- (# as required) soap and paper towels;
- 1 Wheelbarrow;
- 1 Sand ruler;
- 1 Levelling instrument;
- 1 Oil-water observation tool;
- 1 Photo camera;
- 1 Guidelines for fieldwork;
- 1 Reference material for soil profile description;
- 1 Description of soil investigation strategy for the specific site.

Hand-operated equipment (all fieldwork):
- Scoops, blackhoes, spoons and shovels;
- 1 (per drilling person) Augers with different diameters:
  - 1 hand auger, diameter 6 (or 7) and 1 of 10 cm;
  - 1 riverside auger, diameter 7 and 1 of 10 cm;
  - 1 gouge, diameter 3 cm, length 1 meter;
  - 1 tube auger of 1 or 2 meters in length;
  - 10 extension rods of 1 meter in length;
  - PVC screw thread drilling casings;
  - 1 Core sampling apparatus.
- (# as required) Tubes/gouges;
- (# per sample to be taken with this equipment) Thin-walled core samplers;
- 1 Hand pulse.

Power driven drill techniques (only if explicitly required):
- 1 Screw drilling system: hollow auger drill or auger drill;
- 1 Displacement drilling system;
- 1 Cased auger/pulse drill.

Equipment for installing monitoring wells (only if wells are to be installed):
- 1 set of PVC pliers;
- (as required) Monitoring well material.

Groundwater sampling collection tools (only if groundwater samples are to be collected):
- 1 Suction lift pump with fuel or battery charger as required;
- 1 Pressure pump with fuel or battery charger as required;
- 1 Bailer sampler;
- (length as required per sample) Sampling tube and Silicon tube;

- 1 (per sample that needs to be filtered) Filters (0,45 µm) for groundwater sampling.

Sediment sampling collection tools (only if sediment samples are to be collected):
- 1 Piston drill;
- 1 Sediment auger;
- 1 Grabber.

Basic personal safety equipment includes (all fieldwork):
- 1 set (per person) Boots or closed shoes;
- 1 set (per person) Protective clothing;
- 1 (per person) Dust or gas mask with filters as required;
- 1 set (per person) Goggles or safety glasses;
- 1 set (per person) Working gloves;
- (# of sets as required) Gloves for touching or sampling of any material;
- 1 PID-measuring instrument with calibration set;
- 1 Air sampler with glass tubes as required (benzene, toluene, mercury, TPH);
- 1 kit First aid material;
- 1 Fire extinguisher;
- 1 Rotating beacon.

Registration tools:
- The characteristics of the site and the samples taken need to be registered in the field. A hand held computer with specific software may be used for this purpose. Registration on paper is possible as well, the results may then be recorded in the office later. Careful registration of drilling and sampling by unique codes is essential to prevent mistakes in the interpretation of the fieldwork and laboratory results.

3.3.3 Materials
Fieldwork materials typically include HDPE (High Density PolyEthylene) or PE (PolyEthylene) foils for laying out soil or sediment samples (about 1 m2 per 3 m drilling depth), groundwater sampling tubes (as required), filter gravel (as expected to be required), sample containers (number of intended samples, plus doubles and some for buffer) and bentonite for sealing perforated impermeable layers during drilling (as expected to be required). The sample containers may be provided and prepared by the testing laboratory and should, if necessary, come properly prepared with reactive fluids. Materials for labelling of samples and registration of sample codes are required (e.g. stickers, preferably with unique bar codes).

3.4 Laboratory
3.4.1 Introduction
The quality of laboratory work depends on the quality of the staff, availability of test and calibration methods and method validation, sampling and reporting procedures and equipment.

In India, accreditation schemes have been implemented for a great number of laboratory activities. It may be anticipated that in future similar schemes will be implemented for field work and for chemical testing of soil, sediment and groundwater samples.

The Government of India has authorized NABL as the accreditation body for testing and calibration laboratories. The laboratory testing of samples from contaminated sites should be carried out by laboratories working under internationally recognized accreditation standards. The NABL states that the laboratory accreditation services to testing and calibration laboratories are provided in accordance with ISO/IEC 17025: 2005 'General Requirements for the Competence of Testing and Calibration Laboratories'.

The criteria for standard laboratories for sectors relevant for contaminated sites can be found in the following links:
- NABL General information brochure, NABL-100 document;
- NABL specific guidelines for chemical testing laboratories, NABL-103 document.

The number of different contaminants in existence is theoretically without bounds. International best practice is that most laboratories are able to test on a limited number of contaminants, i.e. the most commonly found ones. Table 2.2 presents the contaminants most commonly encountered on contaminated sites, based on the provisional version of the database of contaminated sites available at the time of writing of this report. It is therefore recommended to initially aim capacity building in most laboratories at acquiring the capacities required to perform tests on soil, sediment and groundwater samples on the contaminants listed in table 2.2. A limited number of laboratories may then be assigned to perform the tests on the less commonly encountered contaminants, i.e. the remaining contaminants for which screening and response levels have been developed.

3.4.2 Human resources

As stated in Section 2.4.3, the laboratory team of a site investigator is involved in the Steps of the assessment and remediation process where retrieving information from samples of soil, groundwater, sediment or surface water is essential to confirm the presence or absence of contaminated material. Table 3.3 presents the generic human resources required for an effective performance of these activities. The information in table 3.3 is based on the requirements recorded in the NABL-103 document.

Table 3.3 Generic human resources required for effective performance by Laboratory staff

Key Position	Required expertise	Required experience
Head of chemical testing laboratory	Post graduate in chemistry or Bachelor degree in chemical engineering / technology or equivalent with adequate experience.	Adequate experience in the relevant area especially in the analysis of testing of relevant products.
Technical staff	Graduate in Science with chemistry or Diploma in chemical engineering / technology or equivalent	The staff shall have sufficient training and exposure in analytical chemistry and in analysis and testing of appropriate products.
Laboratory technicians	Higher secondary certificate in science / ITI	At least one year experience or training in a relevant laboratory
Authorized Signatory	Graduate in Science with chemistry as one of the subjects / Diploma in Chemical engineering / technology or equivalent from a recognized university or Post-graduate in chemistry / specialization in relevant subject / Degree in Chemical engineering / technology or equivalent from a recognized university	At least 5 years' experience in relevant field, At least 2 years' experience in relevant field

For more details on the relevant expertise, experience and skills we refer to the ISO/IEC 17025-standard. That document also emphasizes the necessity for regular training.

3.4.3 Equipment and materials

The equipment for laboratory work depends on the requirements in the NABL-guidelines. The following types of equipment are described in the NABL-103 document:

- Measuring instruments, e.g. spectrometers, chromatographs, hydrometers, thermometers, and balances;
- Volumetric equipment, e.g. flasks and pipettes;
- Physical standards e.g. weights and reference thermometers;
- General service equipment, e.g. hotplates, stirrers, and ventilation system.

The most notable materials a laboratory will typically use are chemical reagents. Besides that they will use things like filters.
For more information on the accreditation of laboratories please refer to the Guidance document (December 2015, Volume II-2.1-a, page 3).

3.5 Remediation Contractor

3.5.1 Human resources

The expertise, experience and skills required for remediation contractor are comprehensively described in Dutch protocols and are accepted in many countries worldwide. We have evaluated these against expert judgement.

As stated in Section 2.4.4, the Remediation Contractor is involved in Steps 8 and 11, where the implementation of remediation and post remediation activities takes place. Table 3.4 presents the generic human resources required for an effective performance of these activities at a relatively complex contaminated site, including social issues. The table is organised around a typical team composition for such a site. It should be noted here that team composition, as well as required standards vary, depending on the specific situation at the site at hand. It is of particular note that the requirements for human resources, equipment and materials for a remediation by excavation are quite different from a remediation using in-situ techniques.

Table 3.4 Generic human resources required for effective performance by Remediation Contractor at a relatively complex contaminated site

Key Position	Required expertise	Required experience
Team leader / project manager / planner	Intermediate technical and vocational education and training in Civil Engineering or other relevant discipline. For in-situ remediation a graduate level is preferred	Minimum 2 years' experience in preparation of relevant projects. Knowledge of remediation techniques and safety measures.
Remediation technicians	Intermediate technical and vocational education and training in Civil Engineering or other relevant discipline. For in-situ remediation a graduate level is preferred	Minimum 2 years' experience in preparation of relevant projects. Knowledge of remediation techniques and safety measures.
Engine drivers	Training engine driver.	Minimum 1 year experience in soil excavation.

In addition to these positions, other supporting staff may be required, for instance for logistical aspects. For certain parts of the remediation works subcontractors may be involved, either to provide extra capacity or a specialised service like a specific technique to drill wells.

In addition to these generic capacity requirements, the effective performance of every activity in the site assessment and remediation process requires specific capacities. It should be noted that these requirements do not need to be united within a single person, but the Remediation Contractor's team as a whole should possess them all. The requirements for effective performance of the Remediation contractor's activities are presented below. These requirements are relevant for Steps 8 and 11.

- Expertise:
  - Knowledge of remediation techniques related to the characteristics of the contaminated material;
  - Knowledge of architectural and civil engineering aspects related to reconstruction of buildings and infrastructure;
  - Knowledge of the applied equipment, in particular the mechanical equipment;
- Experience with:
  - Interpretation of results of detailed site assessment reports;
  - Application of strategies for remediation;
  - Use of mechanical equipment and hand-operated equipment;
  - Procurement procedures.
- Skills:
  - Contractor's project manager: able to manage the team, including any subcontractors, at the site. This includes well developed skills in planning, both of time and financial means;
  - Ability to communicate with Authorities and Advisor and ability to take decisions in the field when effective implementation of a remediation strategy may necessitate deviation from the plan;
  - Ability to log and report results of the remediation on a day-to-day basis;
  - Ability to communicate with local population, owners and inhabitants.

3.5.2 Equipment

The variety of equipment for remediation is very large and depends on the characteristics of the site, the selected remediation option and the specific equipment available for the Remediation Contractor. Volume III-5.4-i of the Guidance document provides comprehensive information about remediation techniques and the equipment these require.

Equipment for the implementation of a site remediation typically includes tools for digging, excavation, extraction of groundwater, staff safety and soil transport. A decontamination unit is required to prevent contaminated material from being emitted outside the boundaries of the site.
Equipment for the implementation of an in situ remediation includes for example pumping systems, instruments for monitoring, e.g. measurement instruments or monitoring wells, and units for treatment of groundwater or air.

3.5.3 Materials

Materials for the implementation of a site remediation typically include sheet piles, foils to cover piles of contaminated excavated material, water to prevent emission of dust, active carbon for pump and treat systems, nutrients for in situ enhancing of natural degradation of hydrocarbon and different materials for the implementation of on-site staff health and safety measures.

3.6 Authorities

The expertise, experience and skills required for the Authorities in their programming role and in their remediation implementation role are comprehensively described in Dutch guidelines. These have been evaluated against the Task 4 report of Assignment 3 (December 2015) and expert judgement.

As stated in Sections 2.4.5 and 2.4.6 the Authorities are involved in the Programme management at a programme level as well as in Site remediation management at site level. Table 3.5 presents the generic human resources required for an effective performance of these activities as far as these are related to the technical aspects.
In case an authority also takes on another role see the relevant section for the human resources, equipment and materials for effective performance of that role. For example, if an authority operates its own laboratory, it may need the resources listed in Section 3.4.

Table 3.4 Generic human resources required for effective performance by Authorities at a relatively complex contaminated site, related to the technical aspects.

Key Position*	Required expertise	Required experience
Hazardous waste expert	Post graduate in environmental science or engineering, chemical engineering, environmental chemistry.	Minimum 2 years' experience in hazardous waste and associated industrial processes and environmental issues.
Investigation expert	Post graduate in environmental science or engineering, chemical engineering, environmental chemistry.	Minimum 2 years' experience in application or review of site assessment.
Risk expert	Post graduate in hydro-geology, environment toxicology.	Minimum 2 years' experience in development or review of risk assessment.
Remediation techniques expert	Post graduate in civil engineering, environmental engineering, chemical engineering, micro-biology with specialisation in remediation.	Minimum 2 years' experience in development or review of remediation works.

* Some of the key positions may be combined by a single expert.

In addition to these positions other staff is required:
- Social expert;
- Financial expert;
- Legal expert;
- Database expert;
- Supporting staff, e.g. for support during site visits or support on the administrative processes.

In addition to these generic capacity requirements, the effective performance of every activity in the site assessment and remediation process requires specific capacities. It should be noted that these requirements do not need to be united within a single person, but the Authority team as a whole should possess them all. The Authority may consider hiring consulting experts, perhaps temporarily, to fulfil this capacity requirement. The requirements for effective performance of the Authorities' activities are presented below:

- Expertise in:
  - Environmental fate, transport and degradation characteristics of contaminants (e.g. mobility, biodegradability) (for Steps 2, 5, 6, 8, 10 and 11);
  - Remediation and post-remediation techniques and their physical, chemical, hydrological and social impacts (for Steps 5, 6, 8, 10 and 11);
  - Spatial planning, for effective interpretation of the intended future site use (for Steps 5, 6, 11 and 14);
  - Local legal and environmental requirements (for Steps 2, 5, 6, 8, 10 and 11);
  - The NPRPS framework and the state and local environmental policy (for all Steps);
- Experience with:
  - Studies on hazardous waste and associated industrial processes and environmental fate, transport, degradation characteristics of hazardous substances and its impact on human health and environment (for Steps 1, 2, 3, 4 and 5);
  - Desk study and interpretation of topographic and geological maps and reports on contaminated sites (for Steps 1, 2 and 5);
  - Evaluation of conceptual site models and risk assessments – Human Health Risk Assessment and Ecological Risk Assessment, using both qualitative and quantitative approaches (for Steps 2, 5 8, 9, 10 and 11);
  - Evaluation of remediation techniques, associated impacts (physical, hydrological and social) and development of remediation cost estimates, for an effective establishment of realistic remediation objectives (for Steps 5, 6 and 10);
  - Interpretation of results of remediation investigation reports, remediation verification reports and post remediation status reports (for Steps 9 and 11);
  - Interpretation of how remediation costs are related to performed remediation or site reconstruction activities (for Steps 7 and 12);
  - Communication with stakeholders on conditions for remediation at the site (for Steps 5, 6 and 10);
  - The selection of a remediation option, as this is a delicate balance of multiple aspects like site use and site use restrictions, risks and costs, which may have a long lasting impact on the community and individual stakeholders (for Steps 5, 6 and 10);
  - Applicability of required permits, licenses and consents for specific remediation measures (for Steps 6 and 10);
  - Procurement procedures (for Steps 8 and 11).
- Skills:
  - Ability to interpret information and reports (for all Steps);
  - Ability to interpret technical information and relate this properly to legal, financial and institutional consequences (for all Steps);
  - Ability to summarize and report information and to prepare a memo in preparation of a regulatory decision (for all Steps);
  - Ability to cooperate with the involved stakeholders: site owner, inhabitants and neighbours, local authorities, Consultant, Site investigator, Remediation contractor or with other roles (for Steps 2, 5, 7, 8, 9, 11, 12, 14);
  - Ability to organize and provide clear orders to Advisors, Site investigators and Remediation contractors (for steps 2, 5, 6, 8, 10 and 11).

- ◦ Ability to take decisions when the implementation of the intended assessment or remediation activities deviates from the plan (for Steps, 2, 5, 8 and 11).

Quantification of capacity requirements at central level
Data on the capacities required to start implementation of a national programme for remediation of polluted sites are limited. In table 3.5 below, an estimate is presented of the capacity with which the central Dutch authorities started up the national programme and managed it during the early years. This estimate could be a useful first approximation of what may be required for a new authority.

Table 3.5 Estimated capacity of Dutch central authority in early years of national programme for remediation of polluted sites

Staff type	**Capacity (in fte.)**
Site assessment and remediation	
Financial expertise	8
Legal expertise	8
Technical expertise	4
Policy developers	6
Prevention of contamination	20
Support and administrative staff	10

In general, specific equipment or materials are not required for most activities in these roles.

3.7 Quality assurance and quality control

3.7.1 International best practices
There are many angles from which one can discuss the issue of quality assurance and quality control. This Section explores international best practices in structures that have been developed at a national level to support quality assurance and control. Briefly evaluated below are best practices from Australia, Belgium (Flanders Region), the European Nordic and Baltic countries and the Netherlands. For every practice, a brief conclusion is presented on the capacities required.

Belgium, Flanders Region - licensed Soil remediation experts
In the Flanders Region, comprising the northern part of Belgium, the implementation of certain defined activities related to site assessment and remediation is restricted to licensed consultants. The licensing itself is the exclusive domain of OVAM, part of the central (Flemish) authorities. This structure applies to most types of site assessment and site remediation. The licenses can be issued to individuals or to companies. In either case the licensed person or company is termed a soil remediation expert. Two levels of expertise are distinguished. A level 1 soil remediation expert must have an employee with an academic degree in a study that includes chemistry, geology and soil science and a relevant expertise of at least 3 years. A level 2 expert must have, in addition to the above, employees with academic degrees in studies that include biology, microbiology, civil engineering and soil mechanics and a relevant expertise of at least

5 years. In addition to these requirements, the licensee must have at one's disposal knowledge on the relevant local regulatory framework. As an additional feature key reports have to be authorised by OVAM.
Candidate companies or individuals are assessed by OVAM upon applying for a license. This means that this concept requires a significant minimum capacity on the Authority's side for the handling of the applications for licenses.

Australia – EPA appointed environmental auditors
In Australia the market of site assessment and remediation is, in principle, open to everyone. However, in certain situations site assessments may be subject to an environmental audit , which needs to be performed by an EPA appointed environmental auditor. In case a preliminary or detailed site assessment indicates contamination beyond the site boundary or above certain concentration levels such an audit is a statutory requirement.
The auditing system is managed by the state level Environmental Protection Agencies (EPA). It is this public institution that appoints environmental auditors and regulates their conduct through a quality assurance programme, based on EPA guidelines.
This practice does require a fairly significant minimum capacity on the Authority's side for the handling of the applications for licenses and the monitoring of the auditor's performance. However, this practice has proven to assure the quality of cases of site assessment and remediation, particularly complicated ones. It has been noted that the financing parties tend to experience extra cost, in cases where an environmental audit is performed.

Nordic and Baltic countries - Nordtest
Nordtest is a trademark of conformity assessment. The emphasis of Nordtest is to develop, promote and innovate Nordic test methods and pre-normative activity. Nordtest endeavours to remove technical barriers to trade and promotes the concept 'Approved once, accepted everywhere'. Following this quote from the Nordtest website (nordtest.info) the Nordic and Baltic countries are developing a quality assurance and control structure, based on the certification or accreditation of individuals. This concept requires a comprehensive structure of education and centrally organized exams.

The Netherlands – licensed soil intermediairies
The quality assurance and control structure in the Netherlands is an integrated one, in which both public and private parties have key roles. The basis of the structure is that private enterprise must have a license to carry out certain defined activities that are deemed critical. This applies to fieldwork for site characterisation, sampling of soil depots, laboratory testing, soil and groundwater remediation and its supervision, and handling of soil material. For each of these activities, criteria have been summarized in protocols, each embedded in either an accreditation scheme (laboratories) or a certification scheme (most others). The license however, is a public document, issued by a ministerial agency called Soil+. A license is issued at company level when the company meets the criteria, both for integrity as well as for technical content. For the technical aspect the decision to issue a license is based on whether the applying company holds a privately issued accreditation (laboratories) or certificate (most others).

In this practice, day to day compliance monitoring work is performed by private parties: certifying bodies, which are private companies, perform initial and periodical auditing, and issue and manage certificates. Because of this, the required capacities with the authorities are relatively limited. On the other hand, a public-private organisation managing the criteria against which companies are accredited or certified, is needed. The fact that privately maintained quality criteria are embedded in public regulation presents the regulators with instruments for control, i.e. a public register of licensed companies and enforcement on a meta level.

3.7.2 Conclusions and recommendations for India

The best practices described in the previous Section have been developed over a number of decades and are in fact suitable for well-developed sectors. It is therefore recommended that these best practices be considered once the site assessment and remediation sector in India has been given ample opportunity to establish itself.

The best assurance of quality is control, which can in day to day practice translate into any structure including periodic monitoring of work performance. During the initial stages of development of the sector, it may well be sufficient to set up a basic quality control structure in which a number of shortlisted independent experts are assigned with reviewing roles. This would involve the design of such a basic structure and the appointment of these experts. Initially, the structure could be limited to fieldwork and laboratory testing. These carry the highest priority, as sampling and testing yield the data that will serve as the basis for the activities of all stakeholders. Subsequently, the structure could be expanded to include remediation, i.e. the activities of the remediation contractor and the remediation supervisor, and consultancy respectively. Separate from this structure for quality assurance and quality control of the projects, an associated structure could be aimed at the programming aspects.

The structure for quality assurance and quality control can be basic, but should, based on international best practice, include:

- Procurement procedure for short listing of the experts, including clear and unambiguous criteria for short listing and a procedure for periodical review of the experts themselves by an authority, e.g. the RPS Authority. It should be noted that there are no internationally recognized certification agencies for field sampling, as recognition is organized at national or sub-national (regional) level;
- Procedure for review by experts, including list of documents requiring review and technical review criteria. The list of documents to be reviewed should at least include fieldwork plans, site assessment reports and site investigation reports. It is recommended to also include periodical on site review of fieldwork;
- Arrangements to enable the laboratories to expand their internationally accepted accreditation to include the accreditation schemes relevant for the physical and chemical testing of contaminants in soil, groundwater and sediment samples;

- Procedures to ensure harmonized review of essential documents. These procedures can be implemented by mandatory use of the checklists mentioned in the table below, available in the Guidance document (December 2015).

Checklist	**Location in Guidance document (December 2015)**
Review and approval preliminary site investigation report	Volume II-2.2-c
Review and approval Remediation investigation report	Volume II-5.5-c
Review and approval Detailed Project Report	Volume II-7-a
Review and approval Remediation completion	Volume II-9-a
Review and approval Post remediation plan	Volume II-10-b
Review and approval Post remediation status report	Volume II-11-b

4 Methodology for calculation of required capacities

4.1 Introduction and development approach

The methodology and its applicability

This Chapter presents a methodology for the calculation of capacities required, on a programme level, for effective implementation of the site assessment and remediation process. Examples of these capacities are man-hours per involved role, a quantification of required laboratory equipment, in terms of number of samples to be tested, and contractor activities. The aim of the methodology is to facilitate the capacity development as part of the planning and programming of the NPRPS. It should be mentioned at this stage that this methodology is not suitable to perform calculations of remediation costs per individual site, because such calculations are of a different type, requiring site specific data.

Based on these capacities calculated through this methodology it should be possible to develop a training and investment plan. In case the planned capacity building turns out to be not feasible, the methodology can be used to adjust the plans to reach a situation for which the required capacity can realistically be built.

Limitations and potential

At the time of writing this report (December 2015) NPRPS had yet to be implemented. Once the programme is up and running, the methodology presented here can be applied to make calculations of required capacities on a programme level. It would be premature to perform such a calculation at this time, as there would be a fair chance of the results being misappropriated. Instead, Section 4.4 presents an example on how to use the methodology, by performing model calculations using fictitious data. At a later stage, i.e. after NPRPS has been implemented, an estimate of the costs for implementation of NPRPS can be easily calculated at any time by following that example using real data.

International best practices for calculation of required capacities on a programme level from UK, US and NL are evaluated. This evaluation shows that these international best practice capacity calculations are performed for other purposes than capacities required for effective implementation of NPRPS. Examples of these other purposes are a midterm review to optimise an ongoing national remediation programme and an evaluation of numbers of individual sites. Another example is the implementation of a programme for the assessment and remediation of a specific type of contaminated sites. These types of sites, such as petrol stations, do not always fully fit into the India specific typology developed in Task 1 of this Assignment. Also, many international best practices deal with the monitoring and evaluation of the delisting process rather than with the prediction of remediation costs at a national level.

International best practices do offer some key figures for both cost levels and typical quantities. These figures are based on years of hands-on experience, a local remediation policy (remediation objectives), detailed data of listed sites and specific programmes developed for the implementation on specific types of sites (e.g. gasworks, petrol stations, dry cleaners).

Proposed tailor made methodology
The conclusion from the above is that international best practices do not offer a ready to use methodology for calculation of capacities required to effectively implement NPRPS. Therefore, we propose a tailor made methodology for India. Wherever possible, this methodology is based on international best practices and the project team's hands on experience with site assessment and remediation. A subsequent translation to approximate the Indian situation is implemented, taking into account specific elements of the Indian market.

The methodology is developed under the assumption that it must meet the following conditions:

- It should include the costs for the effective implementation of all fourteen Steps of the site assessment and remediation process as described in the Guidance document;
- It should include all types of sites in the Typology developed for NPRPS (Task 1 of this Assignment, May 2013);
- It should anticipate the best practice remediation options (Task 3 of this Assignment, March 2015);
- It should be possible to use the relevant parameters, provided by the database, developed in Assignment 1 and to recalculate after infusion of new data;
- Meet Indian market conditions.

Summary of the Methodology
The first phase of the Methodology, presented in Section 4.2, is for calculation of estimated generic remediation costs. This is done separately for the role of Remediation Contractor (Section 4.2.2) and for all other roles (Section 4.2.1). The calculations for the other roles are based on simple generic assumptions, derived from international best practices, and aimed at the reference site, i.e. not site specific. In the calculations for the role of Remediation Contractor the remediation option is key: data from situations abroad result in a standard unit cost per remediation option, with an option to convert to Indian currency.
In the second phase of the Methodology the generic results from the first phase are specified by applying correction factors for site specific situations, i.e. land use, site size and complexity of the contamination. The Chapter is completed by an example calculation (Section 4.3) and a brief discussion on output and applicability of and limitations to the Methodology.

4.2 Basic calculation of required capacities

The methodology incorporates two methods for cost calculation. One method is for calculation of costs for the role of Remediation Contractor, the other for the costs for all other roles.

The method for a basic calculation of the costs for the roles of Advisor, Site investigator and Authority is discussed in Section 4.2.1. This method is based on a reference contaminated site. We have defined such a virtual reference contaminated site and refer to the text box below for a description. This approach can yield useful generic estimates, because the required capacity for these roles is not primarily related to the size of a site. After the required capacities are calculated for such a reference site corrections are made for a selected number of site specific characteristics (see Section 4.3).

Reference contaminated site

The Reference contaminated site is a fictitious site, based on the average characteristics of all sites in the Assignment 1 database. Working with this site results in a first broad estimate of required capacities. Adjustments to allow for variation in sites are made at a later stage.

The reference contaminated site has the following main characteristics:
- Size (solid): an area of 5.000 to 50.000 m^2, contaminated with hazardous waste with an average thickness of 2,5 metres;
- Size (liquid): an area of 50.000 to 100.000 m^2 of contaminated groundwater (plume, if present) with an average thickness of 5 metres;
- One single type of contaminated site (as defined in the Typology of Task 1);
- Simple use of site;
- Limited number of third parties involved.

The costs for the role of Remediation Contractor will typically make up the largest part of the total costs for site assessment and remediation. They are largely determined by the selected remediation option and the size or volume of the contaminated part of the site. Because of this a useful estimate of these costs cannot be made on a generic level. Therefore, the calculation of the costs for the role of Remediation Contractor merits a separate approach, not related to a reference contaminated site, but rather based on the size or volume of the contaminated part of a site. This method for a basic calculation of the costs for the role of Remediation Contractor is discussed in Section 4.2.2.

4.2.1 Capacity requirements per role, except Remediation contractor

International best practices for every role are evaluated. Subsequently, the required capacities for a reference contaminated site are calculated, based on these best practices. The estimated capacities are those required for the effective implementation of all fourteen Steps in the site assessment and remediation process for such a reference contaminated site.

Based on international best practice in the UK, US and The Netherlands the following elements are used as input for the development of this method for calculation of the required capacities.

Site assessment (roles: Advisor and Site investigator)

A simple way to aid a quick start is to define an assumption as to how costs for site assessment can be expected to be distributed among the different roles involved. Evidently, this distribution will vary, as a result of parameters like the type of contamination, depth of the investigation and the type of site assessment techniques applied (drilling and sampling or a combination with screening techniques). In this model, the cost distribution for site assessment is assumed to be 1/3 for consultancy, 1/3 for fieldwork and 1/3 for laboratory testing. This rule of the thumb, commonly used by soil remediation experts, is typically used in site assessment plans.

Another commonly used simple way of reaching a cost indication is to calculate assessment costs as a percentage of remediation costs. An example of this is the Dutch public study “Annual Monitoring Report Dutch Soil Remediation Programme, 2009”[6]. This study on the progress of the Dutch national soil remediation programme shows that on average the costs for site assessment, including consultancy, fieldwork and laboratory testing, amount to 10 to 20% of the remediation costs. By linking to Section 4.2.2 the costs for site assessment are validated and presented in table 4.1.

Plenty of data are available from studies into funds needed for site investigation and risk assessment phases leading to a regulatory decision as to whether or not the sites meet the legal definition of a site in need of remediation. However, because these legal definitions vary from country to country these data can only be used to get an impression of the funds needed for implementation of this step. For example, in England and Wales during 2000-2007 approximately £30 million was spent on the site investigation and risk assessment phases[7]. While 781 sites were identified as in need of remediation, the number of sites that was identified as not in need of remediation was not reported. From this it can be derived that the cost per site was at most £30 million / 781 = £38,412. Furthermore, it was reported that a sub-set of 144 sites (‘special sites’) inspected by the EA amounted to £4 million, which comes to £4 million / 144 = £27,800 per site.
It should be noted that all these figures do not include the costs for the roles of Authorities. Also, these figures reflect a particular exposure scenario, i.e. dwellings built directly on land contaminated by previous land-use or in close proximity to old landfills, and cover a subtype specific remediation option meeting the UK standards. These tasks are carried out after the formal identification of a site as ‘contaminated land’, either under a notice or voluntarily by the ‘appropriate person’ as a precursor to the implementation of ‘remediation treatment actions’. In view of these limitations we would recommend to limit the use of these figures in validation of the methodology.

The Dutch organization of cooperating provinces (IPO) developed a reference list with standard costs for preliminary site assessment, site delineation and remediation. Average costs for these three steps together may vary as follows (cost level 2005):

- Site delineation: € 6,500 for a small site with fuel storage tanks to € 50,000 for an industrial site with gas works;
- Site remediation: € 120,000 for a small site with fuel storage tanks to € 1,900,000 for an industrial site featuring a chemical plant.

[6] RIVM, 2010
[7] UK Environment Agency report on the 2011/12 contaminated land grant programme

The limitation to these figures is that they have been based on a typology of sites different from the typology developed for India in Task 1 of this Assignment. In view of this limitation we would recommend to limit the use of these figures in validation of the methodology.

Laboratory testing (role: Laboratory)
Plenty of international data are available on the costs of laboratory testing of samples from soil, groundwater, sediment, waste etc. The costs for the most commonly applied tests in the UK and the Netherlands are evaluated by combining the costs per test with the number of tests performed.
Data on the cost of testing of samples mentioned above in Indian laboratories are limited. However, the data from the UK and the Netherlands could be validated to some degree against cost levels for related tests in Indian laboratories, available on internet sites, e.g.:

- http://uppcb.com/sampling_charges.htm
- http://www.ppcb.gov.in/sample_collection_charges.php
- http://www.tnpcb.gov.in/enforcement.asp?src=analytical.html.

Authorities tasks (role: Programme Management Authority)
The Dutch study “Annual Monitoring Report Dutch Soil Remediation Programme, 2009”[8] shows that on average the costs for effective implementation of the Authority’s tasks amount to 0.67% of the remediation costs. Interviews with public soil remediation officers confirm this ratio.

Table 4.1 specifies the estimated capacities required per role for an effective implementation of the site assessment and remediation process. These capacities are expressed in number of hours or, where applicable, number of samples to be tested. It should be stressed that the numbers in this table apply to a fictitious Reference contaminated site and that these numbers serve as a basis for the calculation of the total required capacities for effective implementation of NPRPS. The numbers should therefore not be used for the calculation of costs for any specific existing site.
Also, the table shows an example in which sampling and ex situ testing of samples was selected as site investigation method. It should be noted that the hours indicated include hours by technical staff only; they do not include hours by supporting staff, whether technical (e.g. IT) or other (e.g. administrative), nor hours needed to meet administrative requirements.

To reach a first basis for the calculation of the required capacities for effective implementation of NPRPS, the numbers in this table are translated into a cost estimate for a Reference contaminated site in Indian Rupees.

The unit costs for Advisor, Programme management Authority and Site related programme implementation Authority represent a regular cost level. For this an assumption is made as to the average hourly rate. The unit costs for Site investigation and Laboratory are translated into all-in prices, related to the number of samples.

[8] RIVM, 2010

Table 4.1 Average required capacities for effective handling of a reference contaminated site, related to the technical aspects of the site assessment and remediation process

Steps in the site assessment and remediation process		**Average required capacities**					
		Advisor charges	**Site investigator**	**Laboratory**	**Remediation contractor**	**Programme management Authority**	**Site related programme implementation Authority**
		hours	**samples**	**samples**	**-**	**hours**	**hours**
1	Identification of probably contaminated sites					8	
2	Preliminary investigation	60	40	40		2	16
3	Notification of polluted site					4	
4	Priority list addition					4	
5	Remediation investigation	440	80	80		10	90
6	Remediation design, DPR	120	30	30		2	12
7	DPR approval and funding					2	8
8	Implementation of remediation	120			#	2	48
	8.3 Execution, supervision and verification of remediation works	#	#	#			
9	Approval of remediation completion					2	40
10	Post remediation Plan	60				2	16
11	Post remediation Action	#	#	#	#	2	20
12	Cost recovery					12	
13	Priority list deletion					4	
14	Site reuse					4	
	Total required capacities	800	150	150	#	90	250
		INR*1,000	**INR*1,000**	**INR*1,000**		**INR*1,000**	**INR*1,000**
	Average standard all-in unit costs	2.2	25	17		2.2	2.2
	Total costs	1,760	3,750	2,550		132	550
						hours	
	Project management, if applicable					300	

Please note: hours refer to hours by technical experts only, and do not include hours by supporting staff, whether technical (e.g. IT) or other, (e.g. administrative), nor for meeting administrative requirements
#: Re. Section 4.2.2

Table 4.1 is based on an estimate of average required capacities for effective handling of a Reference contaminated site. In practice, the required capacities will always be different for any given site. In many cases it will even happen that there are no capacities required for Step 7 and onwards. This will be the case for sites where the preliminary site investigation (Step 2), or the risk analysis (part of Step 5), shows that there are no or very limited risks, and that therefore no further action is required.

In addition to an estimate of the required capacities, table 4.1 shows the distribution of the required capacities per role over the fourteen Steps of the site assessment and remediation process. For example: in a situation where the Site related programme implementation Authority has budgeted 250 hours, they may expect to spend most of these hours on the monitoring of the implementation of the remediation and its approval (Steps 8 and 9) and, if applicable, the post remediation action (Step 11). Likewise, in a situation where the Advisor has budgeted 800 hours, to be distributed over all their Steps, they may typically expect to spend most of his time on Remediation investigation (Step 5) and less on the Remediation design (DPR, Step 6) and additional consulting during implementation (Step 8) of the remediation plan.

4.2.2 Capacity requirements for the role of Remediation contractor

The previous Section provided generic estimates for the capacity required for effective handling of a Reference contaminated site. These estimates were provided for all roles, with the exception of the role of Remediation Contractor. The reason for this is that generic estimates are not suitable to determine the capacities required by the Remediation Contractor. This in turn is because the selected remediation option is too influential a factor. Also, data on contractor remediation costs are available, enabling relatively accurate calculation. Because of this, the costs for the Remediation Contractor merit a separate discussion, which is provided in this Section.

The variable of the selected remediation option

In the previous Section capacities required to effectively deal with a Reference contaminated site were estimated. While this is needed to get a first impression of required capacities, it does no justice to the wide variety in conditions at contaminated sites throughout India. Therefore, this Section presents a first step towards taking this variety into account. This is done by discussing the major variable, the remediation option to be applied. An important discussion at this point, as it will yield the basis for estimating the costs for the role of the Remediation Contractor.

The remediation options and associated required investments vary widely, along with the variety in conditions at the contaminated sites. This Section presents the best practice remediation options per type of site as defined in the Typology from Task 1 of this Assignment. Table 4.2 shows three remediation options per type of site. These options are based on the principle that in any situation remediation options may vary from a maximum, upper limit, to a minimum, lower limit, investment. In between many other options can be considered. From these, table 4.2 shows a best practice option. The three generic options can be characterized as follows:

- Maximum remediation option: for most types of sites this option will result in a full removal of all contaminants to a natural background level. After remediation any use of the site is possible. In some cases this option should be regarded as a theoretical option. This option will yield the upper limit of remediation costs for a contaminated site;
- Minimum remediation option: this is an option which is typically relatively easy to implement with low costs. It should be noted that, for most types of

sites, this option will result in a long period of extensive remediation and post-remediation activities, higher levels of contaminant concentrations at remediation closure, low site use flexibility or minimum removal of contaminants. This option will yield the lower limit of remediation costs for a contaminated site;

- Best practice remediation option: this is considered to be the most likely technical choice to consider in the process of remediation options appraisal and selection and remediation design. The selection of this option is based on the Menu of options, as developed in Task 3 of this Assignment. This option will yield the most likely remediation costs for a contaminated site.

Table 4.2 Maximum, best practice and minimum remediation options for all types of sites identified in the Typology

Type	**Description or activity**	**Typical field characteristics of the site / examples**	**Remediation options**		
			Maximum remediation option	**Best Practice remediation option**	**Minimum remediation option**
S-1	Solid phase contamination (land bound site)				
S1-a	Mixing the soil with contaminated material or materials containing contamination, not including agricultural activities.	Well defined body below surface level defined by boundaries of soil where soil is mixed with contaminants.	C**omplete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – covering with clean soil after contaminated top soil and leaching hotspot removal. Post remediation measures.	Function oriented – **covering** with **less contaminated soil** without any removal of contaminated soil. Post remediation measures.
S1-b	Embankment, filling of pits or depressions, filling of surface waters with contaminated material or materials containing contamination.	Well defined body of non-mixed contaminants . E.g. storage of tailings.	C**omplete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – covering with clean soil after contaminated top soil and leaching hotspot removal. Post remediation measures.	Function oriented – **covering** with **less contaminated soil** without any removal of contaminated soil. Post remediation measures.
S1-c	(Bulk) storage of contaminated material or materials containing contamination. (Industrial) activities in which contaminated solids are used. 'Leftovers' of incineration and burning of material.	Irregular shaped layer of contaminated material, recognizable as such. The shape of the contaminated site is related to the activity leading to the contamination	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – covering with clean soil after contaminated top soil and leaching hotspot removal. Post remediation measures.	Function oriented – **covering** with **less contaminated soil** without any removal of contaminated soil. Post remediation measures.
S1-d	Adding material containing contamination through agricultural activities (e.g. pesticides,	Agricultural site bound contaminations found up to a depth to which the soil is treated by	C**omplete removal** by excavation and treatment/storage	MF – **complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **in situ** restauration. Long term site use restrictions

Type	Description or activity	Typical field characteristics of the site / examples	Remediation options		
			Maximum remediation option	**Best Practice remediation option**	**Minimum remediation option**
	fertilizers or additives to animal feed).	ploughs and other agricultural tools.	of all contaminated soil		
S1-e	Atmospheric deposition (roads, railway, industries) of emissions or wind-blown dust.	Thin layered contaminations found over large areas with the highest concentrations close to the source following the prevailing wind direction.	**Complete removal** by excavation and treatment/storage of all contaminated soil	MF – **complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **in situ** restauration. Long term site use restrictions
S1-f	Deposition by flooding or washing.	Contaminations found in areas flooded by water systems or in downstream areas of flooding areas. The shape of the contaminated site is determined by the flooding of flow of a water system.	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **covering** with **clean sediment** after contaminated **top layer removal**. Post remediation measures.	Function oriented – **in situ** restauration. Long term site use restictions
S-2	Solid phase contaminations (water bound site)				
S-2	Contaminated open water sediments.	Solid phase contaminants sedimented from surface water. The shape of the contaminates site corresponds to the shape of the water system itself. Contaminants may be bound to clay or organic compounds of sediments.	**Complete removal** by dredging and treatment/storage of all contaminated soil	Function oriented – covering with clean soil after contaminated top soil and hotspot removal. Post remediation measures.	Function oriented – **covering** with less contaminated **sediment** without any removal of contaminated sediment. *Possibly In-situ or NA-removal.* Post remediation measures.
L-1	Liquid phase contaminations (land bound site)				
L1-a	(Business) activities involving fluids e.g. solvents, lubricants, paint, etc.	Liquid contamination in soil situated near a potential source of the contamination.	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **In situ** removal to function oriented concentration level	Function oriented – **In situ** removal of hot spots. Post remediation measures.

Type	Description or activity	Typical field characteristics of the site / examples	Remediation options		
			Maximum remediation option	**Best Practice remediation option**	**Minimum remediation option**
			Note: technical not achievable in case of in case layer is situated at large depth		
L1-b	Storage of liquids that contain contaminations in tanks or barrels (either storage on surface or subsurface).	Liquid contamination in soil situated at any place at a liquids storage site.	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **In situ** removal to function oriented concentration level	same option as type L1-a
L1-c	Transfer and transport of fluids through linear infrastructure. Weak points are couplings, pressure regulators, valves, breakpoints and the passage through foundations / buildings.	Liquid contamination in soil situated at any place along a transport piping system or drains.	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **In situ** removal to function oriented concentration level	same option as type L1-a
L1-d	Spills or leaks of liquids	Liquid contamination in soil situated at the end of a transport piping or drain system.	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **In situ removal** to function oriented concentration level	same option as type L1-a
P-1	Liquid phase related (land bound site)				
P1-a	Dense Non-Aqueous Phase Liquid (DNAPL) in permeable soil.	Spreading of liquids due to gravity flow resulting in a characteristic spreading pattern. The DNAPL's laying of the botom of an aquiffer can result in a 'secondary source' of spreading of type P-2)	**Complete removal** by excavation and treatment of all contaminated soil Note: technically not achievable in case layer is situated at large depth	Function oriented – **In situ removal** to function oriented concentration level	Function oriented – **In situ** removal of hot spots. Post remediation measures.

Type	Description or activity	Typical field characteristics of the site / examples	Remediation options		
			Maximum remediation option	**Best Practice remediation option**	**Minimum remediation option**
P1-b	Light Non-Aqueous Phase Liquid (LNAPL) in permeable soil.	Spreading of liquids in a characteristic spreading pattern of floating layers. The LNAPL's laying at the top of a water table can result in a 'secondary source' of spreading of type P-2)	**Complete removal** by excavation and treatment of all contaminated soil	Function oriented – **In situ removal** to function oriented concentration level	Function oriented – **In situ** removal of hot spots. Post remediation measures.
P-2	Leached or dissolved contaminants				
P-2	Groundwater contamination	Due to spreading of leachate or mobile dissolved contaminants in a permeable soil	**Complete removal** by long term pump and treat (P&T)	Cost effective approach – **In situ removal** of hot spots and (stimulated natural attenuation of plume	Function oriented – geohydrological **isolation** and **receptor measures**

Best practice unit costs for the role of Remediation Contractor

At the time of publication of this report (December 2015) only a limited number of sites in India have been remediated. Therefore, available data on remediation are as yet limited. Given this, cost characteristics for different generic remediation options in The Netherlands, UK and US, are considered the most accurate input for estimating generic remediation costs. Data from evaluation studies in US, UK and the Netherlands are evaluated. This evaluation is discussed in more detail below.

By applying a conversion step (see Annexure 2) these costs are translated into costs that fit the actual Indian market situation.

Estimated remediation costs for US Superfund sites

In 2004 a study[9] was done on markets and technology trends on cleaning up of waste sites under the US Superfund program. In this report the costs of remediation of sites were estimated, among others for sites on the National Priority List. The following parameters were used in this calculation: the number of sites, site characteristics (contaminated matrices, types of contaminants and quantities of contaminated material) and estimated clean-up costs. The types of contaminants were assessed in a defined number of major contaminant groups. The estimated quantities of contaminated material (soil, sediment and sludge) were retrieved from the information of remediation investigations of these sites. The estimation of clean-up costs was done based on average remediation costs of sites which were remediated in the past. The following considerations were subsequently reported:

[9] Cleaning Up the Nation's Waste Sites: Markets and Technology Trends, US-EPA, 2004.

- The number of sites to be remediated was found difficult to predict. Most regions did not have a proactive site discovery process, which meant new sites could emerge at all times;
- In the site characteristics the types of contaminated matrices were studied, which resulted in percentages of sites where groundwater, soil, sediment or sludge needed to be remediated;
- In the estimation of costs for the total group of sites on the National Priority List a range in values was presented, taking into account a 20 percent spread.

In more recent evaluation studies[10,11] on program funding requirements for Superfund data are provided on costs for remediation for different categories of contaminated sites related to the (former) production process. Furthermore, a distinction was made between 1,246 non megasites (average costs per site USD 5.3 million) and 151 megasites (average costs per site USD 48.1 million). In these reports the difficulties in providing cost estimates were described, mainly related to unknown type and extent of contaminations. For specific sites it was noted that the estimated costs may vary significantly from actual costs of implemented remediation. This variation depends on the level of information, and hence decreases with the increasing amount of information at every Step in the process of site assessment and preparation of the remediation. After remediation investigation (Step 5) the variation could still be 100 percent, while after remediation design (Step 6) a variation of 20-40 percent was found common. These data emphasise the caution which should be taken when working with generic cost calculations and the need for accurate site related data.

Estimated remediation costs in the UK
The same UK Environment Agency report as was mentioned in Section 4.2.2[12] also evaluated the costs of the remediation itself at the 781 sites during 2000-2007 in England and Wales. The recorded total cumulative cost at that time was £20.5 million, while the cost to complete work was estimated at £62 million. A crude mean can be derived from £82.5 million / 781 = £105,600 per site. 90% of the 781 sites are residential housing developments, and remediation typically involved 'dig and dump' to landfill. A limitation to these figures is that many sites were still in progress when the report was published. In view of this limitation we recommend to limit the use of these figures to validation of the methodology.

Estimated remediation costs in The Netherlands
In the past decades in The Netherlands many studies were developed to assess the requirements for the Dutch site remediation programme.

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10 Superfund. Litigation Has Decreased and EPA Needs Better Information on Site Cleanup and Cost Issues to Estimate Future Program Funding Requirements, US Government Accountability Office, GAO-09-656 report, 2009.
11 Superfund. EPA's Estimated Costs to Remediate Existing Sites Exceed Current Funding Levels, and More Sites are Expected to Be Added to the National Priorities List, US Government Accountability Office, GAO-10-380 report, 2010.
12 UK Environment Agency report on the 2011/12 contaminated land grant programme

In 2005 a baseline study was developed[13], based on a detailed inventory of potentially contaminated sites. In one of the subsequent studies the costs were assessed for sites for which remediation was deemed urgent[14]. The available data indicated that the most important elements for this assessment were the activity which had caused the contamination and the area of the site. Aspects of lesser importance were soil type and situation of the site. Median remediation costs of various categories of contaminated sites were retrieved from projects that were carried out in the years before the study. The median remediation costs for different types of activities causing the contamination varied between € 24,000 and € 900,000 and the contaminated area varied between 758 and 8,000 m^2. The median remediation costs per m^2 were estimated to amount to between € 8 and € 91. Some of the larger contaminated sites were not taken into account in these numbers. In view of this limitation we would advise to limit the use of these figures to validation of the methodology.

A scientific study on the value of contaminated sites[15] concluded that remediation costs mainly depend on two technical aspects, i.e. the amount and the concentration level of contaminated soil and groundwater and the techniques used for remediation. Besides these technical aspects certain institutional and socio-economic aspects and the knowledge involved in the project were regarded to have important effects on costs. The report stressed that assessing costs is very site specific and generic unit cost rates should always be used with great caution.

A Dutch cost-benefit analysis[16] shows that costs for remediation per site vary widely on a programme scale. This variation depends on the types of site in the programme. Because the Dutch programme includes all types of contaminated sites, from small spills of immobile contaminations right up to complex urban gas works, the median remediation costs are € 16/m^2, while the average remediation costs will be up to € 128/m^2.

In 2003, the Dutch national government introduced a method for monitoring the remediation projects in The Netherlands. At that time the competent authorities for the review and approval of remediation projects were 29 provinces and larger municipalities. A national budget for site assessment and remediation was managed by the Ministry of Environment. From this budget remediation projects that met several legal, financial and technical requirements could partly be funded. Part of the method for monitoring was to use certain unit rates for remediation costs. These unit rates had been derived from previous experience with numerous remediation projects:

- € 50 for the remediation of an area of 1 m^2 of contaminated land;
- € 150 for the remediation of 1 m^3 of contaminated soil;
- € 2 for the remediation of 1 m^3 of contaminated groundwater.

13 Baseline study in-progress contaminated sites, 1 May 2005, Kernteam Landsdekkend beeld.
14 Bodemsanering in beleidsaandachtsgebieden –Soil remediation in areas with political priorities-, report no 607700001, RIVM 2007.
15 Waarde van vervuild vastgoed –Value of contaminated real estate-, B. van de Griendt, 2000.
16 MNP Rapport 500122002, 2007

These unit rates were exclusively used for this monitoring purpose. By doing this the authorities recognized the fact that for site specific remediation projects costs would vary, due to the selected remediation option, the scale of the site, the land use and the contaminating substances.

The Dutch Authorities have used a generic list of cost values for assessment and remediation activities[17]. This list includes costs for DPR and the costs the authorities can expect to encounter for the financial management of their remediation programmes. This list is based on the type of site use (dry cleaner, petrol stations, etc.). Average costs for site remediation may vary from € 120,000 to € 1,900,000 (cost level 2005, corrected for inflation in the Netherlands these figures would come to € 145,000 and € 2,290,000 respectively in 2014). It should be reiterated that these average costs are based on a typology of sites different from the one developed for India in Task 1 of this Assignment.

Post remediation activities
A Dutch study[18] shows that hardly any funds are identified to assess post remediation actions. This is considered to be an inconsistency, because a large number of sites with post remediation activities is known. Based on our own expertise we would defend the position that these costs can be considerable, but no data on national scale are available.

Consultation international experts and generic data
International soil remediation experts are consulted on their best practice experience on standard unit costs, with a major role for cost calculations of successfully implemented site remediation activity.

Many generic data are available on costs for remediation on a level of remediation techniques. To use these data additional information is necessary, e.g. other remediation techniques implemented to compose a remediation option, efforts for site assessment et cetera. An example of this is given by the Unites States Federal Remediation Technologies Roundtable (FRTR) which provides a Remediation Technology Screening Matrix (http://www.frtr.gov/scrntools.htm) that lists a more complete set of remediation options.
Due to the character of the methodology, detailed data as described above are typically used in steps like DPR.

Additional to contractor costs a rule of the thumb is commonly used to gain an indication of the costs for the roles of Advisor, Site investigator and Laboratory in Step 8.3 and Step 11. This rule states that 10% of the Remediation Contractor costs should be accounted for these activities. This is broken down as follows:
- 3.6 % for the Advisor in Step 8.3: Execution, supervision and verification of remediation works;
- 2.4 % for the Site investigator in Step 8.3: Execution, supervision and verification of remediation works;

17 Financiële kengetallen voor het gemeentelijk bodemsaneringsprogramma -Financial unit numbers for the municipal soil remediation programmes-, IPO.
18 Annual Monitoring Report Dutch Soil Remediation Programme in 2009, RIVM, 2010

- 1.2 % for the Laboratory in Step 8.3: Execution, supervision and verification of remediation works;
- 0.8 % for the Advisor in Step 11: Post remediation activities;
- 1.2 % for the Site investigator in Step 11: Post remediation activities;
- 0.8 % for the Laboratory in Step 11: Post remediation activities.

This distribution of costs for the roles of Advisor, Site investigator and Laboratory will cover most of the remediation projects, but can vary widely, depending on site specific conditions. Such conditions are closely associated to the remediation objective, e.g. the associated need for post remediation activities.
From the above it can be concluded that for a complete picture of costs for remediation or post remediation 10% should be added to the costs calculated for the role of Remediation Contractor.

Standard unit costs per remediation option
The experts on soil remediation in the project team have derived standard unit costs for remediation. These are presented in table 4.3, specified per remediation option. It should be noted that the standard unit costs in Euros are applicable for the situation in the countries assessed in the best practice study above, i.e. US, UK, NL. The standard unit costs in INR have not been simply converted by applying the currency exchange rate to these. Rather, these have been calculated according to a method presented in Annexure 2.

Table 4.3 Standard unit costs per remediation option, based on practice in US, UK and Netherlands

Remediation option (see table 4.2)	**Standard unit costs**			
	Size/surface based		**Volume based**	
	€ / m²	INR / m²	€ / m³	INR / m³
Complete removal by excavation (exact figure depends on type)			150 – 200	5,527 – 7,369
Complete removal by long term pump and treat			20	766
Complete removal by dredging and treatment or storage of all contaminated soil material			40	1,474
In situ removal to function oriented concentration level (type L and P)			100	3,146
Groundwater plume remediation by in situ removal of high concentrations and NA of low concentrations			0.70	15
Removal contaminated top soil and hot spots. Covering with clean soil. (type S-2 and S1a,b,c)	20 - 50	679 – 1,699	30	1,106
In situ removal of hot spots, followed by post remediation measures (type L and P)			20	665
Geohydrological isolation and receptor measures			1	35
Covering with clean or less contaminated soil (type S-2 and S1a,b,c)	50	737 – 1,842		
In situ remediation (e.g. phyto remediation, type S1-d,e,f)	20	628		

It is noted that the results of the best practice inventory do not represent a universal image of the capacity requirements for the role of Remediation Contractor. This is because in different countries the scope of the identified cost elements is different, identified cost elements cover different types of sites, the costs elements are applicable for non-comparable levels of remediation and the price levels are from different years. Because of this the use of these data is limited to validation of standard unit costs derived by the experts.

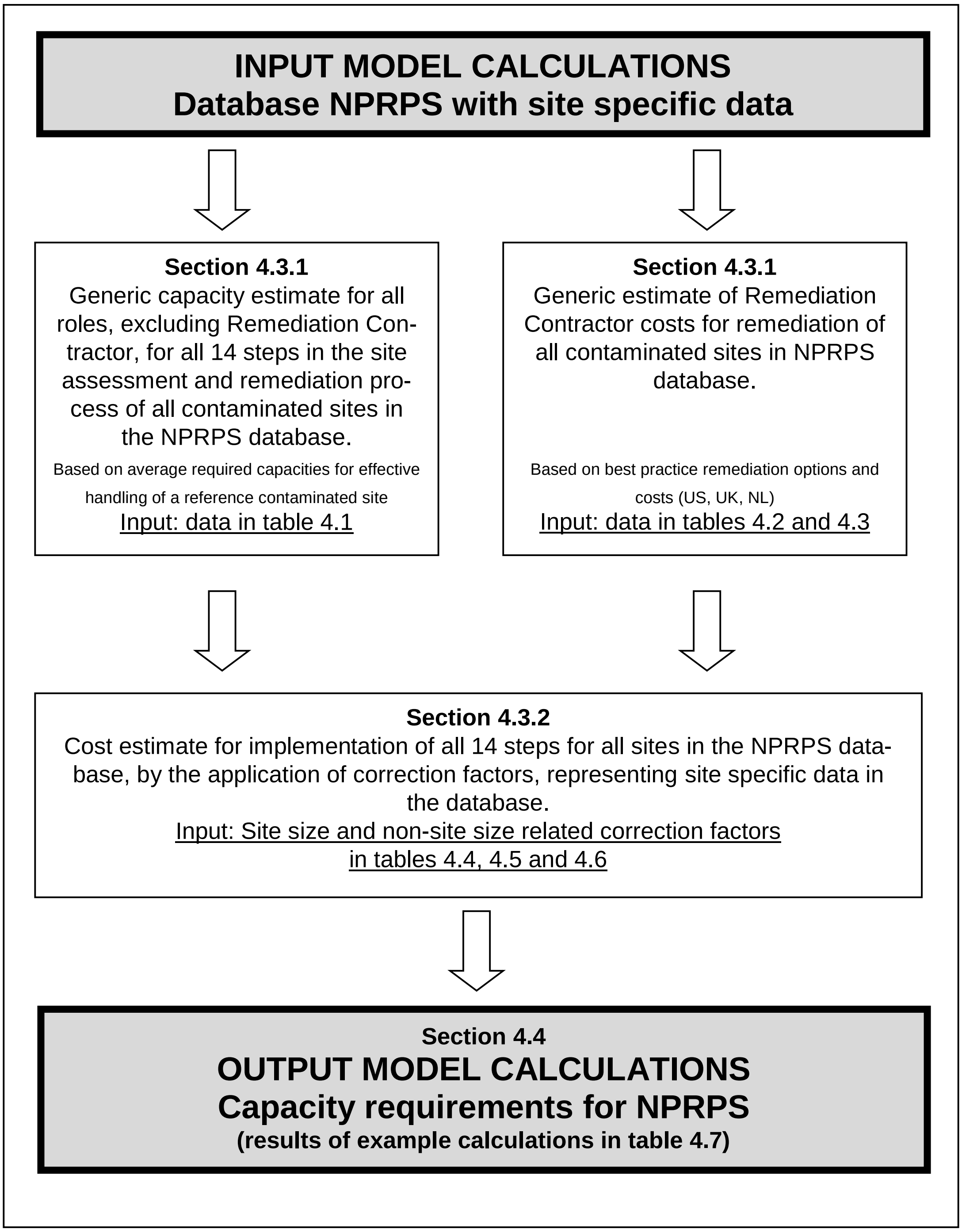
The cost levels presented in table 4.3 are based on either the area (m^2) or the volume (m^3) of the contaminated part of the site. This is because for some remediation options the costs are related to the area of the contamination, while for other remediation options the costs are related to the volume. The Standard unit costs presented are applicable to relatively simple situations where no other activities take place parallel to the remediation. Where the remediation is implemented simultaneously with a redevelopment of the site various activities can be shared with the redevelopment. In such cases the Standard cost units can be expected to turn out lower. This effect can be considerable and generally is site specific.

4.3 Methodology for Calculation of Capacity Requirements

In this Section we present the methodology for the calculation of the capacity requirements for effective implementation of NPRPS. The elements introduced in the previous Sections are essential elements of the methodology. Figure 4.1 below illustrates how the elements are interlinked to shape the methodology.

The methodology is dedicated to converting the numbers for a reference contaminated site to a specific site, using correction factors. While these correction factors have been developed based on expert guess, they have subsequently been validated using a large number of real life cases. The correction factors are a mixture of factors proportional to the size of the contamination and of factors that are not related to the size of the contamination.

Figure 4.1 Methodology for calculation of required capacity for NPRPS



4.3.1 Generic estimate of required capacities for all contaminated sites in NPRPS database

The NPRPS database of contaminated sites in India includes the contaminated sites for which the capacity requirements for all roles are to be estimated.

All roles excluding the role of Remediation contractor

For the estimate of required capacities for all roles excluding the role of Remediation Contractor table 4.1 is used.

This table shows that for example for one reference contaminated site an average of 150 soil- and/or (ground)water samples are needed during the implementation of all Steps in the site assessment and remediation process, excluding Steps 8 and 11. Another example of what this table shows is that for such a site the average number of hours required for the role of Programme management Authority is estimated to be 60. If so desired, these numbers can be expressed in INR by using the standard unit costs as shown in the table.

It should be noted that for an estimate of the total costs for the roles of Advisor, Site investigator and Laboratory the costs for their performance in Steps 8 and 11 should be added to the numbers in table 4.1. This is indicated in the table by the symbol #. According to international experience, these costs amount to 10% of the costs for the Remediation Contractor.

Once the complete number of sites for the NPRPS is known an estimate of required capacities for all roles excluding the role of Remediation Contractor can be made by simply multiplying the required capacities per site with the number of sites. If for example 500 sites are listed and can be expected to pass through all 14 Steps of the site assessment and remediation process 500 x 150 = 75,000 soil and/or (ground)water samples would be needed during all Steps in the site assessment and remediation process, excluding Steps 8 and 11. Section 4.3.2 describes how site specific corrections can be made to improve the accuracy of the estimate.

The role of Remediation Contractor
By using the export of the database a generic estimate of the costs for the role of Remediation Contractor for remediation of all contaminated sites in the database can be made. In order for this estimate to yield useful results the following data need to be available from the database:

- Type of contaminated site (typology, Task 1 report) and, in case of multiple contaminations at the same site, a secondary type of contaminated site;
- Size of contaminated area (per type of contamination). It should be noted that this is not the same as the size of the site itself;
- Volume of contaminated material (per type of contamination).

With these data the costs for the role of Remediation Contractor can be estimated for remediation of all contaminated sites in the database. The methodology for this is based on the calculation of contractor costs, using the best practice remediation option for a specific site (table 4.2), and standard cost units per remediation option (table 4.3).
The result of this calculation is an estimate of costs and time per Step, without taking into account site specific conditions. The example in the box below serves to illustrate the implementation of this methodology.

Data of site characteristics extracted from database:

- Type S-1a
- Size: 25,000 m^2
- Volume contaminated soil: 75,000 m^3.

Best practice remediation option for this type of site, taken from table 4.2, consists of two phases, including post remediation:

- Removal of contaminated top soil (1 m) and hotspot leaching to groundwater: 20% of the volume contaminated soil needs to be removed at a unit price of € 30/m^3 (table 4.3). Estimated costs for this phase: 20% * 75,000 m^3 * € 30/ m^3 = € 450,000.
- Application of a clean top layer and implementation of long term post remediation actions: 100% of the of contaminated part of the site needs to be covered at a unit price of € 50/m^2 (table 4.3). Estimated costs for this phase, i.e. including post remediation activities: 25,000 m^2 * € 50/ m^2 = € 1,250,000.

It can be concluded that the total estimated cost for implementation of the role of Remediation Contractor (Steps 8 and 11 together) for this site is € 450,000 + € 1,250,000 = € 1,700,000.
Following the assumption that the estimated cost for implementation of the activities by the other roles (Steps 8 and 11 together) is 10% of the above total, those costs will amount to an estimated 10% * € 1,700,000 = € 170,000.

4.3.2 Correction of calculated generic estimate of required capacities for site specific conditions

The estimation of capacity requirements to implement the NPRPS programme in the preceding Section fits listed sites, however without taking into account site specific conditions. In reality, conditions at contaminated sites will vary widely, and with that so will the required capacities. Notable variable parameters are the size of the site, the number of contamination types present and the complexity of the situation (technical, legal, social and environmental).

This Section goes into more detail on how the methodology deals with these conditions. This is done by discussing specific conditions that will lead to a higher (or lower) complexity of the technical, legal and social aspects of the site assessment and remediation. We translate the specific conditions to the site related aspects size, number of site types and land use to fine tune the estimate in table 4.1. Because the complexity of a site has already been incorporated in the calculations for the role of Remediation Contractor this will only influence the efforts of the other roles, i.e. those of Advisor, Site investigator, Laboratory, Site related programme implementation Authority.

The reasons for selecting the three aspects mentioned above is that data on these aspects are or will eventually be available from the NPRPS database of contaminated sites, developed in Assignment 1. Secondly, these data present, for the scope of this report, a reasonably accurate basis for estimating the capacity requirements. The accuracy is validated by implementing the parameters on known contaminated sites.

For each of these parameters a correction factor for complexity is introduced. This factor should be used to calculate the total capacities required to implement an assessment and remediation process for a contaminated site. The following complexity aspects lead to the need to apply a correction factor:

- Complexity related to legal, social and environmental aspects of land use;
- Complexity related to the size of the contaminated site;
- Complexity related to the number of contamination types at a site.

In Section 4.3.3 an example calculation is provided to demonstrate the use of the correction factors.

Complexity related to legal, social and environmental aspects of land use
Legal, social and environmental aspects are typically related to the present land use at a site. Contaminated sites situated in an agricultural area or a park are relatively easy to assess and remediate. At the other end of the scale, sites with residential land use with gardens and schools or active industrial sites with complex infrastructure are relatively cost intensive to assess and remediate.
To calculate the complexity effect of legal, social and environmental aspects each present land use mentioned in the NPRPS database of contaminates sites is assigned a capacity requirement correction factor. Table 4.4 below shows the present land uses and the correction factor assigned to each of those.
Note that other issues may lead to a more intricate remediation process and thus to higher costs. Examples are archaeological remains, historical buildings, monumental trees, nature reserves or habitats of endangered species that need to be protected. Because no data of such issues are available in the NPRPS database, these issues are not included in table 4.4.

Table 4.4 Correction factor for complexity related to present land use

Present land use	Correction factor	Background to correction factor
Agriculture	0	Easy physical access, few parties participating in decision on remediation option to be implemented, well defined site use.
Commercial / retail	1	Complex urban situation, economical damage in case of poor access to site during or after implementation of remediation option, nuisance during implementation should be minimized.
Council Owned Nursery / Gardens / Parks	0.25	Easy physical access, well defined site use, many stakeholders may be involved in the decision making process.
Dumpsite	0	Easy physical access, few stakeholders participating in decision on remediation option to be implemented, high support for remediation.
Industrial (active)	2 *)	Industrial activities and premises may not be disturbed by the implementation of a remediation, high level (and costly) safety measures need to be taken into account, complex infrastructure of industrial equipment, piping et cetera.
Natural area	0	Easy physical access, few parties participating in decision on remediation option to be implemented, no specific site use.

Present land use	Correction factor	Background to correction factor
Offices	0.5	Accessibility of the site should be maintained during the implementation of the remediation, multiple stakeholders may be involved in the decision making process, nuisance during implementation should be minimized.
Open Ground (verges, commons etc)	0	Easy physical access, few parties participating in decision on remediation option to be implemented, no specific site use.
Open space (recreation)	0	Easy physical access, few parties participating in decision on remediation option to be implemented, no specific site use.
Other	0	No data to justify any additional correction factor.
Parking Lot / Area	0	Easy physical access, low risk site use, during the remediation an alternative parking lot may be needed.
Playground	0.5	Easy physical access, well defined site use, many stakeholders may be involved in the decision making process, delicate site use.
Residential (no gardens/100% cover)	1	Difficult physical access, well defined site use, many stakeholders may be involved in the decision making process, delicate site usage, nuisance during implementation should be minimized.
Residential (with gardens)	1	Difficult physical access, well defined and delicate (garden) site use, many stakeholders may be involved in the decision making process, delicate site usage, nuisance during implementation should be minimized.
Schools (buildings and associated land)	1	Difficult physical access, well defined and delicate (garden) site use, many stakeholders may be involved in the decision making process, delicate site usage, nuisance during implementation should be minimized.
Vegetation (area covered with shrubs/trees etc.)	0.25	Easy physical access, well defined site use, many stakeholders may be involved in the decision making process.

*) covering a typical multiple source situation

Complexity related to the size of the contamination

The costs for the implementation of the steps in the assessment and remediation process will typically increase with increasing size of the contamination at the site. Examples are costs for site assessment and delineation, and a more complex DPR, because more parameters and circumstances will typically be involved. Table 4.5 illustrates the correction factor for complexity related to size of the contamination at a site.

Table 4.5 Correction factor for complexity related to size of the contamination at a site

Size (m^2) from	up to	Correction factor
0	5,000	-0.5
5,001	50,000	0
50,001	∞	0.5

Complexity related to the number of contamination types at a site
The assessment and remediation process of a single type site can be complex in its own right. In addition, a site may comprise two types of contamination which can be linked together during the remediation phase. Sites with more than two contamination types are expected to be scarce in the database or can otherwise be assessed as two different sites. Where two types of contamination are present, remediation objectives, strategies and technical implementation of the remediation are typically constructed into a single coordinated set of activities. This is done because it will enable an effective and efficient approach to all types of contamination present.
This additional aspect of the assessment and remediation process requires additional effort. An example of such a situation is an industrial dumpsite leaching contaminants into a groundwater contaminated plume. The remediation objectives for the dumpsite should be balanced with the objectives for the plume: to what degree should the leaching be stopped in order to achieve a stable non-spreading contaminated groundwater plume?

In view of the above, sites with two types of contamination are assigned an additional correction factor for complexity as illustrated in table 4.6 below.

Table 4.6 Correction factor for complexity related to the number of contamination types at a site

Number of contamination types at a site	**Correction factor**
1	0
2	1

Synthesis: application of the correction factors
The estimate of capacity requirements to implement the NPRPS programme in table 4.1 is applicable to a Reference contaminated site. Depending on the site specific conditions of present land use, site size and number of contamination types the capacity requirements as listed in table 4.1 should be corrected using the correction factors from tables 4.4, 4.5 and 4.6. This is done by taking the capacities required for the standard unit and multiplying that figure by 1 plus the sum of the one, two or three correction factors:

required capacity for specific site
=
*required capacity for the Reference contaminated site **
(1 + Σ [site use factor, site size factor, # of types factor]).

Approach for clusters of scattered smaller sites
A correction factor for cost efficiency has been considered for situations where a number of smaller sites of the same type are close to each other, but in a scattered fashion. It is concluded that international experience shows that while cost efficiency can be achieved in such situations, often the situation in the field has a significant negative effect on this efficiency. Examples of this are: the type

of contamination or other conditions differ from site to site, the potential remediation approaches differ from site to site, contracting is per individual site, and all sites cannot be remediated in the same period.
In view of the above it is advised to enter the data on every site within a cluster of scattered sites into the model as an individual site. That way all site specific parameters can be applied to every individual site, resulting in maximum reliability of the model calculations. As an exception to this, in cases where a cluster of scattered smaller sites is connected to a single larger groundwater contamination, the relevant data on this plume are better entered into the model as a single remedial approach.

4.3.3 Example calculation

In this Section an example calculation is provided to determine the capacity required per role to go through all Steps of the site assessment and remediation process for an example site. Again, it should be noted that this calculation is only to be used to contribute to calculations on a programme level. The site used in this hypothetical example is characterised by the following data:

- Present land use: offices;
- Size of the site: 25,000 m^2;
- One single type of contamination.

The discussion of this example begins by demonstrating the use of the correction factor to calculate the required capacities for a Advisor to effectively implement all Steps assigned to his role. Table 4.1 reveals that the capacity requirement for a consultant to implement a remediation investigation (Step 5) at the Reference standard site is estimated at 440 hours.

Based on the specific present land use at the site, offices, a correction factor of 0.5 needs to be applied. This figure is taken from table 4.4. The size of the contamination is between 5,001 and 50,000 m^2. From table 4.5 a correction factor of 0 is taken, meaning that for the size of the contamination no additional correction factor needs to be added. Finally, table 4.6 shows that the fact that there is only one type of contamination also leads to a correction factor of 0.

The total capacity requirement for implementation of the role of Advisor in the remediation investigation is calculated using the following formula:

$$\textit{total number of hours for this example site} = \textit{hours for the Reference contaminated site} * (1 + \Sigma\ [\textit{site correction factors}])$$

Combining this formula with the two correction factors the total number of hours the consultant will need for Step 5 will be:

$$440 * (1_{(\text{standard factor})} + 0{,}5_{(\text{site use correction})} + 0_{(\text{site size correction})} + 0_{(\text{\# of types correction})}) = 440 * 1{,}5 = 660 \text{ hours}$$

This can be done in the same way for all figures in table 4.1. Some more examples illustrate this point:
- Total number of hours for implementation of the role of Advisor (all Steps except Steps 8 and 11) at this example site: 800 hours * 1,5 = 1,200 hours;
- Number of samples to be tested in implementation of the role of Laboratory during remediation design, DPR (Step 6): 30 samples * 1,5 = 45 samples. Total number of samples (all Steps except Steps 8 and 11): 150 samples * 1,5 = 225 samples.

Assuming the land use of the otherwise identical site would have been industrial with two types of contamination the figures would be:
- Number of hours for implementation of the role of Advisor for remediation investigation (Step 5): 440 hours * (1+2+0+1) = 440 * 4 = 1,720 hours;
- Total number of hours for implementation of the role of Advisor (all Steps except 8 and 11): 800 * 4 = 3,200 hours;
- Number of samples to be tested in implementation of the role of Laboratory during remediation design, DPR (Step 6): 30 samples * 4 = 120 samples. Total number of samples (all Steps except Steps 8 and 11): 150 samples * 4 = 600 samples.

4.4 Example output

The example calculation demonstrated in the previous Section should be applied to every site in the NPRPS database. This Section presents an example of the output of the methodology when applied to a set of seven imaginary sites. While not based on real sites, these imaginary sites are defined in such a way that they could well be similar to sites in the database. Some ways to use the methodology and its limitations are also discussed in this Section.

Input requirements

For effective use of the methodology the following data should be available for every contaminated site in the NPRPS database:
- Type of contamination (maximum of two types);
- Present land use;
- Size of the contaminated part of the site (m^2);
- Volume of the contaminated part of the site (m^3).

Processing steps

The processing steps are as demonstrated in the example calculation in Section 4.3.3: calculation of capacity building requirements using the site data, the applicable best practice remediation option, and standard costs and hours and application of the correction factors.

Output

Table 4.7 below presents the output, in terms of total cost estimates for the implementation of all Steps in the site assessment and remediation process for the example seven imaginary sites.

Table 4.7 Output of application of methodology on a set of seven imaginary sites

Step	Consultant/ Advisor	Site investigator/ Fieldwork team	Site investigator/ Laboratory	Remediation Contractor	Authority/ Program management	Authority/ Remediation implementation	Total per step
	all amounts in INR x 1,000						
1	₹ -	₹ -	₹ -	₹ -	₹ 301	₹ -	₹ 301
2	₹ 2.259	₹ 17.111	₹ 11.636	₹ -	₹ 75	₹ 602	₹ 31.683
3	₹ -	₹ -	₹ -	₹ -	₹ 151	₹ -	₹ 151
4	₹ -	₹ -	₹ -	₹ -	₹ 151	₹ -	₹ 151
5	₹ 16.564	₹ 34.222	₹ 23.271	₹ -	₹ 376	₹ 3.388	₹ 77.821
6	₹ 4.517	₹ 12.833	₹ 8.727	₹ -	₹ 75	₹ 452	₹ 26.604
7	₹ -	₹ -	₹ -	₹ -	₹ 75	₹ 301	₹ 376
8	₹ 73.285	₹ 22.922	₹ 22.922	₹ 1.146.121	₹ 75	₹ 1.807	₹ 1.267.133
9	₹ -	₹ -	₹ -	₹ -	₹ 75	₹ 1.506	₹ 1.581
10	₹ 2.259	₹ -	₹ -	₹ -	₹ 75	₹ 602	₹ 2.936
11	₹ 37.029	₹ 12.343	₹ 12.343	₹ 617.142	₹ 75	₹ 753	₹ 679.685
12	₹ -	₹ -	₹ -	₹ -	₹ 452	₹ -	₹ 452
13	₹ -	₹ -	₹ -	₹ -	₹ 151	₹ -	₹ 151
14	₹ -	₹ -	₹ -	₹ -	₹ 151	₹ -	₹ 151
Total	₹ 135.911	₹ 99.432	₹ 78.899	₹ 1.763.263	₹ 2.259	₹ 9.411	₹ 2.089.175
# of sites	7	7	7	7	7	7	7
Avg/site	₹ 19.416	₹ 14.205	₹ 11.271	₹ 251.895	₹ 323	₹ 1.344	₹ 298.454

Table 4.7 shows the cost for each individual role per Step as well as for all Steps in total. For example, the total cost for the implementation of the NPRPS for soil and groundwater remediation of these seven imaginary sites would be approximately INR 209 crore, averaging a little under INR 30 crore per site (bottom right hand corner of the table). Two annotations to this figure are important to note: 1) The figure is the result of adding up all costs related to all steps in the site investigation and remediation process, i.e. remuneration and reimbursables, on the private as well as on the public side, and 2) the sites inventoried so far are relatively complex, compared to an average contaminated sites. Therefore, it may be expected that the figure mentioned will be considerably lower for most sites.
It is noted that Step-11, Cost of remediation contractor, will be the dominant cost element in most cases, which is in line with international experience. For that reason the cost estimate of this step is elaborated especially in a separate Section (Section 4.2.2, Capacity requirements for the role of Remediation contractor).

4.5 Applicability of the methodology

Practical use of the methodology

The methodology presents the opportunity to vary all other input parameters. A more detailed evaluation of how these results depend on input parameters gives an impression of how the results of the methodology can be used. As can be seen from table 4.7, the costs for the implementation of the role of Remediation Contractor costs take up by far the largest part of the total costs: Remediation Contractor INR 198 crore, against a total cost of INR 235 crore. From this it is clear that a thorough analysis of the factors influencing Remediation Contractor costs can be a very useful basis for a sound capacity requirement calculation:

- Contractor costs will largely depend on the quality of the estimate of size and volume of the contamination. If the quality of the available estimate of size or volume of a contamination is poor it will result in inaccurate results. An inaccuracy of the volume of a contaminated site of 50% may, depending on the type of site and selected remediation option, result in an inaccuracy in the total costs of 30%. There are plenty of examples that illustrate the importance of this point, mostly in the shape of the contaminated volume turning out to be much larger than estimated based on the site assessment, resulting in significant unanticipated costs during remediation;
- Contractor costs will also largely depend on the remediation objective on which the remediation option is based. Table 4.7 is based on the best practice remediation option. In case the remediation objective necessitates the application of a maximum remediation option the costs may turn out to be as high as 400% of the total costs in the table. At the other end of the scale, in case the remediation objective allows a minimum remediation option the costs might turn out to be as low as 20% of the total costs in the table.

Limitations

To keep the methodology practical the enormous potential variety in site conditions has been simplified. This is also why the methodology cannot be applied to calculate the required capacities for dealing with an individual site. In that kind of calculation much more detail is possible. To illustrate this a limited number of conditions that can be taken into account when calculating for an individual site is listed below:

- Possibility to use a more effective site assessment technique such as geophysical mapping or logging or screening techniques;
- Depth to which site assessment should be implemented;
- Homogeneity of the contaminated soil layer;
- Combination of contaminations, which necessitates implementation of multiple steps in a in situ remediation;
- Need to use a water treatment plant or possibility to discharge contaminated groundwater into the municipal drainage system.

Cost for capacity building not included

The cost calculation is based on the provision that all roles participating in the process of site assessment and remediation are fully trained and equipped, thus enabling to start with a full speed implementation of the NPRPS.

Costs needed for training, investments in equipment and getting familiar with the Steps in the site assessment and remediation process are not included in these calculations. The costs for this start-up phase will depend on the number of sites that will be remediated annually under the programme and thus the number of persons, laboratories and equipment that need to be engaged in the process. However, further calculations on different start up scenarios go beyond the scope of this report.

These specific costs for the capacity building programme will be required mainly during the first years of NPRPS and can be expected to diminish over time, while not disappearing altogether. This process will also show in the actual capacities required for effectively dealing with contaminated sites. During the initial years of NPRPS the actual number of hours that needs to be invested may be expected to be higher than the number of hours presented in table 4.1. As the expertise, experience and skills of involved professionals increase over time, the number of hours required can be expected to approach the hours shown in the table.

Opportunities for cost reduction
As can be seen in table 4.7, after the remediation itself (Step 8), the most costly Step is the post remediation (Step 11). Because post remediation typically takes several years, those costs are usually spread over a prolonged period of time. While the same can also apply to the remediation itself, the largest cash flow will usually take place during implementation of the remediation, i.e. during Step 8. In view of the above, it is relatively easy to see that a programme for the remediation of larger numbers of contaminated sites can run for many years or several decades. In this light, it is good to keep in mind that over such a time span, multiple cost reduction opportunities can be expected to become available. This will be due to e.g. technical innovating, the optimizing of remediation approaches and the combining of remediation with redevelopment of sites. Programming remediation measures for different sites in the database may help in seizing those opportunities.

5 Annexures

Annexure 1 - Elements for Terms of Reference for site assessment

Introduction

The organization that is responsible for the assessment and/or remediation of a contaminated site may contract a third party in order to conduct (part) of the work.

The site investigation activities are usually commissioned to an independent third party investigator, typically a specialized organization (agency, research institute, consultants, contractors and laboratories), where teams of specialists are involved in assessment and remediation projects.

The client who contracts out this assignment may be a private person, private organization or the local, State or Central authority.

The Guidance Document (Task-4 report, December 2015) provides a checklist to support the client in the selection of a specialized agency. To ensure a good quality investigation, it is vital that this third party can demonstrate the expertise, skills and compliance relevant for the assignment. Where available, it is preferable if this is supported by relevant accreditations.

At the outset, it is very important that the client provides clear Terms of Reference (ToR), which should at least include the objectives of the investigation, the required output and the possible constraints. Without a clear ToR the third party may interpret the situation differently, resulting in the proposed activities not leading to the required output. Furthermore, in case more than one party is requested to tender an offer, an unclear ToR can lead to differences that render a fair comparison impossible. If the client is a private organization it may be advisable to contact the competent authority for assistance.

This Annexure presents the elements that should be included in any Terms of Reference for effective completion of a number of activities in the site assessment process. The elements describing the Scope of Work, which are specific to the activity at hand, are preceded by a list of generic elements that should be included in any ToR, irrespective of the activity it is designed for.

Generic elements

The Terms of Reference should include at least the following elements:

- Location of site and explanation of the situation of the site with regard to contamination of soil, sediment, groundwater or surface water;
- Summary of activities regarding assessment and/or remediation which already have been carried out;
- Objective of the project;
- Phases of the project (if applicable)
- Scope of Work, a detailed description of activities (according to the 14 step framework. See Annexure 4 for that framework);
- Expected outputs of the project (reports, drawings, etc.);
- Timeline;
- Procedure for review of draft and final reports;
- Qualifications for agency and project team;

- Expected communication with client and facilities to be provided by client;
- Financial-economic conditions for the project.

Scope of Work elements

In a Terms of Reference for a site assessment the Scope of Work provides a detailed description of activities to be performed. Below, we present the Scope of Work elements to be included in Terms of Reference for the following site assessment activities (position in 14 step framework is indicated between brackets):

- Preliminary site investigation (Step 2, Task 2.2);
- Detailed site investigation (Step 5, Task 5.1);
- Risk Assessment (Step 5, Task 5.2);
- Setting remediation objectives and requirements (Step 5, Task 5.3), Development of remediation options (Step 5, Task 5.4), and Selection remediation option (Task 5, Step 5.5);
- Remediation design, DPR (Step 6).

Preliminary site investigation (Step 2, Task 2.2)

Within this task the following activities are performed:

- Design of the investigation and testing strategy
- Fieldwork and laboratory testing
- Comparison of the test results with standards
- The above mentioned activities are carried out leading to a report including following sections:

Site identification: site name, address, owner, coordinates;

Site description

- History of site use (ownership, operators, users, raw materials, waste related activities, permits, etc.)
- Environs of the site (land use, groundwater use, use of water bodies, estimated number of residents or onsite workers, estimated distances to sensitive use, etc.)
- Climate data (precipitation, temperature and derived information/estimated parameters such as evapo-transpiration and groundwater recharge rate estimated from this data
- Geology and hydrogeology (stratigraphy, aquifers, depth and permeability of subsurface layers, possible karst features, etc.)
- Hydrology and surface water (distance from site to water bodies, migration paths of rainfall to surface water, drainage, flooding patterns)
- Results from previous investigations or incidental data
- Result of site inspection
- Hypothesis on type and characteristics of the contamination
- Features / targets for investigation

Site inspection including:

- Identification of previous and current land use pattern of the site
- Current sources of hazardous waste generation contributing to the pollution of the site and disposal practices in the influence area.

- Site photographs
- Identification of parameters causing immediate threat to the ecology and environment.
- Discussion with local people and other informed people, district administration, municipal and regulatory authorities, NGOS, etc.
- Selection of the available observation wells (Bore Well) in the watershed covering the site, for monitoring water level and quality monitoring at appropriate locations, & Inventory details like total depth of the well, Water column; Frequency of sampling (Pre monsoon/ Post monsoon)

Investigation Strategy

- Draft Conceptual Site Model
- Screening and sampling strategy
- Fieldwork screening methods
- Exploratory hole / sample location pattern (grid or targeted) and numbers of samples (soil, sediment and groundwater) , including benchmark / background samples
- Use of composite and single samples
- Parameters for laboratory testing and chemical analysis methods / detection limits
- Applied method for quality control (QA/QC)

Fieldwork results, interpretation and reporting including

- Site conditions during fieldwork (e.g. dates, weather conditions, access to locations, etc.)
- Visual / olfactory evidence of contamination
- Results of screening techniques (if applied)
- Description of ground conditions and subsurface structure (borehole / exploratory hole log description)
- Selection of samples to be tested
- Laboratory test results
- Comparison of laboratory test results to standards (Screening levels and Response levels)
- Does the site meet the definition of 'Contaminated Site'?
- Recommendation for:
  - further investigation (yes/no);
  - notification as contaminated site (yes/no) leading to prioritisation and remediation investigation;
  - temporary safety measures if in the present situation significant risks to human health or environment are expected.

Detailed site investigation (Step 5, Task 5.1)

Within this task the following activities are performed:

- Development of investigation strategy
- Fieldwork and laboratory testing
- Analysis and interpretation of exploratory data

The above mentioned activities are carried out leading to a report including following sections:

Introduction and background information

- Description of the site (e.g. name, address, site plan and size);
- Reason for the detailed site investigation;
- Summary of the previous investigations at the site;
- Information of the parties involved in the remediation investigation process and allocation of their roles;
- Scope of the investigation;
- Explanation of the structure of the report.

Site situation

- The lay-out on the site (present land use, infrastructure, buildings, use of the surrounding area, included natural features such as lakes, rivers, streams found at least partially within the boundaries of the property) and in the area beyond the site covering the pathway;
- Description of history of the land use and possible causes of the contamination (included constructed features such as, underground storage tanks, lagoons, ditches, sumps within buildings, and waste storage areas);
- Typology of the contaminated site;
- Geology, geohydrology and soil structure and ground conditions of the site in case of contaminated soil and groundwater (depth of groundwater, thickness of aquifers, seasonal groundwater fluctuations; the lithology and vertical permeability of the unsaturated zone; the stratigraphy, structure, geometry, porosity, hydraulic conductivity, storage properties, transmissivity, and groundwater flow direction of the saturated zone).
- If monitoring or drinking water wells have been installed: review of the monitoring results; include data why and when a well was installed and by whom and technical data (depth, filter length, monitoring data, sample and lab methods)
- Soil survey information at a scale of 1:20 000 or larger; on-site map and appropriate cross-sections showing soil types, soil depth and other soil parameters that may be related to location and extent of contaminants;
- Climatic conditions (precipitation, seasonal variations, estimated infiltration rates);
- Morphological and hydraulic aspects including e.g. seasonal variations in water level and floods and and areas affected by floods to estimate the impact of contaminated sediments.

Investigation strategy

- The conceptual site model (CSM) with the combinations of source-pathway-receptor) of concern. A detailed description of the present contamination with characteristics (parameters, concentration, extent in horizontal and vertical direction, mobility, density);
- Data gaps in the CSM and points for investigation;
- Screening and sampling technical equipment;
- Sampling rationale and design (media, locations, pattern and depth of samples), including background samples;

- Number of samples;
- Screening of observations wells or necessity for drilling new wells;
- Methods for establishing stratigraphy and characteristics of subsurface layers;
- Analytical test parameters / determinants required.

Fieldwork and laboratory testing
- Description of executed activities;
- Site conditions during fieldwork (e.g. dates, weather conditions, access to locations, etc.)
- Visual / olfactory evidence of contamination
- Results of screening techniques (if applied)
- Description of ground conditions and subsurface structure (borehole / exploratory hole log description) or water body;
- Selection of samples to be tested;
- Laboratory test results;
- Quality assurance and quality control;
- Possible deviations from sample plan and reasons involved.

Analysis and interpretation of exploratory data
- Comparison of laboratory test results to standards (Screening levels and Response levels);
- Description of situation of the contamination in the various media (soil, groundwater, sediment, surface water, air, biota) including depth and extent of contamination and including estimated quantity of polluted media;
- Implications of contamination, soil structure and general physical, chemical, ecological and spatial site conditions for remediation options;
- Development of groundwater flow, surface water flow, and mass transport models. (if required);
- (Seasonal) contour maps of groundwater flow and explanation of estimated groundwater processes;
- Possible influence of seasonal climatological situation on groundwater and surface water;
- Contour maps and cross-sections to show spatial distribution of contaminants; graphical displays that present the available data in their spatial context; sample values for data on maps or cross-sections; colours; grey scales, or symbols to high-light the locations of the highest sample values;
- Updated Conceptual Site Model, identifying sources, pathways and receptors.

Conclusions and recommendation
- Conclusions on the scope and objectives of the investigation with clear indication of known data gaps and possible uncertainties;
- Recommendations for
  - further investigation;
  - temporary safety measures if in the present situation significant risks to human health or environment are expected. This may include monitoring of a contaminated plume in groundwater.

Annexes

- Topographical map of area with location of the site
- Detailed site survey plan with location of sampling points
- Methods of fieldwork and laboratory testing
- Borehole / exploratory excavation logs with explanation codes
- Relevant screening and response levels
- Laboratory reports
- Calculations or modelling results and explanation characteristics of the model used
- Maps indicating contamination of soil, sediment and groundwater
- Background literature and sources
- Photographic record

Risk Assessment (Step 5, Task 5.2)

Within this task the following activities are performed:

- Assess contaminant concentration levels;
- Identify applicable source-pathway-receptor-combinations for human health;
- Perform a generic quantitative risk assessment for human health;
- If necessary, perform a more detailed quantitative risk assessment for human health;
- If necessary, perform a risk assessment for the environment;
- The above mentioned activities are carried out leading to a report including following sections:

Introduction and background information

- Description of the site (e.g. name, owner, address, site plan and size, GPS-coordinates);
- Summary of the previous investigations at the site;
- Information of the parties involved in the assessment and remediation process and allocation of their roles;
- Reason for and objectives of risk assessment.

Site situation

- The situation of the contamination at the site (present land use, infrastructure, buildings, use of the surrounding area);
- Description of history of the land use and cause of the contamination;
- Description of area with respect to existing land use, demographic profile, social economic and environmental conditions of the people in receptor areas, flora and fauna;
- Comparison of concentration levels against Screening and Response levels.

Relevant source-pathway-receptor combinations

- The conceptual site model (CSM) with the combinations of source-pathway-receptor of concern. A detailed description of the present contamination with characteristics (parameters, concentration, extent in horizontal and vertical direction, mobility, density);
- Relevant exposure pathways, preferably illustrated with diagram.

Results of generic quantitative risk assessment modelling

- Tool/model used to quantify risks
- Site-specific information used for modelling
  - Representative concentrations in soil, sediment and groundwater
  - Size of contamination in soil (3D)
  - Size of contamination in groundwater (3D)
  - Size of the site (contaminated and not contaminated)
  - Level of groundwater
  - Soil type (%organic matter, % clay, grain size, hard rock)
  - Surface water in the environment
  - Drinking water extension in the environment
  - Groundwater flow direction and estimated speed
  - Use of the contaminated site and the vicinity
  - Establishment of the site (buildings, basements, roads, crops)
  - Receptors on-site and off-site
- Model results and comparison to critical exposure value

Results of detailed quantitative risk assessment

- Reason for detailed quantitative risk assessment
- Collection of additional information (methodology used for obtaining data)
- Data obtained, e.g. contaminants investigated, contaminant concentration levels in the relevant contact media (e.g. air, dust), relevant specific circumstances
- Results

Conclusions and communication

- Clear statement on unacceptable risks identified
- Possible uncertainties and information gaps, necessity for further investigation
- Recommendations for further steps, setting remediation options and development of remediation options

Setting remediation objectives and requirements (Step 5, Task 5.3), Development of remediation options (Step 5, Task 5.4), Selection remediation option (Step 5, Task 5.5)

Within task 5.3 (Setting remediation objectives and requirements) the following activities are performed:

- Establish remediation objectives;
- Establish remediation requirements.

Within task 5.4 (development of remediation options) the following activities are performed:

- Assess the remediation objectives and requirements;
- Identify constraints to remediation;
- Identify applicable remediation techniques;
- Develop applicable remediation options.

Within task 5.5 (selection remediation option) the following activities are performed:

- Compare and appraise remediation options;
- Consult with relevant stakeholders;
- Prepare remediation investigation report, including stakeholder views;
- Review and approval of remediation investigation report and select most favourable remediation option.

The above mentioned activities are carried out leading to a report including following sections:

CSM and risk assessment

- Historical information of the site including subsequent site and groundwater use, industrial processes leading to soil contamination
- Geology
- Geohydrology
- Description of all contaminations (sources) including spreading processes (pathways)
- Description of risks (receptors)

Remediation objectives

- Risks to be remediated
- Objectives of the remediation
- Requirements of the remediation including other activities which are executed simultaneously (redevelopment)
- Stakeholders
- Funds
- Other legislation to be met
- Preconditions to be met with the remediation

Description remediation options

- Technical aspects to achieve the remediation objective an requirements
- Effects on surrounding and counter measures: sound, noise, soil vibration, groundwater drop, traffic hinder (intensity and duration), stability of soil
- Practical aspects of implementation: preparation of / on the site, safety measures
- Measurements / sampling program to verify the progress and final result of the implementation phase
- Communication with stakeholders prior to, during and after the remediation
- Production and/or usage of: energy, soil, air, water and activities or technical measures to dispose of products
- Risks and mitigating measures during implementation: technical, planning, concentration levels
- Legal aspects: permits and legal constraints
- Planning: preparation phase, implementation, extensive phase of in situ techniques, post remediation measures
- Post remediation measures: description of residual contaminations and subsequent technical and management measures necessary to prevent future human and ecological risks and risks of spreading of the contaminations

- Costs: implementation, post remediation phase and risks
- Point for further investigation during DPR or pilot phase

Evaluation of possible remediation options

- Points for evaluations
- Method for evaluations
- Evaluations of options (qualitative or quantitative)
- Selection of most favourable remediation option
- Point for further investigation during DPR or pilot phase

Annexes

- Maps, x-sections, tables technical schemes

Remediation design, DPR (Step 6)

Within this Step the following activities are to be performed:

- Design of the remediation: the technical system for the remediation will be presented. Detailed descriptions and drawings of the remediation measures will be reported.
- Costing and planning of the remediation: all activities are summarized and a costing is provided for each of these activities (volumes, amounts and unit prices). A planning of activities is made indicating the time involved for the activities.
- Environmental and social impact assessment and consultation of stakeholders
- The above mentioned activities are carried out leading to a report including following sections:

Introduction and background information

- Description of the site (e.g. name, owner, address, GPS-coordinates, site plan and size);
- Reason for the remediation;
- Summary of the previous investigations at the site;
- Information of the parties involved in the remediation process and allocation of their roles.

Site situation

- The situation of the contamination at the site (present land use, infrastructure, buildings, use of the surrounding area);
- Description of history of the land use and cause of the contamination;
- Typology of the contaminated site;
- Geology, geohydrology and soil structure and ground conditions of the site in case of contaminated soil and groundwater.
- Morphological and hydraulic aspects in case of contaminated sediments in surface water and seasonal variations in water level;
- The conceptual site model with the combinations of source-pathway-receptor) of concern. A detailed description of the present contamination with characteristics (parameters, concentration, extent in horizontal and vertical direction, mobility, density);

– Remediation approach
– Objective of the remediation related to regulatory requirements and the selected remediation option;
– Combination of the remediation with reconstruction activities at the site, possible impact on planning and results of the remediation measures and description of measures to manage this impact;
– Targets levels of the remediation to be achieved;
– Remediation techniques to be used: technical description;
– Stages in the remediation process (if appropriate);
– Necessity of a pilot testing of the remediation technique.

Detailed description of the remediation process

– Preparation activities:
    - o removal of buildings, infrastructure, foundations, tanks in order to achieve access to the contaminated material; if removal is not possible, which working constraints will have to be dealt with;
    - o mobilisation of equipment to the site;
    - o necessary staff during the remediation;
    - o organising the working and storage areas at the site;
    - o possible access limitations to parts of the site or the neighbouring area;
    - o availability of suitably licensed treatment or disposal capacity off site;
– Overview of the necessary permits and licenses;
– Measures necessary to prevent damage or nuisance (such as dust, odours, noise and dirt on roads) on the site and in the surrounding area (including possible transport of removed waste to a treatment or disposal site);
– Measures to improve sustainability aspects (e.g. reducing energy);
– When excavation of soil or dredging of sediment is part of the remediation strategy:
    - o size and contours of the excavation (area and depth);
    - o estimated volume of material to be excavated (in-situ and after excavation) and destination of the material (on-site rearranging or off-site treatment or disposal, for which the procedures of HWR-2008 may apply);
    - o necessary abstraction of groundwater;
    - o in case of dredging sediment: necessary preparation on the water way, lake, river or canal;
    - o temporary storage of material in depots;
    - o quality of the clean material to be used to replace the removed contaminated material;
– When groundwater abstraction is part of the remediation strategy:
    - o Pattern and depth of wells;
    - o Volume and planning of the abstraction period;
    - o Results model calculations of the groundwater remediation;
    - o Method of discharging abstracted water and necessary treatment;
– When in-situ techniques are part of the remediation strategy:
    - o Equipment to be installed (indication, pattern and specific location);
    - o Maintenance activities during the active phase of the remediation;
– Checkpoints during the remediation process and action levels or other criteria for assessment the intermediate results;

- Possible effects of the remediation measures and mitigating activities to be carried out to minimize these effects;
- Possible uncertainties in the situation (e.g. the delineation of the contamination is not very detailed at one side of the location) and ways of dealing with these risks.
- Planning of the remediation activities (project implementation schedule);
- Programme for supervision and environmental verification;
- Suggestions for sampling, testing and other measurements related to verification (to be elaborated further in a verification plan):
  - what are be the key parameters to verify the success of the progressing remediation;
  - which monitoring equipment should be installed before and during the remediation.
- Expected restrictions to future land use after finalizing the remediation activities;
- Identification of the need for post remediation activities;
- Health and safety aspects during the remediation:
  - possible exposure to contaminated material by skin contact, ingestion or inhalation;
  - necessary measures to prevent these risks (description of these measures to be elaborated in step 8);
  - safety measures regarding equipment and transport.
- Record keeping, use of a log;
- Estimation of costs, with distinction between costs for installing equipment, short term measures and costs for long term remediation and maintenance. Sometime an analysis of risks and variation of the costs;
- Insurance;
- Communication aspects in the process of implementation of the remediation. These communication aspects are related to restrictions and nuisance during the remediation and the possible restriction for land use in the final situation. Relevant stakeholders for the communication should be indicated;
- Maps, drawings, calculations must be added as annexed to the remediation design report.

Content of verification plan

- This Section presents a generic checklist for a verification plan, being part of the Detailed Project Report. In this verification plan the activities are described for verifying the results of the remediation.

Supervision and environmental verification

- Description of the tasks of the supervision and environmental verification of remediation works;
- Possible response actions to deal with uncertainties;
- Critical points in the remediation process where the progress should be assessed, a list of critical points during the remediation is given below (examples are the moment where an excavation; has reached its ultimate boundaries. Before supplementing with clean soil/material samples should be taken from the pit wall and bottom. Another example is a check on reaching the

intended depth for a groundwater extraction or treatment unit and verifying the number and pattern of extraction wells);
- Log with daily information of the site: remediation activities; verification activities; visits of regulators, accidents, injuries; etcetera;
- Results of sampling and testing the quality of removed or treated contaminated material and the quality of remaining soil or sediment;
- Results of (periodical) testing of the quality of surface water or groundwater;
- All executed measurements to check health and safety aspects and compliance with environmental permits and licenses;

Communication
- Overview of institutions and persons involved (names, addresses, telephone numbers, email);
- Appointments on communication with stakeholders (authorities, companies, community, press);
- Procedure for reporting for critical and non-critical deviation of the DPR;
- Procedure for reporting incidents and accidents at the site during the remediation;
- Planning of reporting interim and final results in an evaluation report to the authority.

Monitoring programme
- For long-term remediation projects where in-situ techniques are used or where groundwater is extracted and remediated monitoring of interim results is a very important activity to verify if the remediation results are heading in the right direction;
- Part of the monitoring programme is a planned sampling and testing strategy for the quality of soil, groundwater, sediments or surface water (if appropriate);
- Criteria for the evaluation of interim results of the remediation (e.g. the concentration gradient of a parameter in groundwater);
- Action levels for evaluation or response actions.

Annexure 2 – Standard unit cost conversion to the Indian market

In table 4.3 an estimate is presented of Capacity requirements for the role of Remediation Contractor. This estimate is presented in Euros, representing the situation in US, UK and NL. In this Annexure a method is presented for the conversion of these numbers into an estimate applicable to the Indian market.

Weighing cost elements in remediation options
In preparation of the conversion of these Standard unit costs to the situation in India we need to refine the numbers in table 4.3. The costs for every remediation are arrived at by adding up the cost for different cost elements. Typically, the following five cost elements are discerned:

- Energy consumption. This is the energy used for activities in all fourteen Steps of the site assessment and remediation process, e.g. the fuel for excavation and transport of soil, electricity for in-situ or pump and treat systems, water treatment or soil washing;
- Commodities. This includes for example soil or liner material for covering a site, soil for backfilling an excavated site, costs for storage and disposal of contaminated soil on a Sanitary Landfill (SLF) and materials for a water treatment plant (active carbon);
- Machines, trucks and installations. This includes for example water treatment plant, excavator, soil washing plant;
- Human resources, including the costs to hire personnel or to execute tasks;
- Tools and equipment. This includes small materials and measurements tools, safety measures, materials for sampling or monitoring, staff facilities, traffic and local residents.

The weight of each cost element will be different in every remediation option. This is shown in table A2.1 below, which is based on international best practice among soil remediation experts.
It may be noted that this table is not to be used for an Environmental Impact Analysis (EIA) as an analysis of capacity requirements emphasises other aspects of the remediation process than an EIA does.

Table A2.1 Weight of cost elements in remediation options

Remediation option (see table 4.2)	**Weight per cost element (in % of total cost, estimated spread 5%)**				
	Energy consumption	**Commodities**	**Machines, trucks and installations**	**Human resources**	**Tools and equipment**
Complete removal by excavation (exact figure depends on type)	25	30	20	20	5
Complete removal by long term pump and treat	40	20	5	20	15
Complete removal by dredging and treatment	25	30	20	20	5

Remediation option (see table 4.2)	Weight per cost element (in % of total cost, estimated spread 5%)				
	Energy consumption	**Commodities**	**Machines, trucks and installations**	**Human resources**	**Tools and equipment**
or storage of all contaminated soil material					
In situ removal to function oriented concentration level (type L and P)	25	10	10	30	25
Groundwater plume remediation by in situ removal of high concentrations and NA of low concentrations	4	3	1	46	46
Removal contaminated top soil and hot spots. Covering with clean soi. (type S-2 and S1a,b,c)	20	25	20	25	10
In situ removal of hot spots, followed by post remediation measures (type L and P)	25	20	10	30	15
Geohydrological isolation and receptor measures	30	5	20	25	20
Covering with clean or less contaminated soil (type S-2 and S1a,b,c)	25	35	15	20	5
In situ remediation (e.g. phyto remediation, type S1-d,e,f)	25	10	10	30	25

Table A2.1 shows what part of the total cost for remediation is being absorbed by every cost element. For example, of the total cost for a Complete removal by excavation and treatment or storage of all contaminated soil 25% can be expected to be absorbed by energy consumption, whereas 30% is likely to go to Commodities, 20% to Machines, trucks and installations and so forth.

Due to the limited number of available data at the time of publication of this report, the numbers in table A2.1 have been arrived at through theoretical reasoning. As available data mount in the future, these numbers can be validated empirically.

Naturally, the percentages presented in table A2.1 are generic and apply to the entire country. In practice, differences in the local availability of each cost element, and thereby the local market situation, will cause the percentages to vary. However, we assume that in cases where one of the cost elements is not available locally an alternative at a comparable cost level will be available. If for example locally no liner material is available to separate a clean capping layer from contaminated soil below, it can be replaced by a layer of locally abundant, and in that case cheap, river bed gravel. The way the remediation design is being presented determines the degrees of freedom to a large extent. Where the remediation design focuses on the remediation objectives, rather than on the exact methodologies or materials to be applied, it will offer local contractors more options to apply creative and cost-friendly alternative approaches when dealing with locally scarce commodities.

The Standard unit costs per remediation option as presented in Section 4.2.2 above are based on data from US, UK and The Netherlands. As such, these numbers do not fit the situation in India. Therefore, these Standard unit costs need to be converted to Indian cost units. The working method for this involves the application of a price level conversion from the EU to the Indian price level, followed by the application of the current conversion rate from the Euro to the Indian Rupee, i.e. €1 = INR 72 (as of 17th December 2015).

Price level conversion per cost element
First of all, a price level conversion factor is applied to each of the cost elements as presented in Section 4.2.2. For each of these cost elements, the price conversion is based on assumptions on price level ratios between India and the EU. These assumptions are based on comparison of publicly known cost structures, e.g. laboratory price lists, oil and electricity costs at source, and knowledge of the Indian engineering market prices for e.g. construction works. The resulting price ratios are presented in table A2.2 below.

Table A2.2 Price level ratio between India and the EU

Cost element	**Price ratio India/Europe**
Energy consumption	0.8
Commodities	0.5
Machines, trucks and installations	0.5
Human resources	0.25
Tools and equipment	0.25

As an example, it is assumed that costs for energy consumption in India amount to 0.8 of the costs for energy consumption in the EU.

Calculating Standard unit costs for the Indian situation
Application of the numbers in tables 4.3, A2.1 and A2.2 results in Standard unit costs for the Indian situation. This calculation is illustrated by taking the remediation option of Complete removal by long term pump and treat. According to table 4.3 the Standard unit cost for this type of remediation in the EU is €20/m^3. The weight of each cost element is taken from table A2.1, after which the price ratio for each cost element from table A2.2 is applied. This results in a Standard unit cost in Euro for the situation in India. Finally, the current conversion rate is applied, resulting in Standard unit cost in INR. Table A2.3 below presents an example of this calculation.

Table A2.3 Calculation of Standard unit costs for the Indian market

Remediation option: Complete removal by long term pump and treat	Energy consumption	Commodities	Machines, trucks and installations	Human resources	Tools and equipment	Total
Cost element weight (table A2.1)	40%	20%	5%	20%	15%	€ 20.00 / m^3
Cost element cost in Europe	€ 8.00 / m^3	€ 4.00 / m^3	€1.00 / m^3	€ 1.00 / m^3	€ 4.00 / m^3	€ 20.00 / m^3
Price ratio (table A2.2)	0.8	0.5	0.5	0.25	0.25	
Cost element cost in India	€ 6.40 / m^3	€ 2.00 / m^3	€ 0.50 / m^3	€ 1.00 / m^3	€ 0.75 / m^3	€ 10.65 / m^3
Cost element cost in India[1]	INR 461 / m^3	INR 144 / m^3	INR 36 / m^3	INR 72 / m^3	INR 54 / m^3	INR 767 / m^3

[1] €1 = INR 72 (conversion rate as of 17th December 2015)

The numbers in table A2.3 above can be used as basis for budgeting for site remediation. Reproducing the same calculation for the other remediation options results in the Standard unit costs shown in table A2.4 below.

Table A2.4 Estimated Standard unit costs per remediation option in India

Remediation option (see table 4.2)	**Standard unit costs**	
	Based on site size (unit: INR / m^2)	**Based on contaminated site volume (unit: INR / m^3)**
Complete removal by excavation (exact figure depends on contaminants)		5,527 – 7,369
Complete removal by long term pump and treat		766
Complete removal by dredging and treatment or storage of all contaminated soil material		1,474
In situ removal to function oriented concentration level		3,146
In situ removal of hot spots and natural attenuation of contaminated groundwater plume		15
Covering with clean soil after contaminated top soil and hot spot removal	679 – 1,699	1,106
In situ removal of hot spots, followed by post remediation measures		665
Geohydrological isolation and receptor measures		35
Covering with less contaminated sediment without any removal of contaminated sediment (exact number depends on contaminants)	737- 1,842	
In situ remediation (e.g. phyto remediation)	628	

Annexure 3 – Site assessment and remediation process in 14 Steps

This report frequently refers to the fourteen Step sequence that composes the site assessment and remediation process. This Annexure provides a summary of that sequence, for easy reference.

Step	Tasks	Activities
1- Identification of probably contaminated sites		Data collection, Data review
2- Preliminary investigation	2.1 Preliminary site assessment	Desk study, Site inspection, Limited sampling and testing, Comparing analytical results with standards, Reporting and review
	2.1 Preliminary site investigation	Investigation strategy, Fieldwork and laboratory testing, Comparison of test results with standards, Reporting and review
3- Notification of polluted site		Delineate the contaminated site, Impose site use restrictions and temporary safety measures,
4- Priority list addition		Assess available data on the site, Apply prioritisation algorithm to obtain priority score
5- Remediation investigation	5.1 Detailed site investigation	Define scope and investigation strategy, Fieldwork and laboratory testing, Analysis and interpretation of exploratory data, Reporting detailed site investigation
	5.2 Risk assessment	Assess contaminant concentration levels, Identify applicable source-pathway-receptor combinations for human health, Perform a generic quantitative risk assessment for human health, Perform a more detailed quantitative risk assessment for human health, Perform a risk assessment for the environment.
	5.3 Setting remediation objectives and requirements	Establish Remediation objectives, Establish Remediation requirements
	5.4 Development of remediation options	Assess the remediation objectives and requirements, Identify constraints to remediation, Identify applicable remediation techniques, Appraise several remediation options
	5.5 Selection remediation option	Compare and appraise remediation options, Consultation with stakeholders, Prepare remediation investigation report including stakeholder views, Review and approve remediation investigation report and select most appropriate remediation option
6- Remediation design, DPR		Design of the remediation, Costing and planning of the remediation, Environmental and social impact assessment and stakeholder consultation
7- DPR approval and funding		Review and approval of DPR
8- Implementation of remediation	8.1 Preparation and authorization	Inventory of required permits, Applying for the permits
	8.2 Contracting	Preparation of bid document, Selection of contractor
	8.3 Execution, supervision and verification of remediation works	Prepare remediation measures, Execute and manage remediation measures, Verify preparation of remediation measures, Verify remediation measures against contract and specifications Report verification results in a Remediation evaluation report
9- Approval of remediation completion		Review and approval of remediation evaluation report

Step	Tasks	Activities
10- Post re-mediation Plan		Preparation of post remediation plan. Review and approval of post remediation plan
11- Post re-mediation Action		Prepare Post Remediation Implementation Programme, Out-source implementation of post remediation activities, Implement post remediation activities, Supervise and verify post remedia-tion measures and prepare periodical post remediation status re-port, Review and approval of post remediation status report
12- Cost re-covery		Preparing cost overview of executed assessment and (post) re-mediation works
13- Priority List Deletion		Assess and record site use restrictions
14- Site re-use		Anticipate to site use restrictions, Arrangements to enable post remediation action

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Key points from consultations
Key output Report Task 6

Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India

Final

Ministry of Environment, Forest and Climate Change
Government of India

Authorisation

Title	:	Key points from consultations - Key output Report Task 6
Subtitle	:	Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India
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Management summary

General

This report presents the key output of the activities carried out under Task 6 (Addressing key points from consultations and implementing in Task-3 and Task-4 reports) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

Objective and report content

The objective of this Task 6 is to record and respond to the key issues raised during the stakeholder consultation meetings, organised in cooperation with PricewaterhouseCoopers within the framework of both their Assignment 3 (Institutional and legal framework for NPRPS) and this Assignment 2.

The objective of this report is to record the key issues raised during the stakeholder consultation workshops, for as far as these issues touch on the scope of this Assignment 2, as well as the response to the same. The latter is reflected in the incorporation of this response in new versions of the Task 3 report (March 2015) and the Task 4 report (December 2015).

Results

This report presents the results of the stakeholder consultation meetings. These consultations yielded the following salient points:

- The Guidance document as presented is fit for use by professional users;
- Include in the Guidance document:
  - Terms of Reference for preliminary site investigation;
  - Stakeholders to be consulted, with a focus on local stakeholders;
- Format of petition should ensure clear and verifiable information is entered;
- Ensure that scope of approach to a contaminated site (e.g. does it include groundwater?) is clear.

During the consultations the following general concerns were also voiced and addressed:

- There is concern that generic screening and response levels may result in an excessive number of sites that will eventually need action in some form. In response, it is pointed out that the competent authority does have instruments with which it is able to control the site investigation and remediation programme, most prominently prioritisation.
- There is concern about costs, of laboratory testing in particular. In response, it is pointed out that best international practice is to limit laboratory testing to the chemicals of concern, in view of the history of use of the site.

- The Methodology presented is aimed to be applicable to any site. Within this Methodology, the Menu of options, originally presented in the Task 3 report and subsequently included in the Guidance document, is a tool for the first round of elimination of non-eligible remediation options. After applying the Menu of options, the Guidance document literally guides the user through the further steps of elimination, until the most appropriate remediation option has been reached.

Conclusions

For conclusions, this report presents the way in which the stakeholder comments are incorporated in the reports.

Task 3 report, “Options and standards for remediation of polluted sites”

- The term ‘technical risk’ will be further explained in Task 3, Section 2.4.4 and in Task 4, Vol.-I, Step 5.4;
- Information on how to deal with specific climatic conditions in Task 4, Vol.-I, Step 5.3, will be checked and revised where necessary;
- Section 5 of the Task-3 report will refer to the combination of remediation and reconstruction activities.

Task 4 report, “Guidance document for assessment and remediation of contaminated sites in India”

- Standardised Terms of Reference for preliminary site investigation, and guidance for developing site specific Terms of Reference in the Guidance document will be included in Task 4, Vols. I and II, Step 2 and Step 5.1;
- In the description of every Step in Task 4, Vol. I, a separate Section on which stakeholders to consult during the performance of that particular Step, with a focus on local stakeholders, will be included;
- The example petition format for identification of probably contaminated sites (Task 4, Vol. II, 1-a) will be checked on whether it needs to be revised to safeguard that the format petition ensures that only clear and verifiable information is entered;
- The definition of contaminated sites (Task 4, Section 0.2 and Glossary) will be checked on whether it needs clarification on its scope.

Task 5 report, “Capacity building requirements”

- It will be ensured that a mention of the fact that all capacities need to be developed is included in Task 5, Chapter 3. Also, the capacities to identification of the polluter, responsible person or institutions will be included in the Guidance document (Vol. I, Step 1);
- The Task-4 report of Assignment 3 does mention. In Task-5 a timeline for execution of investigation and remediation works will be incorporated, in alignment with Task-4 report of Assignment 3;
- The fact that situations can arise for which commissioning of external expertise may be necessary is part of the description of the responsible parties executing the activities in Section 3.2.1 of the Task 5 report. It will be checked if this needs further clarification.

Table of contents

1 Introduction

1.1 General

This report presents the key output of the activities carried out under Task 6 (Addressing key points from consultations and implementing in Task-3 and Task-4 reports) of Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

1.2 Objectives of Task 6

The objective of Task 6 is to produce a "Summary report documenting key points from consultations and how these are addressed in the final guidance document and technical notes" (quotation from the Terms of Reference for this Assignment).

1.3 Scope of Task 6

The scope of Task 6 contains the response to the reports of this Assignment, recorded during two stakeholder consultation workshops, held after delivery of the draft reports on Task 3, "Options and standards for remediation of polluted sites", and Task 4, "Guidance document for assessment and remediation of contaminated sites in India", of this Assignment. This means the scope consists of the response to both these draft reports from the stakeholder consultation meetings, held on 3rd February 2015 at the Novotel in Ahmedabad (Gujarat), and on 5th February 2015 at the GRT Grand in Chennai (Tamil Nadu).

The response from these meetings to the draft reports of Assignment 3 has been implemented by that Assignment's project team. The implementation of the response has been aligned between the two project teams.

Earlier, stakeholder consultation meetings have also been held (see Section 2.1). Because the response from these stakeholder consultation meetings had already been implemented in the draft reports on Task 3 and Task 4 this response is considered to be outside the scope of Task 6.

1.4 Output and practical applicability

This report presents the response to the draft reports of this Assignment, recorded during the two stakeholder consultation meetings in February 2015 and the way this response has been incorporated in the final versions of the Task 3 and Task 4 reports of this Assignment. Where received comments touched upon the content of the Task 5 report the way this has been dealt with in that report is also presented here.

This Task 6 report is best used when a quick overview of stakeholder response and its incorporation in the other reports of this Assignment is sought.

2 Response by stakeholders

2.1 Setting the stage

The Stakeholder Consultation workshops are a formal deliverable of this Assignment, according to the description under Task 6 in the Terms of Reference. Those Terms also specify that the workshops are to be organised before completion of Task 3 and 4.

Earlier draft versions of both Task 3 and Task 4 reports of this Assignment have been reviewed by the MoEF&CC, CPCB and the World Bank. Those reports have also been discussed in meetings of the Technical Expert Panel (TEP) and other stakeholder meetings. These include multilateral consultations on 29th November 2012 in Hyderabad, with participation by MoEF, CPCB, World Bank and SPCB's from Andhra Pradesh, Goa, Maharashtra, Tamil Nadu and West Bengal, and on 13th August 2013 in Delhi, with participation by MoEF, other TEP-members and State/SPCB-representatives from Andhra Pradesh, Delhi, Gujarat, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal. A complete overview of stakeholder consultations during this Assignment is presented in Annexure 1. The results of these discussions were incorporated in later draft versions of these reports.

The versions of the reports of this Assignment that were used for the Stakeholder consultation meetings were the draft version of the Task 3 report, submitted on 27th June 2014, and the draft version of the Task 4 report, submitted on 29th July 2014. The latter draft report was subsequently widely distributed among stakeholders, notably among SPCB's, with a request for comments. The Assignment 3 consortium delivered its draft Task 3 report in September 2013 and its Task 4 report in June 2014. Similar to this Assignment, Assignment 3 is also required to organise workshops to ensure input by stakeholders. Review by the MoEF&CC, CPCB and the World Bank of the reports mentioned in this Section revealed that it would be most beneficial for the results of both Assignments to combine all required workshops. Thus, during a meeting under the chairmanship of the Joint Secretary of the MoEF&CC on 19th December 2014, it was decided to have both consortia organise two workshops, one in Ahmedabad and another, during the same week, in Chennai. Both workshops were to contain the same content, so that participants only needed to attend one workshop.

The institutions to be invited to the workshops were nominated by the Consultants and subsequently selected by the MoEF&CC, including the designations of the functionaries who would be invited to attend. On 21st January 2015 a formal invitation by the Joint Secretary of the MoEF&CC was distributed among the selected invitees by the Consultants. Organisational aspects for the Ahmedabad workshop were taken up by the Assignment 3 consortium, for the Chennai workshop by the consortium of this Assignment. Both acted on behalf of the MoEF&CC in this regard.

2.2 The meetings

The stakeholder consultation meetings discussed in this report were held on Tuesday, 3rd February 2015 at the Novotel in Ahmedabad (Gujarat), and on Thursday, 5th February 2015 at the GRT Grand in Chennai (Tamil Nadu), both from 10.00 am to 4.00 pm. During the morning part of the meeting the Assignment 3 consortium held a presentation of their findings, after which the response by the stakeholders was taken during discussion of these findings. After lunch the Assignment 2 consortium held a presentation of their findings, after which the response by the stakeholders was taken during discussion of these findings.

The Stakeholder Consultation meeting in Ahmedabad was attended by 25 persons, representing CPCB, four SPCB's (Goa, Gujarat, Madya Pradesh and Punjab), an NGO (Toxics Link), MoEF&CC, and the consultants for all three projects, including the Inventory project. The list of participants is included in Annexure 2.

The Stakeholder Consultation meeting in Chennai was attended by 24 persons, representing CPCB, five SPCB's (Andhra Pradesh, Karnataka, Tamil Nadu, Telengana and West Bengal), a State Government (Kerala), a research institute (CSE), and the consultants of both the Methodologies project and Legal and institutional project. The list of participants is included in Annexure 3.

The results of both stakeholder consultation meetings were discussed with a representation of the MoEF&CC, the World Bank and CPCB during a wrap up meeting, held on Friday, 6th February 2015, from 10.00 am to 2.00 pm at the GRT Grand in Chennai.

2.3 The response, salient points

This Section discusses the response that addressed the draft Task 3 and Task 4 reports of this Assignment. A table presenting all comments on these reports, received during both workshops, is presented in Annexure 4.

The salient points, which were also discussed during the wrap up meeting on 6th February, are briefly outlined below.

Guidance document fit for use

Participants agree that the Guidance document in the presented form is fit for use by SPCB's and other stakeholders while applying the Methodology. It is pointed out that the use of the document does require a certain knowledge of the technical aspects of site investigation and remediation. At the same time, it is recognised that the stakeholders do possess this enough of this capacity to start applying this document in performing their day to day tasks in this field.

While it is expected that application of the Guidance document in this way will disclose suggestions for improvement, there is general agreement that it is time to start its application (Annexure 4, comment 1 to Task-4 report). It is advised to keep the Guidance document up to date by setting up a structured scheme to manage the document. Such a scheme should include a system for the incorporation of user's suggestions.

Include Terms of Reference for preliminary site investigation
However diverse polluted sites may be, preliminary site investigation typically does include aspects that are often similar. An example of this is how to carry out sampling. In view of this, it is suggested to include Standardised Terms of Reference for preliminary site investigation, and guidance for developing site specific Terms of Reference in the Guidance document (Annexure 4, comment 20 on Task-4 report).

Include stakeholders to be consulted
It is indicated that stakeholders, especially on a local level, can often provide a lot of useful information. A considerable number of stakeholders are suggested, like Groundwater authority, District Collector, Kotwal and Patwari. It is therefore proposed to include in the description of every Step in the Guidance document a separate Section on which stakeholders to consult during the performance of that particular Step, with a focus on local stakeholders. For a complete list of the stakeholders mentioned which could be consulted per Step, refer to Annexure 4, comment 7 on Task-4 report.

Ensure clear and verifiable information in the petition
To prevent unfounded complaints the format for petitions should be such that it ensures that information entered is clear and verifiable (Annexure 4, comment 9 on Task-4 report).

Scope of approach to a contaminated site
Some concern was voiced about what exactly is a contaminated site. It is widely agreed that in approaching a contaminated site not only the waste, but also the soil, sediments and (ground)water contaminated by that waste, should be considered (Annexure 4, comment 3 on Task-4 report). It should be noted that there can be more than one source of contamination. The methodologies presented in the Guidance document do take into account that contaminated sites can have effect on the quality of the surface water as well. Assessment and remediation options are presented specifically for these media.

2.4 The response, general concerns

This Section presents the general concerns that were raised during the stakeholder consultation meetings and that do not necessitate revision of the reports. These concerns have been brought to the attention of the client during the wrap up meeting on 6th February.

Response levels and prioritisation
It is stressed that screening and response levels are defined levels that are generically applicable. Concern is raised that this may result in an excessive number of sites that will eventually need action in some form. In addressing this concern it is pointed out that the competent authority does have instruments with which it is able to control the site investigation and remediation programme. Most prominent of these instruments is prioritisation. It is generally recognised

that not all sites can be dealt with at short notice. By applying a clear prioritisation system the competent authority can clarify the selected order of action to stakeholders.

Cost control
Concern was voiced about costs, of laboratory testing in particular. In addressing this concern it is pointed out that best international practice is to limit laboratory testing to the chemicals of concern, in view of the history of use of the site.

Application of the Methodology, role of the Menu of options
The Methodology presented is aimed to be applicable to any site. Within this Methodology, the Menu of options, originally presented in the Task 3 report and subsequently included in the Guidance document, is a tool for the first round of elimination of non-eligible remediation options. After applying the Menu of options, the Guidance document literally guides the user through the further steps of elimination, until the most appropriate remediation option has been reached.

3 Incorporation of response in reports

This Section discusses the way the response that addressed the draft Task 3 and Task 4 reports of this Assignment has been incorporated in the final versions of the reports. The incorporation of all comments on these reports, received during both workshops, is presented in detail in the table in Annexure 4. The comments have been implemented accordingly in the reports of Task 3 (March 2015), and Task 4 (Guidance document, December 2015).

3.1 Task 3 report

The Task 3 report is entitled “Options and standards for remediation of polluted sites”.

With reference to selection of remediation option, it was queried what is meant by technical risk, which was clarified as the risk not tested before. For the purpose of clarification, this point will be further explained in this Section 2.4.4 of the Task 3 report, as well as in the Guidance document (Vol.-I, Step 5.4).

With reference to setting remediation objectives (Task 3 report, Section 3.5), under Indian climatic conditions rainfall plays an important role and therefore also in pathways. The Guidance document (Vol.-I, Step 5.3) includes a discussion on the effects of monsoon. The information provided on this matter will be checked and revised where necessary.

It was suggested that it can be beneficial to combine remediation with other activities. The combination of remediation and reconstruction activities is described in the methodology (Step 5.4 in the Guidance document). In Section 5 of the Task-3 report this will be referred to as well.

3.2 Task 4 report

The Task 4 report is entitled “Guidance document for assessment and remediation of contaminated sites in India”.

Include Terms of Reference for preliminary site investigation

Standardised Terms of Reference for preliminary site investigation, and guidance for developing site specific Terms of Reference in the Guidance document will be included in the Step 2 and Step 5.1 Sections of Vols. I and II of the Guidance document (Annexure 4, comment 20 on Task-4 report).

Include stakeholders to be consulted

In the description of every Step in Vol. I of the Guidance document a separate Section on which stakeholders to consult during the performance of that particular Step, with a focus on local stakeholders, will be included (Annexure 4, comment 7 on Task-4 report).

Ensure clear and verifiable information in the petition
The example petition format for identification of probably contaminated sites (Guidance document, Vol. II, 1-a) will be checked on whether it needs to be revised to safeguard that the format petition ensures that only clear and verifiable information is entered (Annexure 4, comment 9 on Task-4 report).

Scope of approach to a contaminated site
It should be noted that there can be more than one source of contamination. The definition of contaminated sites will be checked on if it needs clarification on its scope (Annexure 4, comment 3 on Task-4 report).

3.3 Task 5 report

The Task 5 report is entitled “Capacity building requirements”.

It was pointed out that basically all capacities still need to be developed. but this needs to be explicitly included. A comprehensive description of required capacities is presented in Chapter 3 of the Task 5 report. It will be ensured that a mention of the fact that all capacities need to be developed is included. Also, the capacities to identification of the polluter, responsible person or institutions will be included in the Guidance document (Vol. I, Step 1).

It was queried what can be regarded as average period for execution of investigation and remediation works. The discussion on this query concluded that time framework should be part of NPRPS-information. The Task-4 report of Assignment 3 does mention a timeline. In the Task-5 report this information will be incorporated.

It was offered that situations can be very complex, and subsequently queried if there should be a team on hand for that kind of situation. The fact that situations can arise for which commissioning of external expertise may be necessary is part of the description of the responsible parties executing the activities in Section 3.2.1 of the Task 5 report. It will be checked if this needs further clarification.

4 Annexures

Annexure 1 – Previous stakeholder and review consultation meetings

Title of Meeting	Date and City	Content	Participants, besides Grontmij (and in some cases other) project team(s)
Inception meeting	10th April 2012, Delhi	Presentation of and discussion on project approach, alignment project strategy with MoEF	MoEF, CPCB, DPCC
Bilateral meetings during Inception phase	10-13th April 2012, Delhi and Mumbai	Bilateral meetings and site visits	CPCB, DPCC, 2 CETP sites in Delhi, MH government, TTC site near Mumbai (MH)
Site visits	February, June, July, November 2012; February, May 2013, April 2014	13 site visits, including interviews with employees of local authorities and SPCB's	Lake NMK (AP, now TS), Ranipet (TN), Nibra (WB), Hoogly (WB), Dhapa (WB), Lucknow (UP), Kanpur Dehat (UP), Kanpur Rakhi Mandi (UP), Ganjam (OD), Eloor (KL), Ratlam (MP), Talcher (OD), Lohia Nagar (UP)
4th TEP meeting	28th June 2012, Delhi	Presentation of and discussion on draft results Tasks 1, 2 and 3 and approach on Task 4	TEP members, among whom representatives of MoEF, WB, CPCB, APPCB and WBPCB
Stakeholder interviews	June-July 2012, Delhi, Chennai and Kolkata; November 2013: Lucknow, Bhubaneshwar and Hyderabad	Interviews with MoEF, CPCB and selected SPCB's to focus scope of typology and to discuss remediation options	June-July 2012: CPCB, TNPCB, WBPCB, Delhi PCC November 2013: UPPCB, OSPCB, APPCB
6th TEP-meeting	13th August 2012, Delhi	Presentation of and discussion on draft results Tasks 1, 2 and 3	TEP members, among whom representatives of MoEF, CPCB, WB, WBPCB, APPCB
Stakeholder consultation workshop	29th November 2012, Hyderabad	Presentation and consultation stakeholders	SPCB's of AP, WB, MH, Goa, TN, and MoEF, CPCB, WB
Review meeting	30th November 2012, Delhi	Discussion on results and planned activities	MoEF, CPCB, WB
Review meeting	14-15th February 2013	Approval of Task 1 and 2 reports. Draft	MoEF, WB

Title of Meeting	**Date and City**	**Content**	**Participants, besides Grontmij (and in some cases other) project team(s)**
		report Task 3 discussed. Points for attention Task 4 provided.	
Stakeholder interviews	March 2013 (Bhubaneshwar, Kolkata, Hyderabad)	Interviews to discuss Guidance Document content and structure	OSPCB, WBPCB, APPCB
Review meeting TEP	16th May 2013, Delhi	Presentation of and discussion on results Task 3 and first draft results Task 4	MoEF, WB, CPCB
Meeting	8th July 2013, Houten, The Netherlands Nov and Dec. 2013 telephone conferences	Discussions on comments with World Bank expert Mr. Kallnischkies.	Mr. Kallnischkies (World Bank)
Stakeholder consultation workshop	13th August 2013, Delhi	Presentation of and discussion on results of Task 3 and second draft report Task 4	MoEF (Secretary, joint-secretary, project director,) other TEP-members and State/SPCB-representatives (AP, MH, UP, Delhi, MP, GJ, TN, WB)
14th TEP-meeting	21st April 2014, Delhi	Presentation of and discussion on results final reports of Task 3 and Task 4	TEP, MoEF, CPCB, WBPCB

Annexure 2 – List of participants workshop Ahmedabad

Stakeholder Consultation Workshop on National Programme for Rehabilitation of Polluted Sites (NPRPS)

Date: 3 February 2015 Venue: Ahmedabad

LIST OF PARTICIPANTS

SL No.	Name of the organization	Person Name	Designation	Signature
1.	CPCB, Delhi	Bharat Kr. Sharma	SEE	[signature]
2.	Kadam Environmental Consultants, Vadodara	JA RATHI	Sr. VP	[signature]
3	"	Mehul Pethkar	Consultant Hydrogeologist	[signature]
4.	MoEF & CC	Dr. [illegible] Rai [illegible]	Joint Director	[signature]
5	Pb. Pollution Control Board	Pawan Kumar Garg	Env. Engineer	[signature] 3/2/15
6	Pb. Pollution Control Board (PB)	Rajesh Kumar	Sr. Scientific Officer	[signature] 3/2/15
7	Advocate (Part of PWC team)	Videh Upadhyay	lawyer	[signature]
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Stakeholder Consultation Workshop on National Programme for Rehabilitation of Polluted Sites (NPRPS)

Date: 3 February 2015 Venue: Ahmedabad

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Annexure 3 – List of participants workshop Chennai

Stakeholder Consultation Workshop on National Program for Rehabilitation of Polluted Sites (NPRPS)
Date: 5 February 2015 – Venue: Chennai

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28						
29						
30						
31						

Annexure 4 – Stakeholder response and implementation in reports

Task-3 report, Options and standards for remediation of polluted sites

Nr.	Section	Page	Comment	Commentator suggested solution	Implementation	Action items and re-marks
1	2.4.4	43	With reference to selection of reme-diation option, it was queried what is meant by technical risk, which was clarified as the risk not tested be-fore.	n/a	Explanation should clarify this.	Further explanation of this point in this section and in Guidance docu-ment Vol.-I, Step 5.4. Implemented in Vol.-II-5.5-a.
2	3.5	53	With reference to setting objectives, under Indian climatic conditions rainfall plays an important role and therefore also in pathways.	Rainfall should be included as element in defining remediation objectives.	As suggested by Commentator.	The Guidance docu-ment (Vol.-I, Step 5.3) includes a discussion on the effects of mon-soon. The information provided on this matter will be checked and re-vised where necessary. Implemented in Vol.-I-5.4, Box I-5.4.1 refers to climatic condition).
3	5	74	It can be beneficial to combine re-mediation with other activities.	Include reference to this option.	The combination of remediation and reconstruction activities is described in the methodology of Step 5.4 in the Guidance document. In Task-3 report this will be referred to as well. Implemented, site redevelopment is referred to in several Chapters.	Example is the remedi-ation of a Cr waste dump in Punjab, where the waste from the ex-cavation was used for brick manufacture.

Task-4 report, Guidance document for assessment and remediation of contaminated sites in India

Nr.	Section and page	Comment	Commentator suggested solution	Implementation	Action items and remarks
	Chapter 0, Introduction				
1	Generic	Participants agree that the Guidance document in this form is fit for use by SPCB's or other organisation while applying the Methodology.	Capacity building by training is required.	There is no need for further revision of major elements of the Guidance document. Consultants have been requested to prepare a proposal for a Training Course.	Comment does not lead to necessity to amend document. Implemented.
2	Vol.-I, Chapter 0	Can the Methodology be applied on radioactive or biomedical waste as well?	Add contamination by other sources in addition to Industrial Hazardous waste.	The NPRPS explicitly focuses on contaminated sites where the contamination is caused by improper use or storage of hazardous waste in the past. For other types of waste specific regulations are in place. However, there are various elements of the process and content of assessment and remediation which can be used for remediation of other types of waste as well.	Check description of scope in the Introduction section of Guidance document. Implemented.
3	Vol. I, 0.2, p. 5 Vol. I, Glossary, p. 5	Does the definition of contaminated sites include groundwater? Does the Methodology take water related aspects of receptors into account?	Include human dependency on ground, surface water, agriculture (as sensitive receptors).	The definition of contaminated sites includes, besides the waste itself, also the soil and groundwater contaminated by the same. It should be noted that there can be more than one source of contamination. Contaminated sites can have effect on the quality of surface water as well. The methodologies do take this into account. Assessment and remediation options are described specifically for these media.	Check if definition of contaminated sites needs the kind of clarification stated here. Implemented.
4	Vol. I, 0.6, p. 14 Vol. I, 2.1.1, p. 2 Vol. II, 2.1-a Vol. I, 2.2.2, p. 2 Vol. I, 5.1.1, p. 1	How to guarantee the quality of the laboratories (and other companies involved)?	n/a	International best practices in Quality assurance and quality control are presented, as is NABL system for laboratory testing.	Check if this needs further clarification.

Nr.	Section and page	Comment	Commentator suggested solution	Implementation	Action items and re-marks
5	Vol. II, 2.1-a	Check if the cross references among the three Volumes are complete.	References to the sample testing protocols should be included.	This Section does include references to the sampling testing protocols.	Comment does not lead to necessity to amend document.
	All steps				
6	Vol. I, All Steps	Case studies do not seem to be included in the Methodology.	Include case studies in the system.	See comment 22. Vol. III, Section 5.4-i provides information on remediation techniques. References to literature and case studies are included in this Section.	Comment does not lead to necessity to amend document. The 100 sites that have been subjected to preliminary site investigation as part of the Inventory project will probably be included in the system. Suggestion to be relayed to the COWI team.
7	Vol. I, All Steps	We could use more information on stakeholders to be consulted.	Elaborate somewhat on how to go about which stakeholders to consult during the 14 steps, with the emphasis on local (grass roots) stakeholders like the phadvari. Suggestion to include this in a dedicated Section at every step. ◦ Step 1: first local stakeholders like residents, farmers, industrialists, then gradually move up towards authorities at district and state level. ◦ Step 2: interviews can be a standard part of this Step. Local people have been consulted. Groundwater authority, Water Supply & Sanitation, Surveyor of India, District administrator for data on ownership etc., SPCB for existing data. Central Ground Water Board for data from their extensive nationwide surveys of groundwater.	Implemented as suggested by Commentator.	PwC can be consulted for examples on stakeholders. Implemented.

Nr.	Section and page	Comment	Commentator suggested solution	Implementation	Action items and re-marks
			◦ Step 3: District Collector, in consultation with SPCB for public consultation, root level staff at local authority (village level), e.g. Revenue Department, Kotwal, Patwari. ◦ Step 4: the Competent Authority. District Collector to be consulted. ◦ Step 5: local and state level responsible authorities, for information and data (during all Steps in fact). Process towards selection of remediation option: different departments, NC's, local experts, depending on the size of the site one looks at local or state level. For large scale site include Central, similar to described under EIA Rules 2006.One nodal officer from CPCB. SPCB should be in the remediation investigation throughout the study and also with consultants, for setting objectives and for local consultation. ◦ Step 6 and 7: The Competent Authority. ◦ Step 8, preparation - all relevant permitting (implementing) authorities, for small sites they will be departments, for large sites ministries, even at the Central level. EIA clearance may not be required. ◦ Step 8, execution – SPCB, State government, Central government. Third party. At Substep 8.2 State and Central Government involvement. Substep 8.3 is performed by contractor, supervision by SPCB, State and Central Government.		

Nr.	Section and page	Comment	Commentator suggested solution	Implementation	Action items and remarks
			◦ Step 9: the Competent Authority. ◦ Step 10: land use designation authority. This could take the form of a stakeholder consultation similar to the one in the run up to remediation (e.g. interdepartmental committee with experts). Land use decision to be taken at this stage; ◦ Step 11: none suggested. ◦ Step 12: technical expertise. Stakeholders are already there. ◦ Step 13: the Competent Authority. ◦ Step 14: Land Use Authority. Information on land use and its restrictions should be shared with the local stakeholders. Change in land value following the performance of all Steps should also be shared in the revenue records, with the Land Registration Office.		
	Step 1, Identification of probably contaminated sites				
8	Vol. I, 1.1, p. 1	Is the definition of ‘probably contaminated sites’ universal? This term could induce blight.	Replace by a more neutral term, like ‘Study sites’ or ‘Reference sites’. The term ‘hot spots’, as was also suggested, does suggest contamination, and does therefore not offer a solution for the issue raised.	The suggested term may be adequate. It has emerged after careful deliberation with the TEP.	Comment does not lead to necessity to amend document.
9	Vol. II, 1-a, p. 1-3	Where is the petition to be addressed to? Also, to prevent unfounded complaints the format for petitions should be such that it ensures that information entered is clear and verifiable.	Replace by ‘competent authority’.	As suggested by Commentator.	Revise document as suggested. Check if format needs revision to ensure that information entered is clear and verifiable. Implemented.

Nr.	Section and page	Comment	Commentator suggested solution	Implementation	Action items and re-marks
	Step 2, Preliminary investigation				
10	Vol. I, 2.1, p. 7	Flowchart for quick assessment of preliminary investigation. What when multiple parameters are involved?	n/a	For every parameter for which samples have been tested on, a comparison should be made with the Screening and Response level for that parameter.	Check if this needs further clarification. Implemented.
11	Vol. II, 2.1-b	Avoid misunderstandings regarding Response levels and Hazardous Waste Rules-levels Schedule II.	No reference to Schedule II Hazardous Waste Rules levels in the Guidance document.	Reference to HWR-2008 will be made only when explicitly required related to the transportation and treatment of contaminated material.	Check present references within Guidance document on this matter. Implemented.
12	Vol. II, 2.1-b	Have elevated natural background levels been considered in determining screening and response levels?	n/a	Sections 2.2, 5.1 and 5.3 in Vol. I of the Guidance document describe the influence of natural contamination on site assessment and remediation.	Comment does not lead to necessity to amend document. One can adapt screening and response levels in case of elevated natural background levels.
13	Vol.-II, 2.1-b	How to deal with natural contamination?	Elevated levels of substances due to the geological origin of the area may cause risks for human health or the environment. This aspect should be taken into account in the Methodology.	Sections 2.2, 5.1 and 5.3 in Vol. I of the Guidance document describe the influence of natural contamination on site assessment and remediation.	Comment does not lead to necessity to amend document. Also see comment 12.
14	Vol. II, 2.1-b, p. 3	Dutch intervention values are adopted as the response levels. However, the response level for Cr6 is set at 50 mg/kg, as opposed to the Dutch intervention level being 78 mg/kg.	n/a	n/a	Comment does not lead to necessity to amend document. It is pointed out that the levels applied in the Hazardous Waste Rules cannot be used to assign response levels.
15	Vol. I, 2.2.2, p. 6	How many parameters should be tested in samples?	n/a	Screening and response levels exist for a large number of contaminants. Also, best international practice is to limit laboratory testing to the chemicals of concern, in view of the history of use of the site.	Check whether this needs further clarification. Implemented.

Nr.	Section and page	Comment	Commentator suggested solution	Implementation	Action items and remarks
	Step 3, Notification of polluted site				
16	Vol. I, 3	What agency is responsible for notification?	n/a	This aspect is relevant for legal issues in NPRPS. Therefore this aspect is relevant for PwC-report.	It is pointed out that notification of a site has to be done by the competent authority. Comment does not lead to necessity to amend document.
17	Vol.-I , 3	Who is the responsible authority/agency for temporary site use? Who will take care of water or food supply in case of site restriction measures?	Provide for a clear description in the Guidance document, or in a policy document NPRPS, on what documents are required for the restriction implementation.	To be discussed with PwC.	PwC and Grontmij will discuss in which of the documents (NPRPS or Guidance Document) this element should be incorporated.
	Step 4, Priority list addition				
18	Vol. I, 4	Priority listing is based on relatively limited information from the preliminary site investigation.	n/a	n/a	Comment does not lead to necessity to amend document.
19	Vol.-I , 4	Priority system should provide for a transparent scoring method.	n/a	COWI-consortium will finalize Task-5 report on prioritisation system. Grontmij will use summary to incorporate in Guidance document (Step 4).	Check current text of Vols.-I and -II for Step 4. Implemented.
	Step 5, Remediation investigation				
20	Vol.-I, 5.1	Some questions on detailed site investigation methodology.	A ToR draft needs to be included on how to carry out sampling etc., criteria for carrying out sampling, analysis.	Incorporate elements of ToR in Step 2 and Step 5.1.	Revise Vol.-I and Vol-II of Step 2 and Step 5.1. Implemented, ToR was added to Volume III-2.1-a Checklist.
21	Vol. I and II, 5.1	Where is the information on the assessment of human health impact?	Somehow add this information in the detailed site investigation. This would be especially welcomed in relation to Pb, As and Hg.	The Sections on detailed site assessment (Step 5.1) and risk assessment (Step 5.2) do pay attention to the impact on human health as a key issue in site assessment.	Comment does not lead to necessity to amend document.

Nr.	Section and page	Comment	Commentator suggested solution	Implementation	Action items and re-marks
				Bear in mind that toxicity to humans is already one of the key factors that de-termine the response levels.	
22	Vol. I, 1 Vol. I, 5.1 (also) Task-3?	Is there a set methodology to deter-mine delineation of area to be inves-tigated? Horizontal distance be-tween two samples while trying to delineate the site?	Would it be possible to include 1 or 2 international case studies? Advance in-formation should be available on the case(s) to be used in the (field) training. Delineation is an issue to be considered from the start.	International best practice is to apply the Conceptual Site Model. Based on that, the investigation strategy and sample protocol can be designed. During detailed site assessment this is a very site specific exercise. Vol.I, Section 5.1 provides a detailed expla-nation.	The intended Training Course should focus on field training and should be conducted in a real life actual situation, and should include a demonstration of pre-liminary site investiga-tion method.
23	Vol. I, 5.1	Make sure plumes are monitored.	Refer to monitoring of plume as re-quired activity.	As suggested by Commentator. The monitoring of plumes before remedia-tion is carried out, should be de-scribed in Vol. I, Section 5.1.	Check if this needs fur-ther clarification. Implemented: addition to Vo.-II-3-a.
24	Vol. I, 5.2		Suggestion to include boundaries below which no action is necessary (e.g. mini-mum area of contamination for action to be required).	This issue has been discussed with MoEF/CPCB/WB earlier in the pro-ject. The conclusion was that there should be no minimum area. This conclusion was mainly based on the principle that if the concentration lev-els of a very small contaminated site are very high they can still put human health or environment at risk.	Comment does not lead to necessity to amend document.
25	Vol.-I, 5.2	Which risk models have been sug-gested in the Methodology?	Describe some five or six models, but do not select a single one. The compe-tent authority should be able to make this selection.	Volume III of Guidance document pro-vides for a description of scope and characteristics of several risk models.	Comment does not lead to necessity to amend document.
26	Vol.-I, 5.3	Does the Methodology provide for the possibility to develop site spe-cific remediation targets? E.g. for Hoogly-site a level of 100 mg/kg Chromium has been chosen, based on risk based assessment.	Provide for an option to develop site specific remediation targets.	Volume-I, Step 5.3, describes the set-ting of remediation objectives. In this Section the possibility to develop risk based site specific remediation tar-gets is described.	Comment does not lead to necessity to amend document.
27	Vol.-I, 5.3	Should there be any involvement of landowners in decision on target levels and remediation options?	The policy document NPRPS should mention the role of the liable parties in deciding the remediation.	n/a	This is a matter for PwC to describe in their Task-4 report.

Nr.	Section and page	Comment	Commentator suggested solution	Implementation	Action items and re-marks
28	Vol.-I, 5.3	The report is silent on Ground Water Remediation Standards that are applied at remediation site.	There should be standards for ground water contamination. Currently, India has wastewater discharge standards, drinking water standards, surface water standards, etc. For instance, in US, it depends upon the ground water classification in which the site is located.	Vol. I, Step 5.3 describes the development of remediation objectives. This may be site specific based on risk assessment. As generic target levels Indian Drinking water standards may be used because they provide a level which is related to save use.	Check if this needs further clarification. Implemented, no revision required.
29	Vol. I, 5.4	Situations can be very complex. Should there be a team on hand for that kind of situation?	n/a	Situations can arise for which commissioning of external expertise may be necessary. This is part of the description of the responsible parties executing the activities in Section 3.2.1 of the Task-5 report.	Check if this needs further clarification. Implemented, no revision required.
30	Vol. I, 5.4	It can be beneficial to combine remediation with other activities.	Include reference to this option.	The combination of remediation and reconstruction activities is described in the methodology, Vol. I, Step 5.4.	Example is the remediation of a Cr waste dump in Punjab, where the waste from the excavation was used for brick manufacture.
31	Vol.-I, 5.4		Report should also explore and recommend the possibility of effective use of decontaminated site for solar power generation. In US many decontaminated sites have been used for setting up solar power for electricity generation. In India, even after decontamination of land, people are unwilling to use that land for residential or other purposes.	As suggested by Commentator.	Revise document as suggested. Implemented, Box I-5.4.4).
32	Vol.-I, 5.4	It was suggested to define parameters under Environmental & Social Impact Assessment, which should be different from the existing Environmental Impact Assessment (EIA).	n/a	The Guidance document provides not only for the method for EIA, but also for elements for a Social Impact Assessment.	Comment does not lead to necessity to amend document.
33	Vol.-I, 5.4	It was opined that in Social Criteria, if the cost is high then the remediation may not be possible.	n/a	Costs are an independent criterion in the list of criteria. It is up to the responsible parties to apply the seven	Comment does not lead to necessity to amend document.

Nr.	Section and page	Comment	Commentator suggested solution	Implementation	Action items and re-marks
				criteria for selection of remediation option and to define the weighting of the different criteria.	
34	Vol.-III, 5.4	Is the list of remediation techniques a restrictive list?	It was suggested to mention under the list of applicable remediation tech-niques that the list is only an indicative option.	The description in Vol.III-5.4-i of this Step provides for such an explana-tion.	Comment does not lead to necessity to amend document.
35	Vol.-III, 5.4	Is it clear for any user of this docu-ment what is meant by PAH in this table?	Provide explanation where abbrevia-tions are used. Other stakeholders however indicated that this document is to be used mainly by experts who will have a good basic knowledge.	This document is meant for profes-sional use but should be as user friendly as possible. A comprehensive Glossary is included in the Guidance document.	Comment does not lead to necessity to amend document.
	Step 8, Implementation of remediation				
36	Vol. I, 8.2	Liability to consultant should be ar-ranged, even at the remediation stage, when it turns out that the re-mediation plan is impossible to exe-cute in practice.	Consider to point out (in Step 8.2?) that the contracting partner should pay at-tention to this issue when designing the contract.	As suggested by Commentator. Check if this is perhaps required at an earlier stage already. Implemented. During Task 5.5 a real-istic remediation option is selected af-ter review by competent authority technical experts.	Templates of contracts including this aspect exist. The clauses that could be used for this are broadly described in the Task-4 report of Assignment on the Le-gal, financial and insti-tutional framework.
	Step 11, Post remediation action				
37	Vol. I, 11.1, p. 2	What exactly is an independent third party?	Include what criteria a third party should meet (how much experience, etc.).	As suggested by Commentator. An in-dependent third party is a party not related to the case in any way. In cer-tain cases it is imaginable that the in-dependent party is the competent au-thority.	Check whether this needs further clarifica-tion. Implemented.

Task-5 report, Capacity Building requirements

Nr.	Section	Page	Comment	Commentator suggested solution	Implementation	Action items and re-marks
	General					
1	-	-		Standards are required for assessment and decision making process.	The Guidance document provides for these guidelines and standards.	Comment does not lead to necessity to amend document.
2	3.1	26	What can be regarded as average period for execution of investigation and remediation works?	Time framework should be part of NPRPS-information.	PwC Task-4 report mentions a time-line. Grontmij will incorporate this in-formation in Task-5 report.	Revise document as suggested. Implemented in Section 3.1 of Task 5 report.
3	3.2.1	26-27	Situations can be very complex. Should there be a team on hand for that kind of situation?	n/a	Situations can arise for which com-missioning of external expertise may be necessary. This is part of the de-scription of the responsible parties ex-ecuting the activities in Section 3.2.1.	Check if this needs fur-ther clarification. Having a team on hand is not usually neces-sary. A note has been included that for partic-ularly complicated situ-ations a team may be composed dedicated to dealing with that situa-tion.
4	3.6	37	Basically all capacities still need to be developed, but this needs to be explicitly included.	Describe what capacities are required during Step 1. Also include identifica-tion of the polluter, responsible person or institutions.	As suggested by Commentator. Additional references to Step 1 have been added in Section 3.6.	Sample testing is spe-cifically mentioned as a topic on which capacity building is required.

Methodologies for NPRPS
Final project report

Development of Methodologies for National
Programme for Rehabilitation of Polluted Sites
in India

Final

Grontmij

STC

Indus Technologies

Ministry of Environment, Forest and Climate Change
Government of India

Authorisation

Title	:	Methodologies for NPRPS – Final project report
Subtitle	:	Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India
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Management summary

Project output and applicability
The main deliverable of this project is the Guidance document, a document to provide different agencies, both public and private, involved in the assessment and remediation of contaminated sites in India with methodologies. These methodologies mainly cover the process for selecting and implementing preferred remediation options and the technical guidelines and standards that can be applied. The Guidance document has been developed so that the agencies involved in the assessment, investigation and remediation of contaminated sites on a day to day basis will find it to be a practical manual for years to come. Furthermore, it is understood that the Guidance document in its present form is an initial reference document for the development of long term a remediation program in India.

The guidance document is organised as a set of documents, arranged in three Volumes:

Volume I	Methodologies and guidance
Volume II	Standards and checklists
Volume III	Tools and manuals

Volume I is the core of the Guidance document set. It presents guidance and instructions as to how to perform each of the fourteen Steps in the site assessment and remediation process. The correlation among the Steps is shown, to enable the user to see what happened before the Step he is involved in and what should happen after completion of that Step. Centred around a concise description of actions to perform the Step the user is involved in, the guidance details aspects for an effective performance, like data needed and where these may be found, and control mechanisms. Wherever relevant, the guidance includes references to Volume II and III and to websites and documents. Volume I is set up in such a way that it may be used in capacity building. It also includes an introduction for aimed at decision makers.

Volume II contains reference data in various forms. Engineers dealing with contaminated sites may use Volume II on a day to day basis to refer to data, standards, criteria and checklists. Every one of these is linked by a reference to one or more descriptions of Steps in Volume I. Therefore the Volume I document should be used in conjunction with the other two Volumes.

Volume III contains more extensive data like technical manuals. Examples of manuals presented in Volume III include a Site Inspection Protocol, points of attention for fieldwork and laboratory testing, an overview of available remediation techniques, and methods for the evaluation of remediation options. Like

Volume II, Volume III is intended for day to day reference by engineers dealing with contaminated sites.

Effective use of the Guidance document: in Volume I the user will find guidance on the performance of every one of the fourteen Steps in the site assessment and remediation process. The structure of the document seeks to aid the user to quickly familiarise himself with the essence of every Step, after which he may refer to the guidance on the activities to be performed.

For more information on the Guidance document please refer to Chapter 5 of this report.

A number of products are delivered in support of the Guidance document.

The **Typology** distinguishes the following main types of contaminated sites in India:

- Source related:
  - Type S1: Land bound solid phase contamination
  - Type S2: Water bound sediments solid phase contamination
  - Type L: Land bound liquid phase contamination
- Pathway related:
  - Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids)
  - Type P2: Groundwater contaminations

Subtypes are defined. Depending on the specific situation, a site may fit into more than one of these types or subtypes. For more information please refer to Chapter 2, for the full Typology, see Annexure 1.
It has been noted that the fact sheets developed in Task 1 are good starting points for initiating a structured approach for the remediation activities in India: these outputs may be used for the ongoing activities in the CBIPM Project and future remediation sub-projects in India. Based on the experience gained, the fact sheet, definition of contaminated site and typologies may subsequently be further refined.

In alignment with the consortia performing Assignments 1 and 3 a **fourteen step approach to site assessment and remediation** has been developed. This approach consists of the following steps.

Identification	Planning	Implementation	Post remedia-tion
• Step 1: Identi-fication of probably con-taminated sites • Step 2: Pre-liminary in-vestigation • Step 3: Notifi-cation of pol-luted site • Step 4: Prior-ity list addi-tion	• Step 5: Remediation investigation • Step 6: Remediation Design, DPR • Step 7: DPR approval and financing	• Step 8: Imple-mentation of remediation • Step 9: Approval of remediation completion	• Step 10: Post remediation plan • Step 11: Post remediation ac-tion • Step 12: Cost recovery • Step 13: Priority list deletion • Step 14: Site re-use

For more information please refer to Chapter 3. For the full fourteen step ap-proach, including sub steps, each annotated with questions to be answered, ac-tivities to be performed, input needed, targeted output, possible tools, and exit or deviation of process, see Annexure 2b, which overview has been further elaborated in Task-4 and presented in Annexure 4 of this report.

A **Menu of generic remediation options**, presenting an overview of technical choices and associated elements to consider in the process of remediation op-tions appraisal and selection and remediation design. Application of this Menu yields a *provisional* most likely remediation option *at an early stage* in the site investigation and remediation process. While the Menu of remediation options offers a good starting point for the selection of tailor-made site specific remedia-tion options (it is in fact a tool for the first round of elimination of non-eligible remediation options), the Guidance document, developed in Task 4, will literally guide the user through all the steps in the process of remediation options ap-praisal and selection.
For more information please refer to Chapter 4. For the full Menu of generic remediation options see Annexure 3c.
A ‘Risk Based Approach’ will help in achieving the objectives of reducing the health and environmental impacts on communities. It is however, important that robust methodologies and models are deployed to understand the risks associ-ated with various contaminated sites and acceptable risk levels are defined in consultation with local communities. These downstream activities are essential to implement this approach.

A tailor made **methodology for the calculation of capacities** required for ef-fective implementation of NPRPS. This methodology:

- includes the costs for the effective implementation of all fourteen Steps of the site assessment and remediation process as described in the Guidance document;

- includes all types of sites in the Typology developed for NPRPS (Task 1 of this Assignment);
- anticipates the best practice remediation options (Task 3 of this Assignment);
- uses the relevant parameters provided by the database developed in Assignment 1;
- meets Indian market conditions;
- can be used to calculate capacities required, both per role and in totals, for effective implementation of NPRPS, based on the input of data from the database developed in Assignment 1. This calculation can be adjusted whenever new data become available;
- consists of a basic method for the generic calculation of required capacities to deal with a Reference contaminated site, and a method to refine the results through the definition of correction factors;
- cannot be used for the calculation of capacities required to effectively deal with an individual contaminated site. This is because that needs methodologies providing room for more detailed site specific data.

For more detail please refer to Chapter 6. For a summarized overview of Human Resources capacities see Annexure 5a. For the Methodology itself see the Task 5 report of this Assignment.

Table of contents

1 Introduction

1.1 Project setting

The Government of India, through the Ministry of Environment, Forest and Climate Change (MoEF&CC), is implementing Capacity Building for Industrial Pollution Management Project (CBIPMP) with financial assistance from the World Bank. The two-fold objective of this project is (i) to build tangible human and technical capacity in selected state agencies for undertaking environmentally sound remediation of the contaminated sites and (ii) to support the development of a policy, institutional and methodological framework for the establishment of a National Programme for Rehabilitation of Polluted Sites (NPRPS).

CBIPMP has three components of which Component 1 deals with strengthening of environment institutions and capacity building to undertake remediation in states. This component has three sub-components, of which one is the development of NPRPS. As part of development of NPRPS three studies (‘Assignments’) are carried out:

- Assignment 1 – Inventory and mapping of probably contaminated sites in India;
- Assignment 2 – Development of methodologies for NPRPS;
- Assignment 3 – Development of legal, institutional and financial framework of NPRPS.

This report presents the key output of all activities carried out for Assignment 2 of the NPRPS, the Development of Methodologies for National Programme for Rehabilitation of Polluted Sites in India.

1.2 Objectives of the project, ‘Assignment 2’

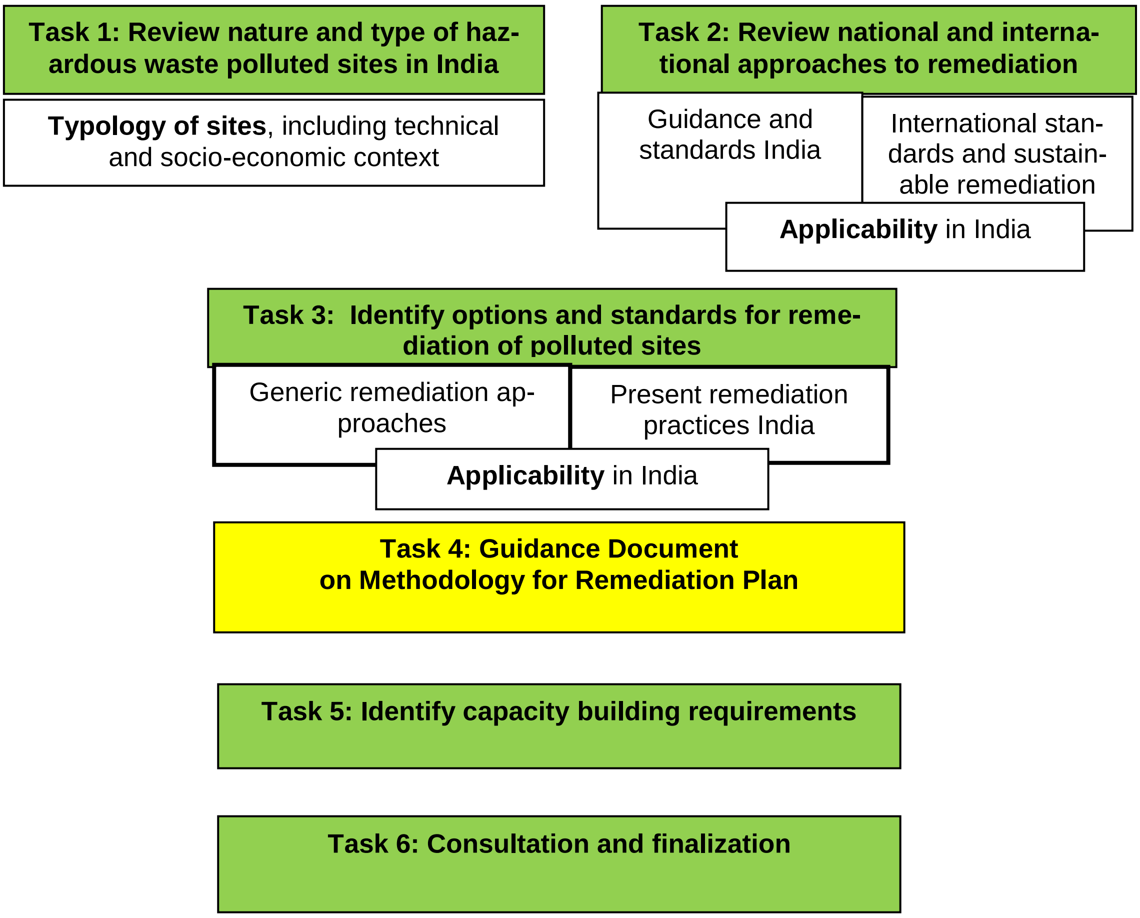
As stated in the Terms of Reference (ToR) the objective of the project ‘Development of methodologies for national programme for rehabilitation of polluted sites’ (‘Assignment 2’) is to develop methodologies to implement remediation projects by government agencies under the NPRPS. These methodologies are to be presented as a clear Guidance Document for implementing agencies.

1.3 Key project features

Project structure

The main deliverable of this Assignment is the Guidance document (see Section 1.4 below) developed in Task 4. Essentially, the methodologies outlined in the Guidance document are developed by applying international best practices to the Indian context: Nature and type of polluted sites in India in Task 1, Approaches to remediation in Task 2, and Options and standards for remediation in Task 3. After completion of the Guidance document Capacity Building requirements are identified in Task 5 and stakeholder consultation and the complete project are finalized in Task 6. Figure 1.1 below presents the project structure.

Figure 1.1 Project structure Assignment 2



Summary of activities
The project consists of extensive desk studies of both international best practices, as well as data, experience, and knowledge in India. Annexure 9 lists the consulted literature. The information gathered was further elaborated and validated in stakeholder consultations, which took the form of meetings and interviews, and in field visits to numerous contaminated sites throughout India. Annexure 8 lists the conducted stakeholder consultation meetings and site visits.

Consortium
The project is carried out by an integrated European-Indian project team. Within the consortium Grontmij Nederland B.V. of the Netherlands is the leading partner, with M/s Shah Technical Consultants (STC) and M/s Technochem Agencies, both of Mumbai, and Indus Technologies of the Netherlands operating as subcontractors. Annexure 7 presents the project team, including each team members' specialties.

1.4 Reading guide

This final project report outlines the key project features, notably output and applicability.

Quick reading
Chapter 1 of this report provides a summary of the key project features. The key project output and practical applicability is presented in the Management summary.

Chapter 1 provides a summary of the key project features, while the project output and applicability is presented in the Management summary. Each of the Chapters 2 through 7 summarizes a Task performed, each presenting at least the Task objectives, report content, results, conclusions and applicability. The key products delivered for each Task are presented in the Annexures.

2 Task 1 - Review the nature and type of hazardous waste contaminated sites in India

2.1 Objective and Task 1 report content

The objective of Task 1 is to review the available inventory on hazardous waste contaminated sites and understand the nature of contaminated sites in India. This insight was used to develop a typology of probably contaminated sites in India, suited for the identification and selection of remediation strategies in Task 3. We define ‘typology’ as ‘The taxonomic classification of characteristics found in contaminated sites, based on a set of common characteristics of sites’.
The Task 1 report, submitted on 1st May 2013, offers a typology covering all contaminated sites as described in the database developed in Assignment 1 (‘Inventory and Mapping of Probably Contaminated Sites in India’). The inventory of available data was used to get thorough insight in the nature and types of contaminated sites in India as well as to validate the typology and the database. The developed typology is robust, offering the possibility for sites not yet inventoried to fit in.

2.2 Data sources

The available version of the inventory on hazardous contaminated sites was consulted and analysed. As the database to be developed in Assignment 1 was not yet available when we started working on this task, we have used initially:

- available data sources from CPCB (including data provided to them by SPCB’s and PCC’s), and the Blacksmith Institute;
- several literature references;
- the results of site visits conducted by members of the project team;
- and the results of our review of international approaches for remediation of contaminated sites, as conducted in Task 2 of this project.

2.3 Results

Site visits conducted by members of the project team resulted in information directly from the field, to strengthen the development, selection and prioritization of realistic remediation options, taking into account practical limitations.
The Typology distinguishes the following main types of contaminated sites in India:

- Source related:
    - Type S1: Land bound solid phase contamination
    - Type S2: Water bound sediments solid phase contamination
    - Type L: Land bound liquid phase contamination
- Pathway related:
    - Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids)

- o Type P2: Groundwater contaminations

Subtypes are defined. Depending on the specific situation, a site may fit into more than one of these types or subtypes.
Data needed to designate a site to a specific type are listed and a number of sites are assigned a type within the typology.

The full Typology, including subtypes and descriptions of field characteristics of each subtype, is summarized in Annexure 1.

2.4 Conclusions and applicability

Care has been taken to make sure that the scope of the typology includes at least the sites included in the data sources mentioned above. The developed typology, is generic and robust, so that it is expected that any contaminated or potentially contaminated site identified in India, including sites that are not yet present in existing site inventories, can be classified within its scope. The typology is based on activities and geometry of the contamination to be used when developing a site assessment strategy.
Combined with site specific information on chemical substances and soil characteristics, this typology is used to get insight in realistic remediation options (developed for each type of site in Task 3) and to support the user of the Guidance document (developed in Task 4) in the process of remediation option appraisal.

2.5 Remarks

The database developed in Assignment 1 is fit for linkage with the typology and with the Guidance document.
A minimum set of data on a site is required to assign the site to a specific type within the Typology. Where available data is too poor to make a detailed analysis of the spreading of contamination, risks and remediation options, it may not be possible to assign such a site to a specific site type. In such cases additional data need to be collected.

For detailed information on the Typology please refer to the Task 1 report of this Assignment.

3 Task 2 – Review of national and international approaches to remediation

3.1 Objective and Task 2 report content

The objective of Task 2 is to provide an overview of the approaches and operational processes for remediation of contaminated sites in India and abroad. This overview is used in Task 3, in which options for remedial actions are recommended. The Task 2 report, submitted on 2nd May 2013, presents an analysis of approaches developed in six countries, in which we also go into their experience in the implementation of these approaches, and reasons for changes, where applicable. The report focuses on those aspects in the approaches that will be key to the user of the Guidance document, developed in Task 4. The Task 2 report presents the approaches in the United States, the United Kingdom and The Netherlands in more detail, as these countries have gone through several policy development stages in more than three decades of dealing with contaminated land. Also, recent developments in sustainable remediation are highlighted, as this concept is gaining considerable weight internationally.

3.2 Results

The Task 2 report presents the following results.
Overview of the approach to the following aspects in the United States, the United Kingdom, The Netherlands, Australia, France, Brazil (state of São Paulo) and India, related to the use of the Guidance document developed in Task 4: number of contaminated sites, important categories of pollution, effects, key documents, management approach, both to historically contaminated sites and current sites (integrated in the prevention policy), responsibility, actors, methodology, standards and post-remediation target value. This overview is also presented in Annexure 2a of this final project report. For more detail on legal and financial issues please refer to the Assignment 3 reporting.

Detailed insight in the following aspects of the approach in the US, the UK and The Netherlands: typology used, site assessment, risk assessment, remediation preparation and execution, the role of standards, and technical possibilities for remediation.

Overview of recent developments in the sustainable remediation concept, offering options to extend the number of environmental aspects to consider during remediation options appraisal.

Sequence of steps to take from initial investigation to remediation action. This has since further developed into the fourteen step approach to site assessment and remediation. The sequence is presented, mentioning each step, annotated with questions to be answered, activities to be performed, input needed, targeted output, possible tools, and exit or deviation of process. This table is also presented in Annexure 2b of this final project report. The elements of this table have been developed in greater detail under Task-4, resulting in the Guidance Document, of which an overview is presented in Annexure 4a of this report.

3.3 Conclusions and applicability

The Task 2 report presents the following conclusions:

- National inventories have invariably led to the conclusion that policy and regulations are needed to manage the effects of soil contamination. Strategic and technical approaches are fundamentally different for severely and less severely contaminated sites.
- Threat to human health, to ecology and to drinking water supply are broadly recognized potential impacts of soil contamination;
- Generally the fit for use approach is used, and the polluter pays principle, in which the preferred actor to execute remediation is the owner or beneficiary of a site, while public funding is needed to intervene at orphan sites;
- Negotiation instead of regulation has been the more common approach;
- Development of brownfield sites has often been the driver for remediation of contaminated sites;
- In some countries regional or provincial state authorities have large responsibilities in drawing up policy and regulations for remediation. Always local and regional authorities play an important role in the agreement procedures when preparing remediation projects;
- The steps described in the fourteen step approach to site assessment and remediation are comparable to approaches abroad. The Guidance document presents these elements in detail for the entire remediation process;
- The Source-Pathway-Receptor approach is generally used for risk assessment and remediation design;
- Typology of contaminated situations is a much used tool for national or regional programming of site assessment and remediation. For common specific types of sites often special programmes are designed and executed, with programme specific funding;
- The objective of site remediation programmes in US, UK and NL in general is to prevent further risks for human health and the environment. The objectives for a specific site are derived from generic standards and site specific risk calculations;
- Remediation options are selected using sets of criteria which in all countries are more or less the same: environmental results, technical feasibility/risks, costs, impact of the works, available time, spatial planning, social aspects;
- During implementation of the remediation works assessments are needed to verify the results of the remediation. Often post-remedial measures are necessary to monitor the effects of the remediation in case not all contamination could be removed or treated. Sometimes, maintenance activities are necessary to ensure long term remediation measures;
- Most discrepancies and gaps in the current Indian situation are addressed by the current CBIPMP NPRPS Assignments. Comparison of the current situation in India to international practices leads to following conclusions on strengths, discrepancies and gaps:

Strengths

- Legal documents are in place for prevention of the uncontrolled dissemination of hazardous substances;
- A methodology for the assessment and remediation of contaminated sites is available;
- Drinking water standards are in place.

Discrepancies

- The number of formally identified sites in India is still limited;
- In the identified sites, a relatively small part of contaminants in use in the Indian industry is represented, i.e. mainly heavy metals, pesticides and fluoride;
- For a relatively large number of the identified sites the land use has not been recorded, preventing the assessment of the impact of the contamination;
- The available methodology for the assessment and remediation of contaminated sites needs detailing out, based on assessment of international practices. Proposals for this are developed in the Guidance document, to be developed in Task 4 of this Assignment;
- The existing institutional framework for the environment needs adaptation to deal effectively with contaminated sites. Proposals for this are developed in Assignment 3;
- A complete set of standard values for soil, groundwater and surface water needs to be developed. Proposals for this are developed in Assignment 1.

Gaps

- Legal documentation for dealing with contaminated soil, groundwater and surface water is still limited. Proposals for these are developed in Assignment 3;
- Responsibilities for dealing with contaminated sites have yet to be assigned. Proposals for this are developed in Assignment 3;
- Remediation target values have not yet been defined. Proposals for this are developed in the Guidance document, to be developed in Task 4 of this Assignment.

- The steps in the process of site assessment and remediation are generally the same.

For more detail on approaches to remediation please refer to the Task 2 report of this Assignment.

4 Task 3 - Options and standards for remediation of polluted sites

4.1 Objective and Task 3 report content

The objective of Task 3 is to provide a generic approach for remediation of contaminated sites and a menu of prioritized options for remediation for all types of contaminated sites. The typology of Task 1 of this Assignment is used as a basis to reach this objective: it presents a site categorization designed for generating remediation solutions for all sites to be remediated in India.

The objective of the Task 3 report, submitted on 11th March 2015, is to present the above, but also to demonstrate its development, thereby providing the results with a sound basis. The results are incorporated in the Guidance Document, aimed at the organisations responsible for the implementation of NPRPS. The Task 3 report is targeted primarily at those who need a deeper understanding of the technical backgrounds.

4.2 Results

The Task 3 report presents the following results.

Remediation approaches

An analysis of advantages and disadvantages of standard based and risk based approach, as well as an overview of principles and characteristics of remediation options. A comprehensive overview of generic characteristics of the most important remediation technique groups is presented. For each of these groups this includes site specific characteristics, as well as a brief analysis of strengths, weaknesses, opportunities and threats is included, and hints as to the usefulness and restrictions of the remediation techniques under certain conditions.

A first evaluation of hands-on experience with remediation practices in India, offering a preliminary selection of elements for a realistic technical approach to site characterisation and remediation.

Remediation options

A Menu of remediation options, presenting an overview of technical choices and associated elements to consider in the process of remediation options appraisal and selection and remediation design.

Applicability in India

Application of the Menu of prioritized remediation options to the list of 100 sites from Assignment 1. Based on that, a discussion on the applicability of the Menu, while stressing that the Menu yields a *provisional* most likely remediation option *at an early stage* in the site investigation and remediation process. Also, a discussion on the implementation of site specific issues in the process of remediation options appraisal and selection to eventually achieve a selection of the preferred remediation option.

4.3 Conclusions and applicability

In the Task 3 report the information presented in the overviews is key. Notwithstanding that, the report also presents the following conclusions on remediation approaches and options:

Remediation approaches

- Based on a profound analysis of risk based versus standard based approach in other countries, the risk based approach provides the best opportunities for India, while the standard based approach may still be useful in certain cases. Annexure 3a provides background information for the remediation approaches;
- The alignment of the remediation target for a site with the result of the site specific risk assessment forms an integrated part of international best practice and offers major opportunities for cost effective remediation and integration of sites in their environment;
- It is established that clean-up standards should meet the following criteria:
  - Should prevent unacceptable environmental risks;
  - Should provide adequate protection of human health and the environment;
  - Should render site suitable for current or intended future use;
  - Can be generic or site specific.
- For target levels the following are proposed:
  - Soil and sediment: screening levels Canadian soil quality guidelines (negligible risk);
  - Groundwater: drinking water IS 10500, other water use referring to specific standards;
  - Site specific remediation targets depending on risk assessment study.

Remediation options

- From the available data on remediation cases it can be derived that most of the successful remediation cases in India to date were the result of excavation and transfer of waste to secured landfills. However, considering the importance of the social aspects and other local conditions, chemical and biological remediation options can be expected to become more important in future. As some of these techniques are still in a laboratory phase of development, full scale use of these techniques may be considered only after thorough pilot testing and field trials;
- An overview of remediation techniques, including characteristics of each technique, is provided in Annexure 3b.
- The Menu of remediation options offers a useful guide to the applicability of the most likely technical and in some cases also non-technical choices for remediation measures in a generic way. Particularly the technical, financial and social situation and the potential to implement sustainability aspects will show a great variability from site to site. This also applies to the potential land use post remediation and estimated cost benefits. Therefore, these

factors cannot be included in the Menu of remediation options in a meaningful generic way: specific site conditions might result in the selection of a remediation option that in the Menu op remediation options is not linked to the type of site at hand. While the Menu of remediation options offers a good starting point for the selection of tailor-made site specific remediation options (it is in fact a tool for the first round of elimination of non-eligible remediation options), the Guidance document, developed in Task 4, will literally guide the user through all the steps in the process of remediation options appraisal and selection.

Annexure 3c to this report presents the Menu of generic remediation options. For more detail on the Menu of generic remediation options please refer to the Task 3 report of this Assignment. Background information for setting remediation objectives is presented in the Volume II-5.3-a of the Guidance document.

5 Task 4 – Guidance document for assessment and remediation of contaminated sites in India

5.1 Objectives and scope of the Guidance document (Task 4 report)

Key objective

The key objective of the Guidance document is to provide different agencies, both Government and non-government, involved in the assessment and remediation of contaminated sites in India with methodologies. These methodologies mainly cover
[i] the process for selecting and implementing preferred remediation options and
[ii] the technical guidelines and standards that can be applied.
The Guidance document has been developed so that the agencies involved in the assessment, investigation and remediation of contaminated sites on a day to day basis will find it to be a practical manual for years to come.

Scope

This Guidance document is arranged in three Volumes as follows:
- Volume I: Methodologies and Guidance;
- Volume II: Standards and Checklists;
- Volume III: Tools and Manuals.

Volume I guides the user through every step of the assessment and remediation process by providing relevant information, flowcharts, practical guidance and considerations. For standards and checklists the user is referred to Volume II, and for more detailed technical manuals to Volume III. The Guidance document is designed as a standalone reference manual and can therefore be considered to either include or refer to all information relevant for dealing effectively with contaminated sites.

It should be noted that the contaminated site remediation industry in Europe, USA and similar countries has accumulated its knowledge and experience over a period of more than 35 years. It is therefore not intended to capture all that in the guidance document. By contrast, the Guidance document aims to provide a judicious mix of general overviews and detailed specifications to encapsulate the global practical knowledge and theoretical basis, international industry practices and above all, the great wealth of practical experience around the world for an experienced and trained technical manager in India to take up the next steps of the National Program for Remediation of Polluted Sites (NPRPS).

The document was developed while keeping in mind factors such as [i] the nascent phase the site remediation industry in India is in, [ii] the wide ranging variety and complexity of individual sites and their particular characteristics, [iii] the capacity gaps at different levels, and [iv] the particular interrelation between technical and non-technical (legislative, legal, financial) factors typical for India.

Content

The Guidance document covers the entire gamut of technical aspects stakeholders need to address while dealing with a contaminated site in India. Each aspect is dealt with the appropriate degree of general descriptions and specific details. The document presents the complete process of dealing with a contaminated site, from identification through assessment and remediation to delisting, in a sequence of fourteen steps, explains their interrelations, and provides detailed presentation of each of the steps. While the focus is on practical, technical, aspects, wherever relevant reference is made to institutional, legal and financial aspects.

Targeted users: technical and non-technical

The aim of the Guidance document is to provide practical guidance to various types of users by providing references to technical issues they face on a day to day basis. While all professionally involved stakeholders may find the information useful, the Guidance document is mainly aimed at the competent authorities and/or agencies assigned to implement any part of site remediation works.

The Guidance document can be used by a non-industry professional, policy-maker or manager, or as a technical manual by those more directly involved in site remediation in India. While the general reader does not need to know anything about site remediation, a degree of familiarity with basic remediation issues is expected from the technical user wishing to explore the details.

The level and complexity of technical details included assumes that the user is trained as an engineer or manager, is dealing with contaminated sites on a day to day basis, and has a background in the fields of one or more of: [i] civil engineering, [ii] chemical engineering, [iii] geology, [iv] hydrology or [v] environmental (waste) management. However, the document is set up in such a way that it is also useful for decision makers and those persons supporting the engineers.

For providing technical guidance and supervision

With the help of the Guidance document a trained engineer should be able to give technical direction to the approach of the assessment and the remediation of a contaminated site. The document will guide such a reader through every step of the assessment and remediation process by providing, among other information, flowcharts, data, checklists, and considerations. Detailed information is included, e.g. in the form of data overviews, checklists and technical manuals. For additional detailed information, e.g. on methods, equipment and models, the Guidance document refers to websites and other documents.

<u>For dealing with contamination, not its prevention</u>
Experience in many countries has led to international consensus that dealing with existing contamination on a site is very different from preventing such contamination in the first place. It is well accepted that the key in prevention is a thorough environmental awareness. For example, at sites where potentially contaminating activities take place, technical measures to prevent hazardous substances from penetrating into soil, groundwater or surface water are necessary. One of the better known of these measures is providing the site with an impermeable floor.

The guidance document primarily deals with issues concerning assessment and remediation of already contaminated sites. Any technical measures for the protection of soil, groundwater and surface water or for the prevention of further contamination are covered only in passing, where appropriate.

<u>For training and technical capacity building</u>
An equally important intended use of the Guidance document is for initial training and technical capacity building among various stakeholders and agencies involved in the Indian site decontamination industry. While it is impractical to capture in one document many hundreds of man years of global site decontamination experience, the emphasis in the Guidance document is on providing practical knowledge and, quite literally, guidance, to a person involved in the Indian site decontamination Industry.

A non-technical person, for example a policy decision maker, a finance professional or a project manager, may use relevant sections of this document to familiarise him- or herself with the process of identification, assessment and remediation of contaminated sites and how it affects the non-technical decision parameters.

For a technical professional involved in a specific aspect of carrying out, supervising or regulating site decontamination, both organised overviews, adequately contextualised, and sufficient details on those aspects are provided. It is intended that after digesting the specific information provided in the Guidance document, the technical professional may seek further details in the wide ranging references the Guidance document provides.

For terms and definitions we refer to the Glossary at the end of Volume I in the Guidance document.

5.2 Introduction to contaminated sites

Generally, around the world, it is an accepted practice to describe contaminated sites as areas in which toxic and hazardous substances exist at levels and in conditions which pose existing or imminent threats to human health or the near and surrounding environment (see Glossary in the Guidance document for the formal definition of a contaminated site).

Such sites often pose multi-faceted health and environmental problems to society. They can adversely impact any or all parts of the surrounding environment,

particularly surface waters, soils, and groundwater and can result in people being knowingly or unknowingly exposed to toxic substances. Contaminated sites may include production areas, landfills, dumps, waste storage and treatment sites, mine tailings sites, spill sites, chemical waste handler and storage sites. These sites may be located in residential, commercial, agricultural, recreational, industrial, rural, urban, or wilderness areas. This situation is also applicable in India. This document is aimed at dealing with a broad range of types of contaminated sites occurring in India.
However under NPRPS bio-medical wastes, mining wastes and radioactive wastes have not been considered as these are dealt separately under the relevant Acts and the rules made thereunder. Various elements of the process and content of assessment and remediation, as described in the guidance Document, can be used for remediation of other types of waste as well.

While it is recognised that legal aspects of the origin of a contaminated site may or may not be clear, the technical issues concerning disposal or dumping remain the same for legal or illegal contamination.

More specifically, the types of sites addressed in the guidance document are:

- "Point" sites, such as dumps of waste or individual contaminated facilities (an example is shown in figure 5.1 below);
- "Area" sites, a site within a broader area of ongoing and legacy contamination where the site of concern needs to be addressed in this wider context. An example of this is an individual dump within an industrial area, where there are also other sources of pollution (an example is shown in figure 5.2 below);
- Municipal dumps, often with an unclear history, which may contain hazardous substances dumped before the municipality gained effective control (an example is shown in figure 5.3 below);
- Brownfields, which may, or may not, have clear ownership and which have development potential if the contamination problems can be successfully resolved.

Figure 5.1 Waste material at Ranipet site, typical "point" site

Figure 5.2 Contaminated land near Eloor, typical "area" site

Waste versus soil contamination

A by-product of almost every human activity anywhere is waste, which can manifest itself in countless different forms. Not all waste automatically leads to soil contamination. In fact, when waste is effectively reused, it can actually avert soil contamination. Waste does lead to soil contamination when it negatively affects soil or groundwater or other environmental features. Most often, this is due to uncontrolled dumping or lack of timely suitable remediation measures.

The soil comprises of three phases

"Soil" is one of the most universally used every day terms in all societies and often means the same to all users, except maybe in very specific contexts. In this document, soil is considered to comprise three phases, including the organisms living in these phases:

- Solid phase, consisting of the sand, loam, and clay particles, but also including the organic solid elements, like decomposing leaves;
- Liquid phase, consisting of the groundwater;
- Gaseous phase, consisting of the air trapped among the soil particles.

Underwater soil is usually referred to as 'sediment', and also comprises three phases, albeit that the gaseous phase is very small.

Soil contamination can occur in any of these three phases or in any combination thereof. Contamination of the solid phase may be visible, e.g. when hazardous waste has been dumped on top of the soil, or not visible, e.g. when dumped waste was covered. However, contamination of the liquid and gaseous phase is often not clearly visible, and almost always entails specific, sometimes far greater, risks. This is because local soil contamination often spreads relatively easily, thereby contaminating ever larger volumes of soil, groundwater or air.

Figure 5.3 Municipal Waste dump site of Dhapa

5.3 General description of contaminated sites in India

At the time of writing this edition of the Guidance document the availability of formal data on contaminated sites in India was still relatively limited. An analysis of available data at the time showed that in the sites already formally identified, only a relatively small number of contaminants were present, i.e. mainly heavy metals, pesticides and fluoride. However, it is felt by experts and generally agreed in India that when a comprehensive inventory of contaminated sites is carried out over longer periods of time, the extent of the contaminated sites, the range of contaminants and types of sites can increase substantially. This is the conclusion when considering the size of the country, the extent and diversity of its economy and industry, the industrial and non-industrial processes adopted (which are usually comparable to international processes) and the current practices of handling contamination in different sectors.

Keeping this in mind and taking cues from global practices, a system has been developed for the generic classification of types of contaminated sites in India. All sites identified in India at the time of writing this document could be assigned to a type within this classification system, except in cases where contamination is limited to surface water.

Contaminated site classification system
The proposed classification system distinguishes the following main types of contaminated sites:

- Source related:
  - Type S1: Land bound solid phase contamination
  - Type S2: Water bound sediments solid phase contamination
  - Type L: Land bound liquid phase contamination
- Pathway related:
  - Type P1: NAPL contaminants in soil (Non Aqueous Phase Liquids)
  - Type P2: Groundwater contaminations

Depending on the specific situation, a site may fit into more than one of these types. Subtypes are defined where necessary to enable the system to absorb additional specific site characteristics.

This system is, in our view, fully suitable to typify and classify the large number of contaminated sites that may be added to the current inventory in future. The complete classification system is outlined in the explanation of the typology in the Glossary.

5.4 Introduction to the concept of Risks and Intervention

When contaminated sites require intervention: the concept of risks

Contaminated sites can cause risks to human health and to the environment. The extent of risk and the impact of contamination depends on many factors, but key is the probability of contact between the contamination and the surroundings. In case there is no contact between the contamination and humans or the environment the contamination carries no risk. This is, in all its simplicity, a conceptually important point to keep in mind.

International experience shows that not all soil contamination requires intervention. In the Netherlands, for example, the soil decontamination industry has evolved over the last 35 years and the expertise developed indicates that an optimum exists between the two extremes of decontaminating all contamination at all sites, so as to eliminate all potential risks, or decontaminating only to a certain acceptable level of risk at selected sites. Such an optimum is specific to a country or region and is influenced by many factors, such as the site inventory, characteristics of sites, geography, hydrology, as well as social, cultural, financial and political factors. For India too such an optimum needs to be found. This will involve taking into account considerations specific for India. Experience from other countries is a useful guide in reaching such an optimum balance.

The perception of a “risk” associated with an event or situation depends on a multitude of complex factors. Among these are the context, the observer, environmental factors, time factors, the historical record, the human factor. In view of this, the international site remediation efforts over the years have developed tools and approaches for quantitative assessment of risks associated with a particular contaminated site. These tools and approaches are applicable in India and it is recommended they should be applied.

<u>Risk assessment: the Source-Pathway-Receptor approach</u>

In this context, it is internationally agreed that it is vital to determine the chance that either humans or the environment will get in contact with the contamination. The widely accepted approach for this risk assessment is the 'Source – Pathway – Receptor' (SPR) approach. Within this approach, the source is the contamination, e.g. a leaking oil tank or a layer of pure oil in the topsoil. The pathway is the route between the source and the receptor, and the receptor is a human, animal, plant, ecosystem, property or a controlled water that may be affected by the contamination. An example of the three is shown in figure 5.4 below. The generally accepted principle is that adverse effects of contamination are only considered to occur when contamination actually threatens humans or resources, i.e. puts them at some substantial risk. This happens only when all of the three elements (source, pathway and receptor) are present.

Figure 5.4 Source - Pathway - Receptor

Risk from contamination?

An amount of waste is stored on an industrial site (source). Water containing hazardous elements leaches into the soil and into the groundwater, which takes it further downstream (pathway). The contaminated groundwater reaches a well that is used for drinking water by the local community (receptor) → *YES, in this situation there is a risk that the contamination causes adverse effects on human health.* Assessment should be aimed at establishing whether that risk may be substantial, in which case there may be a need for intervention.

In the situation described above the waste is stored in an enclosed space and the water that leaches out is captured and removed in a controlled way to be treated elsewhere (there is no pathway, so the hazardous elements cannot reach any receptor → *NO, in this situation there is no substantial risk that the contamination causes adverse effects on human health.*

At any given site the exact situation with respect to each of these three elements and their interconnectivities determine [i] the need to intervene, [ii] the points of intervention (start and end), as well as [iii] the focus and the potential types of remediation options. Site assessment should show whether contamination puts human health or the environment at substantial risk. Only in case these risks are deemed unacceptable by the prevailing law or by the stakeholders the need for intervention arises. Only then a process of selection of intervention (remediation) measures needs to be initiated, eventually leading to remediation action.

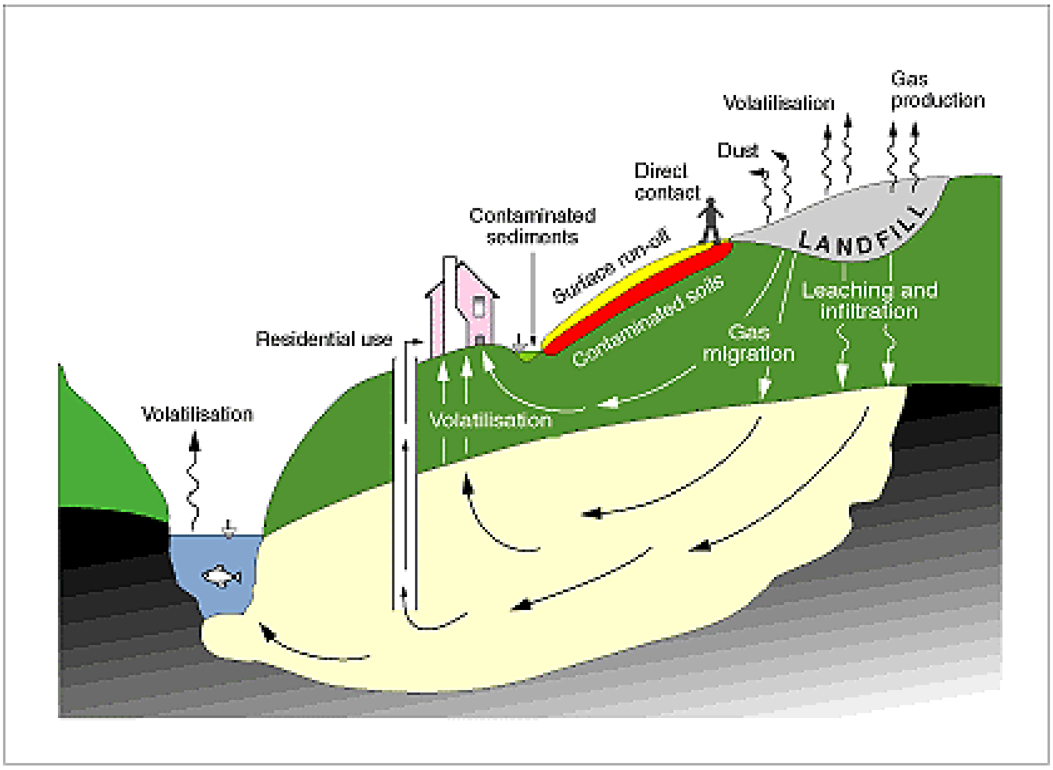
In various risk assessment methodologies, the contamination (source) is clearly identified, as well as what that source may affect (receptor) and through what route the source may reach the receptor (pathway). It is important to note that receptors may be located on-site as well as off-site, and also that while in a current situation there may be no pathway, this can still develop over time (sometimes long periods), by diffusion through groundwater, surface water, sediment or air.

Most of the available risk assessment methodologies use a tiered approach, which starts with a relatively quick qualitative assessment. If needed this may be followed by a more elaborate semi-quantitative assessment, based on model calculations, and, again if needed, a comprehensive quantitative assessment. A quantitative approach involves actual measurements in contact media, such as indoor air, vegetables or drinking water.

Information for risk assessment: the Conceptual Site Model

No matter what approach is used, input of site data will be needed. Conceptual Site Models (CSM) are commonly used to implement a structured and efficient investigation for risk assessment. Such a model is developed by integrating as much relevant information on the contaminant situation as possible. This helps to understand the mechanics at the site, and may result in an image like the one in Figure 5.5 below. Volume III-2.2-i of the Guidance document presents guidance on how to develop a CSM and its role in the assessment and remediation of sites.

Figure 5.5 Conceptual model of landfill exposure sources and environmental pathways



Source: Petts, J. and G. Edulgee. Environmental Impact Assessment for Waste Treatment and Disposal Facilities, p. 229. John Wiley and Sons, Chichester, 1994

<u>Socio-economic issues</u>

In addition to the adverse effects to human health and the environment, a contaminated site and its remediation process can cause lesser or greater social and economic disturbance in local and regional surroundings. International experience gives some pointers, which are also applicable to India.

Pollution during remediation

During remediation works, impacts of air and noise pollution on the local communities depend on the duration of the project activities. For example, if the transportation distance for waste from the site to say a landfill site is short the air pollution impact will be less. Higher air pollution impact can be anticipated if a lot of loading and unloading is required for site development. Noise pollution may be due to excavation activity, loading and unloading of waste, transport vehicle movement. Spillage of wastes during transportation may cause negative impacts on the community. However, if proper measures to stabilise the waste are taken this impact will get reduced.

Potential accidents

Transportation by road may cause accidents. This risk increases with increasing transportation frequency and distance.

Land value
Research has found that the public perception of the value of contaminated land is often not in line with reality. The general public usually perceives contaminated land to have hardly any value. In many cases, this perception has created a significant obstacle for redevelopment plans involving contaminated sites. In reality, when redevelopment and remediation plans are integrated from the start, costs for remediation often turn out to be much lower than the value of the land, even prior to remediation. Communication and awareness building may help to reverse this perception.

Business activity, income and employment
Remediating a site may have both positive and negative effects on income and employment of individuals or a group. The larger the remediation action the more positive the long term impact on employment opportunities is likely to be. Development of a site for storage and disposal of waste also generates employment opportunities. In extreme cases of contamination remediation may induce positive health effects. The reduction of the (unpaid) sick leave days may in turn lead to increased income for the local community.

Remediation action may also negatively impact business activity and endanger the livelihood of the local community or part thereof at and near a contaminated site. As a general rule, the impact of long term remediation action is usually significantly higher than the impact of short term remediation action. An example of negative impact of remediation is a clean capping layer, applied as a remediation measure, that renders impossible existing use of a landfill by the local community. In this situation support for the remediation option is likely to be impacted negatively by of the effect on the existing situation. In such a case a proposed solution should include a livelihood for the affected part of the local community.

Socio-economic impact may be direct, indirect and cumulative, depending on the site and remediation characteristics.

Assessment of the socio-economic issues
In each specific case, these and other potential social-economic issues should be assessed through a formal and structured effort. The aim of this effort should be to determine the level of significance of any given issue and a quantification, as far as possible, of the socio-economic costs and benefits. This process entails
[i] identification of the socio-economic issues of the nearby areas, including the type of settlements, and [ii] assessment of the significance of the impact of each issue, either quantified or in qualitative terms like low, medium, or high.

The need for community involvement
It is generally accepted that the community affected by any economic activity, including remediation of a site, has a legitimate right to understand and to be involved in decisions that may affect them. Therefore, close interaction with the affected community, e.g. by public consultation meetings like the one in figure 5.6 below, is recommended and may also prevent undue concerns about the risks during remediation or site testing work. Community involvement and con-

sultation is most effective when initiated at an early stage of any remediation project.

Assessment of the impact of socio-economic issues is an integrated part of any site assessment and remediation process. Views of the stakeholders, including the local community, are needed for designing any successful remediation project. The consultation process helps in making the project responsive to social development concerns, and increases the chances of reaching options that enhance benefits for the community while mitigating risk and adverse impacts.

Figure 5.6 Public Consultation Meeting
(picture by Andra Pradesh Pollution Control Board)

5.5 Guiding principles for decision making

Programme level
A number of guiding principles serve as reference points for international policymakers and programme managers when developing site assessment and remediation programmes. These principles are commonly applied, regardless of geographic, social, cultural and economic contexts. Therefore, these principles can be, with proper review and adaptation to Indian conditions, considered for use as a reference framework for India, at Central as well as State level.

Strategic principles at programme level
Pollution by itself does not usually incite action, it is when risks become apparent that wheels are set in motion. The main guiding principle is always the elimination of or minimizing the risks for human health caused by pollution, with the prevention of risks for the environment following closely. With drinking water being the strategic asset that it is, a guiding principle is the protection of the groundwater quality in aquifers for drinking water storage or with drinking water storage potential.

Typically, the capacity required to assess and remediate the listed sites exceeds the available capacity. In that case, the guiding principle of site prioritisation is applied. A guiding principle of a different nature is the one that states that the notification of sites should be a solid procedure. The reason for this is that notification of a site usually incites stakeholders, including operators, owners, the local community, developers, NGO's and local authorities, to expect that remediation may be implemented in the near future.

Typical strategic principles for a remediation programme

- Elimination of or minimizing the risks to human health and to the environment caused by contaminated sites;
- Protection of groundwater quality in aquifers for drinking water storage or with drinking water storage potential;
- Prioritisation of sites for remediation action, in case the capacity required to assess and remediate the listed sites exceeds the available capacity;
- Development and implementation of a solid procedure for the notification of contaminated sites.

Typical operational principles for a remediation programme

The operational principles for a remediation programme are largely based on the strategic principles. Because the prevention of risks is key, any site assessment and remediation programme will be based on the assessment of risks. The information such assessment yields is needed to establish the risks, to prioritise the sites and to direct remediation action towards the reduction of those risks.

- Assessment of risks and potential risks caused by contaminated sites and by probably contaminated sites;
- Application of the Source-Pathway-Receptor approach, including standard target values for remediation, coupled with risk-based action;
- Implementation of capacity building, e.g. by offering a structure for the systematic acquisition of knowledge and hands on experience;
- Reconnaissance and notification of newly discovered probably contaminated sites.

<u>Individual Site level</u>

Guiding principles are also available for those dealing with an individual contaminated site.

Typical strategic principles for a site specific approach

- Appraisal of remediation objectives, including prevention of further contamination, using generic and site specific criteria (environmental results, technical feasibility/risks, costs, impact of works, available time, spatial planning, social aspects);
- Application of simple, robust and validated site assessment and remediation solutions. Innovative technologies might be considered if these have been successfully applied in well-documented field trials;
- Prioritisation of the reduction of human health risks, as opposed to ecological risks, unless highly valued ecosystems are under threat.

Figure 5.7 Prevention of actual contaminating activities is important before starting remediation activities

Typical operational principles for a site specific approach

- Whenever possible, application of an integrated approach, i.e. a combination of remediation with reconstruction or redevelopment of the site and/or its surrounding area. In practice, this will usually mean that the remediation design is integrated in the redevelopment plan. In some cases it can be the other way around, when land use planning needs to be adapted to the contamination situation.

> An example of a situation that may call for adapting intended land use to the contamination situation is intended redevelopment of a former dumpsite for toxic waste. Remediation towards a situation that renders the site fit for agricultural or residential use would require high costs, whereas it may be more cost effective to aim the remediation at use of the site as an industrial area.

- Whenever final remediation objectives can be reached in the longer run but not at once, application of a stepwise approach for improvement of the site situation. This under the condition that the most important risks can be brought under control (figure 5.7) and temporary safety measures are in place where necessary;
- Design and implementation of an iterative sequence of activities for the assessment of contamination and the selection of the most appropriate remediation option. Review of and discussion on intermediate data, results and designs at several stages often leads to the most effective and efficient remediation solutions;
- Focus on assessment activities that provide useful information for the selection of a remediation option and re-use of the site.

5.6 Legal, institutional and financial aspects

At the time of writing this edition of the Guidance document which public institutions should become the competent authorities on the assessment and remediation of contaminated sites was still under discussion. The options under consideration were broadly to either grant this responsibility to the State and Territorial Governments or to establish a new **Remediation of Polluted Sites Authority** at the central government level by the **Ministry of Environment and Forests**. In the latter case, the role of the competent authority on dealing with polluted sites would be vested in this Authority and the Environment Restoration Fund would be managed by the **National Environment Restoration Fund**..

In general terms and in either case, the **Central Pollution Control Board (CPCB)** coordinates site assessment and the compilation of data on contaminated sites, and provides conditions for effective dealing with contaminated sites, like training facilities. On state or union territory level the remediation of sites and their reuse is facilitated by the **State or Union Territory Government**, while site assessment and data management lies with the **State Pollution Control Board (SPCB)** or the **Pollution Control Committee (PCC)**.

The performance of site assessment is usually commissioned to an independent third party **site investigator**, while site remediation is usually performed by a third party **remediation contractor**. Post remediation monitoring can be performed by either a site investigator or a remediation contractor. All are likely to engage an independent accredited **laboratory**, either third party or part of CPCB or SPCB, for the analysis and testing of soil, sediment, groundwater and surface water samples, collected during site assessment or remediation.

The guidance document could serve as a knowledge base for the technical aspects that are important for all stakeholders mentioned above. The legal, institutional and financial aspects are set out in more detail in the Task-4 report of Assignment 3, 'National Program for Remediation of Polluted Sites'.

5.7 Steps in the site assessment and remediation process

In the guidance document the entire process of intervention in a contaminated site, from its earliest identification to post remediation measures, is described in a sequence of fourteen distinct Steps. This set of Steps covers all activities that are performed in dealing with such a site. Wherever applicable, the guidance document refers to these fourteen Steps. The same Steps, with identical descriptions, are also used in correlation with the non-technical aspects, i.e. legal, financial and institutional, of dealing with polluted sites.

The fourteen Steps are visualised in table 5.1 below.
Annexure 4a summarizes the complete overview of the process of assessment and remediation of contaminated sites, presenting for every step and substep the tasks, activities, supporting standards, checklists, tools, and manuals, as well as output.

Table 5.1 The fourteen Steps in the site assessment and remediation process

Step	Title	Concise description	Summary in this final report
	Identification		
1	Identification of probably contaminated sites	A structured procedure for the identification of polluted sites, the collection and systematic computerised storage of data serving that purpose.	Annexure 4b presents flow charts for Identification of probably contaminated sites.
2	Preliminary investigation	A preliminary site assessment is performed in a desk study and a site inspection, to confirm types of contaminants present. In case the results of the preliminary site assessment warrant this, a preliminary site investigation is performed. This involves investigation to assess if the site may pose threat to human health and environment.	Annexure 4b presents flow charts for preliminary site assessment and preliminary site investigation. Annexure 4c presents a summary of site investigation techniques, including their characteristics and applicability. Annexure 4d presents the categories of aspects that should be included in a preliminary assessment report and a preliminary site investigation report.
3	Notification of polluted site	Notification of a contaminated site as 'polluted site' to restrict activities pending final remediation, trace liable parties.	
4	Priority list addition	The programme managing activities to rank sites based on the threat to human health and environment.	
	Planning		
5	Remediation investigation	Detailed site assessment, including risk assessment, is commissioned to provide information for inventorying and designing multiple options for rehabilitation. For each option the (post) remediation target and the recommended approach are described. The potential options will be assessed using a set of crite-	Annexure 4c presents a summary of site investigation techniques, including their characteristics and applicability. Annexure 4b presents a flow chart for risk assessment. Annexure 4d presents the categories of aspects that should be included in a detailed site investigation report, a risk assessment report and a remediation investigation report.

Step	Title	Concise description	Summary in this final report
		ria, and as a result of this assessment the optimum option will be selected.	
6	Remediation design, Detailed Project Report	The selected remediation option is designed in greater detail, detailed costing and planning is carried out and responsibilities are analysed in a Detailed Project Report (DPR).	Annexure 4d presents the categories of aspects that should be included in a DPR.
7	DPR approval and funding	The competent authority would approve the DPR. Furthermore, the process of raising funds, maintaining funds and disbursing funds for remediation activities.	
	Implementation		
8	Implementation of remediation	Preparation, commissioning and implementation of remediation works. Supervision and validation investigation during implementation.	Below this table some remarks are made on the contracting procedure. Annexure 4d presents the categories of aspects that should be included in a health and safety plan, in a supervision and verification plan and in a remediation evaluation report. Annexure 4e presents the categories of criteria that may be applied in the prequalification of contractors for remediation.
9	Approval of remediation completion	Evaluation of the remediation works and approval of the results by the competent authority.	Annexure 4b presents a flow chart for the approval of remediation completion. Annexure 4d presents the categories of aspects that should be taken into account for the approval of remediation completion.
	Post remediation		
10	Post Remediation Plan	In case residual contamination remains at the site, post remediation measures are designed to ensure end goals of remediation will be reached. The measures are described in a plan including long term review.	Annexure 4d presents the categories of aspects that should be included in a post remediation plan.

Step	Title	Concise description	Summary in this final report
11	Post Remediation Action	The site is monitored periodically to ensure pollution limits are within the values as determined by the end goals of final clean up report and that the land is being used for the purpose as permitted by the end results. If necessary active maintenance measures are taking place.	Annexure 4d presents the categories of aspects that should be included in a post remediation status report.
12	Cost recovery	Any costs, fees and penalty that have not been paid in advance or recovered from responsible person would be recovered either by enforcing financial security or through the recovery process of arrears of land revenue or public demand.	
13	Priority list deletion	Upon completion of remediation activities, the site is marked in the database as 'remediated'. If necessary monitoring activities may continue.	
14	Site reuse	Reuse of the site after approval of remediation results.	

The procedure for contracting the performance of a remediation of soil, groundwater and/or sediment is not much different from generic contracting procedures in India. The same general contracting regulations apply. Some aspects that may deserve special attention are briefly discussed below.

The bid document should clearly describe how the contractor is expected to deal with the inevitable uncertainties, associated with the site investigation results, during the remediation works, regarding the technical, legal and financial consequences.

Most tendering procedures will start with a procurement notice and for the procedure either Open Tendering, Selective Tendering and Negotiated Tendering may be considered.

In the Indian tendering scenario, frameworks are determined by guidelines set by the relevant international bodies including FIDIC (International Federation of Consulting Engineers for engineering) related tenders like computer tenders, civil work tenders and generators tenders. However, the Indian Central and State Governments, Indian Municipalities and establishments such as Universities, the Military and Hospitals are governed by strict laws and only open competition bids are accepted.

5.8 How to use the guidance document

Document structure

The guidance document is organised as a set of documents, arranged in three Volumes:

Volume I Methodologies and guidance
Volume II Standards and checklists
Volume III Tools and manuals

Volume I is the core of the Guidance document set. It presents guidance and instructions as to how to perform each of the fourteen Steps in the site assessment and remediation process. The correlation among the Steps is shown, to enable the user to see what happened before the Step he is involved in and what should happen after completion of that Step. Centred around a concise description of actions to perform the Step the user is involved in, the guidance details aspects for an effective performance, like data needed and where these may be found, and control mechanisms. Wherever relevant, the guidance includes references to Volume II and III and to websites and documents. Volume I is set up in such a way that it may be used in capacity building. It also includes an introduction for aimed at decision makers.

Volume II contains reference data in various forms. Engineers dealing with contaminated sites may use Volume II on a day to day basis to refer to data, standards, criteria and checklists. Every one of these is linked by a reference to one or more descriptions of Steps in Volume I. Therefore the Volume I document should be used in conjunction with the other two Volumes.

Volume III contains more extensive data like technical manuals. Examples of manuals presented in Volume III include a Site Inspection Protocol, points of attention for fieldwork and laboratory testing, an overview of available remediation techniques, and methods for the evaluation of remediation options. Like Volume II, Volume III is intended for day to day reference by engineers dealing with contaminated sites.

The structure of the Guidance document is further elaborated in Annexure 4a.

Effective use of the document

In Volume I the user will find guidance on the performance of every one of the fourteen Steps in the site assessment and remediation process. The structure of the document seeks to aid the user to quickly familiarise himself with the essence of every Step, after which he may refer to the guidance on the activities to be performed.

Each of the next Chapters presents guidance to a single Step. For quick and easy reference the numbering of the Steps corresponds with the Chapter numbering. For example, Step 5, Remediation investigation, is presented in Section 5. More complex Steps have been subdivided in Tasks, presented in Subsections. For example, Step 5 consists of five Tasks, presented in Subsections 5.1

through 5.5. This means the user may find guidance on the performance of Task 5.3, Setting remediation objectives, in Subsection 5.3, and so on.

The user who wishes to quickly grasp the sequence of steps may refer to the Overview of the Guidance document, on the fold out page at the end of Volume I of the Guidance document. Should he wish some more detail on the different steps he may combine this with the introduction to every Step, invariably presented in the first part of every Section. For example: the introduction to Task 5.3 may be found in Subsection 5.3.1, the introduction to Task 5.4 in Subsection 5.4.1, and so on.

The user who wishes to be guided in the performance of a particular Step may refer to the Section describing that Step. Every Section is invariably structured as shown below.

Presentation of description of Steps and Tasks in Volume I of Guidance document

- Section 1: Introduction to and scope of Step
    - Brief summary of the Step;
    - Flowchart showing the position of the step in the process;
    - List of the activities to be performed within the scope of the Step;
    - Brief reference to the parties responsible for performance of the activities.
- Section 2: Guidance for performing the activities of Step
    - Description of the activities to be performed;
    - References to Volume II for standards and checklists, to Volume III for manuals and tools, and to external sources for more detailed information supporting performance of the activities;
- Section 3: Step output
    - brief summary of the output the Step should result in.

For guidance on a particular Task the user may refer to the outline above, while reading ‘Subsection’ for ‘Section’.

6 Task 5 – Capacity building requirements

6.1 Objective and Task 5 report content

The objective of Task 5 is to identify the capacity requirements for various levels of stakeholders (stakeholder agencies) involved in design, implementation and monitoring of remediation plans, including technical capacity of staff, sampling and laboratory equipment for sample testing, training and capacity building requirements.

The objective of the Task 5 report, submitted on 24th December 2015, is to present the above, but also to demonstrate its development, thereby providing the results with a sound basis. By contrast to the Guidance Document (the product of our Task 4), which is aimed at the organisations responsible for the implementation of NPRPS, the Task 5 report is targeted primarily at those who need a deeper understanding of the technical backgrounds.

6.2 Results

This report presents the following results:

- An evaluation of the key roles involved in the implementation of the fourteen Steps in the site assessment and remediation process, including an inventory of the activities that need to be implemented by the stakeholder agencies responsible for each role;
- An assessment of the capacities each of the key roles requires for effective implementation of the activities assigned to that role, including human resources (expertise, experience and skills), equipment and materials. Also included is a brief evaluation of best international practices in national and semi-national quality assurance and quality control structures. Also included is a brief evaluation of best international practices in national and semi-national quality assurance and quality control structures, and recommendations for India;
- A methodology for calculation of the required capacities for effective implementation of NPRPS. The methodology presented can be used to calculate the required capacities per role and, from there, the total capacities required for effective implementation of NPRPS.

6.3 Conclusions

The Task 5 report presents the following conclusions:

- **Six key roles** need to be involved for effective implementation of the fourteen Steps in the site assessment and remediation process. These are the roles of:
    - Advisor;
    - Site investigator;
    - Laboratory;

  - Remediation Contractor;
  - Programme management Authority;
  - Site related programme implementation Authority.

  While the Site investigator, Laboratory and the Remediation Contractor have clearly defined involvement in a limited number of Steps, the other roles are involved in most of the Steps. The Programme management Authority even has involvement in all Steps. In addition to the roles in Programme management and in Site related Programme implementation the Authority may have a third role where project management for an ‘orphan site’ is required;
- Effective site assessment and remediation involves **a broad range of knowledge fields**, ranging from chemical and civil engineering through fields like hydrogeology to social sciences. This means that effective implementation of NPRPS requires expertise in a considerable number of fields. Significant experience and skills are also required, to be able to properly approach the substantial variety in site specific circumstances;
- The roles of Site investigator, Laboratory and Remediation Contractor in particular require **specialised reusable equipment**, ranging from small hand operated devices to large vehicles and machinery. In addition to that, both Site investigator roles also require a significant amount of **not reusable materials** for an effective implementation of their activities;
- A number of countries around the world have implemented **quality assurance and quality control structure**s in relation to national site assessment and remediation programmes. Each of these are structured in a different way, leading to a number of decisions that may be anticipated on this topic. First of all, a fundamental decision is needed on whether or not to implement a structure on quality assurance and control. In case it is decided to do so, a decision will be needed on how to set up that structure. At the time that decision is faced, a more in depth study of international best practices may be carried out in support of that decision, even though it may be decided to initially develop a more basic structure. An example of a structure which relatively small capacity for quality assurance on the public side does exist (the Netherlands).As in other sectors, it is international consensus that laboratories work under accreditation according to international standards;
- At the time of writing of this report, hands on experience with site assessment and remediation in India is still limited. International best practices do not offer a methodology for determination of capacity building requirements that can be implemented in India without considerable adaptation. Therefore, this report presents a tailor made **methodology for the calculation of capacities** required for effective implementation of NPRPS. The methodology presented:
  - includes the costs for the effective implementation of all fourteen Steps of the site assessment and remediation process as described in the Guidance document;
  - includes all types of sites in the Typology developed for NPRPS (Task 1 of this Assignment);
  - anticipates the best practice remediation options (Task 3 of this Assignment);
  - uses the relevant parameters provided by the database developed in Assignment 1;
  - meets Indian market conditions;

    - can be used to calculate capacities required, both per role and in totals, for effective implementation of NPRPS, based on the input of data from the database developed in Assignment 1. This calculation can be adjusted whenever new data become available;
    - consists of a basic method for the generic calculation of required capacities to deal with a Reference contaminated site, and a method to refine the results through the definition of correction factors;
    - cannot be used for the calculation of capacities required to effectively deal with an individual contaminated site. This is because that needs methodologies providing room for more detailed site specific data.
- The **use of the methodology is demonstrated** through the performance of example calculations, using data on virtual sites, with the methodology. These data are based on international experience, and converted to the Indian situation by application of a number of assumptions;
- By far the **largest part of the cost is needed for remediation** and, if applicable, post remediation. This means that calculation or estimation of the costs for these Steps (8 and 11) are key;
- **Opportunities for effective cost management** are available, most notably the spreading of costs over a prolonged period of time in case of long running remediation or post remediation activities.

For an overview of Human Resources capacities required for implementation of NPRPS see Annexure 5a of this report. Estimates of required capacity are summarized in Annexure 5b.
For more detail on capacity building requirements please refer to the Task 5 report of this Assignment.

7 Task 6 - Key points from consultations

7.1 Objective and Task 6 report content

The objective of Task 6 is to record and respond to the key issues raised during the stakeholder consultation meetings, organised in cooperation with PricewaterhouseCoopers within the framework of both their Assignment 3 (Institutional and legal framework for NPRPS) and this Assignment 2.

The objective of the Task 6 report, submitted on 6th March 2015, is to record the key issues raised during the stakeholder consultation workshops, for as far as these issues touch on the scope of this Assignment 2, as well as the response to the same. The latter is reflected in the incorporation of this response in the final versions of the Task 3 and Task 4 reports.

7.2 Results

This report presents the results of the stakeholder consultation meetings. These consultations yielded the following salient points:

- The Guidance document as presented is fit for use by professional users;
- Include in the Guidance document:
  - Terms of Reference for preliminary site investigation;
  - Stakeholders to be consulted, with a focus on local stakeholders;
- Format of petition should ensure clear and verifiable information is entered;
- Ensure that scope of approach to a contaminated site (e.g. does it include groundwater?) is clear.

During the consultations the following general concerns were also voiced and addressed:

- There is concern that generic screening and response levels may result in an excessive number of sites that will eventually need action in some form. In response, it is pointed out that the competent authority does have instruments with which it is able to control the site investigation and remediation programme, most prominently prioritisation.
- There is concern about costs, of laboratory testing in particular. In response, it is pointed out that best international practice is to limit laboratory testing to the chemicals of concern, in view of the history of use of the site.
- The Methodology presented is aimed to be applicable to any site. Within this Methodology, the Menu of options, originally presented in the Task 3 report and subsequently included in the Guidance document, is a tool for the first round of elimination of non-eligible remediation options. After applying the Menu of options, the Guidance document literally guides the user through the further steps of elimination, until the most appropriate remediation option has been reached.

The results are elaborated in more detail in Annexure 6.

7.3 Conclusions

For conclusions, this report presents the way in which the stakeholder comments are incorporated in the reports.

Task 3 report, "Options and standards for remediation of polluted sites"

- The term 'technical risk' will be further explained in Task 3, Section 2.4.4 and in Task 4, Vol.-I, Step 5.4;
- Information on how to deal with specific climatic conditions in Task 4, Vol.-I, Step 5.3, will be checked and revised where necessary;
- Section 5 of the Task-3 report will refer to the combination of remediation and reconstruction activities.

Task 4 report, "Guidance document for assessment and remediation of contaminated sites in India"

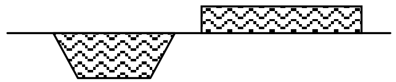
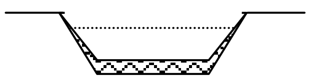
- Standardised Terms of Reference for preliminary site investigation, and guidance for developing site specific Terms of Reference in the Guidance document will be included in Task 4, Vols. I and II, Step 2 and Step 5.1;
- In the description of every Step in Task 4, Vol. I, a separate Section on which stakeholders to consult during the performance of that particular Step, with a focus on local stakeholders, will be included;
- The example petition format for identification of probably contaminated sites (Task 4, Vol. II, 1-a) will be checked on whether it needs to be revised to safeguard that the format petition ensures that only clear and verifiable information is entered;
- The definition of contaminated sites (Task 4, Section 0.2 and Glossary) will be checked on whether it needs clarification on its scope.

Task 5 report, "Capacity building requirements"

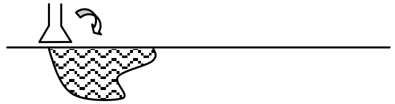
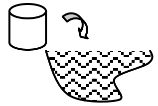
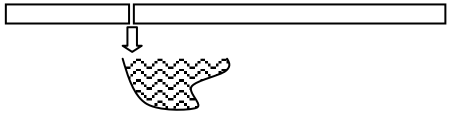
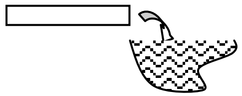
- It will be ensured that a mention of the fact that all capacities need to be developed is included in Task 5, Chapter 3. Also, the capacities to identification of the polluter, responsible person or institutions will be included in the Guidance document (Vol. I, Step 1);
- The Task-4 report of Assignment 3 does mention. In Task-5 a timeline for execution of investigation and remediation works will be incorporated, in alignment with Task-4 report of Assignment 3;
- The fact that situations can arise for which commissioning of external expertise may be necessary is part of the description of the responsible parties executing the activities in Section 3.2.1 of the Task 5 report. It will be checked if this needs further clarification.

Annexures

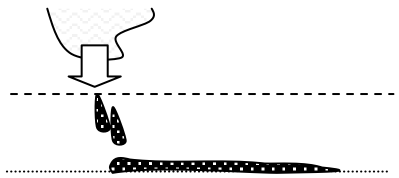
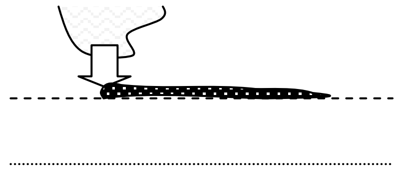
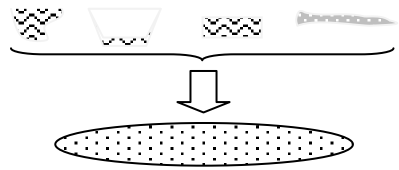
Annexure 1 – Typology (source: Task-1 report)

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
S-1	Solid phase contamination (land bound site)		
S1-a *	Mixing the soil with contaminated material or materials containing contamination, not including agricultural activities.	Well defined body below surface level defined by boundaries of soil where soil is mixed with contaminants.	
S1-b **	Embankment, filling of pits or depressions, filling of surface waters with contaminated material or materials containing contamination.	Well defined body of non-mixed contaminants . E.g. storage of tailings.	
S1-c **	(Bulk) storage of contaminated material or materials containing contamination. (Industrial) activities in which contaminated solids are used. 'Leftovers' of incineration and burning of material.	Irregular shaped layer of contaminated material, recognizable as such. The shape of the contaminated site is related to the activity leading to the contamination	
S1-d *	Adding material containing contamination through agricultural activities (e.g. pesticides, fertilizers or additives to animal feed).	Agricultural site bound contaminations found up to a depth to which the soil is treated by ploughs and other agricultural tools.	
S1-e *	Atmospheric deposition (roads, railway, industries) of emissions or windblown dust.	Thin layered contaminations found over large areas with the highest concentrations close to the source following the prevailing wind direction.	
S1-f *	Deposition by flooding or washing.	Contaminations found in areas flooded by water systems or in downstream areas of flooding areas. The shape of the contaminated site is determined by the flooding of flow of a water system.	
S-2	Solid phase contamination (water bound site)		
S-2 **	Contaminated open water sediments.	Solid phase contaminants sedimented from surface water. The shape of the contaminates site corresponds to the shape of the water system itself. Contaminants may be bound to clay or organic com-	

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
		pounds of sediments.	

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
L-1	Liquid phase contamination*) (land bound site)		
L1-a *	(Business) activities involving fluids e.g. solvents, lubricants, paint, etc.	Liquid contamination in soil situated near a potential source of the contamination.	
L1-b *	Storage of liquids that contain contaminations in tanks or barrels (either storage on surface or subsurface).	Liquid contamination in soil situated at any place at a liquids storage site.	
L1-c *	Transfer and transport of fluids through linear infrastructure. Weak points are couplings, pressure regulators, valves, breakpoints and the passage through foundations / buildings.	Liquid contamination in soil situated at any place along a transport piping system or drains.	
L1-d **	Spills or leaks of liquids. (either on surface or in rivers/lakes) *Note. Possibly leading to type S2 or P2.*	Liquid contamination in soil situated at the end of a transport piping or drain system.	

*) caused by multiple sources or situation where source cannot be attributed.

Type	Description or activity	Typical field characteristics of the site / examples	Icon with typical field situation (cross-section)
P-1	NAPL contaminants in soil		
P1-a	Dense Non-Aqueous Phase Liquid (DNAPL a)) in permeable soil. (bulk density > water)	Spreading of liquids due to gravity flow resulting in a characteristic spreading pattern. The DNAPL's laying of the bottom of an aquifer can result in a 'secondary source' of spreading of type P-2	
P1-b	Light Non-Aqueous Phase Liquid (LNAPL [b])) in permeable soil. (bulk density < water)	Spreading of liquids in a characteristic spreading pattern of floating layers. The LNAPL's laying at the top of a water table can result in a 'secondary source' of spreading of type P-2	
P-2	Leached or dissolved contaminants in groundwater		
P-2	Groundwater contamination	Due to spreading of leachate or mobile dissolved contaminants in a permeable soil	

Notes

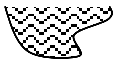
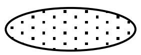
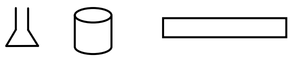
***	Sites present in the available lists of sites (CPCB, Blacksmith-list, Blacksmith database)*

**	Sites meeting the characteristics of waste constituents (HW-rules, Schedule II) or processes generating hazardous waste (HW-rules, Schedule I) or additional sites from inventories of policies in other countries (task 2)*

*a)	A dense non-aqueous phase liquid or DNAPL is a liquid that is both denser than water and is immiscible in or does not dissolve in water. The term DNAPL is used primarily by environmental engineers and hydro geologists to describe contaminants in groundwater, surface water and sediments. DNAPLs tend to sink below the water table when spilled in significant quantities and only stop when they reach impermeable bedrock. Their penetration* *into an aquifer makes them difficult to locate and remediate. Examples of materials that are DNAPLs when spilled include chlorinated solvents or creosote.*

b) *Light Non-Aqueous Phase Liquid (LNAPL) is a groundwater contaminant that is not soluble and has a lower bulk density than water, which is the opposite of DNAPL. Once LNAPL infiltrates through the soil, it will stop at the water table. The effort to locate and remove LNAPL is relatively cheaper and easier than DNAPL because LNAPL will float on top of the water in the underground water table. Examples of LNAPLs are gasoline and other hydrocarbons.*

Key to icons

Icon	Key
	Solid waste or solid waste mixed with soil (all solid phase). Varying in shape, thickness and extent, depending on local conditions.
- - - - - - - - - - - - - - -	Groundwater table Base of aquifer / top of impermeable layer.
	Liquid waste. Pure or mixed with soil.
	Leaching / spreading of contaminants to soil / groundwater. Depending on permeability of the soil.
	Contaminated groundwater plume. Depending on permeability of the soil.
	DNALP or LNAPL.
	Spill / leakage.
	Not soil related human activity / construction e.g. industrial process, storage, bulk transfer.

Annexure 2a: Summarized results inventory international approaches remediation (source: Task-2 report)

1. Soil contamination				
	France	**United States**	**Brazil**	**Netherlands**
Number of contaminated sites	4,318 sites which need action (assessment, remediation or management of restrictions); 406 of these sites have been treated and are clean Start of the inventory: year 1994 Nearly 300,000 ancient industrial sites, which could affect the environment[1]	Between 100,000 and 600,000 brownfields sites and around 1,664 abandoned sites selected for the Superfund program[2] Start of the inventory of the Superfund program: year 1982	Around 4,150 sites in the State of São Paulo[3] Start of the inventory: year 2002	Around 11,000 sites[4] with possible unacceptable risks in total. • 413 sites with unacceptable risks towards human health; • 2,000 estimated number of sites with unacceptable risk to ecology and groundwater. Start of the inventory: year 1980
Important categories of pollution	A large variety of contaminated sites: various industrial processes on metals, chemistry, textile; harbor areas; old mining facilities; cleaners; petrol stations. Frequent contaminants are hydrocarbons and metals (lead, zinc, chromium and copper).	Special attention is given to a.o. pesticides in agricultural areas, mining waste, lead, Dense Nonaqueous Phase Liquids (e.g. trichloroethene), oil spills.	In the list with 4,150 sites the following activities are mentioned: Commercial activities; Industrial activities; Residues; Gas Stations; Accidents.	Important causes of point sources of contamination: metal-industry, oil spills, gasworks, waste dump sites, cleaners, petrol stations. Diffuse contamination exists due to use of waste material for construction purposes (building, infrastructure).

[1] Source: BRGM, BASOL, BASIAS, 2012. Potential polluted sites inventoried. The information 4318 sites date from the 3rd of April 2012. The inventory of 300,000 industrial activities is made based on archives only and the data is from 2012.

[2] Source: US EPA, 2012. The difference between Brownfields sites and Superfund sites is that the brownfields sites are characterized by low or medium contamination, they are easy to cleanup and to redevelop whereas superfund sites are the worst contaminated sites with limited prospect for economically viable reuse.

[3] Source: CETESB, 2011. This number corresponds to number of industries that shut their doors, that is not reused and which critically affect the environment.

[4] Source: VROM, 2009. Number of sites in need of urgent remediation, according to the Dutch criteria.

1. Soil contamination			
	United Kingdom	**Australia**	**India**
Number of contaminated sites	For UK no total estimation has been made. In England 100,000 sites may be contaminated. Of these, 5,000 to 20,000 may be problem sites (2002 the Environment Agency (EA))	No information: there are no national registers of contaminated land.	557 sites have been identified in formal data sources. Some SPCB's have been hesitant about sharing data in view of potential effects.[5]
Important categories of pollution	Greatest surfaces of land affected (area and sites) are: railway land, garages and filling stations, gas works, sewage works, textiles, engineering works, and ceramics and cement works. These various activities were carried out on a wide range of scale of operations, resulting in point sources of contamination of soil and groundwater as well as larger extents of diffuse contamination.	Known categories of possible soil contamination are: service stations, cattle dips, tanneries, wood treatment sites, landfills, fuel storage, refuse tips, mining waste.	The same sources as referenced above states that most of the identified sites are contaminated with various heavy metals, especially chromium and lead, but that also mercury, cadmium and arsenic are common, and that pesticides and fluoride also occur commonly.

[5] Source: COWI et.al, Feb. 2013 – Inventory and mapping of probably contaminated sites in India, Task 1 report: Existing data and general information on contaminated sites

2. Effects of contamination				
	France	**United States**	**Brazil**	**Netherlands**
Effects	Recorded impacts of contaminated are: drinking water, groundwater tables, shallowed water and sediments, vegetation for human or animal consumption, animals for human consumption, smell complaints, human health.	Risks of contamination are categorized in risks to human health and risks to the environment.	When prioritizing sites the following impacts are taken into account: life and health of population (direct impact); supply of drinking water; land use residential and gardens; water (underground and surface); use of agricultural land or lifestock; other public or ecological assets to be protected.	Impacts of contamination assessment are categorized in effects for human health, for ecology and for groundwater. Because in Netherlands much drinking water is produced out of groundwater this pathway is important.

2. Effects of contamination			
	United Kindom	**Australia**	**India**
Effects	Generally effects for human health, (ground)water and ecology are taken into account.	Effects on human health and the environment (ecology and water) are taken into account.	Land use has not yet been recorded for 193 of the identified sites. 138 of the identified sites are on industrial land, a further 109 is in mixed use. Effects for human health and the environment are taken into account.[6]

[6] Source: CPCB Methodology for assessment and remediation of polluted sites

3. General policy/approach				
	France	**United States**	**Brazil**	**Netherlands**
Key documents	No specific law on soil, framework is based on: • Environmental Code • Ministerial letter 8th of February 2007 • Reference values for the water, the foodstuffs and the external air • Directive on wastes **2008/98/CE**	• Hazardous and Solid Waste Amendments (HSWA) of the RCRA (Resource Conservation and Recovery Act), 1984 • Superfund or CERCLA: Comprehensive Environmental Response Compensation and Liability Act, 1980 • Oil Spill Act, 1990	• Law No. 997 of May 31, 1976: establishment of a system of prevention and control of the environmental pollution • Law No. 13577 of July 8th 2009: guidelines and procedures for the protection of soil quality and management of contaminated area	• Soil protection Act *Wet Bodembescherming*, first edition 1987 (replacing the Interim Soil Remediation Act, 1983) • Soil Quality Decree *Besluit bodemkwaliteit*, 2008 • Circular on Soil Remediation *Circulaire Bodemsanering*, 2009 Supportive documents: Guidance document on recovery of soil and sediment quality; sets of standards on quality of executed work.
Management approach for historically contaminated sites	Fit for (future) use approach for historical pollution	Fit for use approach, prioritization (Hazard Ranking System).	Fit for use approach and prioritization (scoring data sheet)	Fit for use approach for immobile contaminants: the top soil quality must meet the requirements for the future use of the site. Cost-effective approach of remediation of mobile contaminants: risks must be eliminated as much as possible and after care should preferably be not intensive.

Responsibility	• Polluter pays principle: responsible of the contamination (the operator, the owner or the former owner) • Orphan sites: ADEME. Funding by TGAP : General Tax on Pollutant Activities	• Polluter pays principle: The landowner, disposal operator, transporter or generator of hazardous waste are potential responsible parties • Orphan sites: EPA, Superfund program. Funding by the federal budget and penalties from responsible parties Many remediations take place when developing brownfields.	• Polluter pays principle+ solidarity principle: -the one that caused the contamination or its successor or -the owner of the area or -the holder of the rights of the ground or -whoever benefits directly or indirectly from the ground • Orphan sites: FEPAC is a program from the Environment Department of the State of Sao Paulo: State Fund for Prevention and Cleaning of Contaminated Area. Funding by international aid, cooperation and intergovernmental agreements, donations, environmental compensation from polluting activities.	• Polluter pays principle: the owner or the operator • Orphan sites: The Financial Provisions Soil Remediation Decree: fund from the government: average deal: 50% government, 50% owner/beneficiary Many remediations take place when developing areas of due to trading estates.
Management of current sites integrated in the prevention policy	• Code de l'environnement • ICPE: environmental permit with requirements to protects the soils and the environment	• Environmental Act • RCRA: law about the disposal of solid hazardous waste and release of the facilities.	• Environmental Act • Licensing and environmental permits with requirements and monitoring	• Environmental Act: environmental permits • Soil protection Act: several regulations on specific activities

3. General policy/approach			
	United Kindom	**Australia**	**India**
Key documents	England: Contaminated Land Law (1995, effective in 2000) EPA 1990: Part 2A Contaminated Land Statutory Guidance, Defra, 2012 CLR 11, Technical Good Practice document (2004).	National Environment Protection (Assessment of Site Contamination) Measure 1999. *Primary responsibility for ensuring the assessment of site contamination rests with the States and Territories.* *Schedule A: recommend general process for assessment of site contamination.* *Schedule B: general guidelines for the assessment of site contamination.*	Land Acquisition Rehabilitation and Resettlement Bill, 2011 Environmental (Protection) Act (1986), under which have been constituted: Municipal Solid Wastes (Management & Handling) Rules, 2000 Hazardous Wastes (Management Handling and Transboundary Movement) Rules, 2008 E-waste (Management & Handling) Rules, 2011 Biomedical Waste (Management & Handling) Rules, 2011[7] Also: Methodology for assessment and remediation of polluted sites, developed by CPCB
Management approach for historically contaminated sites	In spatial planning: the ‘suitable for use’ approach, for the current and proposed new use of the land when assessing the importance of contamination and determining remediation objectives.	• prevention of contamination or further contamination; • when significant risk exposure: implementation of health and safety measures; • planning authorities should ensure a site is suitable for	Not yet defined. Proposals to be developed in NPRPS project within CBIPMP NPRPS, incorporating technical information provided by Methodologies project.

[7] Source: PWC, April 2013 – Development of National Program for Rehabilitation of Polluted Sites, Task 3 draft report, Identification of Options for Legal and Institutional Strengthening

3. General policy/approach			
	United Kindom	**Australia**	**India**
	For orphan sites: a risk based approach.	its intended use; • all relevant information on site contamination should be accessible to the community;	
Responsibility	Polluter pays principle. If not present: the present owner is responsible. For orphan sites the regulating authorities bear the costs. Land contamination is today routinely considered under a variety of drivers including regulatory compliance, corporate policy, land transactions and development. Over 90% of remediation in England has taken place voluntarily by developers under market-lead solutions.	Polluter pays principle. In addition the use of market forces to achieve the objectives of any contaminated site liability scheme.	Not yet defined. Proposals to be developed in NPRPS project within CBIPMP NPRPS, incorporating technical information provided by Methodologies project.
Management of current sites integrated in the prevention policy	Environmental Protection Act, 1990: environmental permitting prevents uncontrolled release of hazardous substances.		Waste management rules, as described under 'Key documents' above, prevent uncontrolled release of hazardous substances.

4. Policy Instruments				
	France	**United States**	**Brazil**	**Netherlands**
Actors: Government: set up the policy, the general approach Enforcement organism: -Permits delivery -Technical guidelines -Communication/public information -Control Scientific support: quality standards, threshold values, toxicological data /soil studies, technique studies Engineering companies, contractors, commercial laboratories	• Ministry of Ecology, Sustainable Development and Energy • ADEME: (national scale) receive fund from Ministry of Ecology, Ministry of financial Economy and Industry, and Ministry of the Research and third level Education. • DREAL: (regional scale) fund by Ministry of Ecology • BRGM: inventory of sites • INERIS: Fund by the Ministry of Ecology • Engineering companies, contractors, commercial laboratories: assessment and execution of remediation	• EPA: Environmental Protection Agency • EPA Regional offices • EPA's Office of Solid Waste and Emergency Response (national scale) • EPA's National Center for Environmental Assessment • ITRC (technology on mining waste treatment) • Engineering companies, contractors, commercial laboratories: assessment and execution of remediation	• Ministry of Environment • CETESB: Environmental Agency of the State of Sao Paulo. Fund by the Ministry of Environment • Environment Department of the State of Sao Paulo role: support the CETESB • GTZ: German Society for Technical Cooperation role: technical and financial support • VIGISOLO program, funded by the Health Ministry role: carry on public health studies related to contaminated sites • Secretaries of Health and Water Resources *Role of private companies not known.*	• I&M: Ministry of the Infrastructure and the Environment • Enforcement of specific assessment and remediation projects by regional (provinces) and local authorities (larger cities) • Soil+: (national scale) agency established by the I&M • RIVM: National Institute for Public Health and the Environment • TNO: Research organization about soil • Engineering companies, contractors, commercial laboratories: assessment and execution of remediation

4. Policy Instruments				
	France	**United States**	**Brazil**	**Netherlands**
Methodology	1. pollution investigation using historical data and other information 2. Conceptual Site Model 3. EQRS – calculation of the sanitary risks 4. Determination of the actions to undertake 5. Costs-benefit analyses 6. Analysis of the residual risks 7. Execution of site management plan	1. Preliminary Assessment/Site Inspection 2. NPL-Listing[8]: list of the most serious contaminated sites according to a ranking system 3. Remedial Investigation/Feasability Study (use of Conceptual Site Model) 4. Records of Decision: explains which cleanup alternatives will be used 5. Remedial Design/Remedial Action 6. Construction Completion: identifies completion of the cleanup construction 7. Post Construction Completion (operation and maintenance, control, five-year review, remedy optimization 8. NPL deletion 9. Site reuse	1. Preliminary Assessment 2. Confirmatory investigation 3. Registration in a database with a ranking system 4. Detailed investigation 5. Risk assessment (following US EPA methodology) 6. Design of remediation 7. Remediation project 8. Remediation of contaminated area 9. Monitoring	• Preliminary assessment (historical research) • First field and laboratory research • Estimation possibility of severe contamination • Detailed investigation • Risk assessment • Determination existence of unacceptable risks • Starting procedure remediation • Selection of remediation option • Design of remediation • Remediation execution • Verification results • Possible after care of monitoring In the administrative procedures much attention is paid to the interests of local residents. Some steps need submission of reports to authorities.

[8] NPL: National Priorities List. Orphan sites that are remediated by the State must be registered in a list which inventories the worst cases of contamination that are hardly reusable. A ranking system called Hazard Ranking System (HRS) aims at giving a score to a site and if the score is higher than 28,5 the site can be added on the NPL. After remediation, the site must be removed from the list.

4. Policy Instruments			
	United Kindom	**Australia**	**India**
Actors: Government: set up the policy, the general approach Enforcement organism: -Permits delivery -Technical guidelines -Communication/public information -Control Scientific support: quality standards, threshold values, toxicological data /soil studies, technique studies Engineering companies, contractors, commercial laboratories	No single authoritative body in the UK responsible for land quality. • Environment Agency = environmental regulatory authority for England and Wales. • Executive agency of the Department for Environment, Food and Rural Affairs (DEFRA) for England and Wales; SEPA (Scottish Environmental Protection Agency); Northern Ireland Environment Agency • Local authorities are the principal regulators. They have contaminated land officers to assess remediation strategies related to spatial development. • Engineering companies, contractors, commercial laboratories: assessment and execution of remediation	Primary responsibility for ensuring the assessment of site contamination rests with the States and Territories.	Not yet defined. • Assignment 3 of CBIPMP NPRPS project is developing proposals. In these proposals MoEF sets up policy, which may be managed by CPCB or a new dedicated Central NPRPS Authority. • The same source proposes to entrust Enforcement to SPCB's or State NPRPS Authorities. • Scientific support from e.g.: NEERI: National Environmental Engineering Research Institute • NGRI: National Geophysical Research Institute • IIT: Indian Institute of Technology • Accredited engineering companies, contractors and commercial laboratories: assessment and execution of remediation.
Methodology	1. preliminary risk assessment (desktop study and site reconnaissance);	• Preliminary investigation (assessment of human health and ecological risks); • Detailed investigation;	Not yet defined. To be developed in this project. Proposed methodology will be described in Task 4 report,

4. Policy Instruments			
	United Kindom	**Australia**	**India**
	2. Intrusive investigation 3. Risk assessment 4. Remediation strategy 5. Remediation works Each step requires submission of reports to authorities.	• Health and environmental (site specific) risk assess-ment; • Remediation plan (approval of authorities needed) • Execution remediation works • Validation of results • Possibly site management plan	Guidance document. CPCB has developed a meth-odology containing the following phases and steps: Phase-I • Review site data; • Preliminary investigations and development of site conceptual plan and sam-pling protocols; • Detailed site investigation; • Risk assessment; • Remediation objectives and remediation plan; • Detailed Project Report (DPR); • Bidding and implementation remediation works; • Monitoring and assessment of remediation works; • Post remediation monitoring plan.

5. Remediation				
	France	**United States**	**Brazil**	**Netherlands**
Standards aiming at initiating the remediation process	Reference values are: • *Natural soil background values* for the metals • *Regulated values for the drinking water, foodstuffs and the outer air* for organic coumpounds • *Regulated values towards ecological area* • For the ICPE, comparison with the state before the use of the site OR, if values non available: • EQRS: risk index by calculation	Recommended action levels: • Environmental Indicator for human exposure: is there an unacceptable level of risk; • The Environmental Indicator for Groundwater ensures that contaminated groundwater does not spread. • HRS: sites with a score > 28.50 are proposed for the NPL • Standard screening levels based upon human health risks (not mandatory)	• Quality reference Value: no contamination, natural quality of the soil/groundwater • Prevention Value: adverse changes may occur, monitoring necessary • Intervention Value: potential risks to human are health, intervention necessary. These values are calculated based on risk assessment for each substance.	• **The Target Value** defines a non polluted state for the **groundwater** • **The Intervention Value**: indicates when functional properties of the **soil or the groundwater** for humans, plants and animal are threatened. If a contaminant is in a higher concentration than this value, a risk assessment is needed.
Post-remediation values	• Suppression of the source of the contamination • Level of risk acceptable towards the people and the environment, The remediation goals depend on the future use of the site. • Regulated values for the drinking water, foodstuffs and the outer air for organic coumpounds • Regulated values towards ecological area	Level of cleaning = Preliminary Remediation Goal, set by: • ARARs : Applicable or Relevant and Appropriate Requirements . Concentration limits set by environmental regulation. • Risk Assessment calculations	Remediation goals must meet the requirements of the risk assessment. The risk must be controlled,	For the **topsoil**: • The Background Value for agriculture and ecological functions *achtergrondwaarde* • The Maximum Housing Value • The Maximum Industrial Value • OR Local Maximum Values For the **subsoil**: risks of spreading and any risk towards human's health must be removed as much as possible. These values are calculated based on risk assessment for each substance taking into account both human's health and ecology.

5. Remediation			
	United Kindom	**Australia**	**India**
Standards aiming at initiating the remediation process	• Soil Guideline Values (EA): indicators of 'significant possibility of significant harm'. SGV do not have a legal status. • Science based risk assessment.	Appropriate investigation levels, varying for various States.	Not yet defined. Proposals to be developed in Inventory project of CBIPMP NPRPS.
Post-remediation values	Risk based approach. Various models can be used for risk assessment (EA-standard and commercial models as well). The remediation should remove or treat the pathway or protect or remove the receptor and remedy the effect on controlled waters. Most remediations take place by excavation and off-site disposal, followed by containment.	Hierarchy of options for site clean-up and/or management: On-site treatment to at least acceptable risk level, or off-site treatment of excavated soil, If not practicable, containment or removal to an approved site or facility, or, when remediation has no net environmental benefit, implementation of an appropriate management strategy.	Not yet defined. Proposals to be developed in Methodologies project of CBIPMP NPRPS. Will be presented in Task 4 report, Guidance document.

Summary UNIDO POP Contaminated Site Investigation and Management Toolkit (source: Task-2 report)

The Stockholm Convention of May 23rd 2001 on Persistent Organic Pollutants is a legally binding multilateral environmental agreement intended to protect human health and the environment from POPs.
The Convention requires the 160 countries who have signed it to reduce or eliminate 12 known POPs which are Aldrin, Chlordane, DDT, Dieldrin, Endrin, Hexachlorobenzene, Heptachlor, Mirex, Toxaphene, PCBs, Dioxins and Furans.
Eight of these chemicals are pesticides and fungicides that are in common use in many developing countries, while two are industrial chemicals and two are common industrial by-products.

The goal of effective management of POP-contaminated sites is a priority for the Stockholm Convention, the Convention does not cover the specifics of how to manage site contamination.
The United Nations Industrial Development Organization (UNIDO) Expert Group on POPs has therefore developed this comprehensive Toolkit.

The Toolkit is developed to aid developing countries with the identification, classification and prioritization of POP-contaminated sites, and with the development of suitable technologies for land remediation in accordance with best available techniques and best environmental practices (BAT/BEP). The Toolkit focuses exclusively on the 12 POPs listed.
The Toolkit is designed to provide a clear step-by-step approach that can be easily followed and implemented by a variety of users following various worksheets, tables, and checklists, currently used in developed countries, that users in developing countries can adopt, and then modify to meet their own needs.

Guidelines for site investigation are presented in the Toolkit from countries with different ecological and environmental conditions and offer an adequate degree of human health protection to developing countries. Two detailed case studies, one from Ghana and the other from Nigeria are included in the Toolkit.

Toolkit has been devised:

- with an approach to the management of POP-contaminated sites by integrating remediation strategy with technical, political, legal, social and economic considerations to develop risk reduction and prevention strategies.
- presenting screening levels, limits for quantitatively evaluating risk levels for soil and groundwater for the 12 POPs.
- presenting easy-to-use and simple screening matrix system that can be used for selecting the most appropriate remediation technology for a specific site according to the local situation.

- presenting a step-by-step approach to economic analysis of POPs-contaminated sites.

There are five main modules in the toolkit which are:

- Module 1:- Policy and Legal Issues
- Module 2:- Conducting a Site Investigation
- Module 3:- Assessing Site Risks
- Module 4:- Managing Contaminated Sites and
- Module 5:- Costing and Financing Site Remediation.

Main points evaluation of site assessment and remediation process for US, UK, NL (source: Task-2 report)
The information on the technical approaches to site assessment and design and execution of remediation in the United States, the United Kindom and the Netherlands leads to the following conclusions:

- **Steps in the remediation process**
  In all countries studied we concluded that the steps in the process of site assessment and remediation are generally the same. An interesting difference in the approaches is that site and risk assessment or remediation option appraisal sometimes is carried out in separate steps (NL) and sometimes in more steps, for instance in the US and UK. In the US during the phase of Remedial Investigation / Feasibility Study the concurrently executed site assessment and remedial option appraisal is done for efficiency reasons: of course the risks of the contamination for human health and environment should result from the assessment but first ideas on the remediation options possibilities will prevent the collection of unnecessary data.
  The steps in the methodology of CPCB are more or less the same compared to the approaches in other countries.

- **Typology**
  Typology of contaminated situations is a much used tool for national or regional programming of site assessment and remediation. For common specific types of sites it can be necessary for reasons of liability, budgeting and efficiency to make a specific program. Government and private organizations can develop agreements on the roles and contributions in these programs recorded in agreements or contracts. An example of such a program is the agreement on remediation and redevelopment of former gas works sites in The Netherlands. Sometimes specific technical approaches to site assessment or remediation are developed in such programs, but mostly it requires further fine tuning of existing techniques and adapting the techniques to local conditions.

For site specific situations the conditions can lead to other approaches than generally described. Therefore the Guidance document, which will be developed in Task 4, has to be robust and flexible in order to be applicable in different situations. In case the local conditions are not uniform such a program mainly has a non technical benefit. Regardless of this kind of programs there are often other reasons to start a remediation. Redevelopment of a site is by far the most common reason to start a remediation of a site.

- **Assessment of sites (identification, initial assessment, detailed assessment, risk assessment)**
  For site specific projects typology helps in one way in the technical approach: to start the assessment process by focussing on the soil threatening activities and the most relevant aspects of the source and pathway of the contamination.
  In the first step of site assessment always a combination of desk study and field work and laboratory testing are applied.
  The Source-Pathway-Receptor approach is essential for assessment of risks and for designing appropriate remediation measures. The Conceptual Site Model is an essential tool to understand the nature of the contaminated site and to develop applicable remediation approaches. Furthermore, it helps to design an effective and efficient investigation program for detailed site assessment.

- **Selection of remediation options and selection and design of technologies**
  The goal of remediation in US, UK and NL in general is to prevent further risks for human health and the environment. The goals for a specific site have to be derived from generic standards and site specific risk calculations.
  Remediation options are selected using sets of criteria which in all countries are more or less the same: environmental results, technical feasibility/risks, costs, impact of the works, available time, spatial planning, social aspects.

- **Implementation of remediation works and post-remediation activities**
  During implementation of the remediation works assessments are necessary to verify the results of the remediation. Often post-remedial measures are necessary to monitor the effects of the remediation in case not all contamination could be removed or treated. Sometimes, maintenance activities are necessary to ensure long term remediation measures.

- **Standards and support on technical possibilities for assessment and remediation**
  The US, UK and NL have various well developed guidelines and tools, which are good examples for the Guidance document that will be developed in Task 4.

Annexure 2b – Steps in the assessment and remediation process (Source: Task-2 report)

(Note: these steps have been further detailed and developed under Task-4 in the Guidance Document, refer to Annexure 4a)

Step	Scope / questions to be answered	Activities	Input	Output	Possible tools	Exit or deviation of process
1) Identification of probably contaminated site						
1) Identification of probably contaminated site	Is the site contaminated or probably contaminated?	• Desk study				
2) Preliminary site investigation						
2.1) Preliminary site Assessment Reconnaissance	Evaluate if there have been activities at a site which might have caused soil contamination?	• Desk study • Interviews local authorities, land user, owner, population • Site visit, possibly limited sampling and testing	• Site coordinates • aerial photographs • topographical data • geological data • records of authorities regarding environmental permits en land use / ownership • Socio-economic factors for site access	Report with: • Type of site • Contaminants / parameters • First CSM of site • Boundaries of the site to be assessed • Potential contaminated area • Site photographs • Phases (waste material, soil, groundwater, sediment) to be assessed • Socio economic factors for further assessment and remediation	• List of activities causing contamination / Typology • CSM • HW-Rules, Schedule II -III • Definition of probably contaminated site • Checklist for analysis socio-economic aspects	In case no activities have been recognized which might have caused potential contamination.
2.2) Preliminary site Assessment Preliminary sam-	Evaluate if activities on the site have caused soil contamination?	• Field survey plan • Sampling	• Report reconnaissance • Sampling and screening meth-	Report with: • Conclusion if any contaminations are present	• Typology • CSM • Guidelines field	In case no contamination are present above screening level.

Step	Scope / questions to be answered	Activities	Input	Output	Possible tools	Exit or deviation of process
pling		• Laboratory testing	ods • Desired quality and accuracy of data • Information regarding local community	on a site and to be related to previous activities • Updated CSM • Identification possible immediate human and / or ecological threats • Check results with screening levels	survey • Checklist of field survey techniques • Checklist for laboratory testing methods • Screening levels for assessing potential risk • Checklist safety measures site access	
3) Notification of polluted site						
3) Notification of polluted site	• How is the site to be delineated? • Which site use restrictions and temporary safety measures need to be imposed?	• Desk study				
4) Priority list addition						
4) Priority list addition	• Which priority needs to be assigned to the site?	• Desk study				
5) Remediation investigation						
5.1) Detailed site investigation	• Information on amount and extent of soil contamination necessary for risk	• Field survey plan • Sampling • Laboratory test-	• Report preliminary assessment • Sampling and screening meth-	Report with: • Delineation of contamination (if necessary) • Soil structure	• Typology • CSM • Guidelines / thumb rules field	In case of no contamination are present above screening level

Step	Scope / questions to be answered	Activities	Input	Output	Possible tools	Exit or deviation of process
	assessment • Which sources, pathways, receptors can be identified and quantified?	ing	ods • Desired quality and accuracy of data • Information soil structure and geohydrology • Information regarding local community	and geohydrology • Check results with screening levels • Updated CSM • Sometimes conclusion on amount and extent of contaminations at the site	survey • Screening levels for assessing potential risk • Parameters on mobility, toxicity, biodegradation, bioavailability of contaminants • Overview of assessment tools • Checklist safety measures site access	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
5.2a) Preliminary risk assessment	Identification of potential significant risk	Inventory of Source, Pathway, Receptor data	• Reports site assessment • Information on value of ecosystem and surface of contaminated area • Information soil structure and geohydrology	Report with: • SPR-combinations with potential significant risk	• CSM • Table with SPR assessment and exposure (human: ingestion (soil, ground water, crop, meat, fish), inhalation, dermal uptake • Definition contaminated site • Screening levels for assessing potential risk	In case there are no SPR-combinations which can cause potential risk
5.2b) Detailed quantitative risk assessment	Does exposure to contaminants exceed significant risk levels?	• Calculation of trans-port/dispersion of contaminants in soil, ground water and to surface water • Calculation of human and ecosystem exposure • Comparing human exposure levels to risk levels	• List of SPR-combinations with potential significant risk • Quantitative information on exposure parameters • Information soil structure and geohydrology	Report with: • Evaluation of exposure and dispersion and risk based levels violations (human, ecological) • Possible need of safety measures in expectation of final remedial actions	• Information on toxicity, bioavailability and mobility of contaminants • Dispersion model (air, surface water, ground water) • Exposure models (dose/response) • Maximum levels for exposure of human and ecosystem	In case there are no SPR-combinations for which significant risk levels are exceeded

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
5.3) Remediation goals and preconditions	• What are goals / objectives for remediation? • Future use and additional option requirements	Consultation of • authorities • initiator	• Soil remediation legislation and standards • Redevelopment plans • Information ownership and stakeholders	• Site specific remediation targets for each SPR-combination	• CSM • Stakeholder analysis • Social economic analysis • Target levels for remediation	In case remediation for some reason is not to be executed within a foreseeable period, temporary safety measures should be taken.
5.4a) Reconnaissance Remediation options	Which remediation options are feasible for this type of contamination?	• Selection of SPR-combinations together with parties involved • Inventory of remediation options targeting these SPR-combinations	• Report risk assessment with SPR-combinations for which significant risk levels are exceeded	• Established SPR-combinations with exceedance of significant risk level • List of applicable options including connotations regarding its applicability and risks	• Tables of Task 3	
5.4b) Design Remediation options	Remediation option design for each SPR-combination	• Analyses of options and techniques regarding the site factors, remediation objectives and practical objectives	• Results of previous step 3b) • predefined range of objectives of remediation and site characteristics	• Remediation options applicable. • Analyses of pros and cons for each remediation option	• CSM • Technique factsheets • Site assessment to investigate the site specific applicability of a specific technique	
5.5) Selection remediation option	Selection of most favourable remedia-	Weighting each remediation options		• Ranking of remediation op-	• Criteria for selection (Task-3)	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
	tion option	on a set of criteria		tions including analyses of pro's/con's • Combining options to possible remediation strategies for the whole site • Indication of short term and long term management aspects • Evaluation missing data needed for analysis of applicability of remediation techniques	report • Methods for weighting	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
6) Remediation Design, DPR and 7) DPR approval and financing						
6a) Highlighting remediation strategy requirements that the design should be in accordance with. Planning and preconditions.	• Ensuring that remediation objectives and all environmental requirements will be met • Plan each phase of the remediation strategy (including monitoring and post remediation phases).	• Desk study	• Selected remediation option • Actual situation of the site (when much time has passed since last step)	• Remediation objectives • Environmental requirements • Remediation schedule (maintenance schedule, monitoring schedule) • Phase determining criteria	• Checklist with relevant aspects • Criteria determining when to start and when to stop.	In case remediation for some reason is not to be executed within a foreseeable period, temporary safety measures should be taken.
6b) Drawing the remediation works	• Detailed description of remediation activities	• Drawing the plans and combine the design eventually with the design of the redevelopment of the site.	• Civil engineering information (water drainage systems,..) • Redevelopment plan for the future use of the site	Remediation plan comprising: • Design maps, • Design reports	• Checklist / generic aspects remediation plan	
6c) Ensuring that the requirements of the authorities for the implementation are met	Concern permits necessary for the works but also environmental permits to manage the produced wastes and other environmental disturbing.	• Applying for regulatory permits: -civil engineering permits, -waste management license -groundwater authorization	• Building regulations • Environmental regulations	• Permits	• Checklist permits	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
8) Implementation of remediation						
8.1 and 8.2) Developing bidding documents	• Detailed technical description of the activities to be carried out. • Total costs calculation	• Developing documents needed for tendering process. • Calculation of the costs of all remediation's phases.	Remediation plan with design of measures.	Bidding documents.	Referring to generic tendering procedures in civil engineering, infrastructural or environmental works.	Tendering process is the last step before the remediation is executed.
		Reporting		Bills		
8.3a) Information to stakeholders	Information of all parties that can be involved (inhabitants, commerce, …)	• Execution of the Communication plan • If necessary: revision of remediation plan	• Remediation plan	• Evaluation report of executed communication.	• Generic communication plan / checklist	
8.3b) Safety, health and environmental measures	Facilitate safe conditions for the contractor and the environment	• Activities in safety plan • Logbook of activities and unforeseen events	• Safety, health and environmental plan	• Logbook	• Generic table of contents of logbook	
8.3c) Monitoring remediation progress	'Plan- do-check-act' of the remediation	• Monitoring and registration of the remediation progress, evaluation and if necessary adjustment of the remediation plan. • Communication with actors in case of deviation of the original	• Remediation plan. • Monitoring plan. • Maintenance plan. • New data of contamination of the site	• Logbook with all data and other information	• Generic table of content of a logbook • Examples of exit-procedures. • List of key procedural point to keep focus on quality of the remediation process	In case the remediation goal cannot be achieved when applying the original remediation plan and additional adjustments.

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
		remediation plan				
8.4d) Termination of remediation	Inventory and report of all activities and data	• Evaluation report with all activities, deviations from original plan, corrective measures and final result	• Logbook with all data collected during remediation process	• Evaluation report describing the remediation process and the final soil quality.	Generic table of content of a evaluation report	
9) Approval of remediation completion						
9a) Evaluation remediation goal	Evaluation if the reached situation meets the remediation goal	• Termination of remediation contract and data-transfer to authorities • Validation of remediation works • Site clearance • Evaluate site use restrictions and post remediation measures	• Remediation objectives as described in the remediation plan • Actual data on site contamination level (revision of site assessment) • Target level evaluation (standard based approach) or risk assessment (risk based approach)	Conclusion: remediation goal is reached or Conclusion: remediation goal is reached. Instructions for site use restrictions and post remedial measures or Remediation goal is not reached, further remedial steps are necessary All data of remediation available for authorities. If necessary a report on site use restrictions and post remediation measures	• Definition of remediation site use restrictions i.r.t. post remedial measures i.r.t. extensive remediation activities. • Examples of site use restrictions and	In case of approval of the executed remediation works site re-use can take place.
9b) Registration of land use restriction and post remediation measures	In case residual contaminants are present, land use restrictions are insti-	• Institutional registration	• Report on site use restrictions • Report on post remediation	• Registered site use restrictions • Registration of post remediation	described by Ass_3 task (land register?)	

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
	tutional registered Institutional registration of post remediation measures		measures	measures		
10) and 11) Post remediation plan and Post remediation action						
10) and 11) Design and execution of post-remediation measures	Operation and maintenance of technical measures to keep measures operational in order to preserve the situation as reached with the remediation process	• Monitoring • Operate • Maintenance • Replacement / restoration	• Maintenance and monitoring plan • Report on site use restrictions	• Report with results • Registered site use restrictions	Checklist post remediation measures	In case goals are reached.
10) and 11) Design and execution of temporary safety measures	Temporary safety measures are needed to prevent unacceptable risks pending final remedial measures.	• Design and execution measures	• SPR-combinations causing too much risk to human health or the environment that	• Report with results	Checklist temporary safety measures	In case final remedial measures are taken
12) Cost recovery						
12) Cost recovery	What costs are made? Where to recover from?	• Preparation of cost overview of site assessment and site remediation and post remediation works				
13) Priority list deletion						
13) Priority list deletion	Can site be considered no longer contaminated or probably contaminated?	• Assess and record site use restrictions.				

Step	Scope / questions to be answered	Activity	Input	Output	Possible tools	Exit or deviation of process
14) Site reuse						
14) Site reuse	What forms of site reuse are possible and permitted? What site restrictions or safety measures apply?					

Annexure 3a – Approaches for remediation (Source: Task-3 report)

Contaminated sites are defined by situations which pose existing or imminent threats to human health and/or the environment.
The key issue is to what level the threats by contaminated sites should be reduced. In this regard, there are three approaches to consider.

Approach 1, Generic total threat reduction in soil, sediment or groundwater
Implementation of the approach of generic total threat reduction is aimed at reducing the identified threats to zero level, rendering the site fit for any use ('multifunctional'). Internationally, 'zero' is most commonly translated into 'as low as technically achievable'. To achieve this the source of the contamination needs to be removed or treated completely, as contaminant concentration levels need to be reduced to background levels.

Approach 2a, Generic fitness for use threat reduction in soil or sediments
Implementation of the approach of generic fitness for use threat reduction in soil or sediment is aimed at reducing threats to a generic acceptable level given the site's present and/or future use. To achieve this:

- The constituents in the source of the contamination need to be removed or treated to a generic level set for the present and/or intended future land use, or
- The pathway from contamination to receptor needs to be cut off, or
- The receptor needs to be protected or removed.

Approach 2b, Cost effective groundwater approach
Implementation of the cost effective groundwater approach is aimed at reducing threats to an acceptable level, while the remediation action is still cost effective. To achieve this contaminants are removed from the pathway to a degree where the costs of the removal is in balance with the amount of contaminants (mass) removed from the pathway. Contaminants in the source of the contamination are removed or treated to such a degree that this action benefits the actions in the pathway. Whenever the receptor is threatened it needs to be protected.

Approach 3a, Site specific fitness for use threat reduction in soil or sediments
Implementation of this approach is aimed at reducing threats to a site-specific acceptable level given the site's present and/or future use. To achieve this:

- The contamination needs to be removed to a predetermined site-specific level at which the contamination is considered to present no threat. This remediation level is based on site-specific risk assessment and is typically less strict than the generic (robust for all uses) level, or
- The pathway of the contamination to the receptor needs to be cut off exactly according to a specific use and spatial planning of the site, or
- The receptor needs to be protected or removed.

The required remediation efforts are most comprehensive in approach 1), less in approach 2a),most limited in approach 3a) and cost balanced in approach 2b). Conversely, the flexibility of the present and future land use and absence of restrictions and required efforts for monitoring and control increase from approach 3) to approach 1). Figure A3a.1 below illustrates this for soil and sediments and figure A3a.2 for groundwater.

Figure A3a.1 Remediation effort and consequences for the different approaches to remediation of soil or sediment

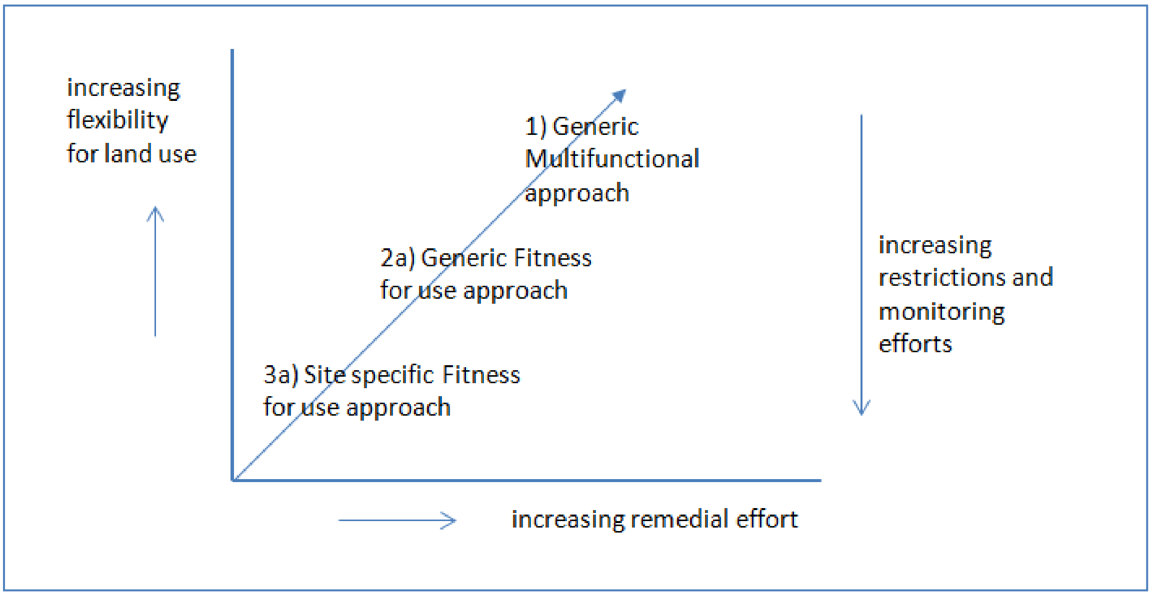
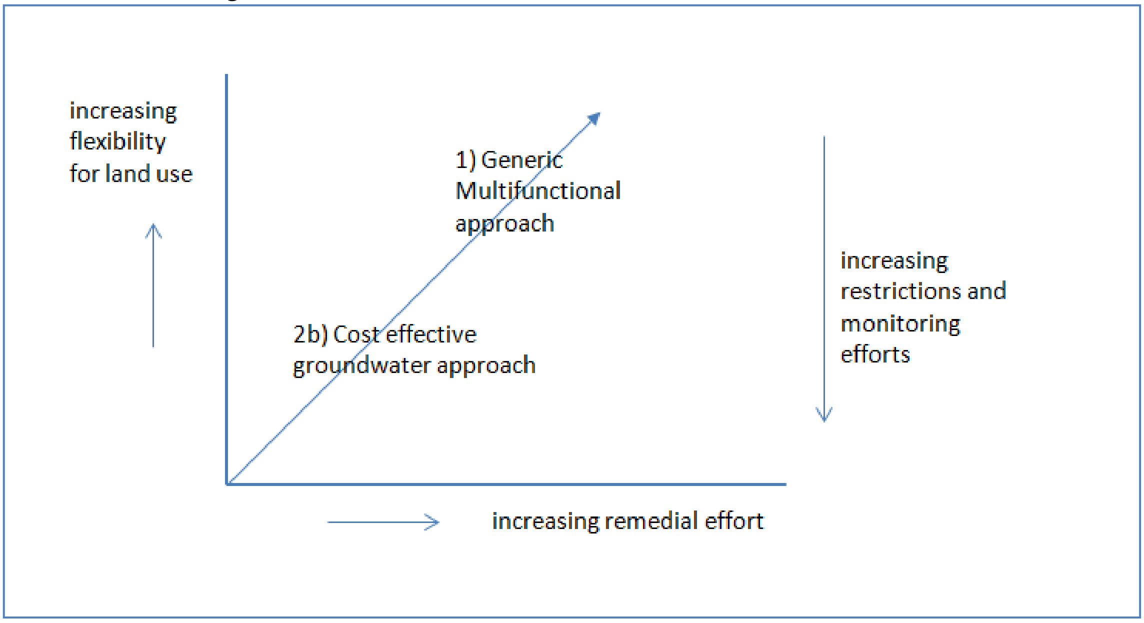


Figure A3a.2 Remediation effort and consequences for the different approaches to groundwater remediation



Annexure 3b – Remediation techniques (Source: Task-3 report)

Remediation techniques can be grouped into four remediation principles:

- Extraction: extraction of the soil material, sediment or groundwater in which the contaminant is located;
- Transformation: destruction or alteration of the contaminant into harmless or less risky products;
- Immobilization: stopping of the migration of the contaminant in its pathway;
- Containment: capturing the contaminant within non penetrable physical limits.

Apart from these four remediation principles, it is also possible to implement temporary safety measures. Table A3b.1 below presents an overview of best practices remediation techniques aimed at the source or the pathway, grouped according to the applicable remediation principle. These remediation techniques have provided good results internationally and seem to be applicable in India as well. For each of the techniques, table A3b.2 provides information on the applicability in the remediation of specific substances.

Table A3b.1 Overview of remediation techniques and their applicability

✓ Remediation option is potentially applicable to a specific media-contaminant combination
✗ Remediation option is not applicable to a specific media-contaminant combination
? A pre-treatment step or pilot may be necessary prior to the method being suitable or case study information is inconclusive regarding applicability
S Soils, made ground en sediments
W Groundwater and surface water

Principle	Technique	Section	Point of entry (SPR)				Applicability substances									
			Source	Pathway	Receptor	Applicable media	VOC's	Halogenated Hydrocarbons	Non-halogenated Hydrocarbons	PAHs	PCBs	Dioxins and furans	Pesticides and herbicides	Heavy metals	Asbestos	Cyanides
Extraction	Excavation, followed by:	4.1	X	X	X	S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	- Biological treatment / biopile	4.1.1	X	X	X	S	✓	✗	✓	✓	✗	✗	✓	✗	✗	✗
	- Soil washing	4.1.2	X	X	X	S	✗	✓	✓	✓	✓	✗	✓	✓	✗	✓
	- Thermal treatment	4.1.3	X	X	X	S	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓
	- Physical separation	4.1.4	X	X	X	S	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗
	- Disposal in landfill	4.1.5	X	X	X	S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Groundwater abstraction (pump & treat)	4.2	X	X		W	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗
	SVE – Soil vapor extraction	4.3	X	X	X	S	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗
	MPE – Multi phase extraction	4.4	X	(X)	X	S,W	✓	✓	✓	?	✗	✗	✗	✗	✗	✗
Transformation	Air-sparging	4.5	X	X		W	✓	✓	✓	?	✗	✗	✗	✗	✗	✗
	Soil Heating	4.6	X			W	✓	✓	✓	✓	?	✗	✗	✗	✗	?
	Elektrokinetics	4.7	X	(X)		S, W	✓	✓	✓	✓	?	?	?	✓	✗	✓
	In-situ chemical oxidation (ISCO)	4.8	X	(X)		S, W	✓	✓	✓	✓	✗	✗	✓	✗	✗	?
	Permeable reactive barriers (PRB)	4.9		X		W	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓
	In-situ bioremediation	4.10	X	X		S, W	✓	✓	✓	✓	✗	✗	✓	✗	✗	✗
	Phyto remediation	4.11	X	X		S, W	✓	✓	✓	✓	✗	✗	✓	✓	✗	?
	Natural attenuation	4.12	X	X		W	✓	✓	✓	✓	✗	✗	✓	✗	✗	✗
Immobilization	Vitrification	4.13	X			S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	In-situ grouting	4.14	X	X		S	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Containment	Vertical wall	4.15		X		S, W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Capping layer	4.16		X		S, W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Geohydrological control	4.17		X		W	✓	✓	✓	✓	✓	✓	?	✓	✓	?
Temporary safety measures	Land use restrictions	4.18			X	S, W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Relocation and safety measures	4.19			X	S, W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Drinking water treatment	4.20			X	W	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

A detailed description of the techniques, including references to examples, is provided in the Guidance document (Task-4 report).

Table A3b.2 on the next pages presents a comprehensive description of characteristics of the most important remediation technique groups. For each group of remediation techniques the table summarizes the generic characteristics and the site specific characteristics, as well as a brief analysis of strengths, weaknesses, opportunities and threats. In addition, the table presents practical experience on both the applicability as well as the limitations of the remediation techniques under certain conditions.

Below the characteristics presented in table A3b.2 are explained.

Generic characteristics
- Risk reduction potential: degree to which health and environmental risks are reduced beyond the target level of remediation, offering an extra surplus of risk reduction or protection. Applicable to both immobile and mobile contaminants.
- Technical success potential: technical complexity, implementability, robustness (intrinsic capacity of the technical measures to accommodate changes in circumstances or performance), and the availability of technical capacity.
- Cost and benefits. Included are:
  - Costs for activities like post remediation actions and measures needed due to failure of originally planned measures;
  - Benefits due increased value of the site and to combined implementation with site redevelopment.
- Sustainability: influence of the remediation on other environmental aspects, e.g. air quality, space, ecology, waste, energy.

Site specific characteristics
- Time: time needed to implement the remediation objective. Note: the time needed to implement post remediation actions is considered as a cost and/or social aspect.
- Post remediation site use: degree to which the site can be used for present, planned or not yet known site uses regarding its technical characteristics.
- Social criteria: social acceptance and impacts:
  - Physical Impacts to neighbourhood such as noise, dust, odour, traffic;
  - Changes in the way the local communities function;
  - Changes that could affect the site usage by communities.

Table A3b.2 Remediation option principles and their characteristics

Remediation option principle: Extraction: extraction of the ground or the groundwater which the contaminant is located in.
Localisation: On site, soil treatment off-site
Remediation technique type: Physical, generic approach

Generic characteristics				**Site specific characteristics**			**Strengths and opportunities**	**Weaknesses and threats**
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
In general a high degree of removal of the contaminant is possible. For shallow contamination, removal of all contaminant is possible	The Conceptual Site Model and the delineation of the contamination must be well defined. Technical risks mainly related to the presence of buildings, foundations or other objects in the ground, that can obstruct the extraction. Technical risks increase with increasing depth of excavation, especially below groundwater level or near / under constructions Increased tech-	Directly linked to: - The volume of soil to be excavated and treated - The treatment method and transportation of the excavated soil - The volume, transportation and quality of material needed to backfill Also linked to: - The excavation depth - Groundwater drainage during excavation - The groundwater extraction depth - The flow of	- High energy consumption by diggers, trucks, pumps, treatment plants. - Transfer of contamination to other compartments than soil/groundwater depending on soil/groundwater treatment - Waste - Long term space consumption (sanitary landfill) - Air contamination: volatile contaminants	Short duration of the operation (excavation) Long duration of the operation (pump & treat)	Limited to no use of site during excavation. Site can be restored for sensitive site use or even full multifunctional use.	May cause: -Noise, -Smell, -Traffic, -Dust, -Damage to adjacent buildings. Temporarily loss of function of the site Temporarily moving out of populations.	Strengths: - robust remediation - possible multifunctional restoration - possible short duration Opportunities: - Relatively small and shallow contaminations - Dynamic sites which require fast results - (partial) source removal, e.g. to prevent contact or spreading risks	Weaknesses: - loss of function of site during excavation - high energy consumption, transfer of contaminant to other compartments than soil/groundwater, waste - costs strongly related to volume of soil to be excavated, transported and treated Threats: - Causing of nuisance, particularly in urban areas - Lack of space, particularly in urban areas

	nical risk if remediation results for groundwater are to be attained mainly by pump & treat.	extracted groundwater - The treatment method of the extracted groundwater	can be released in the air during excavation.					

Remediation option principle: Extraction: extraction of the ground or the groundwater which the contaminant is located in. **Localisation:** On site, soil treatment on-site **Remediation technique type:** Physical, specific approach								
Generic characteristics				**Site specific characteristics**			**Strengths and opportunities**	**Weaknesses and threats**
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
In general a high degree of removal of the contaminant (source) is possible. For shallow contamination, removal of all source material is possible.	The Conceptual Site Model and the delineation of the contamination must be well defined. Technical risks mainly related to the presence of buildings, foundations or other objects in the ground, that can obstruct the extraction. Technical risks increase with increasing depth	Directly linked to: - The volume of soil to be excavated and treated - The treatment method of the excavated soil - The possibility to backfill with the treated soil Also linked to: - The excavation depth - Groundwater drainage dur-	- Energy consumption by diggers, trucks, pumps, treatment plants. - Transfer of contamination to other compartments than soil/groundwater depending on soil/groundwater treatment - Waste - Space con-	Short duration of the operation (excavation) Longer duration of the operation depending on type of soil treatment process Long duration of the operation (pump & treat) if rebound processes should be dealt with	Limited to no use of site during excavation. Space required over longer time for on-site soil treatment Site can be restored for sensitive site use or even full multi-functional use.	May cause: -Noise, -Smell, -Traffic, -Dust, -Damage to adjacent buildings. Temporarily loss of function of the site Temporarily moving out of populations.	Strengths: - robust remediation - possible multi-functional restoration - efficiency on a larger scale Opportunities: - Large contaminations that allow for backfilling with the on-site treated soil - low control on process in case of highly changing weather conditions (monsoon)	Weaknesses: - not cost effective for relatively small contaminations - loss of function of site during excavation - high energy consumption, transfer of contaminant to other compartments, waste - costs strongly related to volume of soil to be excavated and treated Threats: - Causing of nuisance, particularly

	of excavation, especially below groundwater level Increased technical risk if remediation results for groundwater are to be attained mainly by pump & treat.	ing excavation - The groundwater extraction depth - The flow of extracted groundwater - The treatment method of the extracted groundwater	suming, additional space for the on-site soil treatment - Air contamination: volatile contaminants can be released in the air during excavation and soil treatment.				or extreme winter/summer conditions	in urban areas - Lack of space, particularly in urban areas - Depending on length of the process long term supervision and fine tuning is needed

Remediation option principle: Transformation: Destruction or alteration of the contaminant into harmless or less risky products **Localisation:** In-situ **Remediation technique type:** Chemical, specific approach								
Generic characteristics				**Site specific characteristics**			**Strengths and opportunities**	**Weaknesses and threats**
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
Possibility to reduce risks of mobile organic contaminants in source or pathway beyond target level. Multi functional remediation not typical	Chemical agent has to be able to react with the contamination. Chemical reactions are usually non-specific (oxidation): any organic substance in soil (including valuable / natural organic matter)	Related to: -Technical risks -Volume of soil to be treated - Depth of soil to be treated - Accessibility of the site - Chemical	-Relatively little waste generated -Some systems space consuming or energy consuming -Ecosystem of the soil can be affected or	Remediation objectives can be achieved relatively fast compared to other in-situ approaches	More intensive techniques prohibit or limit use of site during treatment. After treatment, typically a large load of contaminants has been removed and risks have been reduced.	Use of reactive chemical agents is a potential hazard to the neighbourhood During treatment phase (part of) site inaccessible due to chemical process equipment Underground pip-	Strengths: - treatment of source zones/pure product of mobile organic contaminants below groundwater - high load removal without excavation Opportunities: Alternative for high load removal	Weaknesses: - while relatively fast, still takes time - not suitable for low permeable soil - multi phases of field activities may be necessary depending on progress of alteration - technical detail engineering is

	can be de-stroyed and will increase amount of agents needed. Approach has to be expertly di-mensioned and executed (dos-age, injection area) to prevent insufficient con-taminant break-down. In case of build-ing/foundations, technical risk increases Type of soil is key in technical risks. Chemical oxidation of or-ganic contami-nants in peat is inefficient.	agent con-sumption by soil matrix and contaminant - Safety measures	destroyed			ing can be re-quired, limiting site use (digging) Low impact on residential area	when excavation of contaminants is not possible	complex in case of high dynamic aquifers (mon-soon depending) Threats - relatively costly - requires hazard-ous chemicals - safety measures for the technicians and the neighbourhood must be planned when chemicals are used.

Remediation option principle: Transformation: Destruction or alteration of the contaminant into harmless or less risky products Localisation: In-situ Remediation technique type: Biological, specific approach								
Generic characteristics				Site specific characteristics			Strengths and opportunities	Weaknesses and threats
Risk reduction potential	Technical success potential	Cost and benefits	Sustainability	Time	Post remediation site use	Social criteria		
Possibility to reduce risks of mobile organic contaminants beyond target level assessing the pathway Multi functional remediation not typical	Contaminants that are not biologically available will not be affected. Contaminants should be biochemical degradable.. The general soil biology (aerobic , anaerobic, nutrients) has to be (made) suitable for the desired biochemical reaction(s). In case of presence of pure product, technical risk increases. Type of soil determines technical risks as the nutrients may	Related to: - Type of deployment: passive / shockload / continuous - Volume of soil to be treated - Depth of soil to be treated - Accessibility of the site - Amount and type of nutrient(s) needed	- Green remediation: use of the soil's natural ability to remediate itself - Relatively little waste generated -Relatively low energy consumption	Relatively slow and time-consuming	After treatment, typically the mobile (biologically available) part of the contaminant load has been removed and risks have been reduced. However a degree of residual groundwater contamination will usually remain, just not spread anymore.	Very limited area occupation above ground Underground piping can be required, limiting site use (digging) Low impact on residential areas	Strengths: - green remediation - treatment of groundwater plumes of mobile organic contaminants. - relatively cheap - low impact on site activities - high temperature environments may speed up the process of degradation of contaminants Opportunities: Groundwater plumes that have the potential to spread, but have not yet reached the receptor	Weaknesses: - time consuming to reach remediation objectives - only applicable below groundwater level - typically not suitable for low permeable soil - typically not suitable for pure product - multi phases of field activities may be necessary depending on progress of alteration - technical detail engineering is complex in case of high dynamic aquifers (monsoon depending) Threats: - residual contamination after treatment - intermediate

	affect the soil or are used to degrade organic compounds of the soil itself.							breakdown products can be more mobile and/or toxic than original contaminant - limited suitability as standalone approach

Remediation option principle: Immobilization: Stopping the spreading of the contaminant in its pathway (ground and/or groundwater) **Localisation:** In-situ **Remediation technique type:** Physical, specific approach								
Generic characteristics				**Site specific characteristics**			**Strengths and opportunities**	**Weaknesses and threats**
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
Reduction of risk of spreading of contaminants towards a receptor. Typically not focused on load removal. Only relevant for mobile contaminations	The CSM - in particular the mechanisms of spreading - and the delineation of the contamination must be well defined. Technical risks highly related to uncertainties in physical parameters like the permeability of the soil or the groundwater flow.	Related to: -Technical risks -The duration of the measures and monitoring (can be a very long) -The chemical and physical properties of the contamination and the point of operation are de-	- Little waste and energy consumption compared to a full scale approach	Spreading can be quickly stopped (pathway As the source remains present in the soil, regular monitoring and other constraints are required. Those extra operations have to be maintained over longer time and	Functional use of soil is limited. Therefore not obvious for dynamics sites Restrictions for underground use must be included in the future project of the site.	Can affect the surrounding populations due to maintenance and regular extra operations. Perception towards remediation that leaves the contamination untouched	Strengths: - quick solution to an immediate risk - cost effective compared to full scale remediation Opportunities: - temporary risk removal while awaiting a future further remediation	Weaknesses: - contamination remains - measures and monitoring can become indefinite in time - difficult to design for monsoon depending high groundwater table fluctuations Threats: - limited use of underground - perception issues by resi-

	Also related to the presence of buildings, foundations or other objects in the ground. Technical risks can increase with depth.	terminant for the design.		can have an indefinite character.				dents/users - Depending on length of the process long term supervision and fine tuning is needed - illegal groundwater pumping activities

Remediation option principle: Containment: capturing the contaminant within non penetrable physical limits
Localisation: In-situ
Remediation technique type: Physical

Generic characteristics				Site specific characteristics			Strengths and opportunities	Weaknesses and threats
Risk reduction potential	**Technical success potential**	**Cost and benefits**	**Sustainability**	**Time**	**Post remediation site use**	**Social criteria**		
Reduction of risk of spreading (leaching from source) of contaminants towards a receptor. Reduction of risk of contact with contaminants by receptor No contaminant removal.	Surface capping: technical risks related to surface area. Vertical shielding: technical risks related to soil layering and required depth Subsurface horizontal shielding: technical risks related to accessi-	Surface capping: costs are linked to the surface area and the type of capping material. Vertical shielding: costs are related to shield dimensions (length x depth) and type of material.	Little waste. Depending on method some to substantial energy consumption. Surface capping is space consuming and can change the landscape. Hard surface	The containment operation is quick. As the contamination itself remains present in the soil, regular monitoring and other constraints are required. Those extra operations have to be maintained	Use of the underground is limited. Therefore not obvious for dynamics sites Restrictions for underground use must be included in the future project of the site. Future use may not breach the containment,	Limited to no use of site during capping Can affect the surrounding populations due to maintenance and regular extra operations. Perception towards remediation that leaves the contamination untouched.	Strengths: - quick solution to an immediate risk - cost effective compared to full scale remediation Weaknesses: - contamination remains - measures and monitoring can become indefinite in time Opportunities:	

	bility, soil layer-ing, required depth and re-quired longevity of the shielding Surface capping is technical complex in a highly parcelled area. Robust design prevents post remediation repairs and maintenance.	Subsurface horizontal shielding: costs are re-lated to shield depth and surface area and method of placement.	capping ne-gates most previous eco-logical value of the soil. Surface cap-ping with suit-able soil re-quires a suffi-ciently thick layer which has to be transported to the site.	over longer time and can have an indefinite char-acter.	unless appropriate countermeasures are taken.	Subject to illegal use of commodi-ties in and below capping layer ('Rag pickers problem')	- temporary risk removal while awaiting a future further remedia-tion Threats: - limits use of un-derground - perception is-sues by resi-dents/users - subsurface shielding is diffi-cult to control and maintain - When chancing site use a com-plete new reme-diation might need to be carried out (all earlier efforts are 'lost')	

Annexure 3c – Menu of generic remediation options (Source: Task-3 report)

This Annexure presents a blueprint or Menu of options for remediation of the types and subtypes of contaminated sites most common in India, as per the current version of the database of contaminated sites.

Table A3c.1 presents a summary of the most common situations in India, as identified in the available database, and links each of these situations to a remediation option eligible for application in that particular situation. The user can then refer to the relevant remediation option in figure A3c.1 for more detailed information. For each type of contaminated site figure A3c.1 provides insight in the most likely ('prioritized') remediation objectives and most likely technical and non-technical choices for remediation measures, as well as specific conditions or alternative approaches in a variety of settings and their applicability to the different types and subtypes of contaminated sites. It should be noted that specific site conditions can lead to the selection of another remediation option than the one indicated in table A3c.1.

Cluster types of contaminated sources and plumes had not been included in the Typology. This was because from a technical point of view these types of sites are similar to the same type of contamination on an isolated site (non-clustered type). However, when looking at best practices, as is done in this report, these clustered sites are of interest, as the technical assessment of sites in these categories can be done on a larger aerial scale, offering an advantage in efficiency when applying remediation options. Therefore, in addition to the regular types and subtypes remediation options for so called 'cluster types' are described as separate options (options 12 and 13) in the Menu of remediation options.

The structure of the Menu of remediation options provides the opportunity to include more types and subtypes in the Menu whenever more information becomes available.

Table A3c.1 Most likely remediation options and their applicability to types of sites

Type of contaminated site	**Land use or setting**	**Nature of contaminants**	**Example situation**	**Example of option that could be applied (see figure A3c.1)**
S1 + P2: Land bound solid phase contamination including groundwater contamination	Urban area	heavy metals	Urban area built on a former dumpsite or on a local depression, filled in with contaminated material and with contaminants leaching into groundwater	Option 1
Type S1-d + P2: Land bound solid phase contamination including groundwater contamination	Agricultural or other rural area	heavy metals, pesticides. Solid phase contaminants are found up to a depth to which the soil is treated by ploughs and other agricultural tools	Pesticides used on agricultural lands leaching into groundwater	Option 2

Type of contaminated site	Land use or setting	Nature of contaminants	Example situation	Example of option that could be applied (see figure A3c.1)
S1 + P2: Land bound solid phase contamination including groundwater contamination	Industrial area	heavy metals	Ore sludge stored on industrial site, leaching into groundwater	Option 3
S2: Solid phase contamination (water bound site) (open water sediments)	Urban, nature or industrial area	heavy metals (effluent related)	Effluent discharging into open water system	Option 4
S1-d-e-f : Land bound solid phase contamination	Agricultural area, open water shores	heavy metals, pesticides found over relatively large areas due to large scale agricultural activities, atmospheric deposition or flooding	River basin flooding area or agricultural areas with excessive pesticide usage	Option 5
S1 : Land bound solid phase contamination	Nature	heavy metals	Dumpsite in an otherwise natural setting	Option 6
S1: Land bound solid phase contamination	Urban area	heavy metals, PAH	Urban area built on a former dumpsite or on a local depression, filled in with contaminated material, but without contaminants leaching into groundwater	Option 7
S1 : Land bound solid phase contamination	Industrial area	heavy metals, PAH	Leakage of storage tanks on industrial site, spreading into groundwater aquifer	Option 8
L : Liquid phase contamination	All site uses	industrial effluents	Oil spill, oil tanker leakage, contamination of groundwater due to well injection	Option 9
P1-a: DNAPL contaminants in soil	Industrial area	Dense Non-Aqueous Phase Liquid (DNAPL) in permeable soil (bulk density > water)	Leakage of storage tanks on industrial site, spreading into the groundwater aquifer	Option 10
P1-b: LNAPL contaminants in soil	Industrial area	Light Non-Aqueous Phase Liquid (LNAPL) in per-meable soil (bulk density < water)	Leakage of storage tanks on industrial site, spreading at the water table or toplayer of groundwater aquifer	Option 11
S1-a/b: Cluster of land bound solid phase contamination	Multiple sites and site usages	heavy metals, PAH, pesticides in well defined (non) soil mixed bodies	Filling of settling soft river delta sediments with contaminated material in a large scale expanding urban area	Option 12

Type of contaminated site	Land use or setting	Nature of contaminants	Example situation	Example of option that could be applied (see figure A3c.1)
L1: Cluster of liquid phase contamination	multiple sites and site usages, urban area	mobile organic compounds	City centre or old industrial area with a large and concentrated number of small industrial sites leaching contaminants into the groundwater	Option 13

In figure A3c.1 below each of the thirteen remediation options mentioned in table A3c.1 is discussed in more detail. Each option is presented in the same format, one option to a page, each divided into four headings:

- Site and setting summary
  This heading presents a brief summary of the main site characteristics, i.e. type of contamination, setting and land use, most prolific risks and most common contaminants, always illustrated by a schematic cross-section.

- Most likely remediation objectives
  This heading presents recommendations for cleanup levels. Where applicable, examples are given of sensitive land use that may require additional evaluation as to whether remediation to the generic level for the corresponding land use will provide sufficient level of protection. In general, fitness for use levels based on the corresponding type of land use are recommended. Setting generic levels as remediation objective may not always result in an economically or technically feasible remediation. In such cases remediation to a concentration level meeting a site specific level based on site specific risk assessment can be considered.

- Most likely remediation measures
  This heading lists the most likely remediation measures according to the targeted point of operation (source, pathway or receptor). It must be stressed that this heading should not be used as the only reference in the design process of remediation option. We refer to Chapter 5 for more information.

- Specific conditions or alternative approaches
  This heading describes specific conditions that may prove pivotal for cost efficient remediation design. Also listed are some alternative remediation options that may come into perspective in case the costs of full scale remediation to generic levels are not in balance with the required level of risk reduction. In specific cases alternative remediation options can be acceptable and viable, e.g. in case the costs render a full scale remediation not feasible, or in case these options are used as a temporary safety measure, or in case the Indian soil remediation policy offers opportunities for a decreased (site-specific) level of risk reduction.

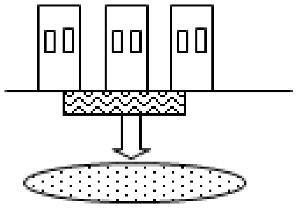
How to use the Menu of options is illustrated below by an example of how to read figure A3c.1, for which we use the factsheet for remediation option 1. Under the heading ‘Site and setting summary’ the situation for the type of contaminated site is described in general terms. Remediation option 1 is aimed at a site in an urban setting with both land bound solid phase contamination as well as and groundwater contamination. In the Typology, this site is classified as a site of both S1 and P2 type. The most likely remediation objectives are described, again in general terms, under their own heading, as are the corresponding measures which could be applied to the source, pathway and receptor. When designing remediation options either one or a combination of more of these most likely technical and non-technical choices for remediation measures can be used. Specific conditions or alternate approaches that may be applicable to the situation at hand are described under the fourth heading of the factsheet. These can be referred to to render a remediation option fit for a specific site.

Figure A3c.1 (next pages) - Menu of options: most likely remediation measures per type of contaminated site in India

Option 1: Remediation of land bound solid phase contamination including groundwater contamination in urban areas

Site and setting summary

Type S1 + P2: Land bound solid phase contamination including groundwater contamination
Landuse/setting: Urban area
Risks: Direct contact, exposure to polluted drinking water
Most common contaminant: heavy metals



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for residential areas
- Groundwater: fit for use based on generic levels for residential areas

Examples of sensitive uses that may require site-specific remediation goals:
- Use of soil as kitchen garden or playground
- Use of groundwater as drinking water

Most likely remediation measures

Source
- Excavation of soil to a concentration level meeting the remediation objective
- Cover with pavement or layer of clean soil
- Reduction of leaching by partial source excavation, sealing or drainage

Pathway (plume):
- Removal to a concentration level meeting the remediation objective by pump & treat
- Geohydraulical containment
- Natural or stimulated precipitation/sorption

Receptor:
- Treatment of well water to meet drinking water standards or alternative water source
- Imposed limits to site use (e.g. no unauthorized digging, no wells)

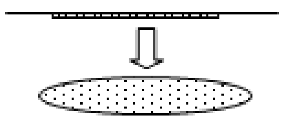
Specific conditions or alternative approaches

- Excavation is more efficient as part of a redevelopment project that involves excavating anyway
- Removal of contamination in pathway (plume) by pump & treat is more efficient if the leaching process has been reduced
- Soil surface elevation can be considered to avoid large volumes of excavated soil
- An alternative option to reduce contact risk and/or leaching may be chemical immobilisation or physical immobilisation (grouting)
- In-situ strategies towards hexavalent chromium are mostly based on reduction to the less toxic and less mobile trivalent chromium by chemical or microbiological means. These techniques are mostly in a laboratory or pilot phase of development

Option 2: Remediation of land bound solid phase contamination including groundwater contamination in agricultural and other rural areas

Site and setting summary

Type S1-d + P2: Land bound solid phase contamination including groundwater contamination
Landuse/setting: Agricultural / rural area
Risks: Direct human contact, exposure to polluted drinking water, ingestion of contaminated crops
Most common contaminants: heavy metals, pesticides



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:

- Top soil: fit for use based on generic levels for agricultural or other rural areas
- Groundwater: fit for use based on generic levels for agricultural or other rural areas

Examples of sensitive uses that may require site-specific remediation goals:

- Specific toxicity of copper to sheep
- Specific uptake of contaminants by crops
- Use of groundwater for irrigation purposes

Most likely remediation measures

Source

- Phytoremediation
- Excavation of soil to a concentration level meeting the remediation objective, on-site treatment (landfarming) and optional backfilling with soil of suitable quality

Pathway (plume):

- Removal to a concentration level meeting the remediation objective by pump & treat
- Geohydraulical containment

Receptor:

- Treatment of well water to meet drinking water standards or alternative water source
- Alternative crops with less uptake of contaminants in edible parts
- Imposed limits to site use (e.g. no unauthorized digging, no wells)

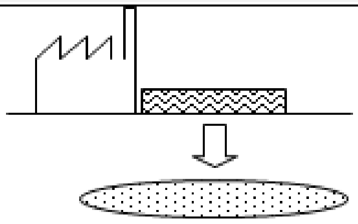
Specific conditions or alternative approaches

- Profile reversion can be considered as alternative approach
- Aggressive treatments like chemical treatments deteriorate the biology of the ground
- The cultivation method and climatic circumstances should also be taken into consideration when evaluating potential risk, cleanup levels and remediation, e.g.:
  - Erosion by wind and/or precipitation
  - Intensified contact with soil due to cultivation by manpower
  - Increased biodegradation rate due to tropical conditions
  - Promotion of anaerobic processes due to submerged cultivation methods
  - Cyclical changes in soil physical, macrochemical and biological properties due to slash and burn agricultural methods

Option 3: Remediation of land bound solid phase contamination including groundwater contamination in industrial areas

Site and setting summary

Type S1 + P2: Land bound solid phase contamination including groundwater contamination
Landuse/setting: Industrial area
Risks: Direct human contact, exposure to polluted drinking water
Most common contaminant: heavy metals



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for industrial areas
- Groundwater: fit for use based on generic levels for industrial areas

Examples of sensitive uses that may require site-specific remediation goals:
- Use of groundwater as drinking water
- Use of groundwater as process water

Most likely remediation measures

Source
- Excavation of soil to a concentration level meeting the remediation objective
- Capping with pavement
- Combined with redevelopment: isolation under new buildings or constructions

Pathway (plume):
- Removal to a concentration level meeting the remediation objective by pump & treat
- Geohydraulical containment
- Natural or stimulated recipitation/sorption

Receptor:
- Treatment of well water to meet drinking water standards or alternative water source
- Imposed limits to site use (e.g. no digging, no wells)

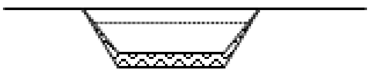
Specific conditions or alternative approaches

- Removal of contamination in pathway (plume) by pump & treat is more efficient if the leaching process has been reduced
- Removal of contamination in pathway (plume) by pump & treat is more efficient if the treated water can be used as process water by the industry or when performed in combination with storage of thermal energy in soil
- Chemical or biological barriers can be considered on sites neighbouring more sensitive (e.g. urban) areas as alternative to full plume treatment
- Treatment of the actual cause of the pollution (industrial activity), if still present, should be performed before starting remedial action

Option 4: Remediation of solid phase contamination in a water bound site (contaminated open water sediments)

Site and setting summary

Type S2: Solid phase contamination (water bound site) (open water sediments)
Landuse/setting: Urban, nature or industrial area
Risks: Direct human contact, ecological risks
Most common contaminant: heavy metals (effluent related)



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
• Sediment: fit for use based on generic level corresponding with type of site use

Examples of sensitive uses that may require site-specific remediation goals:
• Use of open water for swimming or bathing
• Use of surface water for consumption or agricultural purposes

Most likely remediation measures

Source
• Dredging
• Excavation (in times of drought)
• Capping layer with clean sediment

Pathway (plume): n.a.

Receptor:
• Government imposed limits to site use (e.g. fencing, no bathing or swimming)

Specific conditions or alternative approaches

• Capping is only technically feasible for relatively static water systems (lake, pond)
• Dredging or excavation typically involves large volumes for which adequate (temporary) storage has to be provided, also depending on method of treatment (on-site treatment/off-site treatment/sanitary landfill)

Option 5: Remediation of land bound solid phase contamination in agricultural areas or open water shores

Site and setting summary

Type S1-d-e-f: Land bound solid phase contamination
Landuse/setting: Agricultural area, open water shores
Risks: Direct human contact, ingestion of crops, risk of spreading
Most common contaminant: heavy metals, pesticides

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
• Top soil: fit for use based on generic levels for agricultural areas

Examples of sensitive uses that may require site-specific remediation goals:
• Specific toxicity of copper to sheep
• Specific uptake of contaminants by crops

Most likely remediation measures

Source
• Phytoremediation
• Excavation and reuse in levees (open water shore settings) or big bags (fitted into the landscape)

Pathway (plume): n.a.

Receptor:
• Alternative crops with less uptake of contaminants in edible parts

Specific conditions or alternative approaches

• Profile reversion can be considered as alternative approach
• Aggressive treatments like chemical treatments deteriorate the biology of the ground
• Specific excavation of hotspots can be considered as alternative approach, but requires detailed site assessment
• The cultivation method and climatic circumstances should also be taken into consideration when evaluating possible risk, cleanup levels and remediation, e.g.:
  • Erosion by wind and/or precipitation
  • Intensified contact with soil due to cultivation by manpower
  • Increased biodegradation rate due to tropical conditions
  • Promotion of anaerobic processes due to submerged cultivation methods
  • Cyclical changes in soil physical, macrochemical and biological properties due to slash and burn agricultural methods

Option 6: Remediation of land bound solid phase contamination in nature areas

Site and setting summary

Type S1: Land bound solid phase contamination
Landuse/setting: Nature
Risks: Ecological risks, direct human contact
Most common contaminant: heavy metals

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
• Top soil: fit for use based on generic levels for nature areas

Examples of sensitive uses that may require site-specific remediation goals:
• Intensive recreational use

Most likely remediation measures

Source
• Capping to reduce exposure by direct contact and vegetation consumption
• Phytoremediation to reduce concentration levels
• Excavation of hotspots

Pathway (plume): n.a.

Receptor:
• Goverment imposed limits to site use (e.g. fencing, no unauthorized access)

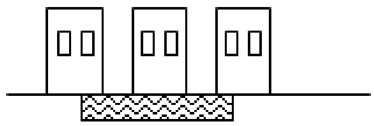
Specific conditions or alternative approaches

• Specific excavation of hotspots requires detailed site assessment
• To reduce the quantity of soil in excavation of hotspots, site-specific remediation levels higher than the generic levels for nature areas can be developed to obtain acceptable risk levels for a particular site under particular circumstances
• Capping can be combined with nature development (landscaping) to both increase environmental quality and biodiversity

Option 7: Remediation of land bound solid phase contamination in urban areas

Site and setting summary

Type S1: Land bound solid phase contamination
Landuse/setting: Urban area
Risks: Direct contact
Most common contaminant: heavy metals, PAH



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for residential areas

Examples of sensitive uses that may require site-specific remediation goals:
- Use of soil as kitchen garden
- Use of soil as playground, potential exposure of children to lead

Most likely remediation measures

Source
- Excavation of soil to a concentration level meeting the remediation objective
- Covering by pavement or layer of clean soil

Pathway (plume): n.a.

Receptor:
- Imposed limits to site use (e.g. no unauthorized digging)

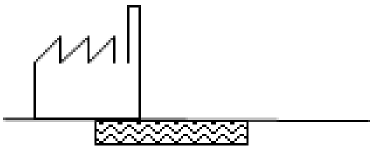
Specific conditions or alternative approaches

- Excavation is more efficient as part of a redevelopment project that involves excavating anyway
- While redeveloping, soil surface elevation can be considered to avoid large volumes of excavated soil
- An alternative option to reduce contact risk may be chemical immobilisation or physical immobilisation (grouting)
- In-situ strategies towards hexavalent chromium are mostly based on reduction to the less toxic and less mobile trivalent chromium by chemical or microbiological means. These techniques are mostly in a laboratory or pilot phase of development

Option 8: Remediation of land bound solid phase contamination in industrial areas

Site and setting summary

Type S1: Land bound solid phase contamination
Landuse/setting: Industrial area
Risks: Direct human contact
Most common contaminant: heavy metals, PAH



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels for industrial areas

Examples of sensitive uses that may require site-specific remediation goals:
- Unpaved sites sensitive to spreading by dust

Most likely remediation measures

Source
- Excavation of soil to a concentration level meeting the remediation objective
- Capping with pavement
- Combined with redevelopment: isolation under new building

Pathway (plume): n.a.

Receptor:
- Imposed limits to site use (e.g. no unauthorized digging)

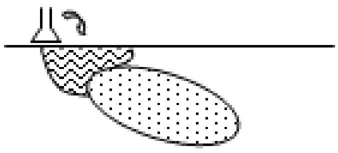
Specific conditions or alternative approaches

- Specific excavation of hotspots can be considered as alternative approach, but requires detailed site assessment
- An alternative option to reduce contact risk may be chemical immobilisation or physical immobilisation (grouting)
- In-situ strategies towards hexavalent chromium are mostly based on reduction to the less toxic and less mobile trivalent chromium by chemical or microbiological means. These techniques are mostly in a laboratory or pilot phase of development
- Treatment of the actual cause of the pollution (industrial activity), if still present, should be performed before starting remedial action

Option 9: Remediation of liquid phase contamination

Site and setting summary

Type L: Liquid phase contamination
Landuse/setting: all site uses
Risks: Direct human contact
Most common contaminant: industrial effluents



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: fit for use based on generic levels corresponding with site use
- Subsoil and groundwater: steady end state and removal of risks

Examples of sensitive uses that may require site-specific remediation goals:
- Habitation (soil vapour intrusion)

Most likely remediation measures

Source
- Excavation (above groundwater)
- Soil vapour extraction

Pathway (plume):
- Pump & Treat (combined with excavation)
- Multi Phase Extraction (combined with excavation)
- Bioremediation (combined with excavation)
- ISCO (combined with excavation)

Receptor:
- Forced ventilation of basement/crawl space, sealing of floors (soil vapour intrusion)
- Imposed limits to site use (e.g. no unauthorized digging)

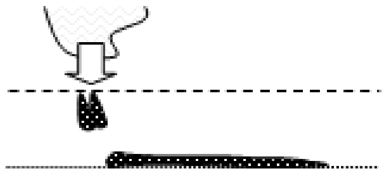
Specific conditions or alternative approaches

- Remediation of source and plume are often combined to obtain the most (cost) efficient remediation
- Several combinations of techniques for source and path remediation are possible, depending on site circumstances and project boundary conditions (timeframe, setting)
- Steady state is a situation, not a concentration level, therefore target concentration levels are not applicable. Proof of steady state is gathered by periodic sampling, condition for steady state is sufficient source load removal (e.g. 80% load removal)
- Typically, steady state does not require complete removal, but only removal of the mobile fraction of the contamination
- Inner air sampling is required to determine actual soil vapour risks, models will overestimate

Option 10: Dense Non-Aqueous Phase Liquid (DNAPL)

Site and setting summary

Type P1-a: Dense Non-Aqueous Phase Liquid in permeable soil (often found in combination with a P2 type)
Setting: Industrial site
Risks: inhalation (if no ground water present), spreading to groundwater
Most common contaminant: VOC, tar/heavy oil related contaminants, PCB



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:

- inhalation risk reduction (soil vapour)
- spreading risk reduction by:
    - mass removal as far as needed to reach a steady state plume
    - mass control (containment)

Most likely remediation measures

Exposure risk removal

- Soil vapour extraction and air sparging
- Vapour proof sealing in building floor

Spreading risk removal by mass removal

- Excavation
- Multi phase extraction
- Shock load bioremediation

Spreading risk reduction by mass control

- Physical/Hydraulic barriers
- Permeable reactive barriers

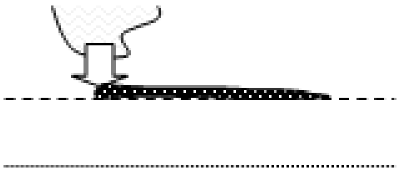
Specific conditions or alternative approaches

- DNAPL characterisation difficult due to irregular spreading pathways and specialistical soil investigation techniques.
- Risk of unintentional DNAPL vertical transport by faulty monitoring wells or drillings.
- Specialized (and thus expensive) in-situ techniques may be worth considering if a high degree of source removal in needed a very short time frame. Example techniques are: chemical oxidation, surfactant-enhanced subsurface remediation, cosolvent flushing, steam/hot air injection and three/six-phase electrical resistance heating.
- Pump and treat is generally not recommended for DNAPL removal due to long lasting rebound of contaminations to groundwater.

Option 11: Light Non-Aqueous Phase Liquid (LNAPL)

Site and setting summary

Type P1-b: Light Non-Aqueous Phase Liquid (LNAPL) in permeable soil (often found in combination with a P2 type)
Setting: Industrial site
Risks: explosion, exposure, spreading to groundwater/surface water
Most common contaminant: VOC and light/medium fraction mineral oil



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Exposure/Explosion risk reduction
- Spreading risk reduction:
  - Mass removal as far as technique is cost effective. If
  - Mass control (containment)

Most likely remediation measures

In case of acute risks requiring immediate action
- Excavation
- Vapour proof sealing in building floor

In absence of acute risks
- Mass recovery: excavation, skimming, dual pump extraction
- Mass recovery by phase change: soil vapor extraction, air sparging, bioslurping
- Mass control: subsurface barrier, trench, wells

In case of low risk profile
- Long-term stewardship
- Natural source zone depletion

Specific conditions or alternative approaches

- The assessment of LNAPL spreading potential and the fitting remediation objectives requires specialist soil characterisation expertise.
- If chosen the right technique, the implementation of this technique to a point it is effective will typically lead to an acceptable risk reduction.
- Specialized (and thus expensive) in-situ techniques may be worth considering if a high degree of source removal in needed a very short time frame. Example techniques are: in-situ chemical oxidation, surfactant-enhanced subsurface remediation, co solvent flushing, steam/hot air injection, radio-frequency heating and three/six-phase electrical resistance heating.
- Pump and treat is generally not recommended for LNAPL removal due to long lasting rebound of contaminations to groundwater.

Option 12: Remediation of cluster of land bound solid phase contamination

Site and setting summary

Type S1-a/b: Cluster of land bound solid phase contamination
Setting: Multiple sites and site usages
Risks: Direct human contact, ecological risks (depending on site use)
Most common contaminant: heavy metals, PAH, pesticides

Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:

- Top soil: fit for use based on generic level corresponding with site use
- Gradual improvement of soil quality over time towards a acceptable risk level and a minimal of site use restrictions

Most likely remediation measures

Technical aspects of the remediation can be found in the description of options for the non-clustered sites of the same type. The cluster approach differs from this sitewise approach regarding the management and coordination of the remediation of all the sites in the cluster area. Examples of aspects in dealing with cluster sites are:

- Remediation strategy and target levels established for the whole area
- Logistical solution for subsequent remediation of individual sites, such as a single sanitary landfill or central mobile soil treatment plant
- A single tender procedure
- A single generic remediation plan to be fine-tuned for individual sites, taking into account site specific conditions and site use
- A single organization dealing with post-remediation procedures
- A single generic plan for soil management (use, reuse and interchange between individual contaminated sites)

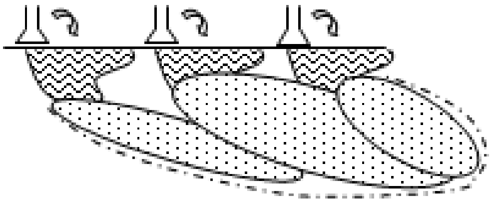
Specific conditions or alternative approaches

- Awareness of local aberrations in contamination situation required
- Generic remediation plans need updating every couple of years to remain aligned with developments in policy, state of the art in remediation approaches and changes in site use

Option 13: Remediation of cluster of liquid phase contamination

Site and setting summary

Type L1: Cluster of liquid phase contamination
Setting: multiple sites and site usages, urban area
Risks: Direct human contact, exposure to polluted drinking water, spreading
Most common contaminant: mobile organic compounds



Draft sketch of typical field situation

Most likely remediation objectives

Recommendations for cleanup standards and levels:
- Top soil: site-specific levels for risk removal or risk reduction
- Subsoil and groundwater: steady end state and removal or reduction of risks over entire system area to be reached over longer timeframe (typically 30 to 40 years)
- Target levels for load removal for individual plumes, based on their contribution to the total plume volume and spreading
- Custom signal and action levels to evaluate spreading (towards receptors).

Most likely remediation measures

Principle: area oriented approach of groundwater remediation

Technical aspects:
- The approaches as listed under the description of the option for P2
- MNA – monitored natural attenuation
- Stimulation of biodegradation of the contaminants
- Monitoring of the groundwater quality to protect receptors

Strategic instruments:
- Remediation strategy and warning or action levels to be developed for the entire area
- Generic remediation plan for the entire area and underlying site specific remediation plans to assess hot spots (leaching) and establish load removal
- A single organization dealing with post-remediation procedures

Specific conditions or alternative approaches

- The area oriented approach is only used in cases where assessment of individual plumes is not technically feasible because remedial action applied to one plume will affect other plumes
- Active, immediate remediation (topsoil, source, plume, receptor) is only applied in case of actual risks
- Signal level: level of contamination at which additional attention is required, e.g. more intense sampling over time or space
- Action level: level of contamination at which additional active measures are required
- Low intensity remediation techniques (vertical biological or chemical barrier) can be considered if active prevention of spreading out of the area towards receptors is required

Annexure 4a – Overview Guidance document for assessment and remediation of contaminated sites in India (Source: Task-4 report)

Overview Guidance document for assessment and remediation of contaminated sites in India

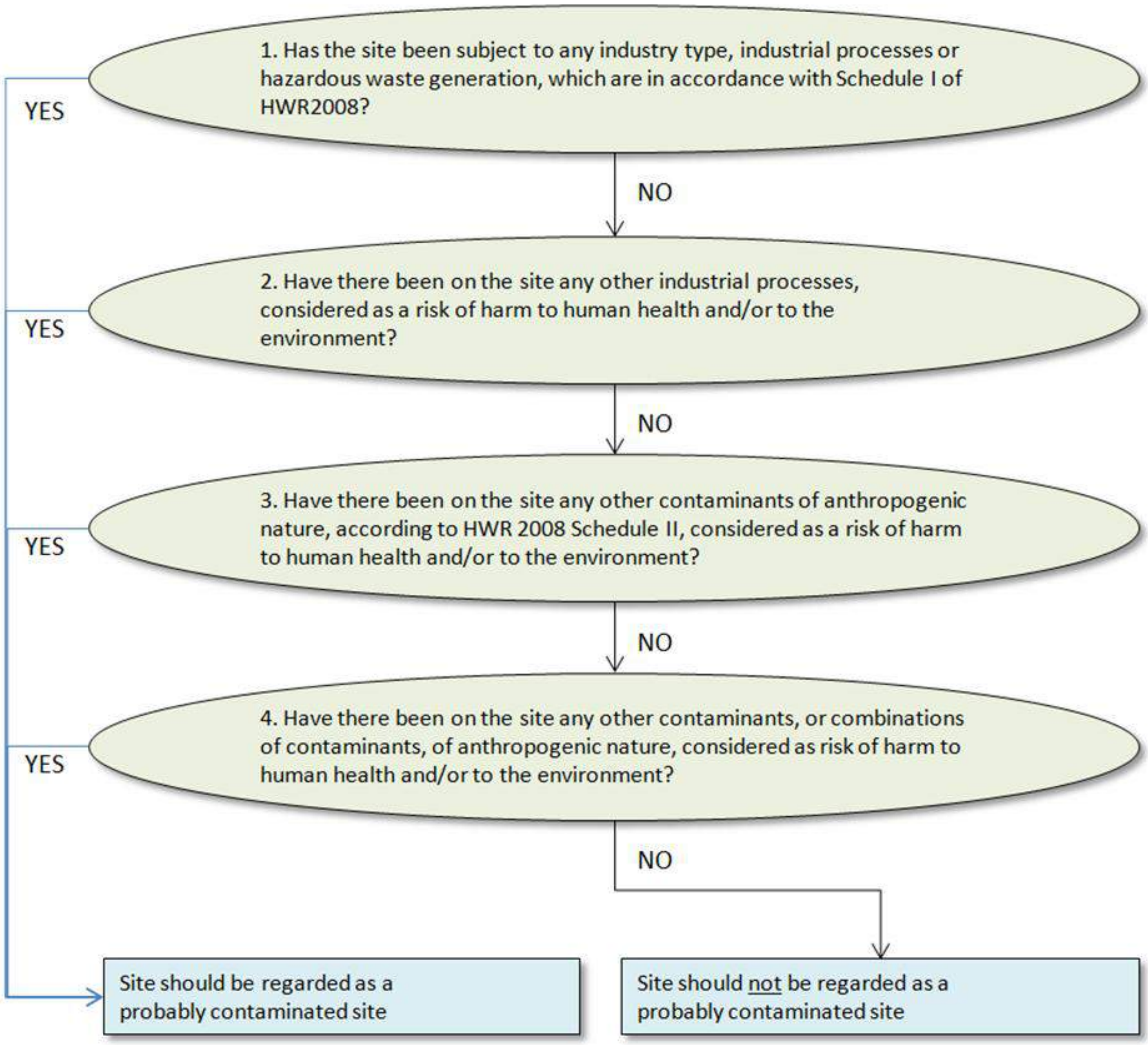
1st edition, December 2015

Step / Task	Volume I: Methodologies and guidance	Volume II: Standards and checklists	Volume III: Tools and manuals
1 Identification of probably contaminated sites	Data collection	II-1-a Example petition format for identification of probably contaminated sites	
	Data verification and evaluation	II-1-b Checklist relevant data for identification of probably contaminated sites	
2 Preliminary investigation			
2.1 Preliminary site assessment	Desk study	II-2.1-a Checklist prequalification for site investigation including ToR	III-2.1-i Site Inspection Protocol
	Site inspection		
	Limited sampling and testing		
	Comparing testing results with standards	II-2.1-b Screening and response levels	
	Reporting and review	II-2.1-c Checklist preliminary site assessment report	
2.1 Preliminary site investigation	Investigation strategy		III-2.2-i Manual Conceptual Site Model and identifying the Source-Pathway-Receptor
	Fieldwork and laboratory testing		III-2.2-ii Protocol investigation strategy preliminary site investigation
	Comparison of testing results with standards		III-2.2-iii Overview of techniques for site investigation
	Reporting and review	II-2.2-a Checklist preliminary site investigation report	
		II-2.2-b Checklist review and approval preliminary site investigation report	
3 Notification of polluted site	Delineate the contaminated site		
	Impose site use restrictions and temporary safety measures	II-3-a Checklist restrictions to site use and temporary safety measures	
4 Priority list addition	Assess available data on the site		
	Apply prioritisation algorithm to obtain priority score	II-4-a Checklist information for application prioritization system	
5 Remediation investigation			
5.1 Detailed site investigation	Investigation strategy		III-5.1-i Example investigation strategy detailed site investigation
	Fieldwork and laboratory testing		
	Analysis and interpretation of exploratory data		
	Reporting detailed site investigation	II-5.1-a Checklist detailed site investigation report	
5.2 Risk assessment	Assess contaminant concentration levels	II-5.2-a Checklist risk assessment report	III-5.2-i Tools for risk assessment
	Identify applicable source-pathway-receptor combinations for human health		
	Perform a generic quantitative risk assessment for human health		
	Perform a more detailed quantitative risk assessment for human health		
	Perform a risk assessment for the environment		
5.3 Setting remediation objectives and requirements	Establish Remediation objectives	II-5.3-a Background information for setting remediation objectives	
	Establish Remediation requirements		
5.4 Development of remediation options	Assess the remediation objectives and requirements		
	Identify constraints to remediation		
	Identify applicable remediation techniques	II-5.4-a Flowchart application newly developed remediation techniques	III-5.4-i Overview remediation techniques and menu of options
	Develop applicable remediation options		
5.5 Selection remediation option	Compare and appraise remediation options	II-5.5-a Checklist Criteria for comparison and appraisal of remediation options	III-5.5-i Examples of methods for remediation option evaluation
	Consultation with stakeholders		
	Prepare remediation investigation report including stakeholder views	II-5.5-b Checklist Remediation investigation report	
	Review and approval of remediation investigation report and selection of most favourable remediation option	II-5.5-c Checklist Review and approval Remediation Investigation report	

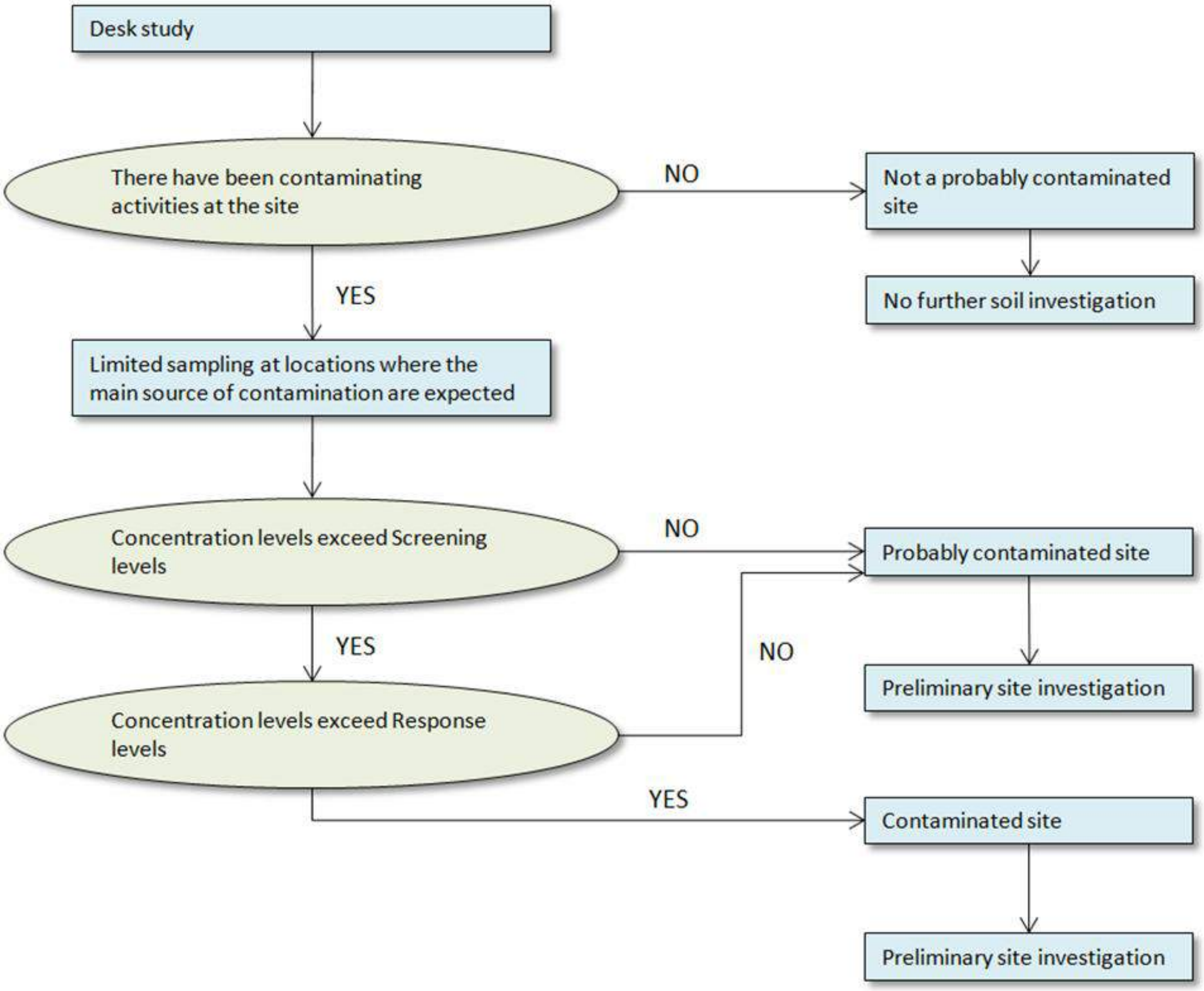
6	Remediation design, DPR	Design of the remediation	II-6-a	Checklist DPR including verification plan		
		Costing and planning of the remediation	II-6-b	Example format cost estimation remediation		
		Environmental and social impact assessment and stakeholder consultation			III-6-i	Manual for environmental and social impact assessment for remediation of contaminated sites
7	DPR approval and financing	Review and approval of DPR	II-7-a	Checklist review and approval Detailed Project Report		
8	Implementation of remediation					
	8.1 Preparation and authorization	Inventory of required permits	II-8.1-a	Checklist permits for remediation works		
		Applying for the permits				
	8.2 Contracting	Preparation of bid document				
		Selection and assignment of contractor	II-8.2-a	Checklist prequalification for remediation		
	8.3 Execution, supervision and verification of remediation works	Prepare remediation measures				
		Verify preparation of remediation measures	II-8.3-a	Checklist Health and Safety plan		
		Execute and manage remediation measures				
		Verify remediation measures against contract and specifications	II-8.3-b	Checklist supervision and verification remediation measures		
		Report verification results in a Remediation evaluation report	II-8.3-c	Checklist Remediation evaluation report		
9	Approval of remediation completion	Review Remediation evaluation report and approval of remediation completion	II-9-a	Checklist review and approval remediation completion		
10	Post remediation plan	Preparation of post remediation plan	II-10-a	Checklist Post remediation plan		
		Review and approval of post remediation plan	II-10-b	Checklist review and approval Post remediation plan		
11	Post remediation action	Prepare Post remediation implementation programme				
		Assign implementation of post remediation activities				
		Implement post remediation activities				
		Supervise and verify post remediation measures and prepare and verify periodical Post remediation status report	II-11-a	Checklist Post remediation status report		
		Review and approval of Post remediation status report	II-11-b	Checklist review and approval Post remediation status report		
12	Cost recovery	Prepare cost overview of executed assessment and (post) remediation works				
13	Priority list deletion	Assess and record site use restrictions				
14	Site reuse	Anticipate to site use restrictions				
		Arrangements to enable post remediation action				
	Glossary					

Annexure 4b – Flow charts (Source: Task-4 report)

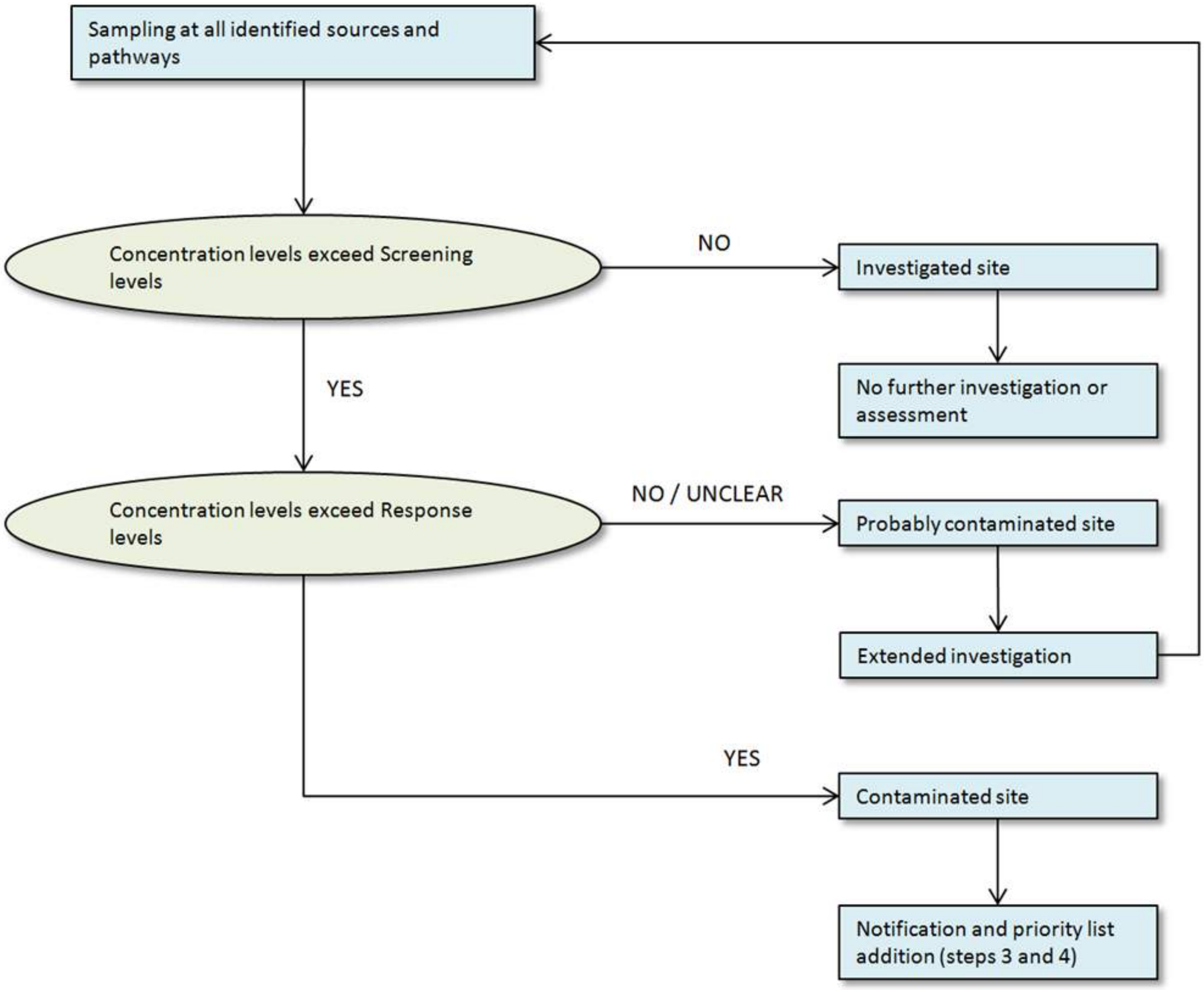
Step 1 – Identification of probably contaminated sites



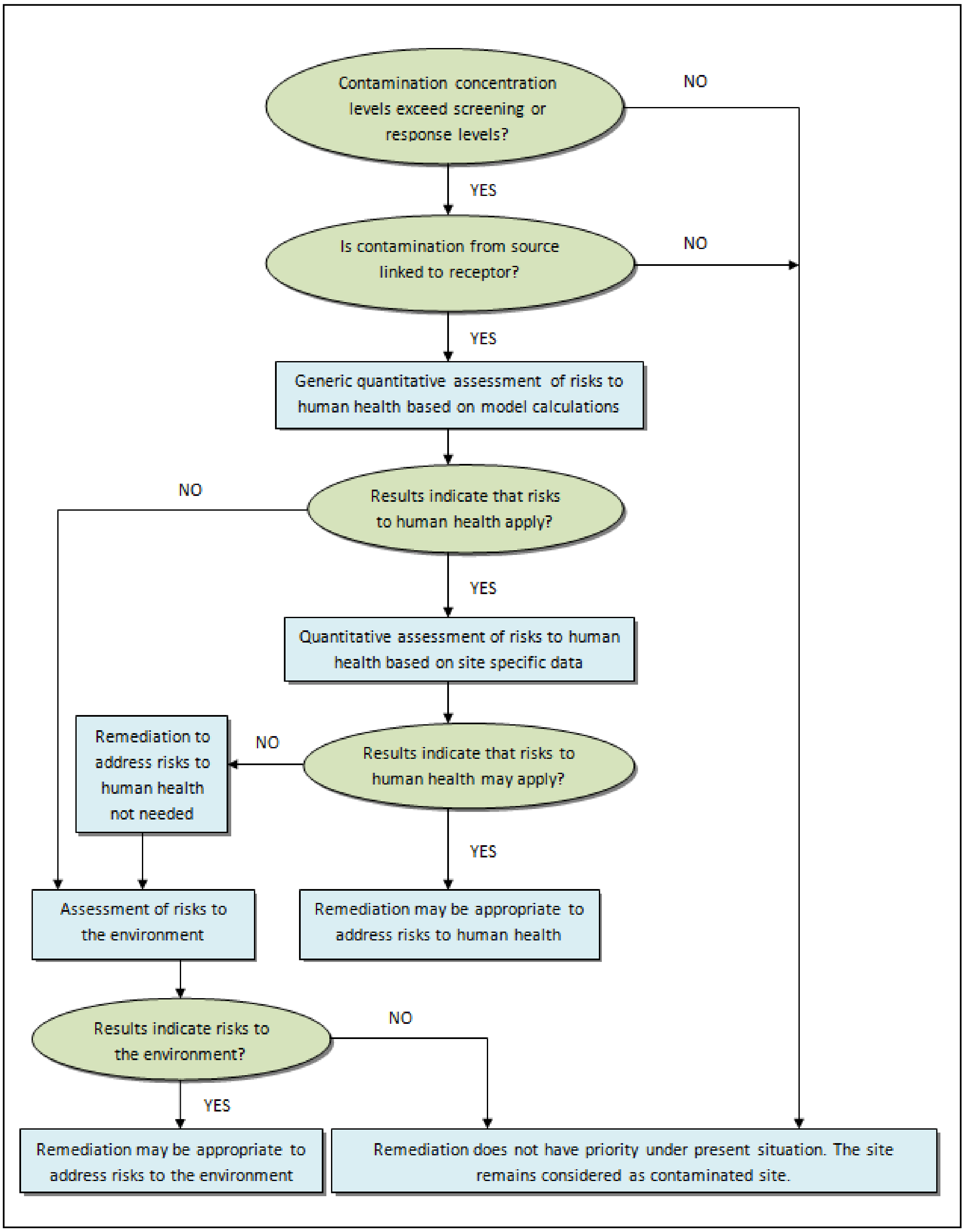
Step 2.1 – Preliminary site assessment



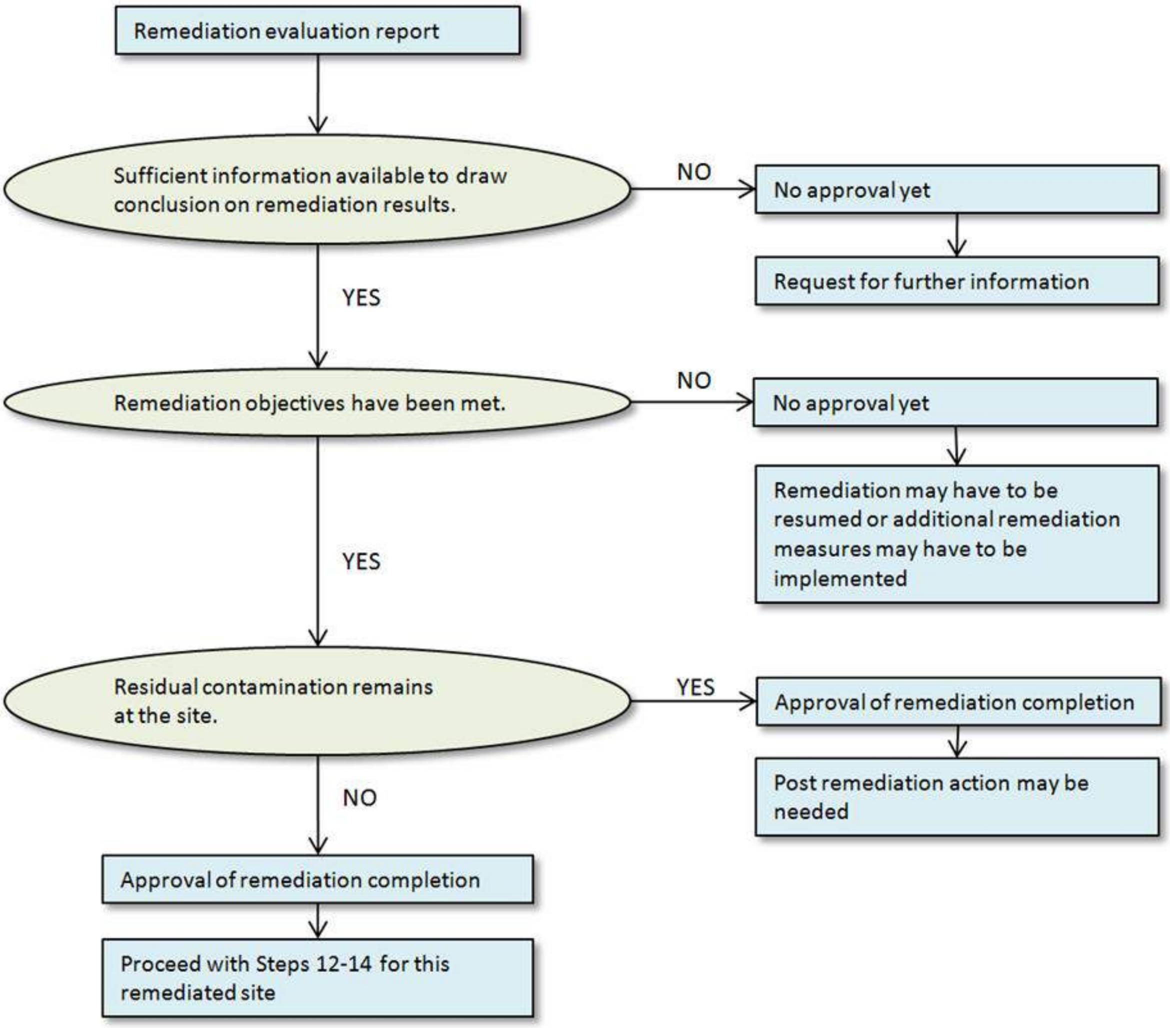
Step 2.2 – Preliminary site investigation



Step 5.2 – Risk assessment



Step 9.1 – Approval of remediation completion



Annexure 4c – Site investigation techniques: basic characteristics and typical application (Source: Task-4 report)

A comprehensive description of site investigation techniques is presented in volume III-2.2-iii of the Guidance document.

Table A4c.1 Survey techniques for quick screening of sites

	Electro magnetic methods	Geo-electric and Self Potential methods	Magnetic field measurement	Ground penetrating radar (GPR)	Radiometric measurement	Seismics (sonar)	Penetration test cones	XRF X-Ray Fluorescence	NIR Near IR luminescence	PID Photo-Ionisation Detector	Gas detection tubes
Basic characteristics											
Parameter	Electrical soil resistivity	Electrical soil resistivity	Magnetic susceptibility	Dielectric constant	Gamma ray radiation	Acoustic impedance	Various	Concentration (heavy metals)	Concentration (heavy metals / some organic compounds)	Concentration of contaminations in the air	Concentration (parameter sensitive reagent)
Unit	Ω/m	Ω/m	Gauss	F/m	Bequerel	ms or kgm^2	Various	ppm	ppm	ppm	ppm
Property of investigation	Electro magnetic induction	Galvanic resistivity	Magnetic field	Reflection/refraction electro-magnetic field	Radio active radiation	Reflection/refraction of sound waves	Various	wavelengths of the emitted X-Rays	Near IR luminescence	Ionisation of charged molecules	Speed of chemical reaction
Typical field specification											
Range of depth	0 – 25 m	0 – 100 m	0 – 10	0 – 25	0.1 m (in situ) > 0.1 m (samples)	1 – 100 m	0 – 50 m	0.1 m (in situ) > 0.1 m (samples)	0.1 m (in situ) > 0.1 m (samples)	NA > 0.1 m (samples)	NA > 0.1 m (samples)
Soil/water/air/ sediment	Soil/sediment	Soil	Soil/sediment	Soil	Soil/water/air/ sediment	Soil/sediment	Soil/sediment	Soil/water/air/ sediment	Soil/sediment	Air (sample)	Air (sample)
Resolution	1 – 25 m	1 – 100 m	1 – 5 m	0.5 – 2.5 m	0.1 m	0.5 – 5 m	0.1 m	0.1 m	0.1 m	1 m	1 m
Point/line/3D	point	point	point	line	point	line/3D	line (vertical)	point	point	point	point
Survey type (Survey technique is (+) highly suitable; (0) suitable with restrictions; (-) not suitable)											
Stratigraphy	+	+	0	+	0	+	+	-	-	-	-
Contamination	+	+	0	0	+	-	+	+	+	+	+
Objects	0	-	+	+	-	0	0	-	-	-	-
Groundwater level	0	0	-	+	-	+	+	-	-	-	-

	Electro magnetic methods	Geo-electric and Self Potential methods	Magnetic field measurement	Ground penetrating radar (GPR)	Radiometric measurement	Seismics (sonar)	Penetration test cones	XRF X-Ray Fluorescence	NIR Near IR luminescence	PID Photo-Ionisation Detector	Gas detection tubes
Practical aspects											
Field personnel (# of field operators)											
	1-2	1-2	1	1	1	>2	1	1	1	1	1
Investigation time needed ((+) quick survey technique; (0) moderate time consuming technique; (-)time consuming survey technique)											
	+	0	+	+	+	-	0	+	0	+	+
Costs (Survey technique is (+) expensive; (0) moderately expensive; (-) low cost)											
	+	0	+	+	+	-	0	+	+	+	+
Much used (Survey technique is (+) used on daily basis; (0) now and then used; (-) seldom used)											
	+	+	0	+	+	-	+	+	-	+	+
Typical type of field survey	Groundwater plume and source recon-naissance / delineation	Groundwater plume and source recon-naissance / delineation	Source and object (drums) reconnaissan-ce / delineation	Stratigraphy, source and object recon-naissance / delineation	Source recon-naissance / delineation	Stratigraphy	Stratigraphy and plume re-connaissance / delineation	Source recon-naissance / delineation	Source and pathway recon-naissance / delineation	Source and pathway recon-naissance / delineation	Source and pathway recon-naissance / delineation

Table A4c.2 Conventional site investigation techniques

	Taking and testing of soil and groundwater samples	Taking and testing of sediment samples
Basic characteristics		
Parameter	Concentration (all parameters)	Concentration (all parameters)
Unit	ppm	ppm
Property of investigation	Sampling and testing	Sampling and testing
Typical field specification		
Range of depth	0 – 8 m (hand) 0 - > 100 m (mechanical)	0 – ?? m
Soil/water/air/ sediment	Soil/water	Sediment
Resolution	0.1 m	0.2 m
Point/line/3D	point	point
Survey type (Technique is (+) highly suitable; (0) suitable with restrictions; (-) not suitable)		
Stratigraphy	+	+
Contamination	+	+
Objects	0	0
Groundwater level	+	n/a
Practical aspects		
Field personnel (# of field operators)		
	1-2	1-2
Investigation time needed ((+) quick technique; (0) moderate time consuming technique; (-) time consuming technique)		
	+	+

	Taking and testing of soil and groundwater samples	Taking and testing of sediment samples
Costs (Technique is (+) expensive; (0) moderately expensive; (-) low cost)		
	+	+
Much used (Technique is (+) used on daily basis; (0) now and then used; (-) seldom used)		
	+	+
Typical type of field survey	Groundwater plume and source reconnaissance and delineation. Testing of quick survey results	Source reconnaissance and delineation

Annexure 4d – Categories of aspects to be included in various products
(Source: Task-4 report)

For the documents produced in the process of assessment and remediation to be effective it should discuss aspects from categories which are listed below. For the detailed checklists reference is made to the specific section in Volume II of the Guidance document.

Preliminary site assessment report (Vol. II-2.1-c):

- Existing and general information
- Overall assessment of data and data gaps
- On site Reconnaissance
- Off site Reconnaissance
- Miscellaneous
- Site map
- Sampling
- Overall assessment of pathways,
- Exposure, impacts and contamination
- Draft Conceptual site model (CSM)
- Photographic Record
- Analysis results from sampling (table with results from sampling)

Preliminary site investigation report (Vol II-2.2-a):

- Site identification
- Introduction (purpose, explanation)
- Site description
- Investigation strategy
- Fieldwork results and interpretation
- Conclusions and recommendations
- Annexes (maps, site survey plan, borehole logs, relevant screening and response levels, laboratory results, QA/QC results, photographic record)

Detailed site investigation report (Vol. II-5.1-a):

- Introduction and background information
- Site situation
- Investigation strategy
- Fieldwork and laboratory testing
- Analysis and interpretation of exploratory data
- Conclusions and recommendations
- Annexes (maps (topography, contamination); site survey plan; methods of fieldwork and laboratory testing; borehole logs; relevant screening and response levels; laboratory reports; calculations or modeling results; literature and sources; photographic record

Risk assessment report (Vol. II-5.2-a):

- Introduction and background information
- Site situation
- Relevant source-pathway-receptor combinations
- Results of generic quantitative risk assessment modeling
- Results of detailed quantitative risk assessment
- Conclusions and recommendations

Remediation investigation report (Vol. II-5.5-b):

- CSM and risk assessment
- Remediation objectives
- Description remediation options
- Evaluation of possible remediation options
- Annexes (maps; x-sections; tables technical schemes)

Detailed Project Report (DPR) (Vol. II-6-a):

- Introduction and background information;
- Site situation;
- Remediation approach;
- Detailed description of the remediation process;
- Content of the verification plan;
- Supervision and environmental verification;
- Communication;
- Monitoring programme.

Health and Safety Plan (Vol. II-8.3-a):

- Materials for onsite workers
- Measures in preparation of remediation
- Hygiene during remediation measures
- Optional measurements during remediation measures

Supervision and verification plan (Vol. II-8.3-b):

- Outline supervisor tasks
- Potential response actions to deviations from remediation plan
- Critical activities in the remediation process.
- Communication (contact information institutions and persons; stakeholders; procedures for reporting deviation and incidents and results)
- Sampling and testing strategy
- Criteria for evaluation of interim results of the remediation
- Action levels for evaluation

Remediation evaluation report (Vol. II 8.3-c):

- Introduction and background information
- Remediation process
- Content of Remediation evaluation report
- Conclusion on the remediation results

Review and approval remediation completion (Vol. II-9-a):

- Checklist Remediation evaluation report (Evaluation on whether the Remediation evaluation report meets the requirements of the Checklist Remediation evaluation report)
- Verification of the remediation (Results of the verification of the remediation results by an independent third party)
- Skills and accreditations (Evaluation on whether the specialized agency or consultant responsible for the preparation of the Remediation evaluation report meets the required skills and accreditations)
- Validity of values (When doubting results: cross-check third party values)
- Stakeholder rights and interests (Evaluation on whether the stakeholder rights are guaranteed. A thorough stakeholder involvement offers a good basis for securing stakeholder warranties)
- Long term guarantees (Evaluation if the Remediation evaluation report offers adequate long term guarantees for risk protection and liability. Aspects involved are: A) Technical aspects; B) Legal aspects; C) Financial aspects; D) Management aspects.
- Conclusion (Can remediation completion be approved? If not, which information has to be provided or which activities have to be carried out?)

Post remediation plan (Vol. II-10-a):

- Conditions and basic data
- Methodology for development of the PRP
- Analysis and evaluation
- Management and finance

Post remediation status report (Vol. II-11-a):

- Introduction
- Background information
- Implementation of post remediation activities
- Conclusions and recommendations

Annexure 4e – Categories of criteria for the prequalification of remediation contractors (Source: Task-4 report)

In a procedure to prequalify contractors for the performance of remediation of soil, groundwater and/or sediment, criteria from the following categories may be taken into account.

- Information about Firm;
- Financial capability;
- Technical capability;
- Management capability;
- Construction capability;
- Past experience;
- Reputation condition;
- Health and safety policy;
- Use of Information Technology & Services.

For a detailed checklist of criteria please refer to Vol. II-8.2a in the Guidance document.

Annexure 5a – HR Capacities required for implementation of NPRPS
(Source: Task-5 report)

This Annexure presents the human resources capacities required for effective performance of tasks in site assessment and remediation process. First, table A5a.1 presents the relevant roles and shows in which steps of the site assessment and remediation process these are involved. The subsequent tables present the required human resources per role. For more detailed information, and information on required equipment, materials and quality assurance we refer to the Task 5 report.

Table A5a.1 Roles required in a typical site assessment and remediation process

Steps in the remediation process		Relevant roles					
		Advisor	**Site investigator**	**Laboratory**	**Remediation contractor**	**Programme management Authority**	**Site related programme implementation Authority**
1	Identification of probably contaminated sites					✓	
2	Preliminary investigation	✓	✓	✓		✓	✓
3	Notification of polluted site					✓	
4	Priority list addition					+	
5	Remediation investigation						
5.1	Detailed site assessment	✓	✓	✓		+	✓
5.2	Risk assessment	✓				+	✓
5.3	Setting remediation objectives and requirements	✓				+	✓
5.4	Development of remediation options	✓				+	✓
5.5	Selection remediation option	✓				+	✓
6	Remediation design, DPR	✓				+	
7	DPR approval and funding					+	✓
8	Implementation of remediation						
8.1	Preparation and authorisation	✓				+	
8.2	Contracting	✓				+	✓
8.3	Execution, supervision and verification of remediation results	✓	✓	✓	✓	+	✓
9	Approval of remediation completion					+	✓
10	Post remediation Plan	✓				+	✓
11	Post remediation Action	✓	✓	✓	✓	+	✓
12	Cost recovery					✓	
13	Priority list deletion					✓	
14	Site reuse					✓	

Key
✓ Role required in a typical site assessment and remediation process
\+ Some involvement of role of Authority/Programme management is required at all other Steps

Table A5a.2 Generic human resources required for effective performance by Consultant/Advisor at a relatively complex contaminated site

Key Position	Required expertise	Required experience
Remediation expert (assessment and / or remediation expert)	Post Graduate in Environ-mental / Civil/Chemical Engineering /Hydrogeology/Science or relevant discipline	At least 7 years' experience in as-sessment and planning for reme-diation of contaminated sites, in-cluding risk assessment, priority setting, management of hazardous wastes and characterization.
Engineering Design Specialist (Remediation works)	Graduate/Post Graduate in Environmental / Civil/Chemical Engineering / relevant discipline	At least 5 years of experience in designing remediation works includ-ing. Experience in designing land-fills, extraction wells, impermeable barriers, liners, capping etc.
Social Development expert	Master Degree in Social Sciences / Sociology / Planning	At least 3 years' experience in so-cial development sector and social impacts

Table A5a.3 Generic human resources required for effective performance by Site Investigator / Fieldwork Team at a relatively complex con-taminated site

Key Position	Required expertise	Required experience
Team Leader	Intermediate technical and vocational education and training in Environmental / Civil/Chemical Engineering or other relevant discipline.	Minimum 2 years' experience in fieldwork on contaminated sites and waste characterization. Knowledge of fieldwork proto-cols/manuals and safety measures.
Member of fieldwork team	Training in fieldwork.	At least 2 months experience in fieldwork on contaminated sites and waste characterization.

Table A5a.4 Generic human resources required for effective performance by Site Investigator / Laboratory staff

Key Position	Required expertise	Required experience
Head of chemical testing laboratory	Post graduate in chemistry or Bachelor degree in chemical engineering / technology or equivalent with adequate experience.	Adequate experience in the relevant area especially in the analysis of testing of relevant products.
Technical staff	Graduate in Science with chemistry or Diploma in chemical engineering / technology or equivalent	The staff shall have sufficient training and exposure in analytical chemistry and in analysis and testing of appropriate products.
Laboratory technicians	Higher secondary certificate in science / ITI	At least one year experience or training in a relevant laboratory
Authorized Signatory	Graduate in Science with chemistry as one of the subjects / Diploma in Chemical engineering / technology or equivalent from a recognized university or Post-graduate in chemistry / specialization in relevant subject / Degree in Chemical engineering / technology or equivalent from a recognized university	At least 5 years' experience in relevant field, At least 2 years' experience in relevant field

Table A5a.5 Generic human resources required for effective performance by Remediation Contractor at a relatively complex contaminated site

Key Position	Required expertise	Required experience
Team leader / project manager / planner	Intermediate technical and vocational education and training in Civil Engineering or other relevant discipline. For in-situ remediation a graduate level is preferred	Minimum 2 years' experience in preparation of relevant projects. Knowledge of remediation techniques and safety measures.
Remediation technicians	Intermediate technical and vocational education and training in Civil Engineering or other relevant discipline. For in-situ remediation a graduate level is preferred	Minimum 2 years' experience in preparation of relevant projects. Knowledge of remediation techniques and safety measures.
Engine drivers	Training engine driver.	Minimum 1 year experience in soil excavation.

Table A5a.6 Generic human resources required for effective performance by Authorities at a relatively complex contaminated site, related to the technical aspects.

Key Position*	Required expertise	Required experience
Hazardous waste expert	Post graduate in environmental science or engineering, chemical engineering, environmental chemistry.	Minimum 2 years' experience in hazardous waste and associated industrial processes and environmental issues.
Investigation expert	Post graduate in environmental science or engineering, chemical engineering, environmental chemistry.	Minimum 2 years' experience in application or review of site assessment.
Laboratory testing expert	Post graduate in environmental science, chemical engineering, environmental chemistry.	Minimum 2 years' experience in laboratory testing of soil and groundwater samples on environmental parameters.
Risk expert	Post graduate in hydrogeology, environment toxicology.	Minimum 2 years' experience in development or review of risk assessment.
Remediation techniques expert	Post graduate in civil engineering, environmental engineering, chemical engineering, micro-biology with specialisation in remediation.	Minimum 2 years' experience in development or review of remediation works.

* Some of the key positions may be combined by a single expert.

Annexure 5b – Estimates of required capacity (Source: Task-5 report)

1. Capacity requirements per role, except Remediation contractor

Table A5b.1 specifies the estimated capacities required per role for an effective implementation of the site assessment and remediation process. These capacities are expressed in number of hours or, where applicable, number of samples to be tested. It should be stressed that the numbers in this table apply to a fictitious Reference contaminated site and that these numbers serve as a basis for the calculation of the total required capacities for effective implementation of NPRPS. The numbers should therefore not be used for the calculation of costs for any specific existing site.
Also, the table shows an example in which sampling and ex situ testing of samples was selected as site investigation method. It should be noted that the hours indicated include hours by technical staff only; they do not include hours by supporting staff, whether technical (e.g. IT) or other (e.g. administrative), nor hours needed to meet administrative requirements.

To reach a first basis for the calculation of the required capacities for effective implementation of NPRPS, the numbers in this table are translated into a cost estimate for a Reference contaminated site in Indian Rupees.

The unit costs for Advisor, Programme management Authority and Site related programme implementation Authority represent a regular cost level. For this an assumption is made as to the average hourly rate. The unit costs for Site investigation and Laboratory are translated into all-in prices, related to the number of samples.

Table A5b.1 Average required capacities for effective handling of a reference contaminated site, related to the technical aspects of the site assessment and remediation process

Steps in the site assessment and remediation process		Average required capacities					
		Advisor charges	**Site investigator**	**Laboratory**	**Remediation contractor**	**Programme management Authority**	**Site related programme implementation Authority**
		hours	**samples**	**samples**	**-**	**hours**	**hours**
1	Identification of probably contaminated sites					8	
2	Preliminary investigation	60	40	40		2	16
3	Notification of polluted site					4	
4	Priority list addition					4	
5	Remediation investigation	440	80	80		10	90
6	Remediation design, DPR	120	30	30		2	12
7	DPR approval and funding					2	8
8	Implementation of remediation	120			#	2	48
	8.3 Execution, supervision and verification of remediation works	#	#	#			
9	Approval of remediation completion					2	40
10	Post remediation Plan	60				2	16
11	Post remediation Action	#	#	#	#	2	20
12	Cost recovery					12	
13	Priority list deletion					4	
14	Site reuse					4	
	Total required capacities	800	150	150	#	90	250
		INR*1,000	**INR*1,000**	**INR*1,000**		**INR*1,000**	**INR*1,000**
	Average standard all-in unit costs	2.2	25	17		2.2	2.2
	Total costs	1,760	3,750	2,550		132	550
						hours	
	Project management, if applicable					300	

Please note: hours refer to hours by technical experts only, and do not include hours by supporting staff, whether technical (e.g. IT) or other, (e.g. administrative), nor for meeting administrative requirements
#: Re. Section 4.2.2

Table A5b.1 is based on an estimate of average required capacities for effective handling of a Reference contaminated site. In practice, the required capacities will always be different for any given site. In many cases it will even happen that there are no capacities required for Step 7 and onwards. This will be the case for sites where the preliminary site investigation (Step 2), or the risk analysis (part of Step 5), shows that there are no or very limited risks, and that therefore no further action is required.

In addition to an estimate of the required capacities, table A5b.1 shows the distribution of the required capacities per role over the fourteen Steps of the site assessment and remediation process. For example: in a situation where the Site related programme implementation Authority has budgeted 250 hours, they may expect to spend most of these hours on the monitoring of the implementation of the remediation and its approval (Steps 8 and 9) and, if applicable, the post remediation action (Step 11). Likewise, in a situation where the Advisor has budgeted 800 hours, to be distributed over all their Steps, they may typically expect to spend most of his time on Remediation investigation (Step 5) and less on the Remediation design (DPR, Step 6) and additional consulting during implementation (Step 8) of the remediation plan.

2. Capacity requirements for the role of Remediation contractor

The previous Section provided generic estimates for the capacity required for effective handling of a Reference contaminated site. These estimates were provided for all roles, with the exception of the role of Remediation Contractor. The reason for this is that generic estimates are not suitable to determine the capacities required by the Remediation Contractor. This in turn is because the selected remediation option is too influential a factor. Also, data on contractor remediation costs are available, enabling relatively accurate calculation. Because of this, the costs for the Remediation Contractor merit a separate discussion, which is provided in this Section.

The variable of the selected remediation option

In the previous Section capacities required to effectively deal with a Reference contaminated site were estimated. While this is needed to get a first impression of required capacities, it does no justice to the wide variety in conditions at contaminated sites throughout India. Therefore, this Section presents a first step towards taking this variety into account. This is done by discussing the major variable, the remediation option to be applied. An important discussion at this point, as it will yield the basis for estimating the costs for the role of the Remediation Contractor.

The remediation options and associated required investments vary widely, along with the variety in conditions at the contaminated sites. This Section presents the best practice remediation options per type of site as defined in the Typology from Task 1 of this Assignment. Table A5b.2 shows three remediation options per type of site. These options are based on the principle that in any situation remediation options may vary from a maximum, upper limit, to a minimum, lower limit, investment. In between many other options can be considered. From these, table A5b.2 shows a best practice option. The three generic options can be characterized as follows:

- Maximum remediation option: for most types of sites this option will result in a full removal of all contaminants to a natural background level. After remediation any use of the site is possible. In some cases this option should be regarded as a theoretical option. This option will yield the upper limit of remediation costs for a contaminated site;
- Minimum remediation option: this is an option which is typically relatively easy to implement with low costs. It should be noted that, for most types of

sites, this option will result in a long period of extensive remediation and post-remediation activities, higher levels of contaminant concentrations at remediation closure, low site use flexibility or minimum removal of contaminants. This option will yield the lower limit of remediation costs for a contaminated site;

- Best practice remediation option: this is considered to be the most likely technical choice to consider in the process of remediation options appraisal and selection and remediation design. The selection of this option is based on the Menu of options, as developed in Task 3 of this Assignment. This option will yield the most likely remediation costs for a contaminated site.

Table A5b.2 Maximum, best practice and minimum remediation options for all types of sites identified in the Typology

Type	Description or activity	Typical field characteristics of the site / examples	Remediation options		
			Maximum remediation option	**Best Practice remediation option**	**Minimum remediation option**
S-1	Solid phase contamination (land bound site)				
S1-a	Mixing the soil with contaminated material or materials containing contamination, not including agricultural activities.	Well defined body below surface level defined by boundaries of soil where soil is mixed with contaminants.	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – covering with clean soil after contaminated top soil and leaching hotspot removal. Post remediation measures.	Function oriented – **covering** with **less contaminated soil** without any removal of contaminated soil. Post remediation measures.
S1-b	Embankment, filling of pits or depressions, filling of surface waters with contaminated material or materials containing contamination.	Well defined body of non-mixed contaminants . E.g. storage of tailings.	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – covering with clean soil after contaminated top soil and leaching hotspot removal. Post remediation measures.	Function oriented – **covering** with **less contaminated soil** without any removal of contaminated soil. Post remediation measures.
S1-c	(Bulk) storage of contaminated material or materials containing contamination. (Industrial) activities in which contaminated solids are used. 'Leftovers' of incineration and burning of material.	Irregular shaped layer of contaminated material, recognizable as such. The shape of the contaminated site is related to the activity leading to the contamination	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – covering with clean soil after contaminated top soil and leaching hotspot removal. Post remediation measures.	Function oriented – **covering** with **less contaminated soil** without any removal of contaminated soil. Post remediation measures.

Type	Description or activity	Typical field characteristics of the site / examples	Remediation options		
			Maximum remediation option	**Best Practice remediation option**	**Minimum remediation option**
S1-d	Adding material containing contamination through agricultural activities (e.g. pesticides, fertilizers or additives to animal feed).	Agricultural site bound contaminations found up to a depth to which the soil is treated by ploughs and other agricultural tools.	**Complete removal** by excavation and treatment/storage of all contaminated soil	MF – **complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **in situ** restauration. Long term site use restrictions
S1-e	Atmospheric deposition (roads, railway, industries) of emissions or windblown dust.	Thin layered contaminations found over large areas with the highest concentrations close to the source following the prevailing wind direction.	**Complete removal** by excavation and treatment/storage of all contaminated soil	MF – **complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **in situ** restauration. Long term site use restrictions
S1-f	Deposition by flooding or washing.	Contaminations found in areas flooded by water systems or in downstream areas of flooding areas. The shape of the contaminated site is determined by the flooding of flow of a water system.	**Complete removal** by excavation and treatment/storage of all contaminated soil	Function oriented – **covering** with **clean sediment** after contaminated **top layer removal**. Post remediation measures.	Function oriented – **in situ** restauration. Long term site use restictions
S-2	Solid phase contaminations (water bound site)				
S-2	Contaminated open water sediments.	Solid phase contaminants sedimented from surface water. The shape of the contaminates site corresponds to the shape of the water system itself. Contaminants may be bound to clay or organic compounds of sediments.	**Complete removal** by dredging and treatment/storage of all contaminated soil	Function oriented – covering with clean soil after contaminated top soil and hotspot removal. Post remediation measures.	Function oriented – **covering** with less contaminated **sediment** without any removal of contaminated sediment. *Possibly In-situ or NA-removal.* Post remediation measures.
L-1	Liquid phase contaminations (land bound site)				

Type	Description or activity	Typical field characteristics of the site / examples	Remediation options		
			Maximum remediation option	Best Practice remediation option	Minimum remediation option
L1-a	(Business) activities involving fluids e.g. solvents, lubricants, paint, etc.	Liquid contamination in soil situated near a potential source of the contamination.	**<u>Complete removal</u>** by excavation and treatment/storage of all contaminated soil Note: technical not achievable in case of in case layer is situated at large depth	Function oriented – **<u>In situ</u>** removal to function oriented concentration level	Function oriented – **<u>In situ</u>** removal of hot spots. Post remediation measures.
L1-b	Storage of liquids that contain contaminations in tanks or barrels (either storage on surface or subsurface).	Liquid contamination in soil situated at any place at a liquids storage site.	**<u>Complete removal</u>** by excavation and treatment/storage of all contaminated soil	Function oriented – **<u>In situ</u>** removal to function oriented concentration level	same option as type L1-a
L1-c	Transfer and transport of fluids through linear infrastructure. Weak points are couplings, pressure regulators, valves, breakpoints and the passage through foundations / buildings.	Liquid contamination in soil situated at any place along a transport piping system or drains.	**<u>Complete removal</u>** by excavation and treatment/storage of all contaminated soil	Function oriented – **<u>In situ</u>** removal to function oriented concentration level	same option as type L1-a
L1-d	Spills or leaks of liquids	Liquid contamination in soil situated at the end of a transport piping or drain system.	**<u>Complete removal</u>** by excavation and treatment/storage of all contaminated soil	Function oriented – **<u>In situ removal</u>** to function oriented concentration level	same option as type L1-a
P-1	Liquid phase related (land bound site)				
P1-a	Dense Non-Aqueous Phase Liquid (DNAPL) in permeable soil.	Spreading of liquids due to gravity flow resulting in a characteristic spreading pattern. The DNAPL's laying of the botom of an aquiffer can result in a 'secondary source' of spreading of type P-2)	**<u>Complete removal</u>** by excavation and treatment of all contaminated soil Note: technically not achievable in case layer is situated at large depth	Function oriented – **<u>In situ removal</u>** to function oriented concentration level	Function oriented – **<u>In situ</u>** removal of hot spots. Post remediation measures.

Type	Description or activity	Typical field characteristics of the site / examples	Remediation options		
			Maximum remediation option	**Best Practice remediation option**	**Minimum remediation option**
P1-b	Light Non-Aqueous Phase Liquid (LNAPL) in permeable soil.	Spreading of liquids in a characteristic spreading pattern of floating layers. The LNAPL's laying at the top of a water table can result in a 'secondary source' of spreading of type P-2)	**Complete removal** by excavation and treatment of all contaminated soil	Function oriented – **In situ removal** to function oriented concentration level	Function oriented – **In situ** removal of hot spots. Post remediation measures.
P-2	Leached or dissolved contaminants				
P-2	Groundwater contamination	Due to spreading of leachate or mobile dissolved contaminants in a permeable soil	**Complete removal** by long term pump and treat (P&T)	Cost effective approach – **In situ removal** of hot spots and (stimulated natural attenuation of plume	Function oriented – geohydrological **isolation** and **receptor measures**

Best practice unit costs for the role of Remediation Contractor

At the time of publication of this report (December 2015) only a limited number of sites in India have been remediated. Therefore, available data on remediation are as yet limited. Given this, cost characteristics for different generic remediation options in The Netherlands, UK and US, are considered the most accurate input for estimating generic remediation costs. Data from evaluation studies in US, UK and the Netherlands are evaluated.

Standard unit costs per remediation option

The experts on soil remediation in the project team have derived standard unit costs for remediation. These are presented in table A5b.3, specified per remediation option. It should be noted that the standard unit costs in Euros are applicable for the situation in the countries assessed in the best practice study, i.e. US, UK, NL. The standard unit costs in INR have not been simply converted by applying the currency exchange rate to these but have been calculated.

Table A5b.3 Standard unit costs per remediation option, based on practice in US, UK and Netherlands

Remediation option (see table A5.b.2	**Standard unit costs**			
	Size/surface based		**Volume based**	
	€ / m^2	INR / m^2	€ / m^3	INR / m^3
Complete removal by excavation (exact figure depends on type)			150 – 200	5,527 – 7,369
Complete removal by long term pump and treat			20	766
Complete removal by dredging and treatment or storage of all contami-			40	1,474

Remediation option (see table A5.b.2	Standard unit costs			
	Size/surface based		Volume based	
	€ / m^2	INR / m^2	€ / m^3	INR / m^3
nated soil material				
In situ removal to function oriented concentration level (type L and P)			100	3,146
Groundwater plume remediation by in situ removal of high concentrations and NA of low concentrations			0.70	15
Removal contaminated top soil and hot spots. Covering with clean soil. (type S-2 and S1a,b,c)	20 - 50	679 – 1,699	30	1,106
In situ removal of hot spots, followed by post remediation measures (type L and P)			20	665
Geohydrological isolation and receptor measures			1	35
Covering with clean or less contaminated soil (type S-2 and S1a,b,c)	50	737 – 1,842		
In situ remediation (e.g. phyto remediation, type S1-d,e,f)	20	628		

It is noted that the results of the best practice inventory do not represent a universal image of the capacity requirements for the role of Remediation Contractor. This is because in different countries the scope of the identified cost elements is different, identified cost elements cover different types of sites, the costs elements are applicable for non-comparable levels of remediation and the price levels are from different years. Because of this the use of these data is limited to validation of standard unit costs derived by the experts.

The cost levels presented in table A5b.3 are based on either the area (m^2) or the volume (m^3) of the contaminated part of the site. This is because for some remediation options the costs are related to the area of the contamination, while for other remediation options the costs are related to the volume. The Standard unit costs presented are applicable to relatively simple situations where no other activities take place parallel to the remediation. Where the remediation is implemented simultaneously with a redevelopment of the site various activities can be shared with the redevelopment. In such cases the Standard cost units can be expected to turn out lower. This effect can be considerable and generally is site specific.

Annexure 6 – Salient points and general concerns voiced during stakeholder meetings of 3rd and 5th February 2015 (Source: Task-6 report)

Salient points

This Section presents the salient points that were voiced during the stakeholder consultation meetings on 3rd and 5th February 2015, and that have been discussed with the client during the wrap up meeting on 6th February 2015.

Guidance document fit for use

Participants agree that the Guidance document in the presented form is fit for use by SPCB's and other stakeholders while applying the Methodology. It is pointed out that the use of the document does require a certain knowledge of the technical aspects of site investigation and remediation. At the same time, it is recognised that the stakeholders do possess this enough of this capacity to start applying this document in performing their day to day tasks in this field.

While it is expected that application of the Guidance document in this way will disclose suggestions for improvement, there is general agreement that it is time to start its application (Annexure 4, comment 1 to Task-4 report). It is advised to keep the Guidance document up to date by setting up a structured scheme to manage the document. Such a scheme should include a system for the incorporation of user's suggestions.

Include Terms of Reference for preliminary site investigation

However diverse polluted sites may be, preliminary site investigation typically does include aspects that are often similar. An example of this is how to carry out sampling. In view of this, it is suggested to include Standardised Terms of Reference for preliminary site investigation, and guidance for developing site specific Terms of Reference in the Guidance document (Annexure 4, comment 20 on Task-4 report).

Include stakeholders to be consulted

It is indicated that stakeholders, especially on a local level, can often provide a lot of useful information. A considerable number of stakeholders are suggested, like Groundwater authority, District Collector, Kotwal and Patwari. It is therefore proposed to include in the description of every Step in the Guidance document a separate Section on which stakeholders to consult during the performance of that particular Step, with a focus on local stakeholders. For a complete list of the stakeholders mentioned which could be consulted per Step, refer to Annexure 4, comment 7 on Task-4 report.

Ensure clear and verifiable information in the petition

To prevent unfounded complaints the format for petitions should be such that it ensures that information entered is clear and verifiable (Annexure 4, comment 9 on Task-4 report).

Scope of approach to a contaminated site

Some concern was voiced about what exactly is a contaminated site. It is widely agreed that in approaching a contaminated site not only the waste, but also the soil, sediments and (ground)water contaminated by that waste, should be considered (Annexure 4, comment 3 on Task-4 report). It should be noted that there can be more than one source of contamination. The methodologies presented in the Guidance document do take into account that contaminated sites can have effect on the quality of the surface water as well. Assessment and remediation options are presented specifically for these media.

The response, general concerns

This Section presents the general concerns that were raised during the stakeholder consultation meetings on 3rd and 5th February 2015 and that do not necessitate revision of the reports. These concerns have been brought to the attention of the client during the wrap up meeting on 6th February 2015.

Response levels and prioritisation

It is stressed that screening and response levels are defined levels that are generically applicable. Concern is raised that this may result in an excessive number of sites that will eventually need action in some form. In addressing this concern it is pointed out that the competent authority does have instruments with which it is able to control the site investigation and remediation programme. Most prominent of these instruments is prioritisation. It is generally recognised that not all sites can be dealt with at short notice. By applying a clear prioritisation system the competent authority can clarify the selected order of action to stakeholders.

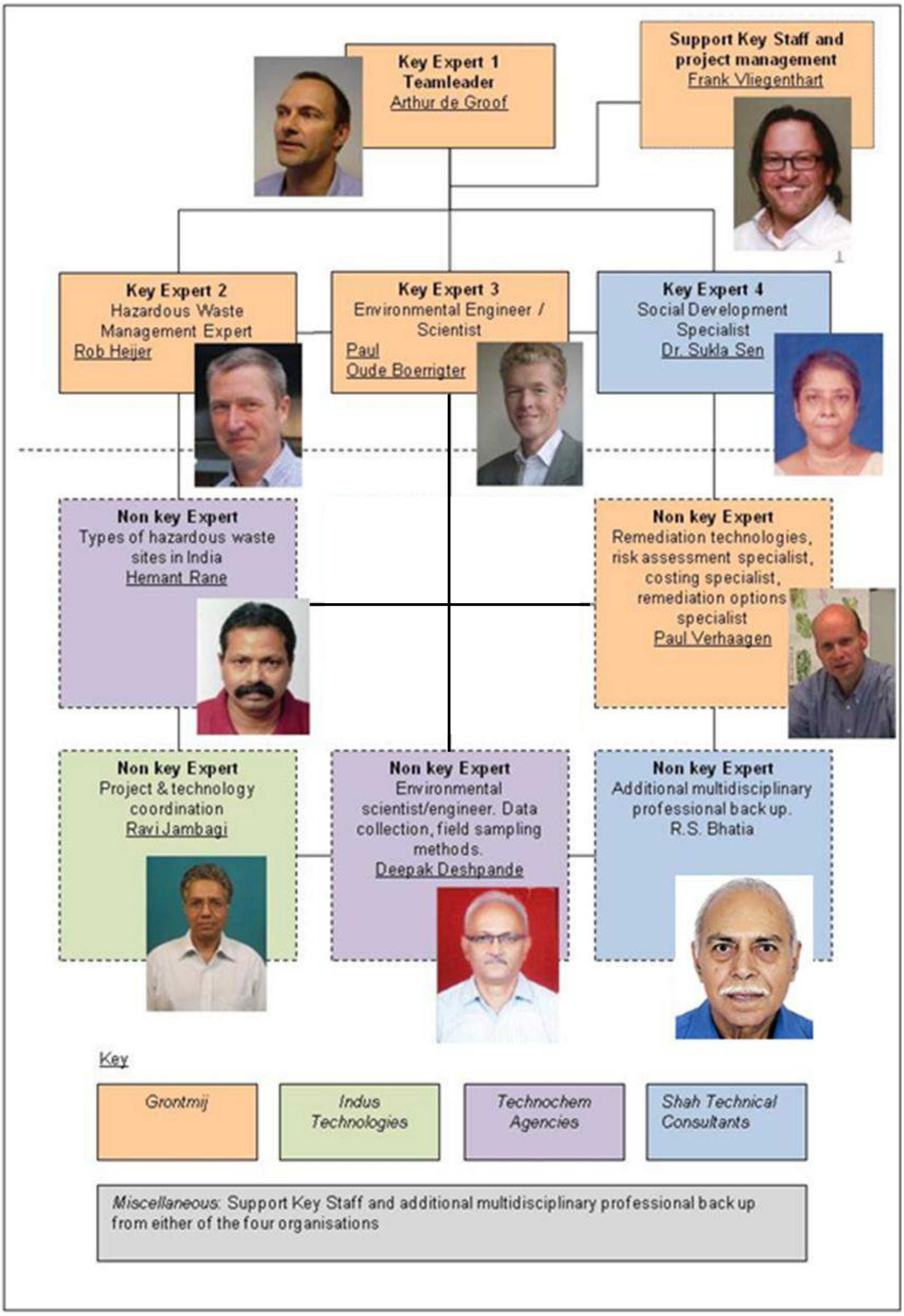
Cost control

Concern was voiced about costs, of laboratory testing in particular. In addressing this concern it is pointed out that best international practice is to limit laboratory testing to the chemicals of concern, in view of the history of use of the site.

Application of the Methodology, role of the Menu of options

The Methodology presented is aimed to be applicable to any site. Within this Methodology, the Menu of options, originally presented in the Task 3 report and subsequently included in the Guidance document, is a tool for the first round of elimination of non-eligible remediation options. After applying the Menu of options, the Guidance document literally guides the user through the further steps of elimination, until the most appropriate remediation option has been reached.

Annexure 7 – Project team



Annexure 8 – Stakeholder and review consultation meetings

Title of Meeting	Date and City	Content	Participants, besides Grontmij (and in some cases other) project team(s)
Inception meeting	10th April 2012, Delhi	Presentation of and discussion on project approach, alignment project strategy with MoEF	MoEF, CPCB, DPCC
Bilateral meetings during Inception phase	10-13th April 2012, Delhi and Mumbai	Bilateral meetings and site visits	CPCB, DPCC, 2 CETP sites in Delhi, MH government, TTC site near Mumbai (MH)
Site visits	February, June, July, November 2012; February, May 2013, April 2014	13 site visits, including interviews with employees of local authorities and SPCB's	Lake NMK (AP, now TS), Ranipet (TN), Nibra (WB), Hoogly (WB), Dhapa (WB), Lucknow (UP), Kanpur Dehat (UP), Kanpur Rakhi Mandi (UP), Ganjam (OD), Eloor (KL), Ratlam (MP), Talcher (OD), Lohia Nagar (UP)
4th TEP meeting	28th June 2012, Delhi	Presentation of and discussion on draft results Tasks 1, 2 and 3 and approach on Task 4	TEP members, among whom representatives of MoEF, WB, CPCB, APPCB and WBPCB
Stakeholder interviews	June-July 2012, Delhi, Chennai and Kolkata; November 2013: Lucknow, Bhubaneshwar and Hyderabad	Interviews with MoEF, CPCB and selected SPCB's to focus scope of typology and to discuss remediation options	June-July 2012: CPCB, TNPCB, WBPCB, Delhi PCC November 2013: UPPCB, OSPCB, APPCB
6th TEP-meeting	13th August 2012, Delhi	Presentation of and discussion on draft results Tasks 1, 2 and 3	TEP members, among whom representatives of MoEF, CPCB, WB, WBPCB, APPCB
Stakeholder consultation workshop	29th November 2012, Hyderabad	Presentation and consultation stakeholders	SPCB's of AP, WB, MH, Goa, TN, and MoEF, CPCB, WB
Review meeting	30th November 2012, Delhi	Discussion on results and planned activities	MoEF, CPCB, WB
Review meeting	14-15th February 2013	Approval of Task 1 and 2 reports. Draft report Task 3 discussed. Points for attention Task 4 provided.	MoEF, WB
Stakeholder interviews	March 2013, Bhubaneshwar, Kol-	Interviews to discuss Guidance Document	OSPCB, WBPCB, APPCB

Title of Meeting	Date and City	Content	Participants, besides Grontmij (and in some cases other) project team(s)
	kata, and Hyderabad	content and structure	
Review meeting TEP	16th May 2013, Delhi	Presentation of and discussion on results Task 3 and first draft results Task 4	MoEF, WB, CPCB
Meeting	8th July 2013, Houten, The Netherlands Nov and Dec. 2013 telephone conferences	Discussions on comments with World Bank expert Mr. Kallnischkies.	World Bank
Stakeholder consultation workshop	13th August 2013, Delhi	Presentation of and discussion on results of Task 3 and second draft report Task 4	MoEF, other TEP-members and State/SPCB-representatives (AP, MH, UP, Delhi, MP, GJ, TN, WB)
14th TEP-meeting	21st April 2014, Delhi	Presentation of and discussion on results final reports of Task 3 and Task 4	TEP, MoEF, CPCB, WBPCB
Meeting on NPRPS	19th December 2014, Delhi	Presentation of and discussion on results of Tasks 3, 4 and 5	MoEF&CC
Stakeholder consultation meetings	3rd and 5th February 2015, Ahmedabad and Chennai, with wrap up meeting on 6th February 2015	Soliciting input from stakeholders on Task 3, 4 and 5 reports	MoEF&CC, CPCB, State/SPCB-representatives (Goa, GJ, MP, PJ, AP, TS, KA, TN, WB, Kerala), NGO (Toxics Link), research institute (CSE)
2nd POC-meeting	15th September 2015, Delhi	Presentation of and discussion on results of Tasks 3, 4, 5 and 6	MoEF&CC, MoUD, MoFinance, DoIPP, WB, CPCB, SPCB-representatives (AP, TS, WB), TEP-members
17th TEP-meeting	20th November 2015, Delhi	Presentation of and discussion on results of Tasks 3, 4, 5 and 6	MoEF&CC, CPCB, TEP-members

Task 1 Review the nature and type of hazardous waste contaminated sites in India

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Task 3 Review of national and international approaches to remediation

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