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CHAPTER-1

INTRODUCTION

The North-Eastern Region is endowed with significant hydro-power potential on account of favourable terrain, heavy rainfall in the region and significant flows in mighty Brahmaputra river and its tributaries. The region is endowed with a total hydro-power potential of 31,864 MW (Refer **Table-1.1**). The region has tremendous potential in hydro-power generation which can go a long way in meeting the ever-increasing demand of power. The state of Arunachal Pradesh accounts for nearly 84% of the total power potential of the north-eastern region. Thus, there is a significant scope for hydropower development in Arunachal Pradesh.

TABLE-1.1
Region wise Hydro-Power Potential in the north-eastern states

| State | Hydro-Power Potential at 60% LF (MW) |
|-------------------|--------------------------------------|
| Assam | 351 |
| Arunachal Pradesh | 26,756 |
| Meghalaya | 1,070 |
| Manipur | 1,176 |
| Tripura | 16 |
| Mizoram | 1,455 |
| Nagaland | 1,040 |
| Total | 31,864 |

Source: Central Electricity Authority

In the present developing state of country's economy, there is a great requirement of electrical power for both industrial and agricultural use. The installed capacity of the north-eastern region of the country is of the order of 2089.7 MW. However, the actual availability of power is about 1340 MW.

As per the records published in the Report of North-East Regional Load Dispatch Centre (NERLDC) during the year 2001-02 the peak demand registered was of the order of 1,085 MW and maximum demand met was 1,043 MW. The power stations of the region met about 930 MW of power requirements. Thus, the peak load met by import from Eastern Region is about 113 MW. The energy generation during the year from the stations in the Region has been 5,238 MU and net import from the Eastern Region was 451 MU. The region at present faces a power deficit of about 8-10%.

As per demand and supply position indicated in the 16th Electric Power Survey conducted by the Central Electricity Authority (CEA), the energy requirement and peak load in the North Eastern Region for the year 2011-12 is 14061 Mkw and 2789 MW respectively. Considering the capacity additions that are envisaged during the period 2003-2011, it is clear that North Eastern region would become surplus in power generation. Based on all India scenario, the excess after meeting the requirement of the north-east can be utilized in the other power deficient regions of the country.

POWER POTENTIAL OF ARUNACHAL PRADESH

Arunachal Pradesh has a huge potential to generate hydroelectric power. The state has number of large, medium, mini and micro hydel projects. The Government of Arunachal Pradesh began planned development of the hydropower potential of the state and invited private developers to invest in the hydropower sector for the economic growth of the state and to decrease the energy deficit in the country. The details of projects being developed in Arunachal Pradesh are indicated in **Table 1.2**.

TABLE -1.2
BASINWISE HYDRO POWER PROJECTS UNDER DEVELOPMENT IN

ARUNACHAL PRADESH

| Sl. No. | Basin | Name of Project | Probable IC (MW) | Allotted to |
|------------------------------|--------|-----------------|------------------|-------------------------------------------------|
| 1 | Tawang | Tawang-I | 750 | NHPC |
| 2 | Tawang | Tawang-II | 750 | NHPC |
| 3 | Tawang | Nykcharongchu | 96 | SEW Energy |
| 5 | Tawang | Mago Chu | 96 | SEW Energy |
| 6 | Tawang | Nyamjungchhu | 900 | Bhilwara Energy Ltd. |
| TOTAL OF TAWANG BASIN | | 2592 | | |
| 1 | Kameng | Kameng-I | 1120 | NEEPCO |
| 2 | Kameng | Kameng-II | 600 | Mountain Fall India Pvt. Ltd. |
| 3 | Kameng | Kameng Dam | 600 | KSK Electricity Financing India Private Limited |
| 4 | Kameng | Gongri | 90 | Patel Engineering Ltd. |
| 5 | Kameng | Saskang | 7 | Patel Engineering Ltd. |
| 6 | Kameng | Talong | 160 | GMR Energy Ltd. |
| 7 | Kameng | Phanchung | 60 | Indiabull Real Estate Ltd. |
| 8 | Kameng | Utung | 100 | KSK Energy Ventures Limited |
| 9 | Kameng | Nazong | 60 | KSK Energy Ventures Limited |
| 10 | Kameng | Dibbin | 125 | KSK Electricity Financing India Private Limited |
| 11 | Kameng | Khuitam | 29 | Adishankar Power Pvt. Ltd. |
| 12 | Kameng | Pichang | 31 | Indiabull Real Estate Ltd. |
| 13 | Kameng | Tarang Warang | 30 | Indiabull Real Estate Ltd. |
| 14 | Kameng | Sepla | 46 | Indiabull Real Estate Ltd. |
| 15 | Kameng | Jameri | 50 | KSK Energy Ventures Limited |
| 16 | Kameng | Tenga | 8 | ECI Engineering & Const. Company Ltd. |
| 17 | Kameng | Dimijin | 20 | KSK Energy Ventures Limited |
| 18 | Kameng | Dinchang | 90 | KSK Energy Ventures Limited |

| Sl. No. | Basin | Name of Project | Probable IC (MW) | Allotted to |
|---------------------------------|-----------|----------------------|------------------|---------------------------------------|
| 19 | Kameng | Dinen | 10 | KSK Energy Ventures Limited |
| 20 | Kameng | Dikhri | 15 | KSK Energy Ventures Limited |
| 21 | Kameng | Nafra | 96 | SEW Energy |
| 22 | Kameng | Pakke Bung-I | 15 | Energy Development Company Ltd. |
| 23 | Kameng | Pakke Bung-II | 15 | Energy Development Company Ltd. |
| 24 | Kameng | Pachuk-I | 60 | Energy Development Company Ltd. |
| 25 | Kameng | Pachuk-II | 60 | Energy Development Company Ltd. |
| 26 | Kameng | Majingla | 60 | Energy Development Company Ltd. |
| 27 | Kameng | Dengzi | 18 | Satyam (North East) Hydro Power Ltd. |
| 28 | Kameng | Lower Ngorgum | 18 | Satyam (North East) Hydro Power Ltd. |
| 29 | Kameng | Upper Ngorgum | 9 | Satyam (North East) Hydro Power Ltd. |
| TOTAL OF KAMENG BASIN | | 3602 | | |
| 1 | Subansiri | Par | 65 | KVK Energy & Infrastructure Ltd. |
| 2 | Subansiri | Dardu | 60 | KVK Energy & Infrastructure Ltd. |
| TOTAL OF SUBANSIRI BASIN | | 125 | | |
| 1 | Dikrong | Pare | 110 | NEEPCO |
| 2 | Dikrong | Turu | 90 | ECI Engineering & Const. Company Ltd. |
| TOTAL OF DIKRONG BASIN | | 200 | | |
| 1 | Siang | Tato-II | 700 | Reliance Energy Ltd. |
| 2 | Siang | Naying | 1000 | D.S.Construction |
| 3 | Siang | Siang Lower | 1600 | Jaiprakash Associates Ltd. |
| 4 | Siang | Siang Middle (Siyom) | 1000 | Reliance Energy Ltd. |
| 5 | Siang | Pauk | 50 | Velcan Energy Ltd. |
| 6 | Siang | Heo | 90 | Velcan Energy Ltd. |

| Sl. No. | Basin | Name of Project | Probable IC (MW) | Allotted to |
|------------------------------|--------|---------------------|------------------|---------------------------------------|
| 7 | Siang | Hirong | 500 | Jaiprakash Associates Ltd. |
| 8 | Siang | Tato-I | 80 | Velcan Energy Ltd. |
| 9 | Siang | Simang-I | 67 | Adishankar Power Pvt. Ltd |
| 10 | Siang | Simang-II | 39 | Adishankar Power Pvt. Ltd |
| 11 | Siang | Simang-III | 44 | Adishankar Power Pvt. Ltd |
| 12 | Siang | Hirit | 84 | Velcan Energy Ltd. |
| 13 | Siang | Barpu | 70 | Raajratna Metal Industries |
| 14 | Siang | Kangtangshiri | 35 | Raajratna Metal Industries |
| 15 | Siang | Ropum | 40 | Raajratna Metal Industries |
| 16 | Siang | Rego | 70 | Tuff Power Pvt. Ltd. |
| 17 | Siang | Yamne Stage-I | 60 | Abir Const. Pvt. Ltd. |
| 18 | Siang | Yamne Stage-II | 60 | Abir Const. Pvt. Ltd. |
| 19 | Siang | Simen | 21 | Satyam (North East) Hydro Power Ltd. |
| TOTAL OF SIANG BASIN | | 5610 | | |
| 1 | Dibang | Etalin | 4000 | NTPC |
| 2 | Dibang | Emra-II | 390 | Athena Energy Venture Pvt. Ltd |
| 3 | Dibang | Agoline | 375 | Bhilwara Energy Limited |
| 4 | Dibang | Malinye | 335 | Bhilwara Energy Limited |
| 5 | Dibang | Emra-I | 275 | Athena Energy Venture Pvt. Ltd |
| 6 | Dibang | Attunli | 500 | NTPC |
| 7 | Dibang | Sissiri | 222 | Soma Enterprise Ltd. |
| 8 | Dibang | Dibang Multipurpose | 3000 | NHPC |
| TOTAL OF DIBANG BASIN | | 9097 | | |
| 1 | Lohit | Hutong-II | 1250 | Moutain Fall India Pvt. Ltd. |
| 2 | Lohit | Gimliang | 31 | Sai Krishnodaya Industries (P) Ltd. |
| 3 | Lohit | Raigam | 32 | Sai Krishnodaya Industries (P) Ltd. |
| 4 | Lohit | Tidding-I | 31 | Sai Krishnodaya Industries (P) Ltd. |

| Sl. No. | Basin | Name of Project | Probable IC (MW) | Allotted to |
|-----------------------------|-------|-----------------|------------------|-------------------------------------|
| 5 | Lohit | Kalai-I | 1450 | Mountain Fall India Pvt. Ltd. |
| 6 | Lohit | Demwe | 3000 | Athena Energy Venture Pvt. Ltd. |
| 7 | Lohit | Kamlang | 22.50 | Sai Krishnodaya Industries (P) Ltd. |
| TOTAL OF LOHIT BASIN | | 5816.5 | | |
| GRAND TOTAL | | 26432.50 | | |

1.4 DIBBIN HYDROELECTRIC PROJECT

The Dibbin Project is a run of river project with diurnal storage located on the Bichom River in the West Kameng district of Arunachal Pradesh. The location of the project is shown in **Figure 1-1**. The project consists of a 33.6 ha reservoir retaining 7.085 million cubic metres behind a dam located at 27°26'49"N, 92°30'58"E, some 400 m altitude below the village of Dibbin and 1 km downstream from the confluence of the Bichom river and the Dhakri Bru and some 250 m below the point where the Difya Nala meets the Bichom. From the intake on the right abutment of the dam a 3'970 m long headrace tunnel leads to a surface powerhouse located at 27°24'42"N, 92°31'09"E (WGS84) on the right bank of the Bichom river just upstream of the point where Ditchi Bru meets the Bichom and some 300 m below the village of Ditchi.

1.4 ACCESSIBILITY TO THE SITE

The project is located in a remote area of Arunachal Pradesh. Access to the state and the Dibbin project is from Assam. From the state capital of Guwahati (165 km distance, 417 km by road) the Dibbin site is accessed via Tezpur (95 km distance, 222 km by road). From Guwahati either national highway NH52 on the northern bank of the Brahmaputra via Mangaldai, Kharupetia and Orang or national highway NH 37 on the southern bank via Jorabat and Nowgoan can be used to reach Tezpur. Both roads are in good condition. From Tezpur a well maintained road leads via Balipara to Balukpong on the state border between Assam and Arunachal Pradesh.

From Balukpong the main road to Tawang leads via Sessa, Jamiri, Dahung and Tenga to a point just before Rupa where the road bears north and climbs rapidly to Bomdilla. Due to the strategic importance of the road – which serves the military encampments of Dahung and Tenga – it is well maintained by the Border Roads Authority. From Bomdilla the road to Tawang is followed to the so called “9 mile” point where a turn off leads towards the village of Salari. The main road to Tawang is maintained by the Border Roads Authority and is in generally good condition. From “9 mile” to Salari the road has recently been resurfaced and is good for light traffic. However as the road serves as access to the Bichom project as well as Dibbin the surfacing is not expected to hold up to heavy traffic. From Salari the road leads via Jerigoan to Nafra. Over most of this portion it is dirt, although upgrading and resurfacing by hand is in progress.

The town of Nafra is the main access point to the Dibbin hydroelectric project site, with the road leading south to Bichom and north to the village of Ditchik. From Nafra a narrow 9 km long dirt road leads to Ditchik. From Ditchik a 12 km road to the village of Dibbin is currently under construction by the Rural

Works Department. The road is being built to the Major District Road classification. From a point 2.3 km from Ditchik a 2.9 km road will need to be constructed to the powerhouse area and from Dibbin a serpentine 6.6 km road will need to be constructed to the dam site. It is proposed to join the dam site and the powerhouse site by a 4.5 km long new road, for easy access to the dam site and for access to the headrace alignment for construction adits. In addition the existing road from Nafra towards Nachibin will be extended by 2.5 km to allow access to borrow pits for fine aggregates.

1.7 PROJECT BACKGROUND

The project was originally identified in studies by the CWC and in 2003 it was selected as part of the Prime Ministers 50'000 MW scheme and allocated for further development to NEEPCO. A pre-feasibility study was prepared for NEEPCO by Premier Mott-Macdonald. NEEPCO were entrusted with the preparation of the DPR for Dibbin and awarded the work to Pöyry (previously Electrowatt). In January 2008, the State Government of Arunachal Pradesh invited expressions of interest from bidders for the implementation of the Dibbin Hydro Electric Project "*in the Private Sector/Joint Sector in Build, Own, Operate and Transfer basis (BOOT)*". A Memorandum of Agreement to develop the project has been signed between the State Government and KSK Electricity Financing India Private Limited (KSKEFIPL) of Hyderabad. KSKEFIPL has formed a company named KSK Dibbin Hydro Power Private Limited for implementation of the Project.

1.8 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The principal Environmental Regulatory Agency in India is the Ministry of Environment and Forests (MOEF), Government of India. MOEF formulates environmental policies and accords environmental clearance for the projects. The State Pollution Control Board (SPCB) accords No Objection Certificate (NOC) Consent for Establishment and consent for Operation for the projects. A Comprehensive Environmental Impact Assessment (CEIA) report is pre-requisite for such a clearance. The Comprehensive Environmental Study including Environmental Impact Assessment and Environmental Management Plan has been prepared by Water and Power Consultancy Services (India) Ltd. (WAPCOS), a Government of India Undertaking in the Ministry of Water Resources (MOWR).

As per EIA notification issued by Ministry of Environment and Forests in September 14, 2006, the proposed hydro-power project comes under category 'A'. For such projects, it is mandatory for the project proponent to get approved the TOR from Ministry of Environment and Forests, (MOEF), Government of India then the environmental clearance will be given by MOEF based on EIA (Environmental Impact Assessment) study of the project. The TOR was approved by MoEF vide their letter no. J-12011/93/2007-IAI, dated February 28, 2008. A copy of the TOR approved by MoEF is enclosed as **Annexure-I**.

1.7 SCOPE OF THE EIA STUDY

The brief scope of EIA study includes:

- Assessment of the existing status of physico-chemical, ecological and socio-economic aspects of environment
- Identification of potential impacts on various environmental components due to activities envisaged during construction and operation phases of the proposed hydro-electric project.
- Prediction of significant impacts on various aspects of environment.
- Delineation of Environmental Management Plan (EMP) outlining measures to minimize adverse impacts during construction and operational phases of the proposed project.
- Formulation of Resettlement and Rehabilitation (R&R) Plan.
- Formulation of Catchment Area Treatment (CAT) Plan.

- Formulation of environmental quality monitoring programmes for construction and operation phases.
- Estimation of Cost for implementation of Environmental Management Plan, Resettlement and Rehabilitation Plan, Catchment Area Treatment Plan and Environmental Monitoring Programme.

1.8 STAGES IN AN EIA STUDY

The purpose of this section is to enumerate the steps involved in an Environmental Impact Assessment (EIA) study, which are described in the following paragraphs.

Scoping: An exhaustive list of all likely impacts drawing information from as many sources as possible was prepared. The next step was to select a manageable number of attributes which were likely to be affected as a result of the proposed project. The various criteria applied for selection of the important impacts were follows:

- magnitude
- extent
- significance

Description of Environment: Before the start of the project, it is essential to ascertain the baseline levels of appropriate environmental parameters which could be significantly affected by the implementation of the project. The baseline status assessed as a part of CEIA study involved both field work and review of data collected from secondary sources.

Prediction of Impacts: is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the construction and operation of the proposed hydroelectric project. An attempt was generally made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters which cannot be quantified, general approach was to discuss such intangible impacts in quantitative terms so that planners and decision-makers are aware of their existence as well as their possible implications.

Environmental Management Plan: the approach for formulation of an Environmental Management Plan (EMP) is to maximize the positive environmental impacts and minimize the negative ones. The steps suggested include modifications of plans, engineering designs, construction schedules and techniques, as well as operational and management practices. After selection of suitable environmental mitigation measures, cost required for implementation of various management measures was also estimated.

Environmental Monitoring Programme: An Environmental Monitoring Programme for implementation during project construction and operation phases has been estimated to oversee the environmental safeguards, to ascertain the agreement between prediction and reality and to suggest remedial measures not foreseen during the planning stage but arising during operation and to generate data for further use.

1.9 OUTLINE OF THE REPORT

The document for the Comprehensive EIA study for the proposed Dibbin hydroelectric project has been presented in two volumes. Volume-I presents the Environmental Impact Assessment (EIA) study and Volume-II delineates the Environmental

Management Plan. The present document (Volume -I) outlines the findings of the EIA study for the proposed Dibbin hydroelectric project.

The contents of the document are organized as follows:

Chapter-1 The Chapter gives an overview of the need for the project. The policy, legal and administrative framework for environmental clearance has been summarized. The objectives and need for EIA study too have been covered.

Chapter-2 gives a brief description of the proposed Dibbin hydroelectric project.

Chapter-3 outlines the methodology adopted for conducting the Comprehensive EIA study for the proposed Dibbin hydroelectric project.

Chapter-4 covers the environmental baseline conditions covering physical aspects of environment. The baseline study involved both field work and review of existing documents, which is necessary for identification of data which may already have been collected for other purposes.

Chapter-5 presents the biological aspects of environment. The study is based on collection of data from various secondary data sources. As a part of the Comprehensive EIA study, detailed ecological survey was conducted for three seasons. The findings of the survey were analyzed and ecological characteristics of the study area have been described in this Chapter.

Chapter-6 covers pre-project environmental baseline conditions covering socio-economic aspects of environment. The baseline study involved data collection using primary as well as secondary sources of data and public consultation.

Chapter-7 describes the anticipated positive and negative impacts as a result of the construction and operation of the proposed hydro-power project. It is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of the construction and operation of the proposed project. An attempt was generally made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters, which cannot be quantified, general approach has been to discuss such intangible impacts in qualitative terms so that planners and decision-makers are aware of their existence as well as their possible implications.

CHAPTER-2

PROJECT DESCRIPTION

2.1 INTRODUCTION

The West Kameng district of Arunachal Pradesh is a mountainous tract in Arunachal Pradesh which covers an area of approximately 7422 Sq. Km. The altitudes of the district varies from 650' to 13714 ft. and lies approximately between 91° 30' to 92°40' East longitudes and 26° 54' to 28° 01' North latitudes. The district is surrounded by the Tibet region of China in the north, Bhutan in the west, Tawang district and East Kameng districts of Arunachal Pradesh are in the northwest and east respectively. The southern boundary adjoins Sonitpur District of Assam. The name of the district is derived from the Kameng River, a tributary of Brahmaputra that flows through this district. By a Government of India Notification of 1914, the area covered by this district, became a part of the 'Western Section' of the 'North East Frontier Tract' to which the entry of the British subject was regulated by an 'Inner Line' permit.

2.2 SITE DETAILS

The Dibbin Hydro Electric Project (Dibbin HEP) is situated in the foot hills of the Central Himalaya. This area is characterized by steep slopes. The minimum level in the project area is 974.6 m, the maximum 2'647.7 m and the mean level over the area considered is 1'616.7 m. The mean slope is 60.6%.

The vegetation is generally temperate forest and grassland with the exception of the Bichom river valley between the Dakhri Bru and Ditchi Bru which is characterized by extremely dense tropical rain forest.

The Bichom river and it's main tributary, the Ditch Bru are rapidly flowing steep rivers with an average slope between the dam and powerhouse of around 2.5%. The local geology of the project area is characterized by massive to schistose quartzitebiotite gneisses, augengneisses and occasional bands of quartzite (Bomdila Gneisses).

2.3 PROJECT DESCRIPTION

The dam site of the proposed Dibbin hydroelectric Project is located in the upper reach of river Bichom just downstream of confluence of Bichom Chu with Difya with its co-ordinates at 27°27'00"N and 92°31'16"E. The dam site is approachable through PWD road from Rupa upto Nafra and then a foot path of about 15 km up to Dibbin village. Power house site is located near Nachibin village with its co-ordinates at 27°24'42"N and 92°31'09"E. Nafra is connected to Rupa town by a PWD road. Up to Rupa town the road from Balipara is maintained by Border Roads Task Force (BRTF) of the Government of India. Balipara, in turn is connected to Tezpur on the National Highway No. 52. The nearest airport is at Tezpur located about 25 km from Balipara. The water conductor system shall comprise an intake channel, surface desilting chamber, a head race tunnel, a surge shaft, pressure shaft and penstocks.

The proposed project envisages construction of:

- A gated dam 92 m high located 1 km downstream of the confluence of Dakri Bru river with Bichom river. The length of the dam will be 165.8 m consisting of 54 m of overflow section and 111.8 m of non-overflow section.
- The reservoir upstream of dam will have gross and live storage of 7.085 Mm³ and 7.04 Mm³.
- A spillway with 3 bays of 12.0 m width each and controlled by 3 nos. radial gates each of size 12 m x 15.53 m. Crest elevation of spillway shall be 1206.0 m.
- A head race tunnel (HRT) 5.5 m diameter and 3.97 km long.
- A surge shaft at the outlet of the head race tunnel 2.4 m diameter and 102.5 m height.
- A surface power house located 250 m upstream of confluence of Bichom Bru and Debra Bru having installation of 2 units of 60 MW each with Francis type turbine designed for a net head of 158 m. The maximum flow through each turbine shall be 44.5 cumecs.
- A tail race tunnel/channel of 150 m length to discharge the tail water of Dibbin HE project into Ditch Bru

The salient features of the project are given in **Table-2.1** and layout plan shown in **Figure-2.1**.

TABLE-2.1**SALIENT FEATURES OF DIBBIN HYDROELECTRIC PROJECT**

| | |
|-----------------------------------------------|---------------------------------------------------------------|
| LOCATION | |
| State | Arunachal Pradesh |
| Districat | West Kameng |
| Tehsil | Nafra |
| River | Bichomchu, tributary of Kameng river, Dokri Bru, Difya Nalla |
| Location of dam | |
| Longitude | 92° 30' 58" E |
| Latitude | 27° 26' 49" N |
| Access to the project | By road from Tezpur (Assam) via Balipara, Bhalukpong and Rupa |
| Nearest Rail head | Bhalukpong |
| Airport | Tezpur |
| HYDROLOGY | |
| Catchment area intercepted at Dam Site | 630 sq.km |
| Average Annual discharge at dam site | 39.6 cumec |
| Average annual rainfall | 2800 mm |
| Specific runoff | 1975 mm/year |
| Probable Maximum Flood | 7300 cumec |
| DAM | |
| Type | Concrete gravity dam |
| Maximum Height above deepest foundation level | 92.0 m |
| Elevation at top of dam | 1223 m |
| River Bed Level | 1158 m |
| Total length at crest | 165.8 m |
| Reservoir | |
| Full reservoir level (FRL) | 1220.0 m |
| Free board (m) | 3.0 to FSL |
| Minimum Draw down level (MDDL) | 1218.0 m |
| Gross storage capacity | 7.085 Mm ³ |
| Live storage capacity | 7.040 Mm ³ |
| Dead storage capacity | 0.045 Mm ³ |
| SPILLWAY | |
| Type | Gated overflow |
| Discharge capacity | 7380 cumec |
| Bay Width | 12 m |
| No. of bays | 3 bays |
| Crest level of spillway | 1206 m |
| SUBMERGENCE | |
| a) (i) Forest land | 33.6 ha |

| | |
|------------------------------------------------|-----------------------------------|
| (ii) Cultivable land | 0 |
| (iii) Other land | 0 |
| Total | 33.6 ha |
| b) No. of villages affected | Nil |
| Fully affected | Nil |
| Partially affected | Nil |
| c) No. of persons/families to be rehabilitated | Nil |
| HEAD RACE TUNNEL | |
| Size (Diameter) | 5.5 m |
| Shape | Circular |
| Velocity | 3.6 m/sec |
| Length | 3970 m |
| SURGE SHAFT | |
| Diameter | Shaft : 2.4, Tank : 11.5 m |
| Height | Shaft: 102.5m, Tank : 71.5 m |
| Top Elevation | 1261.5 m |
| Bottom Elevation | 1081.0 m |
| POWER HOUSE | |
| Installed Capacity | 120 MW |
| Units | 2 x 60 MW |
| Type of Turbine | Francis |
| Design net head | 158 m |
| Design energy (GWh/year) | 370.5 |
| Mean energy (GWh/year) | 449.8 |
| TAIL RACE TUNNEL | |
| Size (m) | 20 |
| Length (m) | 150 |
| FINANCIAL ASPECTS | |
| Total Project Cost | Rs. 767.10 crores (including IDC) |
| Tariff for 1 st year | Rs. 5.44 per kWh |
| Levelised tariff | Rs. 4.45/kWh |

2.5 INFRASTRUCTURE

Access Roads

The main access road for tunnel construction and for access to the dam site will be a new constructed road close to the river. It will closely pass the power house site and continue to the adit for the tunnel and than to the dam site, the quarry site, batching site, contractor camp after which it will loop back to climb the steep left flank of the valley to reach the village Dibbin. From this road the installation work of Adit 1, 2 and 3 will be done. The road construction can be divided in two sections:

- Upgrading of existing road Length: 7.5 Km
- New road permanent construction Length: 14 Km
- New road temporary construction Length: 2.5 Km

Road classification Major District Road, (hill road)

- Right of way, mountainous and steep terrain, open areas 18 m
- Right of way, mountainous and steep terrain, built up areas 15 m
- Carriageway width (hill road) 3.75 m (used 3.8 m)
- Shoulder width (hill road) 2x0.5
- Roadway or formation width (hill road) 4.75 m (used 4.8 m)
- Parapet width (valley side) 0.6 m
- Side drain width (hill side) 0.6 m
- Total roadway width 6.0 m
- Terrain classification (cross slope greater than 60%) Steep
- Ruling gradient 1 in 17, 5.9%
- Limiting gradient 1 in 15, 6.7%
- Exceptional gradient 1 in 12, 8.3%
- Design speed 20 to 30 km/h
- Minimum radius, ruling (hill road) 30 m
- Minimum radius, absolute (hill road) 14 m
- Minimum vertical radius 105 m
- Minimum length of vertical radius 10 m

Extensive networks of temporary access roads sites will have to be constructed at the power house site and the dam site, in order to facilitate good access of construction sites, stockpiles, spoil areas etc.

Temporary access at the Dam site to the left river bank of the river requires temporary bridges or cableways. During the construction of the diversion tunnel on the left river bank temporary steel bridges are proposed to reach the left river bank for excavation of the left river slope and the construction of the diversion tunnel. In the following wet season no heavy machinery is needed on the left river bank. After this wet season the first activity will be the construction of the cofferdams, which will also be used to cross the river. However, this access will not be usable during high floods in following wet seasons of the construction period, when the cofferdams will be overtopped. During this period cableways or derricks have to be installed.

Site Installations

The very highly mechanized works and the site management require some general installation on both construction sites. The following site installations are planned at the Power House and Dam site:

- Workshops
- Warehouse
- Office
- Campsite
- Transmission lines
- Water and compressed air systems

Temporary Construction Camp at Nafra

The general access to the project region is difficult and delays in the transport of the construction equipment can not be excluded. To ensure that all construction equipment will be available on site at time, a temporary camp near to the town Nafra is proposed. In this way the contractor can start with the transport of all necessary construction equipment simultaneously with the beginning of the road construction. After the construction camps at the power house and dam site will be installed, the equipment can be shifted to these sites and the temporary construction camp at Nafra will be dismantled.

Site Installations at Dam Site

Due to the steep terrain around the Bichom valley at the proposed dam site only essential site installations are planned in the immediate vicinity of the working area. All other installations, as well as camps and associated facilities, will have to be constructed around 700 meters upstream of the dam site. There is adequate area which is not too steep and elevated, which is not liable to inundation at times when the Bichom is in flood. For the site installations in total three months are planned. This work will start immediately after the road reaches the Dam site.

Site Installations at Power House Site

Compared to the Dam site there is much more space for site installation available at the power house site. The construction camp as well as installation necessary for the concrete will be installed in close proximity to the power house construction site. Excavation material will be used for temporary dam along the river for flood protection and as fill under the switchyard area. For the site installations two months are scheduled.

River Diversion Works

The construction program is highly dependable from the wet and dry season. To ensure a fast construction progress at the dam site a diversion scheme was selected which allows year round construction. The predominant trend in diversion arrangements for concrete dams, consists of reducing the purpose-built diversion works to a minimum by passing some of the flow through or over the dam while, it is being built. Because of the high flood peaks during the rainy season and the low flood peaks during the dry season a combined diversion scheme is the ideal arrangement to reduce costs and ensure a fast construction progress. During the dry season the flow will be diverted through the diversion tunnel. During one wet season the river flow will be diverted through the channel along the transversal dam axis.

CHAPTER-3

METHODOLOGY ADOPTED FOR THE CEIA STUDY

3.2 GENERAL

The EIA Study is based on collection of relevant data from primary and secondary sources on environmental and baseline parameters. The parameters include meteorology, water quality, soil quality, geology, seismicity, noise level, land use pattern, terrestrial & aquatic ecology, socio-economic aspects, etc. Based on the baseline setting and input loads due to the proposed hydroelectric project, impacts on various facets of environment due to the project have been predicted. Environmental

management measures have been recommended for amelioration of negative impacts. Environmental monitoring programme has been for monitoring of critical environmental parameters during project construction and operation phases. The cost estimates for implementation of Environmental Management Plan (EMP) and Environmental Monitoring Programme has also been suggested. This Chapter describes the methodology adopted for conducting EIA study.

The study area considered for the CEIA study is given as below:

- Submergence area
- Area within 10 km of the periphery of the submergence area
- Area to be acquired for siting of various project appurtenances.
- Area within 10 km of various project appurtenances
- Catchment area intercepted at the barrage site

The study area is shown in **Figure-3.1**.

3.2 SCOPING MATRIX

Scoping Matrix is a tool which gives direction for selection of impacts due to the project activities on the environment. An appropriate 'Scoping' matrix derived from the existing environmental scenario vis-à-vis construction and operation activities is given in **Table-3.1**.

TABLE-3.1
Scoping Matrix adopted for the proposed EIA study

| Aspects of Environment | Likely Impacts |
|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Land Environment | |
| Construction phase | <ul style="list-style-type: none"> • Increase in soil erosion • Pollution by construction spoils • Acquisition of land for labour colonies • Solid waste from labour colonies |
| Operation phase | <ul style="list-style-type: none"> • Acquisition of land for various project appurtenances |
| Water resources & water quality | |
| Construction phase | <ul style="list-style-type: none"> • Increase in turbidity of nearby receiving water bodies • Degradation of water quality due to disposal of wastes from labour colony and construction sites |
| Operation phase | <ul style="list-style-type: none"> • Disruption of hydraulic regime • Sedimentation & siltation risks • Impacts on D.O. due to reservoir stratification • Risk of eutrophication |

| Aspects of Environment | Likely Impacts |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Aquatic Ecology | |
| Construction phase | <ul style="list-style-type: none"> • Increased pressure on aquatic ecology as a result of indiscriminate fishing. • Reduced productivity due to increase in turbidity |
| Operation phase | <ul style="list-style-type: none"> • Impacts on migratory fish species • Impacts on spawning & breeding grounds • Degradation of riverine ecology • Increased potential for reservoir Fisheries |
| Terrestrial Ecology | |
| Construction phase | <ul style="list-style-type: none"> • Increased pressure from labour to meet their fuel wood & timber requirements • Adverse impacts due to increased accessibility of the area |
| Operation phase | <ul style="list-style-type: none"> • Impacts on wildlife movement |
| Socio-Economic Aspects | |
| Construction phase | <ul style="list-style-type: none"> • Improved employment potential during the project construction phase • Development of allied sectors leading to greater employment • Pressure on existing infrastructural facilities • Friction between the labour and the native population |
| Operation phase | <ul style="list-style-type: none"> • Loss of lands • Loss of private properties • Impacts on mineral reserves • Increased revenue from power generation |

Based on the scoping matrix, the environmental baseline data has been collected. The project details have been superimposed on environmental baseline conditions to understand the beneficial and deleterious impacts due to the construction and operation of the proposed project.

3.3 ENVIRONMENTAL BASELINE STUDY

The data on various aspects has been collected to understand the environmental setting of the proposed project site. The basic parameters on which data has been collected are discussed in the foregoing paragraphs.

3.3.1 Physical Resources Aspects

Meteorology

Meteorological factors like precipitation, temperature and evapo-transpiration are important, as they have a profound impact on the water availability, cropping pattern, irrigation and drainage practices, soil erosion and public health, etc. The data for the Bomdila station for various meteorological aspects was collected and has been appropriately utilized in the Comprehensive EIA Report.

Water Resources

Hydrological data for river Bichom Chu as available in the Feasibility Report was collected and suitably incorporated in the EIA study.

Water Quality

The existing data on water quality has been collected to:

- assess the quantitative and qualitative nature of effluent discharges to the river.
- evaluate river water quality on upstream and downstream of the project site.

The water samples were collected from the study area and analyzed for physico-chemical parameters which are given in **Table 3.2**. The sampling has been conducted for three seasons listed as below:

- Winter season : January 2006
- Summer season : April 2006
- Post-monsoon season : October 2007

TABLE-3.2

List of water quality parameters analyzed as a part of the field study

| | |
|----------------|------------------------------|
| pH | Total Dissolved Solids (TDS) |
| Chlorides | Iron |
| Total Hardness | Zinc |
| Nitrates | Cadmium |
| Sulphates | Copper |
| Fluorides | Lead |
| Sodium | Dissolved Oxygen |
| Magnesium | BOD |
| Calcium | COD |
| Potassium | Oil & Grease |
| Manganese | Total coliform |
| Phosphates | Mercury |

Ambient air quality

In order to assess the existing status of air quality an ambient air quality monitoring was done at two locations in the project area. The monitoring stations are located at villages Dibbin and Ditchik. The monitoring was done for three seasons namely winter season (January-February 2006), summer season (April-May 2006) and post-monsoon season (October 2007). The frequency of monitoring was twice a week for four consecutive weeks. The parameters studied were SPM, RPM, SO₂ and NO_x.

Noise Environment

Baseline noise data has been measured using a weighted sound pressure level meter. The survey was carried out in calm surrounding. Sound Pressure Level (SPL) measurement in the outside environment was made using sound pressure level meter. Hourly noise meter readings were taken at different sites, after which day time equivalent noise level was monitored. The monitoring was conducted for three seasons namely, winter (January 2006), summer (April 2006) and post-monsoon (October 2007).

Land use pattern

Land use pattern in the vicinity of the study area including project area and the entire catchment area has been assessed based on satellite data. Digital Satellite imageries (IRS 1D) for the study area have been procured from National Remote Sensing Agency (NRSA), Hyderabad and processed in-house at WAPCOS using IRDAS Imagine software. Based on the remote sensing data and ground truth verification studies, the land use maps of the study area and the entire catchment area have been prepared.

Soil Quality

Soil samples were collected from various locations in the project area as a part of the EIA study, which were then analyzed for various physico-chemical parameters. The sampling was conducted for three seasons namely winter season (January 2006), summer season (April 2006) and post-monsoon season (October 2007). The parameters monitored are listed in **Table-3.3**.

TABLE-3.3
List of soil quality parameters monitored

| | |
|----------------------|-------------------------|
| pH | Electrical Conductivity |
| Available Potassium | Available Nitrogen |
| Available Phosphates | Organic Matter |

3.3.2 Ecological Aspects

Terrestrial Ecology

Data on the forest types, legal status and their extent in the catchment and the study areas has been collected from Forest Department. The other relevant data on bio-diversity, economically important, species, medicinal plants, rare and endangered species in the project area and its surrounding has been collected from various Research Institutes in the region and other sources of secondary data.

In addition, sample survey was also conducted in the study area. The sampling sites were selected based on the topography and floristic composition. The various aspects studied were floral density, frequency and abundance of each species of trees, shrubs, herbs and grasses etc. Plants of economical and medicinal uses and endangered species were also identified. The sampling was conducted for three seasons namely winter season (January 2006), summer season (May 2006) and post-monsoon season (October 2007).

During field survey, a list of wild animals was also prepared through visual observations, pug marks and from local enquiry. The secondary data as available from the Forest department was also collected and used to prepare an inventory of faunal species in the study area. The information as available on wildlife habitats, migratory routes, etc. was also collected as a part of the study.

Aquatic Ecology

Water resources projects have beneficial as well as adverse impacts on fish production. The data on the prevailing fish species in the river Bichom Chu was collected from Fisheries Department and through literature review as well. Fishing was done at various sites in the project area and river stretches both upstream and downstream of the project site to ascertain the disposal pattern of fish species. Identification and measurements of all the fish catch was done and an inventory of the fish species was also prepared. Various migratory species and the species to be affected due to conversion of lentic to lotic conditions as a result of commissioning of the proposed project were also identified.

Water samples from river Bichom were also collected as a part of field studies. The density and diversity of phytoplanktons, zooplanktons, their species diversity index and primary productivity, etc. were also studied. The sampling was conducted for three seasons namely winter season (January 2006), summer season (May 2006) and post-monsoon season (October 2007).

3.3.3 Human Resources and Quality of Life values

Demographic Characteristics

The demographic and socio-economic characteristics of the submergence area were studied through a detailed socio-economic survey. The basic aim of the survey was to understand the socio-economic status of the population residing in the project affected area. All the Project affected families were covered during the survey which was conducted in the month of March 2006. The field investigators were recruited and trained for the survey. Two separate interview schedules were utilized for collecting the village level and household level information. Interview schedules were prepared and pre-tested. The project affected families were interviewed by interacting individually with head of families. In addition to this village level information was also obtained through separate interview schedule.

Infrastructure Facilities

The present status of infrastructural facilities, status and availability of electricity, drinking water, communication and mode of transportation, commercial, educational and health facilities, veterinary services, etc. were collected during the socio-economic survey.

Public Health

Development of water resources could have both beneficial and adverse effects on the health of the people in and around the project area. In order to assess the existing status of Public health, the following data on public health status has been collected:

- prevalent vectors in the area
- prevalence of malaria and other water and vector-borne diseases in the area

3.4 PREDICTION OF IMPACTS

Prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur because of implementation of the project. Impact of project activities has been predicted using mathematical models and overlay technique (super-imposition of activity on environmental parameter). Intangible impacts were predicted by comprising similar type of projects executed in the State of Arunachal Pradesh. The environmental impacts predicted are as follows:

- Loss of cultivable land (including Jhum land) and forests.
- Impacts on land use pattern.
- Displacement of population due to acquisition of private and community properties.
- Disruption of hydraulic regime.
- Impacts on water quality.
- Increase in incidence of water-related diseases.
- Effect on riverine fisheries including migratory fish species.
- Environmental degradation during project construction phase.

3.5 ENVIRONMENTAL MANAGEMENT PLAN AND COST ESTIMATES

Based on the environmental baseline conditions and project inputs, the adverse impacts were identified and a set of measures have been suggested as a part of Environmental Management Plan (EMP) for their amelioration.

The management measures have been suggested for the following aspects:

- Rehabilitation and Resettlement Plan for Project Affected Families (PAFs).
- Prevention of environmental degradation during construction phase.
- Maintenance of water quality.
- Compensatory afforestation.
- Wildlife conservation.
- Control of water-related diseases.
- Air pollution control.
- Stabilization of quarry sites.
- Restoration of muck disposal and construction areas.
- Sustenance and enhancement of fisheries potential.
- Greenbelt development.
- Roadside plantation.
- Control measures for Jhum cultivation.

The expenditure required for implementation of R&R Plan, CAT Plan and EMP has also been estimated.

3.6 CATCHMENT AREA TREATMENT

A treatment plan has been suggested for the catchment area intercepted at the dam site. The following aspects were covered as a part of the study:

- study of land use pattern of the directly draining catchment area under land use / land cover category using the satellite data.
- based on the land use pattern and integration of thematic map, the catchment area would be delineated as per the severity of the soil erosion rates.
- suggestion of measures for sub-watersheds categorized as having very high and high erosion as per Silt Yield Index method.
- formulation of cost estimates for the CAT Plan.

3.7 DISASTER MANAGEMENT PLAN

The Disaster Management Plan (DMP) to cater for the exigencies in case of a dam break has been suggested. It outlines the actions to be taken in the event of a dam break.

3.8 ENVIRONMENTAL MONITORING PROGRAMME

It is necessary to continue monitoring of certain parameters to verify the adequacy of EMP and to assess the implementation of mitigative measures. An environmental monitoring programme for critical parameters has been suggested for implementation during project construction and operation phases. The staff, necessary equipments and agencies at state level for the implementation of this programme and costs have also been indicated.

CHAPTER-4

BASELINE SETTING FOR PHYSICO-CHEMICAL ASPECTS

4.1 GENERAL

Before start of any Environmental Impact Assessment study, it is necessary to identify the baseline levels of relevant environmental parameters which are likely to be affected as a result of the construction and operation of the proposed project. A similar approach has been adopted for conducting the EIA study for the proposed Dibbin hydroelectric Project. A Scoping Matrix as outlined in Chapter-3 was formulated to identify various issues likely to be affected as a result of the proposed project. Based on the specific inputs likely to accrue in the proposed project, aspects to be covered in the EIA study were identified. The other issues as outlined in the Scoping Matrix were then discarded. Thus, planning of baseline survey commenced with the short listing of impacts and identification of parameters for which the data needs to be collected.

The baseline status has been divided into following three categories:

- Physico-chemical aspects

- Ecological aspects
- Socio-Economic aspects

The baseline setting for physico-chemical aspects have been covered in this Chapter.

4.2 METEOROLOGY

Pre-monsoon

In the region of the East-Himalaya it is not until the end of March that the first pre monsoon precipitation, mostly in form of thunderstorms, sets in. The months of April and May are characterized with thundershowers.

Summer-monsoon

The onset of the summer-monsoon in northeast India lies normally between the 30th of May and the 5th of June. The southern trade winds cross the equator and move towards the extreme low-pressure region in Northern India and turn into the southwest monsoon, also known as the summer-monsoon.

Post-monsoon

In September the influence of the summer-monsoon begins to decrease. In northern India a withdrawal of the monsoon-troughs sets in suddenly and the weather becomes clearer. During the post-monsoon season the temperatures decline noticeably. The precipitation activity also declines perceptibly. This time of the year is generally the most pleasant season due to the stable weather condition and the warm climate. In the mornings the valleys are filled with dense fog, but in higher reaches the sky is very clear.

Winter-monsoon

In the northeast Indian mountain range the winter is naturally more severe and characterized by lower temperatures (but without significant snowfall). Precipitation only occurs in conjunction with western disturbances (flat low-pressure areas). From February the temperatures begin to rise slowly again.

Temperature

The temperature in the project area varies with altitude. At higher altitudes, the temperature in the winter months goes even below the freezing point. The temperature rises gradually after February, and the month of August is the hottest month of the year, with mean maximum temperature of 23°C. The temperature under monsoon season is slightly warmer than the summer season lasting from March to May. The temperature begins to drop in the Monsoon months. The month of January is the coolest month with the mean minimum temperature dropping up to 1°C. The average maximum and minimum temperatures at Bomdila monitoring station are 17.71°C and 7.91°C respectively. The month wise variations in maximum and minimum temperatures are shown in **Figure-4.1**.

Rainfall

The annual average rainfall in the catchment area is of the order of 200 mm. A major portion of the rainfall is received under the influence of south-west monsoons during the months from April to October. The months of June and July contribute most of the rainfall. Western disturbances pass across or near the region from west to east from November to March. In association with these disturbances, precipitation is received at lower elevations and snowfall at higher elevations. The rainfall as received in various months of the year are shown in **Figure-4.2**.

Humidity

Humidity is high throughout the year. The relative humidity is close to 90% during monsoon months. However, during the other months of the year, humidity is marginally lower as it ranges from about 82 to 84%. The month wise humidity variations are shown in **Figure-4.3**.

Cloud Cover

During winter months, morning sky remains often obscured due to lifted fog, which withers away as the day advances. During the period from March to May, the sky generally becomes moderately clouded. Heavy cloud cover is occasionally observed. During monsoon months from June to mid-October when the hills and ridges are enveloped in cloud, generally heavy cloud cover is observed. Clear or lightly clouded skies are a common climatic feature of the Monsoon season. However, during the north-east monsoon months too, heavily clouded and overcast conditions prevail.

Special Weather Phenomena

The cyclonic storms originating from the Bay of Bengal sometimes on their way to upper Assam, affect the project area. Thunderstorms occur between February and June. Those occurring between March to May are similar to the north-westers of Bengal, and are violent. Fog appears frequently in the valleys in the monsoon and winter months.

The average meteorological conditions in the project area are summarized in **Table-4.1**.

TABLE-4.1
Average meteorological conditions in the project area

| Month | Temperature (°C) | | Rainfall (mm) | Relative Humidity (%) |
|----------|------------------|---------|---------------|-----------------------|
| | Maximum | Minimum | | |
| January | 11.27 | 1.18 | 27.9 | 84.24 |
| February | 12.04 | 2.0 | 28.5 | 83.63 |
| March | 15.42 | 4.66 | 39.5 | 83.14 |
| April | 18.19 | 7.35 | 217.8 | 83.9 |
| May | 20.128 | 10.32 | 148.7 | 87.31 |
| June | 21.17 | 12.31 | 469.9 | 89.08 |
| July | 22.44 | 13.73 | 421.3 | 88.46 |

| Month | Temperature (°C) | | Rainfall (mm) | Relative Humidity (%) |
|----------------|------------------|-------------|---------------|-----------------------|
| | Maximum | Minimum | | |
| August | 23.14 | 13.75 | 262.6 | 88.01 |
| September | 22.03 | 12.82 | 127.9 | 89.58 |
| October | 18.53 | 9.44 | 213.7 | 88.81 |
| November | 15.09 | 4.91 | 10.8 | 83.65 |
| December | 12.86 | 2.39 | 17.5 | 82.36 |
| Average | 17.71 | 7.91 | 165.51 | 86.01 |
| Total | | | 1986.1 | |

Source: Socio-Economic Review of West Kameng District 2003

4.3 PHYSIOGRAPHY

Physiographically Kameng district is categorized into three broad divisions viz.:

- Siwalik Sub-Himalayan tract, rising from Assam plains to the hilly ranges which trend in east-west to east-northeast - west-southwest, and rising about 1500 m.
- The Lesser Himalayan ranges occurring centrally trend almost-in east-west direction to the south of Tenga valley, the outermost ridges of Lesser Himalayas attain an altitude of 3000 mts. Eastwardly, these ranges maintain their identity with a slight north easterly swerve while westward these merge with almost north-south water divide bordering Bhutan. North of Diggin valley most of the ridges have N-S to NE-SW trend and finally merge with Higher Himalayan elements.
- Great Himalayan range forming the northern most part of the district rising through Sela top (4500 m) and having well known peaks like Gorichin (7000 m) and Kangte (7700 m).

The proposed project is located in the sub-Himalayan zone in Arunachal Pradesh. The topography of the area around the proposed project is rugged with high hills and deep valleys. Major rivers of the area include Bhareli, Tenga, and Papu. Bichom River joins Bhareli River.

4.4 GEOLOGY

Regional Geology

Tentative geological succession in the Kameng district established by various workers including Jain and Basu Roy (1980) and Kaura and Basu Roy (1981) is as follows:

| | |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Siwalik Group | <p>Massive brownish grey sand rock, shaly sandstone and intercalated Clay bands and pebble beds</p> <p>----- Tectonic Contact -----</p> <p>Reddish brown friable sandstone with thin bands of shale, micaceous sandstone and pebbly sandstone</p> <p>-----</p> |
| Kimi Beds | <p>Grey to chocolate colored sandstone, shale with minor band or iron leached trap.</p> |

| | |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gondwana | Fine to coarse grained, brownish grey to black and white sandstone, Carbonaceous shale and slate with plant fossils ----- Tectonic Contact ----- |
| Bichom Group | Unit B – Slates, phyllites, quartzites and minor limestone bands Unit A – Diamictite of various colours, minor limestone bands, slates with cherty nodules and conglomerate ----- Tectonic Contact ----- |
| Tenga Group | Phyllite, quartzite and biotite schist ----- Tectonic Contact ----- |
| Bomdilla Group | Dirang Fm. – Schist and quartzite Bomdila Gneiss – Augen gneiss, quartz-biotite gneiss with occasional bands of quartzite ----- Tectonic Contact ----- |
| Sela Group | Non foliated granite, pegmatite, amphibolite, migmatite, etc. ----- |

Geology of the Project Area

The rocks exposed around the project area are those belonging to Bomdila Group comprising augen gneiss, quartz-biotite gneiss, schist and quartzite. The Bomdila Group has a tectonic contact with the underlying Seta Group and the overlying Tenga Group of rocks.

The project site exposes augen gneiss, quartz-biotite gneiss with occasional bands of quartzite belonging to the Bomdila Gneiss and schist and quartzite belonging to the Dirang Formation of Bomdila Group. The dam site is located within the augen gneiss, quartz-biotite gneiss with occasional bands of quartzite belonging to the Bomdila Gneiss.

The water conductor system is expected to encounter augen gneiss, quartz-biotite gneiss with occasional bands of quartzite in the initial reaches and schist and quartzite belonging to the Dirang Formation in major portion of its alignment.

The proposed powerhouse is located on left bank of Ditchi Bru near its confluence with Bichom Chu. This area also exposes augen gneisses and quartz-biotite gneiss belonging to the Bomdila Gneiss.

4.8 SEISMICITY

The proposed Dibbin Hydro-Electric Project lies within Eastern Himalayas, which are seismically very active. The area is located in Zone V as per the seismic zoning map of India. The region has a history of occurrence of earth quakes having magnitude greater than 6 on Richter scale. In recent past, number of major earthquakes have occurred in the region. Severe damage took place as a result of Assam earthquake of 1897, Srimangal earthquake of 1908, Dhabri earthquake of 1930 and Great Assam earthquake of 1950. All these earthquakes were of magnitude of about 8 or above on Richter scale.

A list of epicentre of earthquakes of magnitude more than 6 on the Richter scale in the North-eastern India is listed in **Table-4.2**. The location of epicenters of these earthquakes is shown in **Figure-4.4**.

TABLE-4.2
Details of earthquakes of magnitude more than 6 (on Richter Scale)
felt in the North-eastern India

| Date and Year | Epicentral location | Magnitude |
|----------------|--------------------------------------------------------|--------------------|
| Jan. 10, 1869 | Cachar | 7.5 |
| Jan.12, 1897 | Great Assam Earthquake. Epicentre near Shillong. | 8.7 |
| Aug. 31, 1906 | 27° N : 97° E | 7.0 (Depth 120 km) |
| Dec. , 1908 | 26°5'N : 97° E | 7.6 |
| July 8, 1918 | 24.5°N : 91°E (Near Srinangal) | 7.6 |
| Sep. 9, 1923 | 25.5°N : 91°E | 7.1 |
| July 3, 1930 | 25.8°N : 90.2°E (Near Dhubri) | 7.1 |
| Jan. 27, 1931 | 25.6° N : 96.8°E | 7.6 |
| Aug. 14, 1932 | 26°N : 95.5°E | 7.0 (Depth 120 km) |
| Jan. 2, 1934 | 24.5°N : 95°E | 6.5 (Depth 130 km) |
| Aug. 16, 1938 | 23.5°N : 94.5°E | 7.2 |
| May 27, 1939 | 24.5°N : 94°E | 6.5 (Depth 75 km) |
| Jan. 21, 1941 | 27.5°N : 92.5°Es | |
| Oct. 23, 1943 | 26°N : 93°E | 7.2 |
| Sept. 12, 1946 | 23.5°N: 90°E | 7.5 |
| July 29, 1947 | 28.5°N : 94°E | 7.75 |
| Aug. 15, 1950 | Near Arunachal Pradesh Tibet border 28.5°N : 96.7°E | 8.6 |
| March 21, 1954 | 24.4°N : 94°E (Manipur-Burma border) | 7-7.25 |
| Feb. 18, 1968 | 25°N : 94°E | 6.2 |
| July 29, 1970 | 26.1°N : 94.4°E | 6.5 |
| June 7, 2000 | 26.8°N : 97.2°E | 6.5 |

Source: Indian Meteorological Department (IMD).

The studied area is a part of a complex tectonic province displaying juxtaposition of two Tertiary mobile belts: the E-W trending Himalayas and the N-S trending Arakan Yoma belt developed as a consequence of collision between the Indian and the Eurasian plates and the subduction of the Indian plate below the Burma plate. The Archaean-Proterozoic cratonic elements are active along these belts.

In the north, the Himalayan belt is represented by the crystalline complexes and the folded cover sequences of the Lesser Himalayas and the frontal belt of the Siwalik. All these tectonic units are separated from each other by trust planes visualized in the Main Central Trust (MCT), Main Boundary Thrust (MBT) and their subsidiary thrusts.

The different tectonic domains present in this area exhibit different seismicity clusters, trends and blocs. Parts of Arunachal Himalayas in the north are active with high magnitude (>5.0) earthquakes mostly concentrated towards east. Though most Himalayan earthquakes have shallow foci (0-40 km), there

are few events with focal depth in the range of 41-70 km. Usually these are similar to thrust or strike slip fault mechanism. The region, being location for shallow foci earthquakes resulting from load adjustment of various thrust zones, is exposed to intermediate earthquakes activities. On 08.11.2005 at around 7.30 pm, a shock with magnitude of 4.6 was felt in Nafra area. Such earthquakes have been interpreted as neotectonic activities resulting from the release of stress in the process of arrangement during post-Himalayan orogenic phase.

Recently, a probabilistic seismic hazard analysis of Northeast India has been carried out, which resulted in seismic hazard maps in terms of the pseudo-spectral acceleration (PSA). These maps are obtained in terms of PSA (in g) contours for 50% confidence level and an exposure period of 100 years. The contours are broadly consistent with the major seismotectonic features in the region. So the average trend of the past seismicity can be considered to represent the future trend with good confidence. Therefore, keeping in view of this incident, the seismotectonic set up of this area (presently classified as Zone-V by the Geological Survey of India) should be taken into consideration for structural design of the Dibbin HEP.

4.9 SOILS

The soil quality in the project area varies with topography. Generally, soil is loose, sandy loam or sandy loam mixed with pebbles. In the region up to elevation of 700-800 msl, the soil texture varies from sandy to loamy and the land is suitable for growing paddy, maize, millet, vegetables, tropical and sub-tropical fruits. Rabi cereals can also be cultivated in this area. At higher altitudes, the soil varies from loamy to clayey with a thick layer of humus at the top. Thick humus is found in areas, which are covered with evergreen forests, whereas the areas with scanty vegetation are having only a few centimeters of topsoil over pebbles and rocks.

The Consultant collected soil samples from various locations in the project area as a part of the EIA study, which were then analyzed for various physico-chemical parameters. The sampling was conducted for three seasons namely winter season (January 2006), summer season (April 2006) and Monsoon season (October 2007). The results of the physico-chemical analysis are tabulated in **Table-4.3**. The soil sampling locations are given in **Figure-4.5**.

TABLE-4.3
Physico-chemical analysis of soil samples

| Size distribution | Sampling Location | | | | |
|------------------------------|-------------------|-----|-----|-----|-----|
| | S1 | S2 | S3 | S4 | S5 |
| Winter season | | | | | |
| pH | 7.3 | 7.1 | 7.2 | 7.1 | 8.0 |
| Conductivity (micro-mhos/cm) | 124 | 236 | 145 | 121 | 136 |
| Potassium, kg/ha | 97 | 115 | 137 | 145 | 166 |
| Available Nitrogen | 215 | 264 | 268 | 272 | 256 |
| Available Phosphates | 9 | 7 | 8 | 6 | 13 |
| Organic matter, % | 0.5 | 0.4 | 0.6 | 0.5 | 0.7 |
| Summer season | | | | | |

| | | | | | |
|------------------------------|-----|-----|-----|-----|-----|
| pH | 7.1 | 7.0 | 7.1 | 7.0 | 7.9 |
| Conductivity (micro-mhos/cm) | 120 | 240 | 105 | 115 | 126 |
| Potassium, kg/ha | 90 | 101 | 139 | 146 | 170 |
| Available Nitrogen | 256 | 216 | 272 | 270 | 247 |
| Available Phosphates | 8 | 8 | 8 | 7 | 14 |
| Organic matter, % | 0.5 | 0.6 | 0.7 | 0.5 | 0.6 |
| Monsoon season | | | | | |
| pH | 7.1 | 7.2 | 7.0 | 7.2 | 7.9 |
| Conductivity (micro-mhos/cm) | 118 | 226 | 102 | 113 | 127 |
| Potassium, kg/ha | 88 | 98 | 135 | 148 | 172 |
| Available Nitrogen | 254 | 213 | 270 | 270 | 248 |
| Available Phosphates | 8 | 7 | 7 | 8 | 14 |
| Organic matter, % | 0.5 | 0.5 | 0.6 | 0.5 | 0.5 |

Note:

- S1 – About 2 km upstream of proposed dam
- S2 – About 1 km upstream of proposed dam
- S3 – About 500 m upstream of proposed dam
- S4 – Near proposed dam site
- S5 – Near proposed power house site

The pH of the soil is in neutral range. The low EC values indicate low salt content. The levels of nutrients indicate that the soil has low to moderate productivity. The continuous washout of nutrients along with runoff as a result of high precipitation and steep slopes can be attributed for this phenomenon.

4.10 WATER RESOURCES

The Dibbin basin is a sub-catchment of the Bichom catchment. The catchment area at the proposed dam site is 630 km² (Bichom catchment area is 2277 km²) and is characterized by a bifurcated network of tributary streams and nallas which drain steep sided valleys.

The dam site is located approximately 250 m downstream of the point where the Difya Nalla enters the Bichom River. This is in turn approximately 1 km downstream of the confluence of the Dakhri Bru and the Bichom. The catchment areas of the Difya Nalla and the Dakhri Bru are 28 km² and 192 km² respectively.

The snow that accumulates in the drainage basin is a natural storage reservoir from which water supply is derived. The snow line is at an elevation of 3500m, and areas above this elevation receive snow between December and March. The catchment area above this elevation of 3500 m is around 28% of the total catchment. Assuming that the precipitation during March to December falls in the form of snow- the stored water in the snow comprises about 2% of the total annual discharge.

As per DPR, 10 daily discharge has been estimated. The same is given in **Table-4.4**.

TABLE-4.4
10 Daily discharge of river Bichom at Dam site

Unit: cumec

| Month | | Average | Maximum | Minimum |
|-----------|-----|---------|---------|---------|
| May | I | 23.8 | 36.6 | 15.6 |
| | II | 29.9 | 44.7 | 11.6 |
| | III | 31.3 | 47.6 | 9.2 |
| June | I | 45.6 | 76.4 | 8.5 |
| | II | 55.7 | 93.0 | 28.4 |
| | III | 65.3 | 93.6 | 42.9 |
| July | I | 71.7 | 99.7 | 48.4 |
| | II | 88.5 | 147.8 | 52.4 |
| | III | 98.4 | 146.5 | 47.3 |
| August | I | 97.4 | 157.0 | 69.3 |
| | II | 82.5 | 112.5 | 60.1 |
| | III | 83.0 | 111.6 | 47.3 |
| September | I | 79.9 | 104.7 | 55.8 |
| | II | 74.8 | 108.9 | 57.1 |
| | III | 64.5 | 96.4 | 43.1 |
| October | I | 56.0 | 90.3 | 16.4 |
| | II | 42.5 | 77.9 | 15.1 |
| | III | 34.7 | 60.6 | 13.7 |
| November | I | 27.2 | 42.1 | 13.0 |
| | II | 24.4 | 36.0 | 13.4 |
| | III | 21.5 | 29.8 | 12.3 |
| December | I | 19.3 | 26.8 | 11.6 |
| | II | 17.4 | 23.9 | 12.0 |
| | III | 15.9 | 21.1 | 10.5 |
| January | I | 14.6 | 20.1 | 9.8 |
| | II | 13.7 | 19.3 | 9.1 |
| | III | 13.0 | 18.9 | 8.3 |
| February | I | 12.3 | 15.8 | 8.5 |
| | II | 12.3 | 15.2 | 8.5 |
| | III | 12.9 | 17.3 | 8.4 |
| March | I | 13.0 | 16.4 | 8.6 |
| | II | 13.4 | 17.3 | 8.5 |
| | III | 14.1 | 18.0 | 8.9 |
| April | I | 16.1 | 21.5 | 11.2 |
| | II | 18.1 | 25.5 | 12.9 |
| | III | 20.2 | 30.8 | 13.5 |

Unit Hydrograph

The unit hydrograph ordinates are given in **Table-4.5**

TABLE-4.5

Unit Hydrograph Ordinates for Dibbin Hydroelectric project

| Time (hrs) | Discharge (m ³ /s) |
|------------|-------------------------------|
| 0 | 0 |
| 1 | 32 |
| 2 | 113 |
| 3 | 252 |
| 4 | 498 |
| 5 | 320 |
| 6 | 210 |
| 7 | 135 |
| 8 | 90 |
| 9 | 52 |
| 10 | 27 |
| 11 | 16 |
| 12 | 8 |
| 13 | 2 |
| 14 | 1 |
| 15 | 0 |

Design Storm

As per DPR a design storm with a return period of 100 years and the Probable Maximum Precipitation (PMP) are used as design storms. The rainfall with a return period of 100 years and duration of 24 hours is estimated from Isopluvial map given in sub-zone report 20. It is approximately 260 mm. The 24 hour probable maximum precipitation PMP for the Bichom catchment was taken as 490 mm in the Dibbin H.E project too, Design storm has been taken as 490 mm.

Flood Hydrograph

The ordinates of flood hydrograph with 100 years return period and hydrograph for PMF is given in **Table-4.6**.

TABLE-4.6
Ordinates of flood hydrograph for return period of 100 years and PMF

Unit: cumec

| Time (hrs) | Flood hydrograph (Return period: 100 years) | PMF |
|------------|------------------------------------------------|------|
| 0 | 133 | 133 |
| 1 | 133 | 133 |
| 2 | 133 | 265 |
| 3 | 190 | 395 |
| 4 | 395 | 923 |
| 5 | 505 | 1133 |
| 6 | 609 | 1395 |
| 7 | 695 | 1665 |
| 8 | 795 | 1831 |

| | | |
|----|------|------|
| 9 | 989 | 2050 |
| 10 | 1105 | 2265 |
| 11 | 1403 | 2748 |
| 12 | 2000 | 3875 |
| 13 | 2750 | 5000 |
| 14 | 3649 | 6545 |
| 15 | 4230 | 7379 |
| 16 | 4000 | 7133 |
| 17 | 3795 | 6665 |
| 18 | 3115 | 5632 |
| 19 | 2403 | 4265 |
| 20 | 1500 | 2850 |
| 21 | 1000 | 1725 |
| 22 | 695 | 1133 |
| 23 | 485 | 745 |
| 24 | 315 | 503 |
| 25 | 205 | 285 |
| 26 | 155 | 253 |
| 27 | 133 | 190 |
| 28 | 133 | 133 |
| 29 | 133 | 133 |

4.8 WATER QUALITY

The proposed project is located in an area with low population density with no major sources of pollution. The major source of water in the project area are rivers or nallahs which flow adjacent to the habitations. The water is conveyed to the point of consumption. The effluent generated from domestic sources in the project area and its surroundings ultimately reaches river Bichom through various streams/channels out falling in the river. Even, for minimum flow condition, there is sufficient water available in river Bichom, for dilution of untreated sewage generated from domestic sources. There are no industries in the area. The area under agriculture in the catchment area is quite less, (about 10%) which coupled with negligible use of agro-chemicals, means that apart from domestic sources, pollution loading is virtually negligible.

As a part of EIA study, water samples were collected for three seasons, i.e., January 2006 (winter season), April 2006 (summer season) and Monsoon season (October 2007) were analyzed. The results are summarized in **Table-4.7**. The location of various sampling stations is shown in **Figure-4.5**. The drinking water quality standards are enclosed as **Annexure-II**.

TABLE-4.7
Results of water quality analysis in the project area

| Parameter | Sampling Location | | | |
|---------------------------------------|-------------------|------|------|------|
| | W1 | W2 | W3 | W4 |
| Winter season (January 2006) | | | | |
| pH | 7.1 | 7.2 | 7.4 | 7.2 |
| Electrical Conductivity, micromhos/cm | 174 | 180 | 180 | 189 |
| TDS, mg/l | 130 | 134 | 132 | 140 |
| Sulphates, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |

| Parameter | Sampling Location | | | |
|---------------------------------------|-------------------|--------|--------|--------|
| | W1 | W2 | W3 | W4 |
| Chlorides, mg/l | 41 | 40 | 44 | 48 |
| Nitrates, mg/l | 3.8 | 3.4 | 5.2 | 2.9 |
| Phosphates, mg/l | 1.1 | 1.0 | 1.0 | 1.4 |
| Sodium, mg/l | 5 | 8 | 10 | 10 |
| Potassium, mg/l | 2 | 2 | 5 | 8 |
| Calcium, mg/l | 5 | 7 | 5 | 10 |
| Copper, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Iron, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Zinc, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Cadmium, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Magnesium, mg/l | 2 | 4 | 3 | 3 |
| Lead, mg/l | <0.01 | <0.01 | <0.01 | <0.01 |
| Manganese, mg/l | <1.0 | <1.0 | <1.03 | <1.0 |
| Fluorides, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Hardness, mg/l | 22 | 34 | 23 | 33 |
| DO, mg/l | 8.2 | 8.0 | 7.9 | 8.0 |
| BOD, mg/l | 1.4 | 1.2 | 1.8 | 1.8 |
| COD, mg/l | 2.9 | 2.6 | 3.9 | 4.0 |
| Oil & grease, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Total Coliform | 41 | 32 | 30 | 29 |
| Faecal coliform | Absent | Absent | Absent | Absent |
| Summer season (April 2006) | | | | |
| pH | 7.1 | 7.1 | 7.2 | 7.2 |
| Electrical Conductivity, micromhos/cm | 160 | 177 | 181 | 189 |
| TDS, mg/l | 110 | 128 | 127 | 136 |
| Sulphates, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Chlorides, mg/l | 39 | 40 | 42 | 47 |
| Nitrates, mg/l | 3.7 | 3.1 | 5.1 | 2.8 |
| Phosphates, mg/l | 1.0 | 1.1 | 1.1 | 1.5 |
| Sodium, mg/l | 6 | 7 | 10 | 9 |
| Potassium, mg/l | 1 | 1 | 6 | 7 |
| Calcium, mg/l | 8 | 9 | 8 | 12 |
| Copper, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Iron, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Zinc, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Cadmium, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Magnesium, mg/l | 3 | 3 | 5 | 4 |
| Lead, mg/l | <0.01 | BDL | BDL | <0.01 |
| Manganese, mg/l | <1.0 | <1.0 | <1.03 | <1.0 |
| Fluorides, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Hardness, mg/l | 24 | 27 | 21 | 31 |
| DO, mg/l | 8.0 | 8.1 | 8.2 | 8.2 |
| BOD, mg/l | 1.2 | 1.6 | 1.7 | 1.7 |
| COD, mg/l | 3.9 | 3.0 | 3.7 | 3.9 |

| Parameter | Sampling Location | | | |
|---------------------------------------|-------------------|--------|--------|--------|
| | W1 | W2 | W3 | W4 |
| Oil & grease, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Total Coliform | 42 | 30 | 32 | 30 |
| Faecal coliform | Absent | Absent | Absent | Absent |
| Monsoon season (October 2007) | | | | |
| pH | 7.1 | 7.1 | 7.2 | 7.2 |
| Electrical Conductivity, micromhos/cm | 160 | 177 | 181 | 189 |
| TDS, mg/l | 110 | 128 | 127 | 136 |
| Sulphates, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Chlorides, mg/l | 39 | 40 | 42 | 47 |
| Nitrates, mg/l | 3.7 | 3.1 | 5.1 | 2.8 |
| Phosphates, mg/l | 1.0 | 1.1 | 1.1 | 1.5 |
| Sodium, mg/l | 6 | 7 | 10 | 9 |
| Potassium, mg/l | 1 | 1 | 6 | 7 |
| Calcium, mg/l | 8 | 9 | 8 | 12 |
| Copper, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Iron, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Zinc, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Cadmium, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Magnesium, mg/l | 3 | 3 | 5 | 4 |
| Lead, mg/l | <0.01 | BDL | BDL | <0.01 |
| Manganese, mg/l | <1.0 | <1.0 | <1.03 | <1.0 |
| Fluorides, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Hardness, mg/l | 24 | 27 | 21 | 31 |
| DO, mg/l | 8.0 | 8.1 | 8.2 | 8.2 |
| BOD, mg/l | 1.2 | 1.6 | 1.7 | 1.7 |
| COD, mg/l | 3.9 | 3.0 | 3.7 | 3.9 |
| Oil & grease, mg/l | <1.0 | <1.0 | <1.0 | <1.0 |
| Total Coliform | 42 | 30 | 32 | 30 |
| Faecal coliform | Absent | Absent | Absent | Absent |

Note : W1 - About 2 km upstream of proposed dam
W2 - About 1 km upstream of the proposed dam
W3 - 1 Km Downstream of the proposed dam site
W4 - Near proposed power house site

The low levels of cations and anions as indicated in the above table indicate the good water quality of river Bichom. The high DO (8.0 to 8.4) and low BOD (1.0 to 1.8 mg/l) levels indicate the absence of organic pollution sources. This is mainly due to absence of pollution sources from industries in the catchment area. The only source of organic pollutants is the domestic source. The area has low population density and even the minimum flow is much higher than the flow required for dilution of sewage, hence, there is no adverse impact on water quality. This is reflected in the low BOD and high D.O. levels. The D.O. levels are close to saturation condition. Most of the heavy metals are below the permissible limits (Refer Table-4.6) indicating absence of pollution from industrial sources. The low hardness levels indicate the soft quality of water. The oil & grease levels were below the Detectable range. Thus, water quality of river Bichom can be considered as good.

4.9 LANDUSE PATTERN

Land use describes how a patch of land is used (e.g. for agriculture, settlement, forest), whereas land cover describes the materials (such as vegetation, rocks or buildings) that are present on the surface. Accurate land use and land cover identification is the key to most of the planning processes.

The land use pattern of the project and catchment area has been studied through digital satellite imagery data. Digital IRS LISS-III and satellite data was procured from National Remote Sensing Agency (NRSA), Hyderabad. The data was processed through ERDAS IMAGINE software.

Ground truthing studies were conducted in the project area to validate various signals in the satellite images and correlate them with different land use domains. As a part of field studies detailed ground truthing was conducted. The image was then classified using the prominent signatures extracted based on the past experience. The FCC and classified image of the study area is shown in **Figures-4.6** and **4.7** respectively. The land use pattern of the study area is given in **Table-4.8**.

TABLE-4.8

Land use pattern of the study area

| Category | Study Area (ha) | Percentage of Study area (%) |
|--------------|-----------------|------------------------------|
| Dense forest | 13209.32 | 60.46 |
| Open forest | 8055.61 | 36.87 |
| Agriculture | 437.75 | 2.0 |
| Water bodies | 48.94 | 0.22 |
| Settlement | 94.64 | 0.43 |
| Total | 21846.26 | 100.00 |

The major land use category in the study area is forest land, which accounts for nearly 97.44% of the total study area. This includes dense forest (60.46%) with crown cover density > 40% and open forest (36.87%) with crown cover density < 10%. The other major land use land cover category in the study area is agriculture land (2.1%), which is mainly under Jhum cultivation. Water bodies and settlements account for about 0.22% and 0.43% of the total study area.

4.11 AMBIENT AIR QUALITY

In a water resource project, impacts on air quality are marginal and limited only during construction phase. The population density in the area is low. The number of vehicles plying in the area is insignificantly low to cause any air pollution. This coupled with the fact that there are no industries in the area, means that there are no major sources of air pollution.

As a part of the CEIA study, ambient air quality was monitored at two locations in order to assess the existing status of ambient air quality in the study area. The monitoring stations were:

- village Dibbin
- village Ditchik

The location of ambient air quality monitoring stations is shown in **Figure-4.5**. The ambient air quality was monitored for three seasons listed as below:

Winter season : January-February 2006
 Summer season : April-May 2006

Monsoon season : October 2007

The frequency of monitoring was twice a week for four consecutive weeks. The parameters studied were SPM, RPM, SO₂ and NO_x. The results of ambient air quality monitoring are summarized in **Table-4.9**. The National Ambient Air Quality Standards are given in **Annexure-III**.

TABLE-4.9
Results of ambient air quality monitoring

Unit : µg/m³

| Station | SPM | RPM | SO ₂ | NO _x |
|--------------------------------------|-----|-----|-----------------|-----------------|
| Winter season (January 2006) | | | | |
| Village Dibbin | 71 | 34 | BDL | 11.4 |
| | 62 | 30 | BDL | 10.6 |
| | 62 | 30 | 6.8 | 12.4 |
| | 60 | 30 | BDL | 12.1 |
| | 65 | 34 | 6.1 | 13.8 |
| | 60 | 28 | 6.8 | 10.9 |
| | 70 | 34 | 7.2 | 11.1 |
| | 68 | 33 | 6.1 | 11.4 |
| Village Ditchik | 62 | 31 | BDL | 12.6 |
| | 64 | 32 | BDL | 14.2 |
| | 62 | 29 | 7.6 | 10.9 |
| | 72 | 35 | 6.8 | 10.4 |
| | 62 | 34 | BDL | 11.8 |
| | 74 | 38 | BDL | 10.6 |
| | 70 | 36 | 6.1 | 10.2 |
| | 68 | 35 | 7.4 | 9.1 |
| Summer season (April 2006) | | | | |
| Village Dibbin | 77 | 32 | BDL | 10.1 |
| | 80 | 30 | 6.1 | 10.2 |
| | 72 | 28 | BDL | 12.1 |
| | 70 | 28 | BDL | 12.2 |
| | 80 | 28 | 6.5 | 14.2 |
| | 90 | 30 | 7.2 | 11.1 |
| | 72 | 32 | 7.1 | 12.2 |
| | 70 | 32 | 6.2 | 12.4 |
| Village Ditchik | 60 | 31 | BDL | 12.8 |
| | 64 | 33 | BDL | 14.0 |
| | 70 | 33 | 7.8 | 11.9 |
| | 72 | 34 | 8.8 | 10.9 |
| | 80 | 37 | BDL | 10.2 |
| | 80 | 36 | BDL | 9.8 |
| | 72 | 35 | 7.4 | 10.1 |
| | 72 | 34 | 6.5 | 10.0 |
| Monsoon season (October 2007) | | | | |
| Village Dibbin | 70 | 33 | 7.8 | 9.2 |

| Station | SPM | RPM | SO ₂ | NO _x |
|-----------------|-----|-----|-----------------|-----------------|
| | 76 | 37 | 6.5 | 9.8 |
| | 75 | 36 | BDL | 8.2 |
| | 78 | 38 | 6.9 | 10.8 |
| | 82 | 40 | BDL | 12.8 |
| | 78 | 36 | 7.3 | 12.2 |
| | 70 | 34 | BDL | 10.3 |
| | 76 | 36 | 7.0 | 10.2 |
| Village Ditchik | 70 | 34 | 7.9 | 9.4 |
| | 60 | 29 | 8.0 | 11.2 |
| | 71 | 34 | BDL | 9.2 |
| | 65 | 32 | BDL | 9.4 |
| | 68 | 33 | 6.8 | 8.7 |
| | 76 | 35 | BDL | 10.5 |
| | 70 | 33 | 7.2 | 10.2 |
| | 68 | 31 | BDL | 8.3 |

Observations on SPM level

The summary of ambient SPM levels is given in **Table-4.10**.

TABLE-4.10
Summary of SPM levels in ambient air (Unit: $\mu\text{g}/\text{m}^3$)

| Station | Average | Maximum | Minimum |
|-----------------------|---------|---------|---------|
| Winter season | | | |
| Dibbin | 64.75 | 71 | 60 |
| Ditchik | 65.50 | 74 | 62 |
| Summer season | | | |
| Dibbin | 76.4 | 80 | 70 |
| Ditchik | 71.25 | 80 | 60 |
| Monsoon season | | | |
| Dibbin | 75.6 | 82 | 70 |
| Ditchik | 68.5 | 76 | 60 |

In the winter season the average SPM levels as observed during field studies ranged from 64.75 to 65.5 $\mu\text{g}/\text{m}^3$. The maximum SPM level observed was 74 $\mu\text{g}/\text{m}^3$, which is well below the permissible limit of 200 $\mu\text{g}/\text{m}^3$ specified for residential, rural and other areas (Refer Annexure-III). In the summer season the average SPM levels as observed during field studies ranged from 65.5 to 71.25 $\mu\text{g}/\text{m}^3$. Likewise, in Monsoon season, average SPM levels ranged from 68.5 to 71.6 $\mu\text{g}/\text{m}^3$. The maximum SPM level observed was 82 $\mu\text{g}/\text{m}^3$, which is well below the permissible limit of 200 $\mu\text{g}/\text{m}^3$ specified for residential, rural and other areas (Refer Annexure-III).

Observations on RPM level

The summary of RPM levels monitored as a part of ambient air quality monitoring programme is given in **Table-4.11**.

TABLE-4.11
Summary of RPM level in ambient air (Unit: $\mu\text{g}/\text{m}^3$)

| Station | Average | Maximum | Minimum |
|-----------------------|---------|---------|---------|
| Winter season | | | |
| Dibbin | 31.13 | 34 | 28 |
| Ditchi | 33.75 | 38 | 29 |
| Summer season | | | |
| Dibbin | 30.0 | 32 | 28 |
| Ditchik | 34.13 | 37 | 31 |
| Monsoon season | | | |
| Dibbin | 36.3 | 40 | 33 |
| Ditchik | 32.6 | 35 | 29 |

In the winter season the average RPM level was observed to range from 31.13 to 33.75 $\mu\text{g}/\text{m}^3$. The RPM levels were observed to be well below the permissible limit of 100 $\mu\text{g}/\text{m}^3$ specified for residential, rural and other areas. In summer season the average RPM level was observed to range from 30.0 to 34.13 $\mu\text{g}/\text{m}^3$. In post-monsoon season, RPM level ranged from 32.6 to 36.3 $\mu\text{g}/\text{m}^3$. The RPM levels were observed to be well below the permissible limit of 100 $\mu\text{g}/\text{m}^3$ specified for residential, rural and other areas (Refer Annexure-III).

Observations on SO₂ level

The summary of SO₂ level is given in Table-4.12.

TABLE-4.12
Summary of SO₂ level in ambient air (Unit: $\mu\text{g}/\text{m}^3$)

| Station | Average | Maximum | Minimum |
|-----------------------|---------|---------|---------|
| Winter season | | | |
| Dibbin | 6.6 | 7.2 | BDL |
| Ditchik | 6.93 | 7.6 | BDL |
| Summer season | | | |
| Dibbin | 6.62 | 7.2 | BDL |
| Ditchik | 7.83 | 7.6 | BDL |
| Monsoon season | | | |
| Dibbin | 7.1 | 7.8 | BDL |
| Ditchik | 7.5 | 8.0 | BDL |

Note: Average has been calculated excluding BDL values

In winter, summer as well as Monsoon season the SO₂ level observed during ambient air quality monitoring was observed to be well below the permissible limit of 80 $\mu\text{g}/\text{m}^3$ specified for residential, rural and other areas (Refer Annexure-III).

Observations on NO_x levels

The summary of NO_x level is given in **Table-4.13**.

TABLE-4.13
Summary of NO_x level in ambient air (Unit: µg/m³)

| Station | Average | Maximum | Minimum |
|-----------------------|---------|---------|---------|
| Winter season | | | |
| Dibbin | 11.71 | 13.8 | 10.6 |
| Ditchik | 11.22 | 14.2 | 9.1 |
| Summer season | | | |
| Dibbin | 11.81 | 15.9 | 10.1 |
| Ditchik | 11.21 | 14.0 | 9.8 |
| Monsoon season | | | |
| Dibbin | 10.4 | 12.8 | 8.2 |
| Ditchik | 9.6 | 11.2 | 8.3 |

In the winter season the highest NO_x value of 14.2 µg/m³ was observed at village Ditchik, which too was well below the maximum permissible limit of 80 µg/m³ for residential, rural and other areas whereas, in summer and Monsoon seasons, highest NO_x value of 15.9 µg/m³ and 12.8 µg/m³ respectively was observed, which too was well below the maximum permissible limit of 80 µg/m³ specified for residential, rural and other areas (Refer Annexure-III).

4.11 Noise Environment

Baseline noise data has been measured using a weighted sound pressure level meter. The survey was carried out in calm surrounding. Sound Pressure Level (SPL) measurement in the outside environment was made using sound pressure level meter. Hourly noise meter readings were taken at different sites. The monitoring was conducted for three seasons namely, winter (January 2006), summer (April 2006) and Monsoon (October 2007). The location of various noise monitoring stations is shown in Figure-4.5. The ambient noise levels recorded are tabulated in **Table-4.14**. The monitoring was carried out in day time, at sampling locations, where ambient air quality monitoring was carried out. The noise standard for various categories is given in **Annexure-IV**. The day time equivalent noise levels are given in **Table-4.15**.

TABLE-4.14
Hourly equivalent noise levels

| Location | Near dam site | Nachibin village | Mathow village | Near Power house site |
|-------------------------------------|---------------|------------------|----------------|-----------------------|
| Winter Season (January 2006) | | | | |
| 6-7 AM | 34 | 33 | 34 | 34 |
| 7-8 AM | 34 | 34 | 34 | 34 |
| 8-9 AM | 36 | 37 | 35 | 34 |
| 9-10 AM | 37 | 37 | 36 | 35 |
| 10-11 AM | 37 | 38 | 36 | 35 |
| 11-12 Noon | 40 | 40 | 37 | 38 |
| 12 noon – 1 PM | 43 | 42 | 38 | 38 |

| Location | Near dam site | Nachibin village | Mathow village | Near Power house site |
|--------------------------------------|---------------|------------------|----------------|-----------------------|
| 1-2 PM | 42 | 41 | 39 | 37 |
| 2-3 PM | 40 | 40 | 38 | 39 |
| 3-4 PM | 38 | 38 | 38 | 38 |
| 4-5 PM | 37 | 37 | 37 | 38 |
| 5-6 PM | 36 | 37 | 36 | 37 |
| 6-7 PM | 35 | 35 | 35 | 36 |
| 7-8 PM | 34 | 33 | 34 | 35 |
| 8-9 PM | 32 | 32 | 32 | 34 |
| Summer Season (April 2006) | | | | |
| 6-7 AM | 33 | 32 | 32 | 34 |
| 7-8 AM | 35 | 34 | 35 | 35 |
| 8-9 AM | 35 | 34 | 35 | 35 |
| 9-10 AM | 36 | 35 | 38 | 36 |
| 10-11 AM | 36 | 38 | 40 | 37 |
| 11-12 Noon | 38 | 38 | 42 | 38 |
| 12 noon – 1 PM | 38 | 40 | 42 | 40 |
| 1-2 PM | 41 | 42 | 38 | 40 |
| 2-3 PM | 38 | 39 | 38 | 40 |
| 3-4 PM | 38 | 39 | 38 | 40 |
| 4-5 PM | 38 | 37 | 38 | 38 |
| 5-6 PM | 35 | 35 | 36 | 38 |
| 6-7 PM | 34 | 34 | 35 | 36 |
| 7-8 PM | 32 | 32 | 34 | 35 |
| 8-9 PM | 32 | 32 | 32 | 34 |
| Monsoon Season (October 2007) | | | | |
| 6-7 AM | 32 | 32 | 32 | 33 |
| 7-8 AM | 34 | 35 | 36 | 35 |
| 8-9 AM | 34 | 35 | 36 | 36 |
| 9-10 AM | 35 | 36 | 36 | 37 |
| 10-11 AM | 36 | 38 | 39 | 38 |
| 11-12 Noon | 38 | 39 | 40 | 39 |
| 12 noon – 1 PM | 38 | 39 | 42 | 40 |
| 1-2 PM | 40 | 40 | 39 | 41 |
| 2-3 PM | 40 | 41 | 37 | 41 |
| 3-4 PM | 39 | 40 | 38 | 41 |

| Location | Near dam site | Nachibin village | Mathow village | Near Power house site |
|----------|---------------|------------------|----------------|-----------------------|
| 4-5 PM | 39 | 38 | 38 | 39 |
| 5-6 PM | 38 | 36 | 37 | 37 |
| 6-7 PM | 38 | 35 | 34 | 35 |
| 7-8 PM | 35 | 33 | 33 | 33 |
| 8-9 PM | 33 | 32 | 33 | 32 |

TABLE-4.15
Average ambient noise levels

| S. No. | Location | Zone | Winter Season (January 2006) | Summer Season (April 2006) | Monsoon Season (October 2007) |
|--------|-----------------------|-------------|---------------------------------|----------------------------------|-------------------------------------|
| 1. | Near Dam site | Residential | 38.1 | 36.5 | 37.3 |
| 2. | Nachibin village | Residential | 37.9 | 36.5 | 37.5 |
| 3. | Mathow village | Residential | 36.3 | 37.3 | 37.5 |
| 4. | Near Power house site | Residential | 36.4 | 37.6 | 38.1 |

The day time equivalent noise level at various sampling stations ranged from 36.4 to 38.1 dB (A) and 36.5 to 37.6 dB (A) in winter and summer seasons respectively. In Monsoon season, the day time equivalent noise level at various sampling stations ranged from 37.3 to 38.1 dB(A) The noise levels were observed to be well within permissible limits specified for residential area (Refer Annexure-IV).

CHAPTER-5

BASELINE SETTING FOR ECOLOGICAL ASPECTS

5.2 GENERAL

Before start of any Environmental Impact Assessment study, it is necessary to identify the baseline levels of relevant environmental parameters which are likely to be affected as a result of the construction and operation of the proposed project. The planning of baseline survey commenced with the shortlisting of impacts and identification of parameters for which the data needs to be collected. The same was derived through a Scoping Matrix outlined in Chapter-3 of this Report.

The baseline status has been divided into following three categories:

- Physico-chemical aspects
- Ecological aspects
- Socio-Economic aspects.

The baseline setting for ecological aspects are outlined in the present Chapter. The study area represents diverse biological assemblages unique in structure, composition, and spatial pattern. These

have been under a long influence of local communities. The following section highlights floral and faunal diversity, based on a review of available information and followed by primary data collection.

5.2 FLORA

The proposed project lies in Eastern Himalaya. The nature and type of vegetation occurring in the area depends upon various factors including climatic conditions, altitude, topography, slope, biotic factor, etc. The Forests occupy a prominent place in the economy of the project area district. Extensive tracts of forests exist throughout the district which are richly wooded. Forests constitute a major proportion of the total land. The forest in the project area may be classified into following groups:

- Sub-tropical pine forest
- Temperate broad-leaved forest
- Temperate conifer forest
- Sub-alpine

The sub-tropical Pine forests occur between altitudes of 1,200m and 1,800m. The predominant species of conifers are represented by *Pinus merkusii*, *P. roxburghii* and *P. wallichiana* and *Tsuga dumosa*. These forests occur with occasional patches of broad-leaf species like *Alnus nepalensis*, *Betula alnoides*, etc. Blue pine (*Pinus wallichiana*) is found higher up on the ridges and at higher altitudes. The area under cultivation upstream of the project site is quite low. The ground flora comprises of *Ajuga* sp., *Berberis* sp., *Colebrookia oppositifolia*, *Daphne cyclea*, *Elsholtzia* sp., *Osbeckia* sp. and *Potentilla* sp. Only in the areas downstream of dam site agriculture is practiced in the vicinity of small villages like Dibbin and Dishing.

Most of the forested areas in the project area are unclassified forests. At higher elevations, temperate broad-leaved forests are predominant. These forests comprise of plant species like *Alnus nepalensis*, *Quercus lamellosa*, *Q. lineata*, *Q. griffithii*, *Betula alnoides*, *Engelhardtia spicata*, *Exbucklandia populnea*, *Cornus controversa*, *Michelia cathartii*, *Michelia excelsa*, *Populus gamblei* and a number of species of *Castanopsis indica*, *Acer*, *Magnolia*, etc. The middle storey is represented by species of *Prunus*, *Rubus*, *Spiraea*, *Symplocos*, *Rhododendron*, etc. The shrubby layer comprises of *Debregeasia longifolia*, *Mahonia semiserrata*, *Vaccinium sprengelii*, etc.

The Temperate Conifer forests are found at elevations between 2,800 m up to 3,500 m. The dominant species in these forests are *Abies densa*, *Tsuga dumosa*, etc. Dense Mixed Oak-conifer forests in the area comprises of *Castanea tribuloides* var. *armata*, *Clausena heptaphylla*, *Engelhardtia spicata*, *Pinus khasiana*, *P. wallichiana*, *Quercus semiserrata*, *Q. spicata*, *Rhus succedanea* and *Toona ciliata*. Dense thickets of tall bamboos alongwith some small trees and woody shrubs comprise the second storey of these forests. *Coriaria nepalensis*, *Eupatorium odoratum*, *Eurya acuminata*, *Leea indica*, *Lyonia ovalifolia*, *Rhododendron* sp., etc. are important constituents of this layer. Wild banana (*Musa acuminata*) also occurs in shaded and damp areas. Amongst the climbers *Cissus discolor*, *C. repens*, *Rubus* sp., *Smilax aspericaulis* and *Vitis* sp. are predominant in these forests. Herbaceous flora is represented by *Ageratum conyzoides*, *Arthraxon hispidus*, *Arundinella nepalensis*, *Asparagus filicinus*, *Brachiaria ramosa*, *Carex* sp., *Colocasia affinis*, *Curcuma angustifolia*, *Cyperus niveus*, *Desmodium* sp., *Dichrocephala bicolor*, *Eupatorium adenophorum*, *Hedychium acuminatum*, *Urtica dioica* etc. Furthermore rich density of ferns is also found in this area.

Towards the power house site, trees are represented by *Callicarpa arborea*, *Castanea tribuloides* var. *barbata*, *Pinus khasiana*, *Quercus lamellosa*, etc. Second storey is represented by many woody tree and some shrubby species. Important among these are *Leea aequata*, *Lyonia ovalifolia*, *Melastoma hispida*, *Rhus javanica*, *Rhododendron* sp. and *Xanthoxylum alatum*. Among climbers are *Cissus discolor*, *C. repens*, *Entada phaseoloides*, *Rubus* sp., and *Vitis* sp. Agriculture is practiced at lower slopes near the proposed site.

The forests on the left bank slopes of Bichom river are dense. Important constituents of these forests are *Castanea tribuloides* var. *barbata*, *Clausena heptaphylla*, *Engelhardtia spicata*, *Eurya acuminata*, *Leea compactiflora*, *Quercus lamellosa*, *Rhus succedanea* and *Trema politoria*. Second storey of these forests is comprised of tall bamboo species and some shrubs like *Boehmeria macrophylla*, *Casearia glomerata*, *Melastoma hispida*, *Lyonia ovalifolia*, *Rhamnus nepalensis*, *Rubus ellipticus* and *Viburnum* sp.

Legal Status

Administratively, the forest area is under the jurisdiction of Bomdila forest division. The legal status of forests is Unclassified State Forest (USF). Though the State Government is the ultimate owner of these forests, these are neither surveyed nor demarcated and as such no detailed record and maps are available with the Forest Department. The village community traditionally enjoys the rights of the physical possession of forest land and removal of timber and forest produce, free of loyalty for domestic use.

Field studies

As a part of the EIA study, a detailed Ecological survey was conducted for three seasons listed as below:

- Winter season : January 2006
- Summer season : May 2006
- Monsoon season : October 2007

The objectives of the ecological survey were to:

- Prepare a checklist of flora in the submergence area.
- List of rare/endangered, economically important and medicinal plant species.
- Determine frequency, abundance and density of different vegetation components.
- Estimate density and volume of the tree component with height above 8 m.
- Estimate density and diversity of phytoplanktons, zooplanktons, and benthic flora and fauna in river water.
- Estimate phytoplankton primary productivity in the river.
- List wildlife in the project area, encountered during field study.

Sampling Sites

The study area was spread from Nachibin village (powerhouse site) to Dibbin village (dam site) along the river Bichom, a tributary of Kameng river. The study area falls under Nafra circle of West Kameng district of Arunachal Pradesh. The following sample sites were selected for the detailed vegetation study:

i) **Dam site:** The dam site is located near village Dibbin. Sampling included primary undisturbed vegetation on east and west bank of river Bichom (about 1.5 km).

ii) **Power House site:** This site is located near village Nachibin. The sampling included secondary vegetation on both the banks of river Bichom.

iii) **Catchment area:** This site starts near village Dibbin and continues about 7 km upstream of the same river Bichom.

iv) **Submergence area:** The right side of the submergence area shows deep slope with good forest cover. However, most of the submergence area is dominated by jhum cultivation. The total area under submergence is about 33.6 ha.

Methodology Adopted

The sampling was done within 1 km of the riverbed. Considering the difficult terrain, quadrat method was used for vegetation sampling. The phytosociological data for trees and shrubs were collected from random quadrats of 10 x 10 m size laid at the project site. Random quadrats of 1 x 1 m size were laid for the study of herb component at each site. The number of quadrats used for the study of different vegetation components at each sampling site is given in **Table-5.1**.

TABLE-5.1
Number of quadrats used for vegetation study at different sampling sites for different vegetation components in Dibbin project area

| Sampling Sites | Tree | Shrub | Herb |
|-----------------------|-------------|--------------|-------------|
| Dam site | 10 | 10 | 10 |
| Power House site | 10 | 10 | 10 |
| Catchment site | 10 | 10 | 10 |
| Submergence site | 10 | 10 | 10 |

During the survey, number of plants of different species in each quadrat was identified and counted. The height of individual trees was estimated using an Abney level/ Binocular and the DBH of all trees having height more than 8 m was measured. Based on the quadrat data, frequency, density and cover (basal area) of each species were calculated. The IVI values for different tree species were determined

by summing up the Relative Density, Relative Frequency and Relative Cover values. The Relative Density and Relative Frequency values were used to calculate the IVI of shrubs and herbs.

The volume of wood for trees was estimated using the data on DBH (measured at 1.5 m above the ground level) and height. The data on density and volume were presented in per ha basis. Two species diversity indices viz., Shannon index of general diversity (H) and Evenness index (e) were computed using the following formula:

Shannon index of general diversity (H): $-\sum P_i \log P_i$

Where, n_i = importance value for each species

N = total importance values

P_i = importance probability for each species = n_i / N

Evenness index (e): $H / \log S$

Where, H = Shannon index of general diversity

and, S = number of species

IVI values were used for computation of both the diversity indices.

During the vegetation survey, herbaria were prepared for the plants those had flowers. Rare and endangered species were identified referring to the Red Data Book of India and other available literature, flora and herbarium pertaining to the rare/ endangered species of Arunachal Pradesh.

Floristic composition

A total of 134 plant species were recorded during floristic survey. The lists include the plants belonging to different groups such as Angiosperms, Pteridophytes, Fungi, Algae, Bryophytes and Lichen is given in **Annexure-V**. The names of the family and the local names (wherever possible) are also given. The number of plant species belonging to different groups is summarised in **Table-5.2**.

TABLE-5.2
Summary table of plants belonging to different groups listed
during the vegetation survey in the project area

| Plant Group | No. of species |
|---------------|----------------|
| Angiosperm | 105 |
| Pteridophytes | 7 |
| Fungi | 5 |
| Algae | 7 |
| Bryophytes | 4 |
| Lichen | 6 |
| Total | 134 |

During the course of survey, no threatened category of plant species was encountered. About 30 economically important plant species were recorded from the study area. The economically important and wild crop relative plants observed during the vegetation survey have been listed in **Table 5.3**.

TABLE-5.3
List of economically important plant species found in the study area

| Species | Uses |
|---------|------|
|---------|------|

| Species | Uses |
|------------------------------------|--------------------------|
| <i>Ageratum conyzoides</i> | Medicinal |
| <i>Artemisia nilagirica</i> | Medicinal |
| <i>Bambusa</i> sp. | Construction |
| <i>Castanopsis tribuloides</i> | Timber, Fruits edible |
| <i>Citrus aurantium</i> | Fruit |
| <i>Clematis gouriana</i> | Medicinal |
| <i>Clerodendron colebrookianum</i> | Leafy vegetable |
| <i>Colocasia</i> sp. | Leafy vegetable |
| <i>Cyathea spinulosa</i> | Fodder |
| <i>Dendrobium hamiltonii</i> | Tender shoots |
| <i>Drymaria cordata</i> | Medicinal |
| <i>Ficus semicordata</i> | Fodder |
| <i>Ficus roxburghii</i> | Fodder, fruits edible |
| <i>Impatiens chinensis</i> | Fodder, Medicinal |
| <i>Indigofera atropurpurea</i> | Dye |
| <i>Macaranga denticulate</i> | Fuel |
| <i>Nephrolepis cordifolia</i> | Tuber edible |
| <i>Oxalis corniculata</i> | Medicinal |
| <i>Pinus roxburghii</i> | Wood, Timber, Resins |
| <i>Polygonum capitatum</i> | Leafy vegetable |
| <i>Pouzolzia bennetiana</i> | Leafy vegetable |
| <i>Pouzolzia</i> sp. | Fodder |
| <i>Pteris biaurita</i> | Medicinal |
| <i>Quercus griffithii</i> | Timber |
| <i>Rhus javanica</i> | Fruits edible, Medicinal |
| <i>Rubus</i> sp. | Medicinal |
| <i>Solanum nigrum</i> | Fruit edible |
| <i>Rhododendron arboretum</i> | Ornamental |
| <i>Syzygium</i> sp. | Fruit edible |
| <i>Thysanolaena maxima</i> | Broom industry, fodder |

Vegetation characteristics

The vegetation in the project area broadly falls under two categories:

- tropical semi-evergreen forests
- sub-tropical forests

All along the valley, the forests have been much disturbed mainly due to the jhum cultivation that is practiced. One can see different ages of fallows. In these fallows, there is hardly any tree that can be seen. Although the river Bichom flows at much lower elevation (at about 1660 m), the approach road passes through much higher elevation area, that bears subtropical pine forests, with *Pinus roxburghii* forming extensive patches. Many of these trees are tapped for its commercial product, the resin. In

some trees, the blaze they make has almost covered the full circumference of the trees. This has affected the health of such trees.

At certain patches, particularly in the areas close to the dam site, which are more moist sub-tropical broad leaved forests is observed. The dominant tree species in these forests are *Michelia*, *Alnus*, *Castanopsis*, *Dalbergia*, found in association with *Ostodes paniculata*, *Alangium begoniaefolium*, *Ficus semicordata*, *Actinodaphne obovata* and *Macropanax dispermus*, etc.

Much of the landscape near powerhouse site is an exposition of a mosaic of degraded forests, with very few trees. However few of the left over trees belong to *Callicarpa arborea*, *Cordia dichotoma*, *Aralia* sp. etc. The recent fallows have a weed cover with *Eupatorium odoratum*, *Ageratum conyzoides*, *Phegopteris auriculata*. While a little older ones have an admixture of shrubs like *Maesa chisia*, *Osbeckia crenata*, and new recruits of *Macranga denticulata*. In addition to these degraded vegetation types, one can see the isolated patches of vegetation formed by wild banana and *Saccharum* grass species together with *Callicarpa* trees. *Alnus nepalensis* patches were also seen in small pockets.

The Pine – oak - chestnut forests have a few Rhododendrons too. Few abandoned and current Orange orchards were also observed

There is a scope for regeneration of the degraded forests near powerhouse site. In some of the areas, which had long fallow period, usually in remote areas, had *Macranga denticulate*, which essentially is a pioneer species. Such trees are good for fuel. A few fodder trees, which were seen include, *Villebrunea* and *Bauhinia* sp. Wild Banana and *Pandanus* are some of the fibre yielding plants observed during field studies. These are seen commonly here. No rare and endangered species was observed.

In general, the Shannon's Index for most of the components (tree, shrub and herb) was more than 1 at various sampling sites. The details of frequency, density of various species observed in winter, summer and Monsoon seasons are given in **Tables-5.4 to 5.6** respectively. The species diversity index and evenness index are given in **Tables 5.7 and 5.8** respectively.

TABLE-5.4
Community characteristics of the vegetation at various sampling locations
in Dibbin project area (Winter season)

A. Dam site

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|--------------------------------|-------------|------------------|---------------------------------|-------|
| Trees | | | | |
| <i>Ailanthus grandis</i> | 10 | 20 | 1.02 | 19.93 |
| <i>Callicarpa arborea</i> | 10 | 10 | 0.16 | 9.12 |
| <i>Castanopsis tribuloides</i> | 20 | 20 | 1.44 | 28.23 |
| <i>Dalbergia rimosa</i> | 10 | 10 | 0.34 | 10.69 |
| <i>Eurya acuminata</i> | 10 | 20 | 0.35 | 13.95 |
| <i>Ficus roxburghii</i> | 10 | 10 | 0.07 | 8.31 |
| <i>Lagerstoemia purviflora</i> | 10 | 20 | 0.20 | 12.54 |
| <i>Macaranga denticulata</i> | 20 | 40 | 0.29 | 24.16 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|--------------------------------|-------------|------------------|---------------------------------|---------------|
| <i>Prunus cerasoides</i> | 10 | 10 | 0.07 | 8.31 |
| <i>Quercus griffithii</i> | 20 | 30 | 1.93 | 35.81 |
| <i>Quercus spicata</i> | 10 | 20 | 1.59 | 25.07 |
| <i>Rhus javanica</i> | 10 | 20 | 0.14 | 12.08 |
| <i>Saurauia macrotricha</i> | 10 | 10 | 0.07 | 8.31 |
| <i>Syzygium cuminii</i> | 20 | 20 | 1.15 | 25.66 |
| <i>Terminalia belerica</i> | 10 | 20 | 1.15 | 21.11 |
| <i>Toona ciliata</i> | 10 | 10 | 0.80 | 14.81 |
| <i>Xanthoxylum armatum</i> | 20 | 30 | 0.38 | 21.89 |
| Total | | 320 | 11.15 | 300 |
| Shrubs | | | | |
| <i>Ficus squamata</i> | 10 | 30 | - | 14.46 |
| <i>Hedyotis scandens</i> | 10 | 40 | - | 16.50 |
| <i>Maesa chisia</i> | 10 | 80 | - | 24.66 |
| <i>Melastoma nepalensis</i> | 10 | 20 | - | 12.41 |
| <i>Osbeckia nutans</i> | 20 | 100 | - | 37.07 |
| <i>Rubus mollucanus</i> | 20 | 70 | - | 30.95 |
| <i>Schefflera venulosa</i> | 10 | 20 | - | 12.41 |
| <i>Solanum nigrum</i> | 20 | 70 | - | 30.95 |
| <i>Woodfordia fruticosa</i> | 10 | 60 | - | 20.58 |
| Total | | 490 | | 200 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 20 | 70000 | - | 28.86 |
| <i>Bidens biternata</i> | 20 | 40000 | - | 20.57 |
| <i>Cardamine hirsuta</i> | 10 | 3000 | - | 5.59 |
| <i>Cassia occidentalis</i> | 10 | 25000 | - | 11.67 |
| <i>Commelina appendiculata</i> | 20 | 20000 | - | 15.05 |
| <i>Cynoglossum furcatum</i> | 20 | 50000 | - | 23.34 |
| <i>Cyperus kyllinga</i> | 10 | 3000 | - | 5.59 |
| <i>Eupatorium odoratum</i> | 20 | 20000 | - | 15.05 |
| <i>Galinsoga parviflora</i> | 20 | 80000 | - | 31.62 |
| <i>Hedychium coccineum</i> | 10 | 2000 | - | 5.31 |
| <i>Impatiens chinensis</i> | 20 | 20000 | - | 15.05 |
| <i>Pteridium aquilinum</i> | 10 | 18000 | - | 9.73 |
| <i>Plantago ovata</i> | 10 | 1000 | - | 5.04 |
| <i>Persicaria capitata</i> | 10 | 10000 | - | 7.52 |
| Total | | 362000 | | 199.99 |

B. Power house site

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|---------|-------------|------------------|---------------------------------|-----|
|---------|-------------|------------------|---------------------------------|-----|

| | | | | |
|--------------------------------|----|---------------|--------------|------------|
| Trees | | | | |
| <i>Altingia excelsa</i> | 10 | 10 | 0.13 | 18.41 |
| <i>Bombax ceiba</i> | 10 | 10 | 0.20 | 20.76 |
| <i>Bridelia</i> sp. | 10 | 10 | 0.07 | 16.57 |
| <i>Callicarpa arborea</i> | 20 | 20 | 0.20 | 34.85 |
| <i>Citrus aurantium</i> | 10 | 30 | 0.15 | 30.89 |
| <i>Cordia dichotoma</i> | 10 | 10 | 0.16 | 19.52 |
| <i>Eurya acuminata</i> | 10 | 20 | 0.32 | 30.71 |
| <i>Ficus semicordata</i> | 10 | 10 | 0.07 | 16.57 |
| <i>Persea gamblei</i> | 10 | 20 | 0.40 | 33.20 |
| <i>Pinus roxburghii</i> | 20 | 30 | 1.34 | 78.52 |
| Total | | 320 | 11.15 | 300 |
| Shrubs | | | | |
| <i>Artemisia nilagirica</i> | 20 | 50 | - | 19.88 |
| Clematis gouriana | 20 | 30 | - | 16.37 |
| <i>Desmodium sequax</i> | 10 | 30 | - | 10.82 |
| <i>Eupatorium cannabinum</i> | 30 | 120 | - | 37.72 |
| <i>Ficus squamata</i> | 10 | 10 | - | 7.31 |
| <i>Indigofera atropurpurea</i> | 20 | 40 | - | 18.13 |
| <i>Osbeckia nutans</i> | 20 | 80 | - | 25.15 |
| <i>Rubus molucanus</i> | 20 | 70 | - | 23.39 |
| <i>Schefflera venulosa</i> | 10 | 30 | - | 10.82 |
| <i>Urtica dioica</i> | 10 | 80 | - | 19.59 |
| <i>Woodfordia fruticosa</i> | 10 | 30 | - | 10.82 |
| Total | | 490 | | 200 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 20 | 9000 | - | 15.37 |
| <i>Arundinaria</i> sp. | 10 | 12000 | - | 11.71 |
| <i>Bidens biternata</i> | 20 | 1000 | - | 11.06 |
| <i>Cassia occidentalis</i> | 10 | 12000 | - | 11.71 |
| <i>Centella asiatica</i> | 10 | 15000 | - | 13.33 |
| <i>Colocasia esculenta</i> | 10 | 2000 | - | 6.34 |
| <i>Dioscorea</i> sp. | 20 | 3000 | - | 12.14 |
| <i>Eupatorium odoratum</i> | 20 | 25000 | - | 23.97 |
| <i>Galinsoga parviflora</i> | 10 | 50000 | - | 32.14 |
| <i>Impatiens chinensis</i> | 20 | 6000 | - | 13.75 |
| <i>Plantago ovata</i> | 10 | 6000 | - | 8.49 |
| <i>Persicaria capitata</i> | 10 | 20000 | - | 16.02 |
| <i>Tridax procumbens</i> | 20 | 25000 | - | 23.97 |
| Total | | 362000 | | 200 |

C. Catchment area

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|---------|-------------|------------------|---------------------------------|-----|
|---------|-------------|------------------|---------------------------------|-----|

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|------------------------------------|-------------|------------------|---------------------------------|------------|
| Trees | | | | |
| <i>Ailanthus grandis</i> | 10 | 10 | 0.16 | 9.73 |
| <i>Betula alnoides</i> | 10 | 10 | 0.16 | 9.73 |
| <i>Callicarpa arborea</i> | 20 | 40 | 0.59 | 28.68 |
| <i>Castanopsis tribuloides</i> | 20 | 30 | 1.93 | 43.47 |
| <i>Dalbergia rimosa</i> | 10 | 10 | 0.45 | 13.49 |
| <i>Dysoxylum gobara</i> | 10 | 20 | 0.14 | 12.36 |
| <i>Grewia dispernum</i> | 20 | 30 | 0.48 | 24.44 |
| <i>Litsea monopetala</i> | 10 | 10 | 0.13 | 9.29 |
| <i>Macaranga indica</i> | 20 | 40 | 0.56 | 28.32 |
| <i>Persea gamblei</i> | 10 | 20 | 0.32 | 14.71 |
| <i>Pinus roxburghii</i> | 10 | 20 | 0.57 | 18.00 |
| <i>Premna latifolia</i> | 10 | 20 | 0.25 | 13.82 |
| <i>Quercus griffithii</i> | 20 | 40 | 1.15 | 35.99 |
| <i>Quercus lanuginosa</i> | 10 | 20 | 0.32 | 14.71 |
| <i>Rhododendron arboreum</i> | 10 | 20 | 0.32 | 14.71 |
| <i>Rhus javanica</i> | 10 | 10 | 0.07 | 8.56 |
| Total | | 350 | 7.6 | 300 |
| Shrubs | | | | |
| <i>Artemisia nilagirica</i> | 20 | 80 | - | 23.46 |
| <i>Buddleja asiatica</i> | 10 | 20 | - | 8.99 |
| Clematis gouriana | 10 | 20 | - | 8.99 |
| <i>Clerodendron colebrookianum</i> | 10 | 80 | - | 17.21 |
| <i>Eupatoriun adenophorum</i> | 10 | 190 | - | 32.28 |
| <i>Ficus squamata</i> | 10 | 20 | - | 8.99 |
| <i>Indigofera atropurpurea</i> | 10 | 40 | - | 11.73 |
| <i>Maesa chisia</i> | 10 | 20 | - | 8.99 |
| <i>Osbeckia nutans</i> | 20 | 90 | - | 24.83 |
| <i>Rubia cordifolia</i> | 10 | 20 | - | 8.99 |
| <i>Rubus ellipticus</i> | 10 | 30 | - | 10.36 |
| <i>Saccharum spontaneum</i> | 10 | 60 | - | 14.47 |
| <i>Schefflera venulosa</i> | 10 | 10 | - | 7.62 |
| <i>Urtica dioica</i> | 10 | 50 | - | 13.10 |
| Total | | 730 | | 200 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 20 | 40000 | - | 25.22 |
| <i>Hoya lanceolata</i> | 10 | 5000 | - | 6.56 |
| <i>Impatiens chinensis</i> | 10 | 6000 | - | 6.96 |
| <i>Bidens biternata</i> | 20 | 50000 | - | 29.25 |
| <i>Cyperus sp.</i> | 10 | 10000 | - | 8.58 |
| <i>Lycopodium selago</i> | 10 | 10000 | - | 8.58 |
| <i>Begonia sp.</i> | 10 | 2000 | - | 5.35 |
| <i>Molineria curculigoides</i> | 10 | 3000 | - | 5.76 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|-------------------------------|-------------|------------------|---------------------------------|------------|
| <i>Nephrolepis cordifolia</i> | 10 | 2000 | - | 5.35 |
| <i>Oxalis corniculata</i> | 10 | 8000 | - | 7.77 |
| <i>Plantago ovata</i> | 20 | 25000 | - | 19.17 |
| <i>Pogostemon</i> sp. | 10 | 2000 | - | 5.35 |
| <i>Persicaria capitata</i> | 20 | 30000 | - | 21.19 |
| <i>Pouzolzia wednnettiana</i> | 10 | 25000 | - | 14.63 |
| <i>Pteridium aquilinum</i> | 10 | 2000 | - | 5.35 |
| <i>Rivea ornata</i> | 10 | 25000 | - | 14.63 |
| <i>Sabia lanceolata</i> | 10 | 2000 | - | 5.35 |
| <i>Tridax procumbens</i> | 10 | 1000 | - | 4.95 |
| Total | | 248000 | | 200 |

D. Submergence area

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|------------------------------|-------------|------------------|---------------------------------|------------|
| Trees | | | | |
| <i>Betula alnoides</i> | 10 | 10 | 0.13 | 14.99 |
| <i>Bombax ceiba</i> | 10 | 20 | 1.44 | 44.16 |
| <i>Bridelia</i> sp. | 10 | 10 | 0.13 | 14.99 |
| <i>Cordia dichotoma</i> | 10 | 10 | 0.34 | 18.76 |
| <i>Ficus roxburghii</i> | 20 | 20 | 0.14 | 27.98 |
| <i>Grewia dispernum</i> | 10 | 10 | 0.24 | 17.04 |
| <i>Litsea monopetala</i> | 10 | 10 | 0.64 | 24.32 |
| <i>Quercus griffithii</i> | 10 | 10 | 0.58 | 23.07 |
| <i>Quercus lanuginosa</i> | 20 | 40 | 1.15 | 57.18 |
| <i>Rhododendron arboreum</i> | 10 | 20 | 0.20 | 21.77 |
| <i>Symplocos racemosa</i> | 20 | 20 | 0.57 | 35.73 |
| Total | | 180 | 5.56 | 300 |
| Shrubs | | | | |
| <i>Desmodium sequax</i> | 10 | 20 | - | 9.89 |
| <i>Buddleja asiatica</i> | 10 | 10 | - | 8.07 |
| <i>Hedyotis scandens</i> | 10 | 10 | - | 8.07 |
| <i>Inula cappa</i> | 10 | 20 | - | 9.89 |
| <i>Rubia cordifolia</i> | 20 | 90 | - | 28.86 |
| <i>Rubus mollucanus</i> | 20 | 200 | - | 48.86 |
| <i>Sida acuta</i> | 10 | 20 | - | 9.89 |
| <i>Thysanolaena maxima</i> | 20 | 30 | - | 17.95 |
| Triumfetta pilosa | 10 | 20 | - | 9.89 |
| <i>Urena lobata</i> | 20 | 40 | - | 19.77 |
| <i>Vitis heyneana</i> | 20 | 90 | - | 28.86 |
| Total | | 550 | | 200 |
| Herbs | | | | |

| | | | | |
|--------------------------------|----|---------------|---|------------|
| <i>Ageratum conyzoides</i> | 20 | 9000 | - | 12.13 |
| <i>Asplenium nidus</i> | 20 | 12000 | - | 13.50 |
| <i>Bidens biternata</i> | 10 | 3000 | - | 5.38 |
| <i>Cassia occidentalis</i> | 10 | 1000 | - | 4.46 |
| <i>Centella asiatica</i> | 10 | 2000 | - | 4.92 |
| <i>Cynoglossum furcatum</i> | 10 | 20000 | - | 13.17 |
| <i>Drymaria cordata</i> | 20 | 5000 | - | 10.29 |
| <i>Elatostemma hookerianum</i> | 10 | 6000 | - | 6.75 |
| <i>Eupatorium odoratum</i> | 20 | 50000 | - | 30.94 |
| <i>Galinsoga parviflora</i> | 20 | 60000 | - | 35.52 |
| Hedychium coccineum | 10 | 2000 | - | 4.92 |
| <i>Lilium grande</i> | 10 | 2000 | - | 4.92 |
| <i>Mikania micrantha</i> | 20 | 20000 | - | 17.17 |
| <i>Polygonum capitatum</i> | 20 | 18000 | - | 16.26 |
| <i>Pouzolzia</i> sp. | 10 | 1000 | - | 4.46 |
| <i>Sida acuta</i> | 10 | 2000 | - | 4.92 |
| <i>Tridax procumbens</i> | 10 | 4000 | - | 5.83 |
| <i>Urtica parviflora</i> | 10 | 1000 | - | 4.46 |
| Total | | 218000 | | 200 |

TABLE-5.5
Community characteristics of the vegetation at various sampling locations
at different sites in Dibin project sites (Summer season)

A. Dam site

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|--------------------------------|-------------|------------------|---------------------------------|-------|
| Trees | | | | |
| <i>Ailanthus grandis</i> | 10 | 20 | 1.02 | 19.93 |
| <i>Callicarpa arborea</i> | 10 | 10 | 0.16 | 9.12 |
| <i>Castanopsis tribuloides</i> | 20 | 20 | 1.44 | 28.23 |
| <i>Dalbergia rimosa</i> | 10 | 10 | 0.34 | 10.69 |
| <i>Eurya acuminata</i> | 10 | 20 | 0.35 | 13.95 |
| <i>Ficus roxburghii</i> | 10 | 10 | 0.07 | 8.31 |
| <i>Lagerstoemia parviflora</i> | 10 | 20 | 0.20 | 12.54 |
| <i>Macaranga denticulata</i> | 20 | 40 | 0.29 | 24.16 |
| Prunus cerasoides | 10 | 10 | 0.07 | 8.31 |
| <i>Quercus griffithii</i> | 20 | 30 | 1.93 | 35.81 |
| <i>Quercus spicata</i> | 10 | 20 | 1.59 | 25.07 |
| <i>Rhus javanica</i> | 10 | 20 | 0.14 | 12.08 |
| <i>Saurauia macrotricha</i> | 10 | 10 | 0.07 | 8.31 |
| <i>Syzygium cuminii</i> | 20 | 20 | 1.15 | 25.66 |
| <i>Terminalia belerica</i> | 10 | 20 | 1.15 | 21.11 |
| <i>Toona ciliata</i> | 10 | 10 | 0.80 | 14.81 |
| <i>Xanthoxylum armatum</i> | 20 | 30 | 0.38 | 21.89 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|---------------------------------|-------------|------------------|---------------------------------|---------------|
| Total | | 320 | 11.15 | 300 |
| Shrubs | | | | |
| <i>Ficus squamata</i> | 10 | 30 | - | 14.46 |
| <i>Hedyotis scandens</i> | 10 | 40 | - | 16.50 |
| <i>Maesa chisia</i> | 10 | 80 | - | 24.66 |
| <i>Melastoma nepalensis</i> | 10 | 20 | - | 12.41 |
| <i>Osbeckia nutans</i> | 20 | 100 | - | 37.07 |
| <i>Rubus mollucanus</i> | 20 | 70 | - | 30.95 |
| <i>Schefflera venulosa</i> | 10 | 20 | - | 12.41 |
| <i>Solanum nigrum</i> | 20 | 70 | - | 30.95 |
| <i>Woodfordia fruticosa</i> | 10 | 60 | - | 20.58 |
| Total | | 490 | | 200 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 20 | 9000 | - | 6.72 |
| <i>Aspidopterys elliptica</i> | 100 | 12000 | - | 26.42 |
| <i>Bidens biternata</i> | 20 | 4000 | - | 5.63 |
| <i>Cardamine hirsute</i> | 10 | 3000 | - | 3.03 |
| <i>Cassia occidentalis</i> | 10 | 25000 | - | 7.82 |
| <i>Commelina appendiculata</i> | 20 | 20000 | - | 9.11 |
| <i>Cynoglossum furcatum</i> | 20 | 90000 | - | 24.33 |
| <i>Cyperus kyllinga</i> | 10 | 3000 | - | 3.03 |
| <i>Dioscorea sp.</i> | 10 | 6000 | - | 3.69 |
| <i>Drymaria cordata</i> | 10 | 2000 | - | 2.82 |
| <i>Elastostemma hookerianum</i> | 20 | 50000 | - | 15.63 |
| <i>Equisetum debile</i> | 30 | 9000 | - | 9.10 |
| <i>Eupatorium odoratum</i> | 20 | 20000 | - | 9.11 |
| <i>Galinsoga parviflora</i> | 20 | 150000 | - | 37.37 |
| <i>Hedychium conccinum</i> | 10 | 2000 | - | 2.82 |
| <i>Impatiens chinensis</i> | 20 | 20000 | - | 9.11 |
| <i>Mikania micrantha</i> | 10 | 2000 | - | 2.82 |
| <i>Nephrolepis cordifolia</i> | 10 | 1000 | - | 2.60 |
| <i>Oxalis corniculata</i> | 20 | 20000 | - | 9.11 |
| <i>Plantago ovata</i> | 10 | 1000 | - | 2.60 |
| <i>Persicaria capitata</i> | 10 | 10000 | - | 4.55 |
| <i>Urtica parviflora</i> | 10 | 1000 | - | 2.60 |
| Total | | 460000 | | 200.02 |

B. Power house site

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|-------------------------|-------------|------------------|---------------------------------|-------|
| Trees | | | | |
| <i>Altingia excelsa</i> | 10 | 10 | 0.13 | 18.41 |
| <i>Bombax ceiba</i> | 10 | 10 | 0.20 | 20.76 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|--------------------------------|-------------|------------------|---------------------------------|---------------|
| <i>Bridelia</i> sp. | 10 | 10 | 0.07 | 16.57 |
| <i>Callicarpa arborea</i> | 20 | 20 | 0.20 | 34.85 |
| <i>Citrus aurantium</i> | 10 | 30 | 0.15 | 30.89 |
| <i>Cordia dichotoma</i> | 10 | 10 | 0.16 | 19.52 |
| <i>Eurya acuminata</i> | 10 | 20 | 0.32 | 30.71 |
| <i>Ficus semicordata</i> | 10 | 10 | 0.07 | 16.57 |
| <i>Persea gamblei</i> | 10 | 20 | 0.40 | 33.20 |
| <i>Pinus roxburghii</i> | 20 | 30 | 1.34 | 78.52 |
| Total | | 170 | 3.04 | 300 |
| Shrubs | | | | |
| <i>Artemisia nilagirica</i> | 20 | 50 | - | 19.88 |
| Clematis gouriana | 20 | 30 | - | 16.37 |
| <i>Desmodium sequax</i> | 10 | 30 | - | 10.82 |
| <i>Eupatorium cannabinum</i> | 30 | 120 | - | 37.72 |
| <i>Ficus squamata</i> | 10 | 10 | - | 7.31 |
| <i>Indigofera atropurpurea</i> | 20 | 40 | - | 18.13 |
| <i>Osbeckia nutans</i> | 20 | 80 | - | 25.15 |
| <i>Rubus molucanus</i> | 20 | 70 | - | 23.39 |
| <i>Schefflera venulosa</i> | 10 | 30 | - | 10.82 |
| <i>Urtica dioica</i> | 10 | 80 | - | 19.59 |
| <i>Woodfordia fruticosa</i> | 10 | 30 | - | 10.82 |
| Total | | 570 | | 200 |
| Herbs | | | | |
| <i>Hoya lanceolata</i> | 10 | 5000 | - | 9.43 |
| <i>Impatiens chinensis</i> | 10 | 6000 | - | 10.14 |
| <i>Lilium grande</i> | 10 | 1000 | - | 6.59 |
| <i>Lycopodium selago</i> | 10 | 10000 | - | 12.97 |
| <i>Molineria curculigoides</i> | 10 | 2000 | - | 7.30 |
| <i>Nephrolepis cordifolia</i> | 10 | 2000 | - | 7.30 |
| <i>Oxalis corniculata</i> | 10 | 8000 | - | 11.56 |
| <i>Plantago ovata</i> | 20 | 25000 | - | 29.50 |
| <i>Pogostemon</i> sp. | 10 | 2000 | - | 7.30 |
| <i>Persicaria capitata</i> | 20 | 30000 | - | 33.04 |
| <i>Pteridium aquilinum</i> | 10 | 2000 | - | 7.30 |
| <i>Rivea ornate</i> | 10 | 25000 | - | 23.61 |
| <i>Sabia lanceolata</i> | 10 | 2000 | - | 7.30 |
| <i>Urtica parviflora</i> | 10 | 20000 | - | 20.07 |
| Total | | 140000 | | 193.41 |

C. Catchment area

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|---------|-------------|------------------|---------------------------------|-----|
|---------|-------------|------------------|---------------------------------|-----|

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|------------------------------------|-------------|------------------|---------------------------------|---------------|
| Trees | | | | |
| <i>Ailanthus grandis</i> | 10 | 10 | 0.16 | 9.73 |
| <i>Betula alnoides</i> | 10 | 10 | 0.16 | 9.73 |
| <i>Callicarpa arborea</i> | 20 | 40 | 0.59 | 28.68 |
| <i>Castanopsis tribuloides</i> | 20 | 30 | 1.93 | 43.47 |
| <i>Dalbergia rimosa</i> | 10 | 10 | 0.45 | 13.49 |
| <i>Dysoxylum gobara</i> | 10 | 20 | 0.14 | 12.36 |
| <i>Grewia dispernum</i> | 20 | 30 | 0.48 | 24.44 |
| <i>Litsea monopetala</i> | 10 | 10 | 0.13 | 9.29 |
| <i>Macaranga indica</i> | 20 | 40 | 0.56 | 28.32 |
| <i>Persea gamblei</i> | 10 | 20 | 0.32 | 14.71 |
| <i>Pinus roxburghii</i> | 10 | 20 | 0.57 | 18.00 |
| <i>Premna latifolia</i> | 10 | 20 | 0.25 | 13.82 |
| <i>Quercus griffithii</i> | 20 | 40 | 1.15 | 35.99 |
| <i>Quercus lanuginosa</i> | 10 | 20 | 0.32 | 14.71 |
| <i>Rhododendron arboreum</i> | 10 | 20 | 0.32 | 14.71 |
| <i>Rhus javanica</i> | 10 | 10 | 0.07 | 8.56 |
| Total | | 350 | 7.6 | 300.01 |
| Shrubs | | | | |
| <i>Artemisia nilagirica</i> | 20 | 80 | - | 23.46 |
| <i>Buddleja asiatica</i> | 10 | 20 | - | 8.99 |
| Clematis gouriana | 10 | 20 | - | 8.99 |
| <i>Clerodendron colebrookianum</i> | 10 | 80 | - | 17.21 |
| <i>Eupatorium adenophorum</i> | 10 | 190 | - | 32.28 |
| <i>Ficus squamata</i> | 10 | 20 | - | 8.99 |
| <i>Indigofera atropurpurea</i> | 10 | 40 | - | 11.73 |
| <i>Maesa chisia</i> | 10 | 20 | - | 8.99 |
| <i>Osbeckia nutans</i> | 20 | 90 | - | 24.83 |
| <i>Rubia cordifolia</i> | 10 | 20 | - | 8.99 |
| <i>Rubus ellipticus</i> | 10 | 30 | - | 10.36 |
| <i>Saccharum spontaneum</i> | 10 | 60 | - | 14.47 |
| <i>Schefflera venulosa</i> | 10 | 10 | - | 7.62 |
| <i>Urtica dioica</i> | 10 | 50 | - | 13.10 |
| Total | | 730 | | 200.01 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 20 | 9000 | - | 6.45 |
| <i>Aspidopterys elliptica</i> | 50 | 25000 | - | 16.76 |
| <i>Asplenium nidus</i> | 20 | 1200 | - | 4.47 |
| <i>Bidens biternata</i> | 10 | 3000 | - | 2.84 |
| <i>Cassia occidentalis</i> | 10 | 1200 | - | 2.39 |
| <i>Hydrocotyle asiatica</i> | 10 | 2000 | - | 2.59 |
| <i>Commelina appendiculata</i> | 20 | 25000 | - | 10.51 |
| <i>Cynoglossum furcatum</i> | 10 | 20000 | - | 7.15 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|---------------------------------|-------------|------------------|---------------------------------|------------|
| <i>Cyperus kyllinga</i> | 10 | 9000 | - | 4.37 |
| <i>Dioscorea</i> sp. | 20 | 3000 | - | 4.93 |
| <i>Drymaria cordata</i> | 20 | 5000 | - | 5.43 |
| <i>Elastostemma hookerianum</i> | 10 | 6000 | - | 3.60 |
| <i>Equisetum debile</i> | 10 | 2000 | - | 2.59 |
| <i>Eupatorium odoratum</i> | 20 | 50000 | - | 16.84 |
| <i>Galinsoga parviflora</i> | 30 | 90000 | - | 29.07 |
| <i>Hedychium concnium</i> | 10 | 2000 | - | 2.59 |
| <i>Hoya lanceolata</i> | 10 | 2000 | - | 2.59 |
| <i>Impatiens chinensis</i> | 10 | 8000 | - | 4.11 |
| <i>Lycopodium selago</i> | 20 | 30000 | - | 11.77 |
| <i>Mikania micrantha</i> | 20 | 20000 | - | 9.24 |
| <i>Molineria curculigoides</i> | 10 | 2000 | - | 2.59 |
| <i>Nephrolepis cordifolia</i> | 10 | 1000 | - | 2.34 |
| <i>Oxalis corniculata</i> | 10 | 20000 | - | 7.15 |
| <i>Persicaria capitata</i> | 20 | 20000 | - | 9.24 |
| <i>Pouzolzia sanguina</i> | 10 | 1000 | - | 2.34 |
| <i>Pteridium aquilinum</i> | 10 | 1000 | - | 2.34 |
| <i>Pteris biaurita</i> | 20 | 2000 | - | 4.67 |
| <i>Sabia lanceolata</i> | 10 | 1000 | - | 2.34 |
| <i>Selaginella</i> sp. | 10 | 25000 | - | 8.42 |
| <i>Senecio scandens</i> | 10 | 2000 | - | 2.59 |
| <i>Sida acuta</i> | 10 | 2000 | - | 2.59 |
| <i>Tridax procumbens</i> | 10 | 4000 | - | 3.10 |
| Total | | 394400 | | 200 |

D. Submergence area

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|------------------------------|-------------|------------------|---------------------------------|---------------|
| Trees | | | | |
| <i>Betula alnoides</i> | 10 | 10 | 0.13 | 14.99 |
| <i>Bombax ceiba</i> | 10 | 20 | 1.44 | 44.16 |
| <i>Bridelia</i> sp. | 10 | 10 | 0.13 | 14.99 |
| <i>Cordia dichotoma</i> | 10 | 10 | 0.34 | 18.76 |
| <i>Ficus roxburghii</i> | 20 | 20 | 0.14 | 27.98 |
| <i>Grewia dispernum</i> | 10 | 10 | 0.24 | 17.04 |
| <i>Litsea monopetala</i> | 10 | 10 | 0.64 | 24.32 |
| <i>Quercus griffithii</i> | 10 | 10 | 0.58 | 23.07 |
| <i>Quercus lanuginosa</i> | 20 | 40 | 1.15 | 57.18 |
| <i>Rhododendron arboreum</i> | 10 | 20 | 0.20 | 21.77 |
| <i>Symplocos racemosa</i> | 20 | 20 | 0.57 | 35.73 |
| Total | | 180 | 5.56 | 299.99 |
| Shrubs | | | | |

| | | | | |
|----------------------------|----|-----|---|-------|
| <i>Desmodium sequax</i> | 10 | 20 | - | 9.89 |
| <i>Buddleja asiatica</i> | 10 | 10 | - | 8.07 |
| <i>Hedyotis scandens</i> | 10 | 10 | - | 8.07 |
| <i>Inula cappa</i> | 10 | 20 | - | 9.89 |
| <i>Rubia cordifolia</i> | 20 | 90 | - | 28.86 |
| <i>Rubus mollucanus</i> | 20 | 200 | - | 48.86 |
| <i>Sida acuta</i> | 10 | 20 | - | 9.89 |
| <i>Thysanolaena maxima</i> | 20 | 30 | - | 17.95 |
| Triumfetta pilosa | 10 | 20 | - | 9.89 |
| <i>Urena lobata</i> | 20 | 40 | - | 19.77 |
| <i>Vitis heyneana</i> | 20 | 90 | - | 28.86 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|--------------------------------|-------------|------------------|---------------------------------|---------------|
| Total | | 550 | | 200 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 20 | 9000 | - | 10.92 |
| <i>Arundinaria sp.</i> | 20 | 12000 | - | 12.41 |
| <i>Asplenium nidus</i> | 10 | 2000 | - | 4.22 |
| <i>Bidens biternata</i> | 20 | 1200 | - | 7.05 |
| <i>Bulbophyllum griffithii</i> | 10 | 2000 | - | 4.22 |
| <i>Cardamine hirsute</i> | 10 | 1000 | - | 3.72 |
| <i>Cassia occidentalis</i> | 20 | 12000 | - | 12.41 |
| <i>Centella asiatica</i> | 10 | 1200 | - | 3.82 |
| <i>Colocasia esculanta</i> | 10 | 2000 | - | 4.22 |
| <i>Dioscorea sp.</i> | 20 | 3000 | - | 7.94 |
| <i>Eupatorium odoratum</i> | 20 | 25000 | - | 18.86 |
| <i>Galinsoga parviflora</i> | 10 | 50000 | - | 28.05 |
| <i>Hoya lanceolata</i> | 10 | 2000 | - | 4.22 |
| <i>Impatiens chinensis</i> | 20 | 6000 | - | 9.43 |
| <i>Mikania micrantha</i> | 10 | 2000 | - | 4.22 |
| <i>Nephrolepis cordifolia</i> | 10 | 5000 | - | 5.71 |
| <i>Plantago ovata</i> | 10 | 6000 | - | 6.20 |
| <i>Polygonum capitatum</i> | 10 | 20000 | - | 13.16 |
| <i>Pouzolzia sanguinea</i> | 10 | 1000 | - | 3.72 |
| <i>Pseudodryaria sp.</i> | 10 | 10000 | - | 8.19 |
| <i>Rivea ornate</i> | 10 | 2000 | - | 4.22 |
| <i>Sabia lanceolata</i> | 10 | 2000 | - | 4.22 |
| <i>Tridax procumbens</i> | 20 | 25000 | - | 18.86 |
| Total | | 201400 | | 199.99 |

TABLE-5.6

**Community characteristics of the vegetation at various sampling locations
in Dibbin project area (Monsoon season)**

A. Dam site:

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|------------------------------------|-------------|------------------|---------------------------------|------|
| Trees | | | | |
| <i>Ailanthus grandis</i> | 10 | 20 | 0.195 | 0.11 |
| <i>Callicarpa arborea</i> | 10 | 10 | 0.127 | 0.08 |
| <i>Castanopsis tribuloides</i> | 20 | 30 | 0.800 | 0.25 |
| <i>Dalbergia rimosa</i> | 10 | 15 | 0.299 | 0.11 |
| <i>Eurya acuminata</i> | 10 | 15 | 0.361 | 0.12 |
| <i>Ficus roxburghii</i> | 10 | 10 | 0.161 | 0.08 |
| <i>Lagerstoemia parviflora</i> | 10 | 15 | 0.242 | 0.11 |
| <i>Macaranga denticulata</i> | 20 | 40 | 0.390 | 0.22 |
| <i>Musa sp. (wild banana)</i> | 10 | 50 | 0.090 | 0.17 |
| <i>Pandanus odoraratissima</i> | 20 | 20 | 0.195 | 0.15 |
| <i>Prunus cerasoides</i> | 10 | 10 | 0.127 | 0.05 |
| <i>Quercus griffithii</i> | 20 | 40 | 2.580 | 0.48 |
| <i>Quercus spicata</i> | 10 | 20 | 0.673 | 0.17 |
| <i>Rhus javanica</i> | 10 | 15 | 0.048 | 0.08 |
| <i>Saurauia macrotricha</i> | 10 | 10 | 0.161 | 0.08 |
| <i>Syzygium cuminii</i> | 20 | 20 | 0.322 | 0.17 |
| <i>Terminalia bellerica</i> | 10 | 15 | 0.764 | 0.17 |
| <i>Toona ciliata</i> | 10 | 20 | 0.464 | 0.14 |
| <i>Xanthoxylum armatum</i> | 20 | 30 | 0.484 | 0.21 |
| Shrubs | | | | |
| <i>Buddleia asiatica</i> | 10 | 40 | - | 0.07 |
| <i>Clematis gouriana</i> | 20 | 50 | - | 0.11 |
| <i>Clerodendron colebrookianum</i> | 10 | 50 | - | 0.08 |
| <i>Desmodium sequax</i> | 10 | 15 | - | 0.04 |
| <i>Emblica officialis</i> | 20 | 35 | - | 0.09 |
| <i>Eupatoriun adenophorum</i> | 30 | 100 | - | 0.19 |
| <i>Ficus squamata</i> | 10 | 25 | - | 0.05 |
| <i>Maesa chisia</i> | 10 | 30 | - | 0.06 |
| <i>Melastoma nepalensis</i> | 10 | 20 | - | 0.05 |
| <i>Moutia puya</i> | 20 | 20 | - | 0.08 |
| <i>Osbeckia nutans</i> | 30 | 40 | - | 0.13 |
| <i>Pegia nitida</i> | 10 | 20 | - | 0.05 |
| <i>Rubus moluccanus</i> | 20 | 70 | - | 0.13 |
| <i>Saccharum spontaneum</i> | 10 | 90 | - | 0.12 |
| <i>Schefflera venulosa</i> | 10 | 20 | - | 0.05 |
| <i>Sida spp.</i> | 10 | 30 | - | 0.06 |
| <i>Smilax perfoliatum</i> | 20 | 50 | - | 0.11 |
| <i>Solanum nigrum</i> | 20 | 70 | - | 0.14 |
| <i>Thysanolaena maxima</i> | 10 | 90 | - | 0.12 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|--------------------------------|-------------|------------------|---------------------------------|-------|
| <i>Triumfetta rhomboidea</i> | 10 | 10 | - | 0.04 |
| <i>Urena lobata</i> | 10 | 40 | - | 0.07 |
| <i>Woodfordia fruticosa</i> | 10 | 60 | - | 0.09 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 30 | 80 | | 9.11 |
| <i>Angiopteris evecta</i> | 20 | 40 | | 5.33 |
| <i>Bidens biternata</i> | 20 | 20 | | 4.23 |
| <i>Blechnum orientale</i> | 10 | 30 | | 3.22 |
| <i>Blumea procera</i> | 10 | 10 | | 2.11 |
| <i>Calamintha umbrosa</i> | 10 | 10 | | 2.11 |
| <i>Centella asiatica</i> | 20 | 40 | | 5.33 |
| <i>Christella parasitica</i> | 30 | 80 | | 9.11 |
| <i>Coelogyne nitida</i> | 20 | 50 | | 5.89 |
| <i>Colocassia fallax</i> | 10 | 10 | | 2.11 |
| <i>Crepis japonica</i> | 10 | 20 | | 2.67 |
| <i>Crotalaria mysorensis</i> | 10 | 10 | | 2.11 |
| <i>Cyperus rotundus</i> | 10 | 60 | | 4.88 |
| <i>Dendrobium moschatum</i> | 30 | 30 | | 6.34 |
| <i>Eryngium foetidum</i> | 20 | 50 | | 5.89 |
| <i>Gastrochilus longiflora</i> | 10 | 30 | | 3.22 |
| <i>Gerbera macrophylla</i> | 10 | 10 | | 2.11 |
| <i>Gynura angulosa</i> | 10 | 10 | | 2.11 |
| <i>Hedychium gardnerium</i> | 10 | 20 | | 2.67 |
| <i>Impatiens chinensis</i> | 10 | 10 | | 2.11 |
| <i>Ipomoea angustifolia</i> | 10 | 10 | | 2.11 |
| <i>Lepisorus nudus</i> | 20 | 70 | | 6.99 |
| <i>Lindernia cordifolia</i> | 10 | 20 | | 2.67 |
| <i>Lobelia angulata</i> | 20 | 50 | | 5.89 |
| <i>Lygodium flexuosum</i> | 20 | 90 | | 8.1 |
| <i>Nephrolepis cordifolia</i> | 20 | 60 | | 6.44 |
| <i>Panicum auritum</i> | 10 | 10 | | 2.11 |
| <i>Panicum auritum</i> | 20 | 250 | | 16.94 |
| <i>Piper thomsonii</i> | 20 | 40 | | 5.33 |
| <i>Pothos cathcartii</i> | 10 | 10 | | 2.11 |
| <i>Pteridium aquilinum</i> | 10 | 20 | | 2.67 |
| <i>Pteris cretica</i> | 10 | 30 | | 3.22 |
| <i>Pyrrosia manii</i> | 20 | 60 | | 6.44 |
| <i>Rubia cordifolia</i> | 20 | 10 | | 3.68 |
| <i>Selaginella kraussiana</i> | 20 | 60 | | 6.44 |
| <i>Sonerila maculata</i> | 20 | 60 | | 6.44 |
| <i>Sphenomeris chinensis</i> | 20 | 10 | | 3.68 |
| <i>Themeda villosa</i> | 30 | 280 | | 20.16 |
| <i>Torrenia vagana</i> | 20 | 50 | | 5.89 |

B. Power house site

| Species | Frequency % | Density (No./ha) | Basal area (m²/ha) | IVI |
|--------------------------------|--------------------|-------------------------|--------------------------------------|------------|
| Trees | | | | |
| <i>Altingia excelsa</i> | 10 | 5 | 0.116 | 0.06 |
| <i>Bombax ceiba</i> | 10 | 5 | 0.53 | 0.08 |
| <i>Bridelia</i> spp. | 10 | 10 | 0.127 | 0.07 |
| <i>Callicarpa arborea</i> | 10 | 10 | 0.140 | 0.07 |
| <i>Citrus aurantium</i> | 10 | 40 | 0.282 | 0.15 |
| <i>Cordia dichotoma</i> | 10 | 10 | 0.161 | 0.07 |
| <i>Dalbergia rimosa</i> | 10 | 20 | 0.322 | 0.11 |
| <i>Eurya acuminata</i> | 10 | 20 | 0.255 | 0.10 |
| <i>Ficus cunia</i> | 10 | 10 | 0.072 | 0.07 |
| <i>Ficus</i> spp. | 10 | 3 | 0.038 | 0.05 |
| <i>Grewia microcosm</i> | 10 | 20 | 0.255 | 0.10 |
| <i>Ostodes paniculata</i> | 10 | 15 | 0.242 | 0.09 |
| <i>Persea gamblei</i> | 40 | 80 | 5.159 | 0.64 |
| <i>Pinus roxburghii</i> | 30 | 80 | 6.369 | 0.66 |
| <i>Quercus griffithii</i> | 20 | 40 | 2.580 | 0.32 |
| <i>Rhus javanica</i> | 10 | 5 | 0.025 | 0.06 |
| <i>Terminalia bellerica</i> | 10 | 20 | 1.019 | 0.15 |
| <i>Trema orientalis</i> | 10 | 20 | 0.780 | 0.13 |
| Shrubs | | | | |
| <i>Artemisia nilagirica</i> | 20 | 50 | - | 0.08 |
| <i>Clematis gouriana</i> | 20 | 30 | - | 0.07 |
| <i>Desmodium sequax</i> | 10 | 30 | - | 0.04 |
| <i>Eupatoriun adenophorum</i> | 40 | 120 | - | 0.19 |
| <i>Ficus squamata</i> | 10 | 10 | - | 0.03 |
| <i>Indigofera atropurpurea</i> | 20 | 40 | - | 0.08 |
| <i>Inula cappa</i> | 10 | 30 | - | 0.04 |
| <i>Maesa chisia</i> | 10 | 10 | - | 0.03 |
| <i>Melastoma nepalensis</i> | 10 | 40 | - | 0.05 |
| <i>Moutia puya</i> | 20 | 60 | - | 0.09 |
| <i>Osbeckia nutans</i> | 30 | 80 | - | 0.14 |
| <i>Pegia nitida</i> | 10 | 30 | - | 0.05 |
| <i>Rubia cordifolia</i> | 10 | 30 | - | 0.04 |
| <i>Rubus moluccanus</i> | 20 | 80 | - | 0.12 |
| <i>Schefflera venulosa</i> | 10 | 50 | - | 0.06 |
| <i>Sida</i> spp. | 20 | 40 | - | 0.08 |
| <i>Smilax perfoliatum</i> | 10 | 40 | - | 0.05 |
| <i>Solanum nigrum</i> | 20 | 100 | - | 0.13 |
| <i>Triumfetta rhomboidea</i> | 10 | 20 | - | 0.04 |
| <i>Urena lobata</i> | 10 | 60 | - | 0.07 |
| <i>Urtica dioica</i> | 20 | 250 | - | 0.23 |
| <i>Vitis heyneana</i> | 10 | 60 | - | 0.07 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI |
|-------------------------------|-------------|------------------|---------------------------------|-------|
| <i>Wallichia districha</i> | 10 | 20 | - | 0.04 |
| <i>Wenlandia tinctoria</i> | 10 | 30 | - | 0.04 |
| <i>Woodfordia fruticosa</i> | 10 | 30 | - | 0.04 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 30 | 80 | | 10.54 |
| <i>Alocasia macrorrhiza</i> | 10 | 10 | | 2.40 |
| <i>Angiopteris evecta</i> | 20 | 40 | | 6.13 |
| <i>Asplenium nudum</i> | 20 | 40 | | 6.13 |
| <i>Asplenium tenuifolium</i> | 30 | 30 | | 7.19 |
| <i>Begonia arborensis</i> | 10 | 10 | | 2.40 |
| <i>Begonia hatacoa</i> | 20 | 10 | | 4.12 |
| <i>Bidens biternata</i> | 10 | 20 | | 3.07 |
| <i>Blechnum orientale</i> | 10 | 30 | | 3.74 |
| <i>Blumea procera</i> | 10 | 10 | | 2.40 |
| <i>Boerhaavia diffusa</i> | 10 | 20 | | 3.07 |
| <i>Calamintha umbrosa</i> | 10 | 10 | | 2.40 |
| <i>Centella asiatica</i> | 20 | 40 | | 6.13 |
| <i>Christella parasitica</i> | 30 | 80 | | 10.54 |
| <i>Coelogyne nitida</i> | 10 | 50 | | 5.08 |
| <i>Crepis japonica</i> | 10 | 20 | | 3.07 |
| <i>Cyperus rotundus</i> | 10 | 60 | | 5.75 |
| <i>Dendrobium moschatum</i> | 20 | 30 | | 5.46 |
| <i>Eryngium foetidum</i> | 20 | 50 | | 6.80 |
| <i>Gerbera macrophylla</i> | 10 | 10 | | 2.40 |
| <i>Gynura angulosa</i> | 10 | 10 | | 2.40 |
| <i>Impatiens chinensis</i> | 10 | 10 | | 2.40 |
| <i>Ipomoea angustifolia</i> | 10 | 10 | | 2.40 |
| <i>Lepisorus nudus</i> | 20 | 70 | | 8.15 |
| <i>Lycopodium selago</i> | 30 | 60 | | 9.20 |
| <i>Lygodium flexuosum</i> | 20 | 90 | | 9.49 |
| <i>Nephrolepis cordifolia</i> | 20 | 60 | | 7.48 |
| <i>Onychium lucidum</i> | 30 | 50 | | 8.53 |
| <i>Panicum auritum</i> | 20 | 250 | | 20.23 |
| <i>Piper thomsonii</i> | 20 | 40 | | 6.13 |
| <i>Pteridium aquilinum</i> | 10 | 20 | | 3.07 |
| <i>Selaginella kraussiana</i> | 20 | 60 | | 7.48 |
| <i>Sonerila maculata</i> | 20 | 60 | | 7.48 |
| <i>Torrenia vagana</i> | 20 | 50 | | 6.80 |

C. Catchment area

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI (%) |
|---------|-------------|------------------|---------------------------------|---------|
|---------|-------------|------------------|---------------------------------|---------|

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI (%) |
|------------------------------------|-------------|------------------|---------------------------------|---------|
| Trees | | | | |
| <i>Ailanthus grandis</i> | 10 | 12 | 0.153 | 0.07 |
| <i>Betula alnoides</i> | 10 | 5 | 0.195 | 0.06 |
| <i>Callicarpa arborea</i> | 20 | 25 | 0.403 | 0.14 |
| <i>Castanopsis tribuloides</i> | 20 | 20 | 1.019 | 0.17 |
| <i>Dalbergia rimosa</i> | 10 | 10 | 0.199 | 0.07 |
| <i>Duabanga grandiflora</i> | 10 | 20 | 0.398 | 0.10 |
| <i>Dysoxylum gobara</i> | 10 | 12 | 0.019 | 0.06 |
| <i>Ficus roxburghii</i> | 10 | 10 | 0.032 | 0.06 |
| <i>Grewia dispernum</i> | 20 | 15 | 0.287 | 0.11 |
| <i>Litsea monopetala</i> | 10 | 10 | 0.287 | 0.07 |
| <i>Macaranga indica</i> | 20 | 15 | 0.146 | 0.11 |
| <i>Musa sp. (wild banana)</i> | 10 | 80 | 0.143 | 0.21 |
| <i>Persea gamblei</i> | 10 | 10 | 0.072 | 0.06 |
| <i>Persea villosa</i> | 10 | 10 | 0.390 | 0.08 |
| <i>Pinus roxburghii</i> | 40 | 100 | 9.634 | 0.97 |
| <i>Premna latifolia</i> | 10 | 15 | 0.430 | 0.09 |
| <i>Quercus griffithii</i> | 20 | 40 | 0.510 | 0.18 |
| <i>Quercus lanuginosa</i> | 20 | 20 | 0.398 | 0.13 |
| <i>Rhododendron arboreum</i> | 30 | 35 | 0.564 | 0.21 |
| <i>Rhus javanica</i> | 10 | 15 | 0.039 | 0.07 |
| Shrubs | | | | |
| <i>Artemisia nilagirica</i> | 20 | 80 | - | 0.23 |
| <i>Buddleia asiatica</i> | 10 | 20 | - | 0.09 |
| <i>Clematis gouriana</i> | 10 | 20 | - | 0.09 |
| <i>Clerodendron colebrookianum</i> | 10 | 80 | - | 0.17 |
| <i>Eupatoriun adenophorum</i> | 10 | 190 | - | 0.32 |
| <i>Ficus squamata</i> | 10 | 20 | - | 0.09 |
| <i>Indigofera atropurpurea</i> | 10 | 40 | - | 0.12 |
| <i>Maesa chisia</i> | 10 | 20 | - | 0.09 |
| <i>Osbeckia nutans</i> | 20 | 90 | - | 0.25 |
| <i>Rubia cordifolia</i> | 10 | 20 | - | 0.09 |
| <i>Rubus ellipticus</i> | 10 | 30 | - | 0.10 |
| <i>Saccharum spontanum</i> | 10 | 60 | - | 0.14 |
| <i>Schefflera venulosa</i> | 10 | 10 | - | 0.08 |
| <i>Urtica dioica</i> | 10 | 50 | - | 0.13 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 30 | 80 | | 7.40 |
| <i>Alocasia macrorhiza</i> | 10 | 10 | | 1.67 |
| <i>Angiopteris evecta</i> | 20 | 40 | | 4.29 |
| <i>Asplenium nudum</i> | 20 | 40 | | 4.29 |
| <i>Asplenium tenuifolium</i> | 30 | 30 | | 5.01 |
| <i>Begonia arborensis</i> | 10 | 10 | | 1.67 |
| <i>Begonia hatacoa</i> | 20 | 10 | | 2.86 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI (%) |
|--------------------------------|-------------|------------------|---------------------------------|---------|
| <i>Bidens biternata</i> | 10 | 20 | | 2.15 |
| <i>Blechnum orientale</i> | 10 | 30 | | 2.63 |
| <i>Blumea procera</i> | 10 | 10 | | 1.67 |
| <i>Boerhaavia diffusa</i> | 10 | 20 | | 2.15 |
| <i>Calamintha umbrosa</i> | 10 | 10 | | 1.67 |
| <i>Centella asiatica</i> | 20 | 40 | | 4.29 |
| <i>Christella parasitica</i> | 30 | 80 | | 7.40 |
| <i>Clematis gouriana</i> | 20 | 10 | | 2.86 |
| <i>Coelogyne nitida</i> | 20 | 50 | | 4.77 |
| <i>Colocassia fallax</i> | 10 | 10 | | 1.67 |
| <i>Crepis japonica</i> | 20 | 20 | | 3.34 |
| <i>Crotalaria mysorensis</i> | 10 | 10 | | 1.67 |
| <i>Cyperus rotundus</i> | 10 | 60 | | 4.06 |
| <i>Dendrobium moschatum</i> | 30 | 30 | | 5.01 |
| <i>Dioscorea bulbifera</i> | 20 | 20 | | 3.34 |
| <i>Diplazium paleaceum</i> | 30 | 30 | | 5.01 |
| <i>Eryngium foetidum</i> | 20 | 50 | | 4.77 |
| <i>Gastrochilus longiflora</i> | 10 | 30 | | 2.63 |
| <i>Gerbera macrophylla</i> | 10 | 10 | | 1.67 |
| <i>Gynura angulosa</i> | 10 | 10 | | 1.67 |
| <i>Hedychium gardnerium</i> | 10 | 20 | | 2.15 |
| <i>Hedychium gracile</i> | 10 | 10 | | 1.67 |
| <i>Impatiens chinensis</i> | 10 | 10 | | 1.67 |
| <i>Ipomoea angustifolia</i> | 10 | 10 | | 1.67 |
| <i>Lepisorus nudus</i> | 20 | 70 | | 5.73 |
| <i>Lobelia angulata</i> | 20 | 60 | | 5.25 |
| <i>Lycopodium selago</i> | 30 | 60 | | 6.44 |
| <i>Lygodium flexuosum</i> | 20 | 90 | | 6.69 |
| <i>Nephrolepis cordifolia</i> | 20 | 60 | | 5.25 |
| <i>Onychium lucidum</i> | 30 | 50 | | 5.96 |
| <i>Panicum auritum</i> | 20 | 250 | | 14.34 |
| <i>Piper thomsonii</i> | 20 | 40 | | 4.29 |
| <i>Pothos cathcartii</i> | 10 | 10 | | 7.40 |
| <i>Pteridium aquilinum</i> | 10 | 20 | | 1.67 |
| <i>Pteris cretica</i> | 10 | 30 | | 4.29 |
| <i>Pyrrosia manii</i> | 20 | 60 | | 4.29 |
| <i>Rubia cordifolia</i> | 10 | 10 | | 5.01 |
| <i>Selaginella kraussiana</i> | 20 | 60 | | 1.67 |
| <i>Sonerila maculata</i> | 20 | 60 | | 2.86 |
| <i>Sphenomeris chinensis</i> | 10 | 10 | | 2.15 |
| <i>Themeda villosa</i> | 30 | 280 | | 2.63 |
| <i>Torrenia vagana</i> | 20 | 50 | | 1.67 |

D. Submergence area

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI (%) |
|--------------------------------|-------------|------------------|---------------------------------|---------|
| Trees | | | | |
| <i>Betula alnoides</i> | 10 | 10 | 0.199 | 0.08 |
| <i>Bombax ceiba</i> | 10 | 5 | 0.255 | 0.07 |
| <i>Bridelia</i> spp. | 10 | 10 | 0.127 | 0.07 |
| <i>Castanopsis tribuloides</i> | 10 | 20 | 0.573 | 0.14 |
| <i>Cordia dichotoma</i> | 10 | 10 | 0.448 | 0.10 |
| <i>Cyathea spinulosa</i> | 10 | 10 | 0.072 | 0.07 |
| <i>Engelhardtia spicata</i> | 10 | 10 | 0.072 | 0.07 |
| <i>Ficus roxburghii</i> | 10 | 10 | 0.127 | 0.07 |
| <i>Grewia dispernum</i> | 10 | 10 | 0.127 | 0.07 |
| <i>Litsea monopetala</i> | 10 | 10 | 0.287 | 0.09 |
| <i>Ostodes paniculata</i> | 10 | 15 | 0.191 | 0.09 |
| <i>Persea gamblei</i> | 10 | 5 | 0.100 | 0.06 |
| <i>Persea villosa</i> | 20 | 20 | 0.195 | 0.14 |
| <i>Pinus roxburghii</i> | 40 | 80 | 5.159 | 0.80 |
| <i>Quercus griffithii</i> | 10 | 10 | 0.390 | 0.09 |
| <i>Quercus lanuginosa</i> | 20 | 35 | 1.365 | 0.28 |
| <i>Rhododendron arboreum</i> | 20 | 35 | 0.564 | 0.21 |
| <i>Rhus javanica</i> | 10 | 10 | 0.161 | 0.07 |
| <i>Schleichera trijunga</i> | 10 | 10 | 0.287 | 0.09 |
| <i>Symplococos racemosa</i> | 20 | 20 | 0.255 | 0.14 |
| <i>Syzygium cuminii</i> | 10 | 5 | 0.120 | 0.06 |
| <i>Trema orientalis</i> | 10 | 10 | 0.161 | 0.07 |
| <i>Vernonia volkamerifolia</i> | 10 | 10 | 0.098 | 0.07 |
| Shrubs | | | | |
| <i>Desmodium sequax</i> | 10 | 20 | - | 0.07 |
| <i>Oxyspora paniculata</i> | 10 | 10 | - | 0.05 |
| <i>Hedyotis scandens</i> | 10 | 10 | - | 0.05 |
| <i>Inula cappa</i> | 10 | 20 | - | 0.07 |
| <i>Maesa</i> spp. | 10 | 40 | - | 0.10 |
| <i>Melastoma nepalensis</i> | 10 | 20 | - | 0.07 |
| <i>Rubia cordifolia</i> | 20 | 90 | - | 0.21 |
| <i>Rubus mollucanus</i> | 40 | 200 | - | 0.44 |
| <i>Sida</i> spp. | 10 | 10 | - | 0.05 |
| <i>Solanum nigrum</i> | 10 | 10 | - | 0.05 |
| <i>Tephrosia candida</i> | 10 | 20 | - | 0.07 |
| <i>Thysanolaena maxima</i> | 20 | 30 | - | 0.12 |
| <i>Triumfetta rhomboidea</i> | 10 | 20 | - | 0.07 |
| <i>Triumfetta pilosa</i> | 10 | 20 | - | 0.07 |
| <i>Urena lobata</i> | 20 | 40 | - | 0.13 |
| <i>Vitis heyneana</i> | 30 | 90 | - | 0.24 |
| <i>Wallichia disticha</i> | 20 | 50 | | 0.15 |
| Herbs | | | | |
| <i>Ageratum conyzoides</i> | 30 | 80 | | 9.58 |

| Species | Frequency % | Density (No./ha) | Basal area (m ² /ha) | IVI (%) |
|--------------------------------|-------------|------------------|---------------------------------|---------|
| <i>Asplenium tenuifolium</i> | 30 | 30 | | 6.43 |
| <i>Begonia arborensis</i> | 10 | 10 | | 2.14 |
| <i>Begonia hatacoa</i> | 20 | 10 | | 3.66 |
| <i>Bidens biternata</i> | 10 | 20 | | 2.77 |
| <i>Blechnum orientale</i> | 10 | 30 | | 3.40 |
| <i>Blumea procera</i> | 10 | 10 | | 2.14 |
| <i>Calamintha umbrosa</i> | 10 | 10 | | 2.14 |
| <i>Centella asiatica</i> | 20 | 40 | | 5.55 |
| <i>Christella parasitica</i> | 30 | 80 | | 9.58 |
| <i>Clematis gouriana</i> | 10 | 10 | | 2.14 |
| <i>Coelogyne nitida</i> | 20 | 50 | | 6.17 |
| <i>Colocassia fallax</i> | 10 | 10 | | 2.14 |
| <i>Crepis japonica</i> | 10 | 20 | | 2.77 |
| <i>Crotalaria mysorensis</i> | 10 | 10 | | 2.14 |
| <i>Cyperus rotundus</i> | 10 | 60 | | 5.29 |
| <i>Dendrobium moschatum</i> | 30 | 30 | | 6.43 |
| <i>Diplazium paleaceum</i> | 30 | 30 | | 6.43 |
| <i>Eryngium foetidum</i> | 20 | 50 | | 6.17 |
| <i>Gastrochilus longiflora</i> | 10 | 30 | | 3.40 |
| <i>Gerbera macrophylla</i> | 10 | 10 | | 2.14 |
| <i>Gynura angulosa</i> | 10 | 10 | | 2.14 |
| <i>Hedychium gracile</i> | 10 | 10 | | 2.14 |
| <i>Impatiens chinensis</i> | 10 | 10 | | 2.14 |
| <i>Ipomoea angustifolia</i> | 10 | 10 | | 2.14 |
| <i>Lepisorus nudus</i> | 20 | 70 | | 7.43 |
| <i>Lobelia angulata</i> | 20 | 80 | | 8.06 |
| <i>Lycopodium selago</i> | 30 | 60 | | 8.32 |
| <i>Lygodium flexuosum</i> | 20 | 90 | | 8.69 |
| <i>Nephrolepis cordifolia</i> | 20 | 60 | | 6.80 |
| <i>Onychium lucidum</i> | 30 | 50 | | 7.69 |
| <i>Panicum auritum</i> | 20 | 250 | | 18.75 |
| <i>Pothos cathcartii</i> | 10 | 10 | | 2.14 |
| <i>Pteridium aquilinum</i> | 10 | 20 | | 2.77 |
| <i>Pteris cretica</i> | 10 | 30 | | 9.58 |
| <i>Pyrrosia manii</i> | 20 | 60 | | 6.43 |
| <i>Rubia cordifolia</i> | 10 | 10 | | 2.14 |
| <i>Selaginella kraussiana</i> | 20 | 60 | | 3.66 |
| <i>Sonerila maculata</i> | 20 | 60 | | 2.77 |
| <i>Sphenomeris chinensis</i> | 10 | 10 | | 3.40 |

TABLE-5.7
Shanon's Diversity Index for different vegetation components
at different sampling sites in Dibin project

| Vegetation | Winter season | Summer season | Monsoon season |
|-------------------------|---------------|---------------|----------------|
| Dam site | | | |
| Trees | 1.19 | 1.19 | 1.22 |
| Shrubs | 0.92 | 0.92 | 1.31 |
| Herbs | 1.07 | 1.18 | 1.50 |
| Catchment area | | | |
| Trees | 1.15 | 1.15 | 1.11 |
| Shrubs | 1.09 | 1.10 | 1.09 |
| Herbs | 1.17 | 1.37 | 1.51 |
| Power house site | | | |
| Trees | 0.94 | 0.94 | 1.08 |
| Shrubs | 1.00 | 0.99 | 1.33 |
| Herbs | 1.07 | 1.07 | 0.95 |
| Submergence area | | | |
| Trees | 0.99 | 0.99 | 1.20 |
| Shrubs | 0.96 | 0.96 | 1.12 |
| Herbs | 1.14 | 1.27 | 1.44 |

TABLE-5.8
Pielou's Evenness Index for different vegetation components
at different sampling sites in Dibin project

| Vegetation | Winter season | Summer season | Monsoon season |
|-------------------------|---------------|---------------|----------------|
| Dam site | 0.96 | 0.96 | 0.95 |
| Trees | 0.97 | 0.97 | 0.97 |
| Shrubs | 0.93 | 0.88 | 0.94 |
| Herbs | | | |
| Catchment area | 0.95 | 0.95 | 0.85 |
| Trees | 0.96 | 0.96 | 0.96 |
| Shrubs | 0.93 | 0.91 | 0.89 |
| Herbs | | | |
| Power house site | 0.94 | 0.94 | 0.86 |
| Trees | 0.96 | 0.96 | 0.95 |
| Shrubs | 0.96 | 0.80 | 0.95 |
| Herbs | | | |
| Submergence area | 0.95 | 0.96 | 0.88 |
| Trees | 0.92 | 0.92 | 0.91 |
| Shrubs | 0.91 | 0.93 | 0.90 |
| Herbs | | | |

Wood volume

The estimated volume of wood present in the forest at dam site was maximum (144.46 m³/ha) followed by forest stand at catchment area (77.08 m³/ha) and submergence zone (58.59 m³/ha). The estimated

volume of wood found at the power house site was 32.73m³/ha only as this site is dominated by jhum cultivation done by the people of the nearby village. The details estimated wood volume present at various sampling sites is given in **Table-5.9**.

TABLE-5.9
Estimated volume of wood (m³/ha) at different
sampling sites in Dibbin project area

| Species | Dam site | Submergence area | Power house site | Catchment area |
|--------------------------------|-----------------|-------------------------|-------------------------|-----------------------|
| <i>Ailanthus grandis</i> | 13.25 | - | - | 1.37 |
| <i>Altingia excelsa</i> | - | - | 1.02 | - |
| <i>Betula alnoides</i> | - | 1.02 | - | 1.45 |
| <i>Bombax ceiba</i> | - | 21.56 | 1.99 | - |
| <i>Bridelia sp.</i> | - | 1.02 | - | - |
| <i>Callicarpa arborea</i> | 1.29 | - | 1.56 | 4.71 |
| <i>Castanopsis tribuloides</i> | 20.12 | - | - | 27.09 |
| <i>Citrus aurantium</i> | - | - | - | - |
| <i>Cordia dichotoma</i> | - | 4.04 | 1.29 | - |
| <i>Dalbergia rimosa</i> | 2.86 | - | - | 4.48 |
| <i>Dysoxylum gobara</i> | - | - | - | - |
| <i>Eurya acuminata</i> | - | - | 2.74 | - |
| <i>Ficus roxburghii</i> | - | - | - | - |
| <i>Ficus semicordata</i> | - | - | - | - |
| <i>Grewia dispernum</i> | - | 2.41 | - | 3.87 |
| <i>Lagerstoemia parviflora</i> | - | - | - | - |
| <i>Litsea monopetala</i> | - | 9.03 | - | 1.02 |
| <i>Macaranga denticulata</i> | 2.58 | - | - | - |
| <i>Macaranga indica</i> | - | - | - | 4.49 |
| <i>Persea gamblei</i> | - | - | 3.98 | 2.74 |
| <i>Pinus roxburghii</i> | - | - | 20.15 | 5.73 |
| <i>Premna latifolia</i> | - | - | - | 2.04 |
| <i>Prunus cerasoides</i> | - | - | - | - |
| <i>Quercus griffithii</i> | 34.82 | 8.05 | - | 12.61 |
| <i>Quercus lanuginosa</i> | - | 11.46 | - | 2.58 |
| <i>Quercus spicata</i> | 23.89 | - | - | - |
| <i>Rhododendron arboreum</i> | - | - | - | 2.90 |
| <i>Rhus javanica</i> | 1.15 | - | - | - |
| <i>Saurauia macrotricha</i> | - | - | - | - |
| <i>Symplocos racemosa</i> | - | 6.31 | - | - |
| <i>Syzygium cuminii</i> | 16.11 | - | - | - |
| <i>Terminalia belerica</i> | 17.26 | - | - | - |
| <i>Toona ciliata</i> | 11.15 | - | - | - |
| <i>Xanthoxylum armatum</i> | - | - | - | - |
| Total | 144.46 | 58.59 | 32.73 | 77.08 |

5.3 FAUNA

Jhum cultivation is prevailing in the proposed project area. As a result of Jhum cultivation the area is disturbed and proposed submergence is not support the habitate of major fauna. The proposed submergence area is neither potential site for wildlife sanctuary nor offer migration route to any major animal species. There is no national Park or sanctuary in the project area.

Catchment area provides habitation and sustenance for numerous fauna. The mountains, forests and streams, abundant food, shelter, water and large stretches of uninhabited and comparatively inaccessible country provide favorable factors for sheltering many kinds of wild animals. Earlier, this area used to harbour good wildlife. However, with increase in human interferences, and as a result of clearing of forests for *Jhum* cultivation, forests and wildlife are under threat. The locals, informed that in the past, good number of wildlife was reported in the project area. However, with the degradation of forests due to various reasons, the faunal species have become more or less absent from the project area.

The study of fauna takes substantial amount of time to understand the specific faunal characteristics of the area. In an EIA study, faunal studies are generally conducted based on the available secondary data. In the present study, secondary data sources have been used to a large extent. In addition to above the following sources were also used.

- Sighting during ecological studies
- Animal call
- Foot mark and excreta

Among mammals jungle cat mongoose and field mouse were observed. Among reptile House Gecko was observed. Avian fauna includes Pегion, Dove, Myna sparrow. No rare and endangered species were observed in the submergence area. However, based on the available record with the forest department, major faunal species reported in the project area and their status are given in **Table-5.10**.

TABLE-5.10
Wildlife species reported in the project area

| Local Name/Common Name | Scientific Name | Status as per Wildlife Act 1972 |
|------------------------|------------------------------------------|---------------------------------|
| A. Mammals | | |
| White tailed mole | <i>Talpa leucura</i> | |
| Mole shrew | <i>Anourosorex squamipes</i> | |
| Shrew | Species of <i>Soriculus & Suncus</i> | |
| Tree shrew | <i>Tupaia belangeri</i> | |
| Bats | Species of <i>Microchiroptera</i> | |
| Small Indian civet | <i>Viverricula indica</i> | Schedule II |
| Indian grey mongoose | <i>Herpestes edwardsii</i> | Schedule IV |
| Crab eating mongoose | <i>Herpestes urva</i> | Schedule IV |
| Jungle cat | <i>Felis chaus</i> | Schedule II |
| Leopard cat | <i>Felis bengalensis (Vu)</i> | Schedule I |
| Wild boar | <i>Sus scrofa (Ik)</i> | Schedule III |

| Local Name/Common Name | Scientific Name | Status as per Wildlife Act 1972 |
|-----------------------------------|-------------------------------------|---------------------------------|
| Barking deer | <i>Munticus muntjak</i> | Schedule III |
| Orange bellied himalayan squirrel | <i>Dremomys lokriah</i> | |
| House mouse | <i>Mus musculus</i> | Schedule V |
| Little Indian field mouse | <i>Mus booduga</i> | Schedule V |
| House rat | <i>Rattus rattus</i> | Schedule V |
| Large bandicoot rat | <i>Bandicota indica</i> | Schedule V |
| White bellied rat | <i>Niviventer niviventer</i> | Schedule V |
| Bay bamboo rat | <i>Cannomys badius</i> | Schedule V |
| B. Reptiles | | |
| Keel box turtle | <i>Pyxidea mouhotii</i> | |
| Brook's house gecko | <i>Hemidactylus brookii</i> | |
| Tockay | <i>Gecko gecko</i> | |
| Common calotes | <i>Calotes versicolor</i> | |
| Green forest calotes | <i>Calotes jerdoni</i> | |
| Striped olive sunskink | <i>Mubaya dissimilis</i> | |
| Asian long tailed grass skink | <i>Takydromus sexlineatus</i> | |
| Common blind snake | <i>Ramphotyphlops brahminus</i> | |
| Copperhead snake | <i>Elaphae radiata</i> | |
| Black banded trinket snake | <i>Elaphae porphyracea</i> | |
| Indo Chinese rat snake | <i>Ptyas korros</i> | |
| Painted bronzeback snake | <i>Dendrolaphis pictus</i> | |
| Twin spotted wolf snake | <i>Lycodon jara</i> | |
| Buff striped snake | <i>Amphiesma stolatum</i> | |
| Checkered keelback snake | <i>Xenochrophis piscator</i> | |
| Himalayan keelback snake | <i>Rhabdophis himalayanus</i> | |
| Falsa cobra | <i>Pseudoxenodon macrops</i> | Schedule II |
| Irridescent snake | <i>Blythia reticulata</i> | |
| Eastern gamma | <i>Boiga gokool</i> | |
| Lesser black hill krait | <i>Bungarus lividus</i> | |
| Monocellate cobra | <i>Naja kaouthia</i> | Schedule II |
| Green bamboo pit viper | <i>Trimerurus yunaniensis</i> | |
| Brown spotted pit viper | <i>Protobothrops mucrosquamatus</i> | |
| C. Amphibia | | |
| <i>Bufo melanostictus</i> | | |
| <i>Microhyla ornate</i> | | |
| <i>Philautus annadalii</i> | | |
| <i>Rhacophorus maximus</i> | | |
| <i>Amolops afghanus</i> | | |
| D. Birds | | |
| Kalij pheasant | <i>Lophura leucomelanos</i> | Schedule IV |
| Lesser yellow nape woodpecker | <i>Picus chlorophus</i> | Schedule IV |
| Lineated barbet | <i>Megalaima lineata</i> | Schedule IV |
| Blue throated barbet | <i>Megalaima franklinii</i> | Schedule IV |

| Local Name/Common Name | Scientific Name | Status as per Wildlife Act 1972 |
|------------------------------|---------------------------------|---------------------------------|
| Common hoopoe | <i>Upupa epops</i> | |
| Indian roller | <i>Coracias bengalensis</i> | Schedule IV |
| Common kingfisher | <i>Alcedo atthis</i> | Schedule IV |
| White throated kingfisher | <i>Halcyon smyrnensis</i> | Schedule IV |
| White throated kingfisher | <i>Halcyon smyrnensis</i> | Schedule IV |
| Pied kingfisher | <i>Ceryle rudis</i> | Schedule IV |
| Green bee eater | <i>Merops orientalis</i> | |
| Common hawk cuckoo | <i>Hierococcyx varius</i> | |
| Green billed malkoha | <i>Phaenicophaeus tristis</i> | |
| Lesser coucal | <i>Centropus bengalensis</i> | |
| Himalayan swiftlet | <i>Collocalia brevirostris</i> | |
| House swift | <i>Apus affinis</i> | |
| Colored scops owl | <i>Glaucidium brodiei</i> | Schedule IV |
| Brown hawk owl | <i>Ninox scutulata</i> | Schedule IV |
| Oriental turtle dove | <i>Streptopelia orientalis</i> | Schedule IV |
| Emerald dove | <i>Chalcophaps indica</i> | Schedule IV |
| Spotted dove | <i>Streptopelia chinensis</i> | Schedule IV |
| Pin tailed green pigeon | <i>Treron apicauda</i> | Schedule IV |
| Little ringed plover | <i>Charadrius dubius</i> | |
| Red wattled lapwing | <i>Vaneiius indicus</i> | |
| Black kite | <i>Milvus migrans</i> | |
| Crested goshawk | <i>Accipter trivirgatus</i> | |
| Collared falconet | <i>Microhierax caerulescens</i> | |
| Oriental hobby | <i>Falco severus</i> | |
| Darter / Snake bird | <i>Anhinga melanogaster</i> | |
| Little cormorant | <i>Phalacrocorax niger</i> | |
| Blue napped pitta | <i>Pitta nipalensis</i> | |
| Orange bellied leafbird | <i>Chloropsis hardwickii</i> | |
| Grey treepie | <i>Dendrocitta formosae</i> | |
| Large billed crow | <i>Corvus macrorhynchos</i> | |
| Black hooded oriole | <i>Oriolus xanthornus</i> | |
| Bar bellied cuckoo shrike | <i>Coracina striata</i> | |
| Long tailed minivet | <i>Pericrocotus ethologus</i> | |
| Black drongo | <i>Dicrurus macrocercus</i> | Schedule IV |
| Bronzed drongo | <i>Dicrurus aeneus</i> | Schedule IV |
| Common iora | <i>Aegithina tiphia</i> | Schedule IV |
| Large wood shrike | <i>Tephrodornis gularis</i> | |
| Brown dipper | <i>Cinclus pallasii</i> | |
| Chestnut bellied rock thrush | <i>Monticola rufiventris</i> | Schedule IV |
| Blue whistling thrush | <i>Myophonus caeruleus</i> | Schedule IV |
| Lesser shortwing | <i>Brachypteryx leucophrys</i> | |
| Rufous gorgeted flycatcher | <i>Ficedula strophciata</i> | Schedule IV |
| Large niltava | <i>Niltava grandis</i> | |
| Pale chinned flycatcher | <i>Cyornis poliogenys</i> | Schedule IV |

| Local Name/Common Name | Scientific Name | Status as per Wildlife Act 1972 |
|-----------------------------------|------------------------------------|---------------------------------|
| White rumped sama | <i>Copsychus malabaricus</i> | |
| Oriental magpie robin | <i>Copsychus saularis</i> | |
| Hodgson's redstart | <i>Phoenicurus hodgsoni</i> | |
| White capped water redstart | <i>Chaimarrornis leucocephalus</i> | |
| Slaty backed forktail | <i>Enicurus schistaceus</i> | |
| Black capped forktail | <i>Enicurus immaculatus</i> | |
| White crowned forktail | <i>Enicurus leschenaulti</i> | |
| Little forktail | <i>Enicurus scouleri</i> | |
| Grey bushchat | <i>Saxicola ferrea</i> | |
| Common myna | <i>Acridotheres tristis</i> | Schedule IV |
| Jungle myna | <i>Acridotheres fuscus</i> | Schedule IV |
| Green backed tit | <i>Parus monticolus</i> | Schedule IV |
| Black throated tit | <i>Aegithalos concinnus</i> | Schedule IV |
| Red vented bulbul | <i>Pycnonotus cafer</i> | Schedule IV |
| White throated bulbul | <i>Alophoixus flaveolus</i> | Schedule IV |
| Black bulbul | <i>Hypsipetes leucocephalus</i> | Schedule IV |
| Oriental white eye | <i>Zosterops palpebrosus</i> | |
| Mountain tailor bird | <i>Orthotomus cuculatus</i> | |
| Greenish warbler | <i>Phylloscopus trochiloides</i> | |
| Black faced warbler | <i>Abrosopus albogularis</i> | |
| White crested laughing thrush | <i>Garrulax leucolophus</i> | Schedule II |
| Greater necklaced laughing thrush | <i>Garrulax pectoralis</i> | Schedule IV |
| Rufous necked laughing thrush | <i>Garrulax ruficollis</i> | Schedule IV |
| Grey sided laughing thrush | <i>Garrulax caerulatus</i> | Schedule IV |
| Abbott's babbler | <i>Malacocincla abbotti</i> | Schedule IV |
| White broad scimitar babbler | <i>Pomatorhinus rufficollis</i> | Schedule IV |
| Slender billed scimitar babbler | <i>Xiphirhynchus superciliaris</i> | Schedule IV |
| Spotted wren babbler | <i>Spelaeoris formosus</i> | Schedule IV |
| Rufous fronted babbler | <i>Stachyris rufifrons</i> | Schedule IV |
| Silver eared mesia | <i>Leiothrix argentauris</i> | |
| Red tailed minla | <i>Minla ignotincta</i> | |
| Rufous winged fulvetta | <i>Alcippe castaneiceps</i> | |
| Straited yuhina | <i>Yuhina castaniceps</i> | |
| Black chinned yuhina | <i>Yuhina nigrimenta</i> | |
| White napped yuhina | <i>Yuhina bakeri</i> | |
| Long tailed sibia | <i>Heterophasia picaoides</i> | |
| Purple throated sunbird | <i>Nectarinia sperata</i> | Schedule IV |
| Streaked spiderhunter | <i>Arachnothera magna</i> | |
| White wagtail | <i>Motacilla alba</i> | |
| Grey wagtail | <i>Motacilla cinerea</i> | |
| Scaly breasted munia | <i>Lonchura punctulata</i> | |

Note : Vu – Vulnerable; IK – Insufficiently known

Threatened species

A total of 2 threatened species (*Felis bengalensis* and *Sus scrofa*) of mammals were reported in the project area and their status as per Red Data Book, published by (ZSI in 1994) is given in **Table-5.11**.

TABLE-5.11

Threatened species reported in the project area

| Species | Status |
|--------------------------|--------------------|
| <i>Felis bengalensis</i> | Vulnerable |
| <i>Sus scrofa</i> | Insufficient known |

It would also be worthwhile to mention that during the field survey none of the above mentioned threatened species were observed. It is possible that these species were once found in the study area, but due to increased human interferences and indiscriminate hunting by the locals and habitat degradation due to Jhum cultivation most of these species have dwindled in number.

5.5 AQUATIC ECOLOGY

Biological parameters are very important in the aquatic ecosystem, since they determine the productivity of a water body. Primary productivity is an important indicator of pollution level in any aquatic ecosystem. Fish production is dependent on production of zooplanktons which in turn is dependent on the phytoplankton production or primary productivity. All these are related to the physico-chemical characteristics of the water.

As a part of EIA exercise, field studies were conducted to assess density and diversity of phytoplanktons, zooplankton, primary productivity. The findings of the field survey are outlined in the following paragraphs:

Phytoplanktons and zooplanktons

The density and diversity of phytoplankton in the river water was studied by collecting the water samples from two sites i.e. from Dam site and powerhouse site. Samples were collected from Bichom river near the village Dibbin (Dam site) and the village Nachibin (powerhouse site) for assessing the density and diversity of phytoplankton and zooplankton. The sampling was conducted for three seasons namely winter season (January 2006), summer season (May 2006) and Monsoon season (October 2007).

Methodology

For enumeration of phytoplankton population, 100 litre composite water samples were collected from the river surface up to 60 cm depth and were filtered through a 20 µm net to make 1 litre of bulk sample. The bulk samples so collected were preserved in 2% formalin solution and were brought to the laboratory for analysis. Ten replicate water samples each of 15 ml were made out of the preserved 1 litre bulk sample and were centrifuged at 1500 rpm for 10 minutes. After centrifuging, the volume of aliquot concentrate was measured. 0.1 ml of aliquot concentrate was used for enumeration of phytoplankton population in each replicate. A plankton chamber of 0.1 ml capacity was used for counting of plankton under a light microscope. The total number of plankters present in a litre of water sample was calculated using the following formula:

$$N = (n \times v \times 100) / V$$

Where, N= Number of phytoplankton per litre

n = average number of plankton cells in 0.1 ml of aliquot concentrate

v = volume of plankton concentrate (aliquot)

V= volume of water from bulk sample centrifuged

Phytoplankton species diversity index was calculated using Shannon's species diversity index (H) formula taking the density values of each phytoplankton species into consideration.

Shannon index of general diversity (H): - $\sum P_i \log P_i$

Where n_i = density value for each species

N = total density values

P_i = density probability for each species = n_i / N

Results

Phytoplankton species and their population as observed during sampling conducted in winter, summer and monsoon seasons are given in **Tables-5.12 to 5.14** respectively. The phytoplankton communities in Bichom River were dominated by *Frustulia* species. Moreover the total population of Phytoplankton and zooplankton was found to be low as compared to the rivers in the plains area.

TABLE-5.12
Density (No. per liter) and Diversity of Phytoplankton, Benthos and Zooplankton species in Bichom river at two different sites in Dibbin project area (Winter season)

| Species | Class/Order | Dam site | Power House site |
|-----------------------|-----------------|-----------|------------------|
| Phytoplankton | | | |
| <i>Ulothrix</i> | Chlorophyta | 3 | - |
| <i>Spirogrya</i> | Chlorophyta | 2 | 1 |
| <i>Cytonema</i> | Chlorophyta | - | 2 |
| <i>Frustulia</i> sp. | Bacillariophyta | 15 | 11 |
| <i>Navicula</i> sp. | Bacillariophyta | 4 | - |
| <i>Amphora onalci</i> | Bacillariophyta | 5 | 3 |
| <i>Stauroneis</i> sp. | Bacillariophyta | - | 1 |
| Total | | 29 | 18 |
| Benthos | | | |
| Stonefly | Plecoptera | 7 | 3 |
| Damjel fly | Zygoptera | 2 | - |
| Mayfly | Ephemeroptera | - | 7 |
| Total | | 9 | 10 |
| Zooplankton | | | |
| <i>Diffugia lebes</i> | Rhizopoda | 4 | 7 |
| Protozoan | - | 1 | 2 |

| | | | |
|-----------------|---|----------|-----------|
| <i>Diptera</i> | - | 1 | - |
| <i>Copepoda</i> | - | - | 3 |
| Total | | 6 | 12 |

TABLE – 5.13
Density (No. per liter) and Diversity of Phytoplankton, Benthos and Zooplankton species in Bichom river in Dibbin project area (Summer season)

| Species | Class/Order | Dam site | Power House site |
|-----------------------------------|-----------------|-----------|------------------|
| Phytoplankton | | | |
| <i>Ulothrix</i> sp. | Chlorophyta | 3 | 1 |
| <i>Spirogrya</i> sp. | Chlorophyta | 9 | 4 |
| <i>Cytonema</i> sp. | Chlorophyta | 1 | 2 |
| <i>Frustulia</i> sp. | Bacillariophyta | 10 | 11 |
| <i>Navicula</i> sp. | Bacillariophyta | 4 | 5 |
| <i>Amphora ovalis</i> | Bacillariophyta | 2 | 3 |
| Total | | 29 | 26 |
| Benthos | | | |
| Stonefly | Plecoptera | 5 | 5 |
| Damjel fly | Zygoptera | 3 | 3 |
| Mayfly | Ephemeroptera | 4 | 3 |
| Total | | 12 | 11 |
| Zooplankton | | | |
| <i>Diffugia lebes</i> | Rhizopoda | 1 | 1 |
| <i>Chydorus sphaericus</i> | Cladocera | 12 | 11 |
| <i>Arcella vulgaris</i> | Rhizopoda | 9 | 10 |
| <i>Centropyxis haemisphaerica</i> | Rhizopoda | 1 | 1 |
| <i>Trichocerca elongata</i> | Rotifera | 1 | 1 |
| <i>Cyclops</i> sp. | Copepoda | 23 | 19 |
| Total | | 47 | 43 |

TABLE – 5.14
Density (No. per liter) and Diversity of Phytoplankton, Benthos and Zooplankton species in Bichom river in Dibbin project area (Monsoon season)

| Species | Class | Dam site | Power House site |
|---------------------------------|-----------------|----------|------------------|
| Phytoplankton | | | |
| <i>Frustulia</i> sp. | Bacillariophyta | 3 | 7 |
| <i>Pinnularia</i> sp. | Bacillariophyta | 2 | 1 |
| <i>Gomphonema</i> sp. | Bacillariophyta | 2 | 1 |
| <i>Fragilaria capucina</i> | Bacillariophyta | 1 | - |
| <i>Navicula</i> sp. | Bacillariophyta | - | 1 |
| <i>Stauroneis phoenicuteron</i> | Bacillariophyta | 1 | 2 |

| Species | Class | Dam site | Power House site |
|------------------------------|-----------------|-----------|------------------|
| <i>Gomphoneis erculeanum</i> | Bacillariophyta | 1 | 4 |
| Total | | 10 | 16 |
| Benthos | | | |
| <i>Stone fly</i> | Plecoptera | 8 | 12 |
| <i>May fly</i> | Ephemeroptera | 2 | - |
| <i>Damjel fly</i> | Zygophera | 4 | 3 |
| Total | | 14 | 15 |
| Zooplankton | | | |
| <i>Rotifera sp.</i> | - | 3 | 1 |
| <i>Cladocera sp.</i> | - | 1 | 4 |
| <i>Diptera sp.</i> | - | 1 | 3 |
| Total | | 5 | 8 |

Species diversity index of Phytoplankton, Benthos and Zooplankton and values in Bichom and Bichom River for winter, summer and Monsoon seasons are given in **Table-5.15**.

TABLE-5.15
Species diversity index at various sampling sites in river Bichom

| Site | Winter | Summer | Monsoon |
|----------------------|--------|--------|---------|
| Phytoplankton | | | |
| Dam site | 0.58 | 0.67 | 0.73 |
| Power house site | 0.51 | 0.67 | 0.64 |
| Zooplankton | | | |
| Dam site | 0.38 | 0.55 | 0.41 |
| Power house site | 0.42 | 0.57 | 0.42 |
| Benthos | | | |
| Dam site | 0.23 | 0.47 | 0.41 |
| Power house site | 0.27 | 0.46 | 0.21 |

ESTIMATION OF PHYTOPLANKTON PRIMARY PRODUCTIVITY IN THE RIVER

Methodology

The phytoplankton primary productivity was determined by light and dark bottle method (Wetzel and Likens 1991). The water samples were collected in light and dark BOD bottles. Three replicates were maintained for each sample. The experimental bottles were kept for 6 hours in the river from where the water samples were collected. Winkler's method was used for determination of oxygen in the light and dark bottles. Following formula was used for calculation of phytoplankton primary productivity.

$$\text{Gross Primary Productivity (GPP) (mgC/m}^3\text{/hr)} = \frac{(\text{O}_2 \text{ content of light bottle} - \text{O}_2 \text{ content of dark bottle}) \times 0.375 \times 1000}{1.2 \times \text{Incubation hour.}}$$

$$\text{Net Primary Productivity (NPP) (mgC/m}^3\text{/hr)} =$$

$$\frac{(\text{O}_2 \text{ content of light bottle} - \text{O}_2 \text{ content of control bottle}) \times 0.375 \times 1000}{1.2 \times \text{Incubation hour.}}$$

Results

The primary productivity was higher at the dam site than the power house site (Refer **Table-5.16**).

TABLE-5.16
Primary Productivity at different sampling sites in Bichom River in Dibbin study area

| Sampling sites | Productivity (gC/m ³ /day) | |
|----------------------------|---------------------------------------|------------------|
| | Dam site | Power House site |
| Winter season | | |
| Gross Primary Productivity | 93.75 | 57.82 |
| Net Primary Productivity | 31.25 | 28.97 |
| Summer season | | |
| Gross Primary Productivity | 98.96 | 96.4 |
| Net Primary Productivity | 20.83 | 23.44 |
| Monsoon season | | |
| Gross Primary Productivity | 350 | 16 |
| Net Primary Productivity | 138 | 13 |

5.5 FISHERIES

The state of Arunachal Pradesh is endowed with rich fisheries potential in the form of riverine resources. An assessment of literature survey on fishery resources reveals that a vast and varied potential occurs in the Kameng river of which Bichom is a tributary. The published account on fish species from Kameng has been given by Nath and Dey (1990). A total 73 fishes have been listed from the Kameng basin. Depending upon the water temperature and DO levels these species undertake short and long journey to survive and propagate in most optimal condition. As per the information provided by the Department of Fisheries, Arunachal Pradesh, the fish production (including cold water fisheries) in the State has increased from 1499 t/annum in 1992-93 to 2395 t/annum in 1999-2000. The demand for fish in the state, based on nutritional standard of its production is estimated as 10,000 t/annum.

The District Fishery Development Officer (DFDO) having its head quarter at Bomdilla is the District Officer incharge of the fishery development with the help of Extension officer fishery are helping in extension services in the different village for fishery development in this district. In order to boost up the production of fish and fisheries ship are being taken to establish more fish from as well as extension of existing fish farm.

The fish production (including aquaculture) in West Kameng district was 30 tonnes/ annum during the year 2002-2003. The state government has 8 government fish farms and 4 private fish farm in West Kameng district of these 3 in Nafra circle.

These are primarily used to raise seeds of Indian major carps and common carps for meeting the seed requirement of various fish tanks/ponds developed in the district.

The Mahaseer species undertake upstream migration in river Bichom during summer and monsoon months for feeding and breeding. As the winter sets in the upper reaches, the species takes a downstream journey. In addition certain species of *Schizothorax* (Snow trout) also undertake migration from upper reaches up to the project site during winter months. This fish species breeds in the lower reaches.

River Bichom is a tributary of river Kameng and has good fisheries potential. There are no regular fish landing centers in the entire state of Arunachal Pradesh. Similarly, there are no fish landing centers in the project area also. It was also observed during the field visit, that no large scale fishing activities are being practiced by the population in and around the project area.

It was during our interaction with the locals and Fisheries Department, it was confirmed that there are no permanent fishermen in the project area. However, few locals are involved in fishing activities to augment their income. No family is fully dependent on fishing for earning his living. The fisheries is mostly subsistence type.

The fisheries survey was conducted during January 2006 using cast net. 50 castings each in the upstream and downstream of the dam site and near power house were done in different sections of the river. A total of 11 species were observed during survey, and are listed in **Table-5.17**. The composition of various fish species observed during the fisheries survey is given in **Table-5.18**.

TABLE-5.17
Fish species observed in Bichom river during survey

| Scientific Name | Common/Local Name |
|-------------------------------------|-------------------|
| <i>Schzopyge Progastus</i> | Trout |
| <i>Schizothorax richardsonii</i> | Snow Trout |
| <i>Danio aequipinnatus</i> | Danio |
| <i>Danio dangila</i> | - |
| <i>Barilius barna</i> | Khasray |
| <i>Barilius bendelisis</i> | - |
| <i>Acrossocheilus hexagonolepis</i> | Mahaseer |
| <i>Crossocheilus latius</i> | - |
| <i>Gara gotyla</i> | - |
| <i>Gara annandalei</i> | Budhuna |
| <i>Glyptothorax horai</i> | - |

TABLE-5.18
Composition of fish species observed in Bichom river during survey

| Name | Composition (%) | | |
|-------------------------------------|-----------------|--------|---------|
| | Winter | Summer | Monsoon |
| <i>Schizothorax sp.</i> | 35 | 10 | |
| <i>Danio sp.</i> | 30 | 20 | |
| <i>Acrossocheilus hexagonolepis</i> | 10 | 30 | |

| | | | |
|-----------------------------|----|----|--|
| <i>Crossocheilus latius</i> | 8 | 10 | |
| <i>Glyptothorax horai</i> | 5 | 12 | |
| Others | 12 | 18 | |

It is observed from the Tables-5.17 and 5.18, that *Schizothorax* sp. contributes 10-35% of the total catch which is followed by *Danio* sp. (20-30%), *Acrossocheilus hexagonolepis* (10-30%), *Crossocheilus latius* (8-10%), *Glyptothorax horai* (5-12%) and others (12-18%). The catch per manhour in river Kameng about 1 km upstream of the proposed dam site, has been worked out as 350 – 500 gm. The occurrence of varying sizes of *Schizothorax* in cast net catch (100-150 mm) indicates the possibility of the spawning of this species in this stretch of the river. *Schizothorax* are normally observed at elevations more than 700 m above mean sea level. They migrate to the lower reaches for spawning. During the fisheries survey conducted in the project area, which has an elevation ranging from 600-1000 m above mean sea level *Schizothorax* was observed. There is every possibility of developing a local stock of this species. In due course of time the local stock is bound to undertake upstream migration from the proposed reservoir.

CHAPTER – 6

BASELINE STATUS FOR SOCIO-ECONOMIC ASPECTS

6.2 GENERAL

Most often, development projects are planned based on the availability of exploitable natural resources. Upon commissioning these act on growth foci. This attracts flow of finances, investments, jobs and other livelihood opportunities, which brings in people from different cultural and social background. Such planned activities not only provide impetus to the local economy but also bring about a multi-dimensional economic, social and cultural change. Most often it has been observed that such development projects are commissioned in economically and socially backward areas, which are inhabited by some of the indigenous populations. Commissioning of development project invariably brings about a number of desired and undesired impacts along with it. The baseline status has been divided into following three categories:

- Physico-chemical aspects
- Ecological aspects
- Socio-Economic aspects.

The baseline setting for socio-economic aspects are outlined in the present Chapter.

6.2 SOCIO-ECONOMIC PROFILE OF THE STUDY AREA

The study area comprises of 17 villages, which also includes Nafra headquarters. The entire study area lies in the Nafra Circle of District West Kameng. The baseline setting for socio-economic aspects are outlined in the following sub-sections of the present Chapter.

6.2.1 Demographic profile in the study area

The total population in the study area villages is 4036 residing in 791 households. The percentage of male and female population is 51.51% and 48.49% respectively. The overall average sex ratio in the study area is 941 females per 1000 males. The population below the age of 6 years (or infant population) accounted for about 22.45% of the total population. The average family size in the study

area villages is 5 persons per household. The village-wise demographic details in the Study Area Villages are shown in **Table 6.1**.

TABLE – 6.1
Demographic profile of the Study Area Villages

| S. No. | Study Area Villages | Total Households | Total Population | Male Population | Female Population | Population < 6 Yrs. | Sex Ratio | Family Size |
|--------|------------------------|------------------|------------------|-----------------|-------------------|---------------------|------------|-------------|
| 1 | Nijung | 14 | 69 | 37 | 32 | 14 | 865 | 4.9 |
| 2 | Khellong | 53 | 315 | 168 | 147 | 76 | 875 | 5.9 |
| 3 | Sanchipam | 15 | 83 | 40 | 43 | 24 | 1075 | 5.5 |
| 4 | Nakhu | 36 | 193 | 104 | 89 | 36 | 856 | 5.4 |
| 5 | Nachibon | 36 | 179 | 97 | 82 | 23 | 845 | 5.0 |
| 6 | Najang | 18 | 85 | 43 | 42 | 17 | 977 | 4.7 |
| 7 | Dibirick | 27 | 141 | 71 | 70 | 26 | 986 | 5.2 |
| 8 | Wothung | 2 | 12 | 8 | 4 | 4 | 500 | 6.0 |
| 9 | Dillung | 8 | 46 | 24 | 22 | 12 | 917 | 5.8 |
| 10 | Dishing | 6 | 19 | 13 | 6 | 2 | 462 | 3.2 |
| 11 | Dibbin | 47 | 251 | 115 | 136 | 69 | 1183 | 5.3 |
| 12 | Chillang | 4 | 18 | 9 | 9 | 3 | 1000 | 4.5 |
| 13 | Mathow | 24 | 134 | 67 | 67 | 34 | 1000 | 5.6 |
| 14 | Ditchik | 110 | 543 | 276 | 267 | 138 | 967 | 4.9 |
| 15 | Rurang | 43 | 233 | 124 | 109 | 60 | 879 | 5.4 |
| 16 | Khoina (Ding Changpam) | 54 | 308 | 156 | 152 | 77 | 974 | 5.7 |
| 17 | Nafra H.Q. | 294 | 1407 | 727 | 680 | 291 | 935 | 4.8 |
| | Total | 791 | 4036 | 2079 | 1957 | 906 | 941 | 5.1 |

Source: Primary Census Abstract, 2001.

6.2.2 Caste profile in the study area

As already mentioned, total population residing in the project affected villages is 4036. The Scheduled Tribe population is observed to be present, and is the dominant caste group, accounting for about 76.44% of the total population. The General Castes (GC) population constitutes about 23.19% of the total population followed by population belonging to the Scheduled caste category, comprising of about 0.37% of the total population in the impact area. The village-wise details of the caste profile in the Study Area Villages are summarized in **Table – 6.2**.

TABLE – 6.2
Caste profile in the study area villages

| S. No. | Study Area Villages | Total Population | Total General Caste Population | Total Scheduled Caste Population | Total Scheduled Tribe Population |
|--------------|------------------------|------------------|--------------------------------|----------------------------------|----------------------------------|
| 1 | Nijung | 69 | 0 | 0 | 69 |
| 2 | Khellong | 315 | 73 | 0 | 242 |
| 3 | Sanchipam | 83 | 0 | 0 | 83 |
| 4 | Nakhu | 193 | 0 | 0 | 193 |
| 5 | Nachibon | 179 | 0 | 0 | 179 |
| 6 | Najang | 85 | 0 | 0 | 85 |
| 7 | Dibirick | 141 | 0 | 0 | 141 |
| 8 | Wothung | 12 | 0 | 0 | 12 |
| 9 | Dillung | 46 | 0 | 0 | 46 |
| 10 | Dishing | 19 | 0 | 0 | 19 |
| 11 | Dibbin | 251 | 6 | 0 | 245 |
| 12 | Chillang | 18 | 0 | 0 | 18 |
| 13 | Mathow | 134 | 7 | 0 | 127 |
| 14 | Ditchik | 543 | 6 | 0 | 537 |
| 15 | Rurang | 233 | 8 | 0 | 225 |
| 16 | Khoina (Ding Changpam) | 308 | 6 | 0 | 302 |
| 17 | Nafra H.Q. | 1407 | 830 | 15 | 562 |
| Total | | 4036 | 936 | 15 | 3085 |

Source: Primary Census Abstract, 2001.

6.2.3 Literacy Levels in the study area

The overall average literacy rate in the Study Area Villages is about 32.60%. The male and female literacy rates are 38.77% and 26.06% respectively. The village-wise details of literate population in the study area villages are given in **Table – 6.3**.

TABLE – 6.3
Village-wise Literate population in the study area villages

| S. No. | Study Area Villages | Total Population | Literate Population | Male Literates | Female Literates |
|--------|---------------------|------------------|---------------------|----------------|------------------|
| 1 | Nijung | 69 | 25 | 13 | 12 |
| 2 | Khellong | 315 | 70 | 43 | 27 |
| 3 | Sanchipam | 83 | 6 | 3 | 3 |
| 4 | Nakhu | 193 | 65 | 39 | 26 |
| 5 | Nachibon | 179 | 69 | 46 | 23 |
| 6 | Najang | 85 | 29 | 18 | 11 |
| 7 | Dibirick | 141 | 54 | 36 | 18 |
| 8 | Wothung | 12 | 4 | 3 | 1 |
| 9 | Dillung | 46 | 12 | 7 | 5 |
| 10 | Dishing | 19 | 3 | 2 | 1 |

| S. No. | Study Area Villages | Total Population | Literate Population | Male Literates | Female Literates |
|--------------|------------------------|------------------|---------------------|----------------|------------------|
| 1 | Nijung | 69 | 25 | 13 | 12 |
| 11 | Dibbin | 251 | 100 | 60 | 40 |
| 12 | Chillang | 18 | 5 | 5 | 0 |
| 13 | Mathow | 134 | 31 | 22 | 9 |
| 14 | Ditchik | 543 | 32 | 27 | 5 |
| 15 | Rurang | 233 | 59 | 33 | 26 |
| 16 | Khoina (Ding Changpam) | 308 | 57 | 34 | 23 |
| 17 | Nafra H.Q. | 1407 | 695 | 415 | 280 |
| Total | | 4036 | 1316 | 806 | 510 |

Source: Primary Census Abstract, 2001.

6.2.4 Occupational Profile in the study area

The village-wise details on occupational profile within the Study Area Villages are outlined in **Table – 6.4**. It is observed that about 41.18% of the total population in the Study Area Villages is engaged in different economically productive activities, and have been classified as “Total Workers” by the Census Department. On the other hand, remaining 51.824% are non-workers or dependent population. Among the working population, about 85.38% constitute the Main workers, while the Marginal workers comprise about 14.62% of the total population.

TABLE – 6.4
Occupational profile in the study area villages

| S. No. | Study Area Villages | Total Population | Total Working Population | Main Workers | Marginal Workers | Total Non Working Population |
|--------|------------------------|------------------|--------------------------|--------------|------------------|------------------------------|
| 1 | Nijung | 69 | 36 | 36 | 0 | 33 |
| 2 | Khellong | 315 | 113 | 91 | 22 | 202 |
| 3 | Sanchipam | 83 | 39 | 20 | 19 | 44 |
| 4 | Nakhu | 193 | 93 | 66 | 27 | 100 |
| 5 | Nachibon | 179 | 85 | 85 | 0 | 94 |
| 6 | Najang | 85 | 48 | 39 | 9 | 37 |
| 7 | Dibirick | 141 | 72 | 66 | 6 | 69 |
| 8 | Wothung | 12 | 5 | 2 | 3 | 7 |
| 9 | Dillung | 46 | 25 | 9 | 16 | 21 |
| 10 | Dishing | 19 | 12 | 5 | 7 | 7 |
| 11 | Dibbin | 251 | 115 | 111 | 4 | 136 |
| 12 | Chillang | 18 | 10 | 10 | 0 | 8 |
| 13 | Mathow | 134 | 63 | 63 | 0 | 71 |
| 14 | Ditchik | 543 | 277 | 266 | 11 | 266 |
| 15 | Rurang | 233 | 122 | 99 | 23 | 111 |
| 16 | Khoina (Ding Changpam) | 308 | 161 | 144 | 17 | 147 |

| S. No. | Study Area Villages | Total Population | Total Working Population | Main Workers | Marginal Workers | Total Non Working Population |
|--------------|---------------------|------------------|--------------------------|--------------|------------------|------------------------------|
| 17 | Nafra H.Q. | 1407 | 386 | 307 | 79 | 1021 |
| Total | | 4036 | 1662 | 1419 | 243 | 2374 |

Source: Primary Census Abstract, 2001.

CHAPTER-7

PREDICTION OF IMPACTS

7.1 GENERAL

Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of the proposed Dibbin hydroelectric project have been identified. This Chapter addresses the basic concepts and methodological approach for conducting a scientifically based analysis of the potential impacts likely to accrue as a result of the proposed project. The Environmental Impact Assessment (EIA) for quite a few disciplines is subjective in nature and cannot be quantified. Wherever possible, the impacts have been quantified and otherwise, qualitative assessment has been undertaken. This Chapter deals with the anticipated positive as well as negative impacts due to construction and operation of the proposed project. The construction and operation phase comprises of various activities each of which is likely to have an impact on environment. Thus, it is important to understand and analyze each activity so as to assess its impact on environment. The key activities have been categorized for construction and operation phases.

Construction Phase Activities

- Site preparation
- Earthwork and excavation including controlled blasting and drilling
- Project headquarter, offices and colonies
- Disposal of muck and construction wastes
- Transportation of construction material
- A gated dam 92 m high located 1 km downstream of the confluence of Dakri Bru river with Bichom river. The length of the dam will be 165.8 m consisting of 54 m of overflow section and 111.8 m of non-overflow section.
- The reservoir upstream of dam will have gross and live storage of 7.085 Mm³ and 7.04 Mm³.
- A spillway with 3 bays of 12.0 m width each and controlled by 3 nos. radial gates each of size 12 m x 15.53 m. Crest elevation of spillway shall be 1206.0 m.
- A head race tunnel (HRT) 5.5 m diameter and 3.97 km long.

- A surge shaft at the outlet of the head race tunnel 2.4 m diameter and 102.5 m height.
- A surface power house located 250 m upstream of confluence of Bichom Bru and Debra Bru having installation of 2 units of 60 MW each with Francis type turbine designed for a net head of 158 m. The maximum flow through each turbine shall be 44.5 cumecs.
- A tail race tunnel/channel of 150 m length to discharge the tail water of Dibbin HE project into Ditch Bru
- Operation and maintenance of construction equipment
- Civil and mechanical fabrication works for construction of various project components.
- Operation of DG sets
- Disposal of pollutants from workshops, etc.
- Disposal of effluents and solid waste from labour camps and colonies

Operation Phase Activities

- Diversion of water from river Bichom for hydropower generation
- Equipment maintenance and equipment restoration
- Sewage and solid waste generation from project colonies

The various project activities and associated potential environmental impacts on various environmental parameters have been identified and summarized in a matrix and the same is outlined in **Table-7.1**.

TABLE-7.1
Matrix for various project activities and associated potential Environmental Impact on various Environmental Parameters

| S. No. | Project Activities | Soil & Land | Geology | Hydrology | Water quality | Air quality | Noise | Flora/ Fauna | Employment | Socio-culture |
|-----------|----------------------------------------------------------|-------------|---------|-----------|---------------|-------------|-------|--------------|------------|---------------|
| A. | Construction Phase | | | | | | | | | |
| 1. | Sire preparation including tree cutting | √ | | | | √ | √ | | √ | |
| 2. | Earthwork and excavation including blasting and drilling | √ | √ | | √ | √ | √ | √ | √ | |
| 3. | Construction of Diversion barrage across river Bichom | √ | | √ | | √ | | √ | √ | |
| 4. | Construction of head race tunnel | √ | √ | | | | | | √ | |
| 5. | Construction of underground surge shaft | √ | √ | | | | | | √ | |
| 6. | Construction of underground power house | √ | √ | | | | | | √ | |
| 7. | Widening of approach roads | √ | | | | √ | √ | √ | √ | |
| 8. | Disposal of muck and construction wastes | √ | √ | | √ | | | √ | | |
| 9. | Transportation of construction materials | | | | | √ | √ | √ | √ | |
| 10. | Operation and maintenance of | | | | √ | √ | √ | | √ | |

| S. No. | Project Activities | Soil & Land | Geology | Hydrology | Water quality | Air quality | Noise | Flora/ Fauna | Employment | Socio-culture |
|-----------|--------------------------------------------------------|-------------|---------|-----------|---------------|-------------|-------|--------------|------------|---------------|
| | construction equipment | | | | | | | | | |
| 11. | Disposal of sewage and solid waste from labour camps | √ | | | √ | | | | | |
| 12. | Acquisition of private land | √ | | | | | | | | √ |
| 13. | Acquisition of forest land | √ | | | | | | √ | | √ |
| 14. | Acquisition of labour population | √ | | | √ | √ | √ | √ | √ | √ |
| B. | Operation Phase Activities | | | | | | | | | |
| 1. | Diversion of water for hydropower generation | | | √ | √ | | | √ | | |
| 2. | Equipment maintenance | | | | √ | √ | √ | | √ | |
| 3. | Disposal of sewage and solid waste from project colony | √ | | | √ | | | | | |
| 4. | Mushrooming of allied activities | √ | | | √ | √ | √ | | √ | √ |

Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of the proposed Dibbin Hydro-electric Project have been identified. The Environmental Impact Assessment for quite a few disciplines are subjective in nature and cannot be quantified. Wherever possible, the impacts have been quantified and otherwise, qualitative assessment has been undertaken. This Chapter deals with the anticipated positive as well as negative impacts due to construction and operation of the proposed Dibbin hydroelectric project.

7.3 IMPACTS ON LAND ENVIRONMENT

a) Construction phase

Very few impacts of construction phase are permanent. Majority of the environmental impacts attributed to construction works are temporary in nature, lasting mainly during the construction phase and often little beyond the construction period. However, if these issues are not properly addressed, the impacts can continue even after the construction phase for longer duration. The time required for construction of the project shall be of the order of 4 years. Though, impacts due to construction, are temporary in nature, but may attach significance due to the nature and intensity of the impacts. The major anticipated impacts during the construction phase are as follows:

- Environmental degradation due to immigration of labour population.
- Quarrying operations.
- Operation of construction equipment.
- Soil erosion / increased siltation.
- Muck disposal.
- Impacts due to construction of roads.

Environmental degradation due to immigration of labour population

About 400 workers and 100 technical staff are likely to work during the peak construction phase in the project area. Thus a total of 500 persons along with their families will reside in the project area during peak construction phase considering family size as 4, the total population to immigrate in the project area during construction phase shall be of the order of 2000.

Separate accommodation and related facilities for workers, service providers and technical staff are to be provided as a part of the project. The congregation of labour force is likely to create problems of sewage disposal, solid waste management and felling of trees for meeting fuel requirements, etc. These aspects have been adequately covered in Sections 7.4 and 7.5 of this Chapter and suitable management measures have been suggested in Environmental Management Plan which is being presented as separate volume of this report.

Quarrying operations

The total quantity of coarse aggregate required for concreting and masonry is about 0.3 Mm³ and 0.15 Mm³ of sand. The project proponent has identified the quarry sites for extraction of sand and coarse aggregates required during project construction. As per the DPR, the area to be acquired

for quarry site will be about 5 ha. The boulders in the river bed are also available these can be utilized for construction.

The quarrying operations are semi-mechanized in nature. Normally, in a hilly terrain like Arunachal Pradesh, quarrying is normally done by cutting the hill face. A permanent scar is likely to be left, once quarrying activities are over. With the passage of time, rock from the exposed face of the quarry under the action of wind and other erosional forces, get slowly weathered and after some time, they become a potential source of landslide. Thus, it is necessary to implement appropriate slope stabilization measures to prevent the possibility of soil erosion and landslides at the quarry sites.

Operation of construction equipment

During construction phase, various types of equipment will be brought to the site. These include crushers, batching plant, drillers, earth movers, rock bolters, etc. The siting of these construction equipment would require significant amount of space. In addition, land will also be temporarily acquired, i.e. for the duration of project construction for storage of the quarried material before crushing, crushed material, cement, rubble, etc. Efforts must be made for proper siting of these facilities. The various criteria for selection of these sites would be:

- Proximity to the site of use.
- Sensitivity of forests in the nearby areas.
- Wildlife, if any, in the nearby area
- Proximity from habitations.

Efforts shall be made to select the site for locating the construction equipment in such a way that the adverse impacts on environment are minimal. Efforts must be made to site the construction equipment, so that the residents of nearby villages are not adversely affected.

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Large quantity of dust is likely to be entrained due to the movement of trucks and other heavy vehicles on unpaved road. However, such ground level emissions do not travel for long distances. In addition, there are no major habitations in the project area. Thus, no significant impacts are anticipated on this account.

Soil erosion/Increased siltation

The runoff from the construction sites will have a natural tendency to flow towards river Kameng or its tributaries. For some distance downstream of major construction sites, such as dam, power house, etc. there is a possibility of increased sediment levels in river water, which can lead to reduction in light penetration, which in turn could reduce the photosynthetic activity to some extent as it depends directly on sunlight. This is likely to have an adverse impact on the primary productivity of the affected stretch of river Bichom and its tributaries. Since river Bichom has sufficient flow the impact on this account are not expected to be significant. However, some adverse impacts are anticipated on the streams and nallahs which have low flow during lean season.

Muck Disposal

About 1.254 Mm³ of muck is expected to be generated as a result of construction of Dam, Head Race Tunnel (HRT), power house and other appurtenant work. Component wise detail of muck to be generated is given in **Table-7.2**.

TABLE-7.2
Component wise detail of muck to be generated (Unit :Mm³)

| Component | Quantity of Excavation |
|---------------------|-------------------------------|
| Coffer Dam | 0.005 |
| Diversion Works | 0.0325 |
| Switchyard | 0.06 |
| Intake structure | 0.077 |
| Head Race Tunnel | 0.1678 |
| Surge shaft | 0.0845 |
| Tail Race Tunnel | 0.10 |
| Power house complex | 0.30 |
| Concrete dam | 0.429 |
| Total | 1.254 |

A part of muck is likely to be utilized as a construction material and levelling of the construction sites. The balance muck is proposed to be disposed off at designated area. Muck disposal can lead to impacts on various aspects of environment. Normally, the land is cleared before muck disposal. During clearing operation trees are cut, but undergrowth perishes as a result of muck disposal.

- In many of the sites, muck is stacked without adequate stabilization measures. In such a scenario, the muck moves along with runoff and creates landslide like situations. Many a times, boulders/large stone pieces enter the river/water body, affecting the benthic fauna, fisheries and other components of aquatic biota.
- The increased vehicular movement near muck disposal sites lead to adverse impacts on ambient air quality as well. However, increase in vehicular traffic is not significant to cause major impact on ambient air quality.
- Normally muck disposal is done at low lying areas, which gets filled up due to stacking of muck. This can sometimes affect the natural drainage pattern of the area leading to accumulation of water or partial flooding of some area which can provide ideal breeding habitat for mosquitoes.

Thus, it is necessary to develop a proper muck disposal plan for amelioration of above referred impacts. Various management measures on this aspect have been covered in Chapter 6 of this Report. An area of 5 ha has been identified for muck disposal.

Construction of roads

The topography of the project area has steep slopes, which descend rapidly into narrow valleys. The conditions can give rise to erosion hazards due to downhill movement of soil aggregates. The project construction would entail significant vehicular movement for transportation of large construction material, heavy construction equipment. Most of the roads in the project area would require widening apart from the new roads proposed to be constructed for this project. The details of the roads proposed to be constructed and improved are given below.

Main Access road

The dam site is located just downstream of the confluence of Bichom with Difya river. A PWD road (53 km) is available from Rupa town to Nafra. Then new road from Nafra to dam site near Dibbin (15 km) would be provided to provide accessibility to the dam and power house sites. The length of the road to be constructed from existing PWD road to dam sites and power house sites would be approximately 15 km.

Project road

A number of access road having width 5 m with 3 m metalled taking off from the main project road need to be constructed to provide connectivity to various project appurtenances. The details are given in **Table-7.3**.

TABLE-7.3
Details of project roads to be constructed

| Road | Length (km) |
|------------------------------------------|--------------------|
| Access road to the dam site | 1.0 |
| Access road to project workshop | 0.5 |
| Access road to colony office power house | 0.5 |
| Access road to quarries site | 1.5 |
| Access road to dumping area | 2.0 |
| Access road to magazine | 1.0 |
| Access road to surge shaft | 2.5 |
| Access road to colony near dam site | 0.5 |
| Assess road to power house site | 1.0 |
| Total | 11 |

Thus, about 26 km (15 + 11) of new roads are proposed to be constructed as a part of the project. The construction of roads can lead to removal of trees on slopes and re-working of the slopes in the immediate vicinity of roads which increases the vulnerability of the area to landslides, gully erosion, etc.

The indirect impact of the construction of new roads is the increase in accessibility of an hitherto undisturbed areas, resulting in greater human interferences and subsequent adverse impacts on the ecosystem. Appropriate management measures required during road construction have been recommended as a part of Environmental Management Plan which has been presented as a separate volume of this Report.

b) Operation phase

The total land required for the project is about 162 ha. The details are given in **Table-7.4**.

TABLE-7.4
Land requirement for proposed project

| S. No. | Project Component | Home stead | Agricultural Land | | Hortic ultural land | Apna Ban | Dry Land | River body/ USF | | Total |
|--------|------------------------------------------------|-------------|-------------------|--------------|---------------------|-------------|--------------|-----------------|--------------|---------------|
| | | | WRC | Jhum | | | | River body | USF | |
| 1. | Reservoir | Nil | Nil | Nil | Nil | Nil | Nil | 11.00 | 24.00 | 35.00 |
| 2. | Dam site including Colony area | Nil | Nil | 35.00 | Nil | 1.00 | 12.00 | 3.00 | 14.00 | 65.00 |
| 3. | Power house, switch yard including Colony area | 2.00 | Nil | 21.00 | 5.00 | Nil | 10.00 | 9.00 | Nil | 47.00 |
| 4. | Muck disposal | Nil | Nil | Nil | Nil | Nil | Nil | Nil | 5.00 | 5.00 |
| 5. | Access Road | Nil | Nil | Nil | Nil | Nil | Nil | Nil | 5.00 | 5.00 |
| 6. | Head Race Tunnel | Nil | Nil | Nil | Nil | Nil | Nil | Nil | 5.00 | 5.00 |
| | Total (ha) | 2.00 | Nil | 56.00 | 5.00 | 1.00 | 22.00 | 23.00 | 53.00 | 162.00 |

The majority of land (i.e. 76 ha) belong to Forest Department, and about 56 ha of agriculture land, 5 ha of horticulture land, 1 ha of apna ban and about 2 ha of homestead. Out of this only 21.4 ha of agriculture land belongs to private land category, for which adequate compensation has been suggested as a part of Resettlement and Rehabilitation Plan outlined in separate volume –II of this Report, which outlines the Environmental Management Plan.

7.3 IMPACTS ON WATER RESOURCES

The construction of dam leads to the formation of a reservoir. The passage of floods through a reservoir leads to the reduction in peak flow. The dry season flow in the river too is regulated. The river stretch downstream of the dam site up to the confluence point of tail race discharge from power house will have reduced flow. The reduction in flow of the river in the intervening stretch is not likely to have any adverse impact on the downstream users. This is mainly because of the fact that settlements/villages within this stretch are not dependent on the water of river Bichom, as the villagers use the water of the adjacent flowing streams. However, reduced flow in this river stretch can have adverse impacts on the aquatic ecology. A provision for release of minimum flow of 1 cumec has been made to sustain the downstream riverine ecology.

7.4 IMPACTS ON WATER QUALITY

a) Construction phase

The major sources of water pollution during project construction phase are as follows:

- Sewage from labour camps/colonies
- Effluent from crushers

Sewage from labour camps

The project construction is likely to last for a period of 4 years. As mentioned earlier in Section-7.2, about 400 workers and 100 technical staff are likely to work during project construction phase. However, most of the employees/workers during construction phase are likely to be employed from outside the project area. But, the construction phase, also leads to mushrooming of various allied activities to meet the demand of immigrant labour population in the project area. Therefore, the maximum increase in the population during construction phase is expected to be of the order of 2,000. The domestic water requirements of the immigrant population are expected to be of the order of 0.14 mld @ 70 lpcd. It is assumed that about 80% of the water supplied will be generated as sewage. Thus, the total quantum of sewage generated is expected to be of the order of 0.11 mld. The BOD load contributed by domestic sources will be about 90 kg/day. Even if, the sewage is discharged without treatment, in river Bichom then the flow required for dilution is of the order of 0.3 to 0.4 cumecs. The minimum flow in river Bichom is much higher, higher than this flow. Thus, no major adverse impacts are anticipated as a result of disposal of even untreated sewage from labour camp.

Normally, during project construction, the labour population is concentrated at 2 locations. Thus, the sewage/BOD loading would outfall into river Bichom at 2 odd locations. The sewage is proposed to be treated before disposal to avoid deterioration of water quality of the receiving water body. During construction phase, normally large scale secondary treatment facilities are not commissioned, because they are rendered useless, once the construction activities are over. Therefore, the present project, it is proposed to commission adequate number of septic tanks for treatment of sewage. The details are covered in Environmental Management Plan, which is presented as a separate Report.

Effluent from crushers

During construction phase, at least two crusher each will be commissioned at the dam site and the power house site. The total capacity of the crusher is likely to be of the order of 120-150 tph. Water is required to wash the boulders and to lower the temperature of the crushing edge. About 0.1 m³ of water is required per tonne of material crushed. The effluent from the crusher would contain high suspended solids. The quantum of effluent generated is of the order of 12-15 m³/hr or 0.0033 to 0.0042 m³/sec. The natural slope in the area is such that, the effluent from the crushers will ultimately find its way in river Bichom through natural drains. However, no major adverse impacts are anticipated due to small quantity of effluent and large volume water available for dilution in river Bichom. However, turbidity levels in small tributaries, especially, in lean season may increase marginally. To minimise the impact, it is proposed to treat the effluent before disposal to ameliorate even the marginal impacts likely to accrue on this account.

b) Operation phase

The various aspects covered as a part of impact on water quality during project operation phase are:

- Effluent from project colony.

- Impacts on reservoir quality.
- Eutrophication risks.

Effluent from project colony

During the operation phase, due to absence of any large scale construction activity, the cause and source of water pollution will be much different. Since, only a small number of O&M staff will reside in the area in a well designed colony with sewage treatment plant and other infrastructural facilities, the problems of water pollution due to disposal of sewage are not anticipated. In the operation phase, about 50 families (total population of 250) will be residing in the area. About 0.04 mld of sewage will be generated. The total BOD loading will be of the order of 12 kg/day. It is proposed to provide biological treatment facilities including secondary treatment for the sewage so generated. Thus, no impacts are anticipated as a result of disposal of effluents from the project colony.

Impacts on reservoir water quality

The flooding of previously forest and agricultural land in the submergence area will increase the availability of nutrients resulting from decomposition of the vegetative matter. Phytoplankton productivity can supersaturate the euphotic zone with oxygen before contributing to the accommodation of organic matter in the sediments. Enrichment of impounded water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However, this phenomenon is likely to last for a short duration of few years from the filling up of the reservoir.

Eutrophication risks

Another significant impact observed in the reservoir is the problem of eutrophication which occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. The fertilizer use in the project area is negligible, hence, runoff at present does not contain significant amount of nutrients. Even in the post-project phase, the use of fertilizers in the project catchment area is not expected to rise significantly. Thus, in the post-project phase, problems of eutrophication, which is primarily caused by enrichment of nutrients in water are not anticipated.

Impacts due to Sedimentation

The average sediment concentrations at the Bichom gauging station is given in **Table-7.5**.

TABLE-7.5
Average Sediment Concentrations at Bichom

| Month | Coarse | | Medium | | Fine | | Total | |
|----------|--------|--------|--------|--------|--------|--------|--------|--------|
| | (kg/s) | (mg/l) | (kg/s) | (mg/l) | (kg/s) | (mg/l) | (kg/s) | (mg/l) |
| January | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 1.5 | 0.1 | 1.6 |
| February | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 2.9 | 0.2 | 3.0 |
| March | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 2.1 | 0.1 | 2.4 |

| | | | | | | | | |
|-----------|------|------|------|------|------|-------|------|-------|
| April | 0.1 | 1.7 | 0.1 | 1.5 | 0.3 | 3.8 | 0.4 | 7.0 |
| May | 0.4 | 3.7 | 1.1 | 10.2 | 1.0 | 9.1 | 2.5 | 23.0 |
| June | 4.9 | 24.1 | 7.1 | 34.1 | 5.9 | 29.9 | 17.9 | 88.1 |
| July | 27.9 | 82.5 | 18.9 | 60.0 | 41.5 | 129.4 | 88.2 | 271.8 |
| August | 17.8 | 64.2 | 17.2 | 60.0 | 18.6 | 61.0 | 53.6 | 185.2 |
| September | 8.6 | 30.6 | 4.2 | 16.5 | 7.0 | 25.0 | 19.8 | 72.1 |
| October | 3.5 | 18.2 | 4.4 | 22.9 | 1.8 | 10.0 | 9.7 | 51.1 |
| November | 0.0 | 0.4 | 0.1 | 0.9 | 0.2 | 2.5 | 0.4 | 3.8 |
| December | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 2.8 | 0.2 | 2.9 |

The distribution Coarse/Medium/Fine is around 33% / 29% / 38% in the monsoon period and 14% / 29% / 57% in the dry season. The monthly variation of the suspended sediment load in the Bichom River shows low concentrations during the dry months, December to April, and increases to a maximum in July. The measured data show clearly that high suspended sediment load occurs during the wet months (May–October), whereas in the dry months the suspended sediment load is negligible.

The total suspended load is estimated as 353,000 m³/ yr and sediment yield as 785 t/km²/ year. For the estimate a distribution of Coarse / Medium / Fine material of 30% / 30% / 40% was assumed. A suspended sediment transport of 495'000 kg/year was assumed, with a bed load component equal to 50% of the suspended load. The bed load is not measured by sediment sampling, but typical values for mountainous areas are 100% to 33.3% of the suspended load, (Maniak 2005). The theoretical time in years until the sediment reaches the spillway crest (FRL – 14 m) is shown in **Table 7.6**.

TABLE 7.6
Time for reservoir sedimentation to reach spillway crest in years

| Reservoir Level (FRL) | Spillway Crest Level | Brune | Brown (Design Curve) | Brown (Upper Curve) | Brown (Lower Curve) |
|-----------------------|----------------------|-------|----------------------|---------------------|---------------------|
| 1185 | 1171 | 1 | 1 | 1 | 1 |
| 1200 | 1186 | 5 | 3 | 2 | 4 |
| 1210 | 1196 | 9 | 4 | 3 | 6 |
| 1220 | 1206 | 15 | 7 | 6 | 9 |

Passing the sediments, including bed loads over the spillway is not recommended as it can cause extensive damage and place the whole structure at risk.

For the chosen FRL of 1,220 m the invert of the power intake is at 1,197.7 m. The time to reach the intake level is shown in **Table 7.7**.

TABLE 7.7
Time for reservoir sedimentation to reach power intake in years

| Reservoir Level (FRL) | Power Intake Level | Brune | Brown (Design Curve) | Brown (Upper Curve) | Brown (Lower Curve) |
|-----------------------|--------------------|-------|----------------------|---------------------|---------------------|
| 1,220 | 1,197.7 | 9 | 4 | 3 | 5 |

7.5 IMPACTS ON TERRESTRIAL FLORA

Increased human interferences

The direct impact of construction activity for any water resource project in a mountainous terrain similar to that of proposed project is generally limited in the vicinity of the construction sites only. As mentioned earlier, a large population (2000) including technical staff, workers, and their family members are likely to congregate in the area during peak project construction phase. It can be assumed that the technical staff will be of higher economic status and will live in a more urbanized habitat, and will not use wood as fuel, if adequate alternate sources of fuel are provided. However, workers and other population groups residing in the area may use fuel wood (if no alternate fuel is provided) for whom firewood/coal depot could be provided.

- * Average fuel wood consumption : 20 kg pcd
- * Average population size over : 1600
project construction phase
- * Average consumption per day : 320 quintals/day
Or 116800 quintals/year
- * For a construction period of 4 years : 467200 quintals or
584000 m³.
- * One tree produces about 2.5 m³ of wood, thus, about 2.34 lakh tree will be cut to meet the fuelwood requirements to the labour population, over a construction phase of 4 years.

Hence to minimize impacts, community kitchens have been recommended. These community kitchens shall use LPG or diesel as fuel. The details are covered in Environmental Management Plan covered in Volume-II of this Report.

The other major impact on the flora in and around the project area would be due to increased level of human interferences. The workers may also cut trees to meet their requirements for construction of houses and other needs. Thus, if proper measures are not undertaken, adverse impacts on terrestrial flora is anticipated. Since, labour camps are proposed to be constructed by the contractor along with necessary facilities, such impacts are not envisaged.

During construction of various components of the project, e.g., road, colony, dam axis, muck disposal, etc. trees will have to be cleared. The tree felling or clearing shall be done by the State Forest Department.

Impacts due to Vehicular movement and blasting

Dust is expected to be generated during blasting, vehicle movement for transportation of construction material or construction waste. The dust particles shall settle on the foliage of trees and plants, thereby reduction in amount of sunlight falling on tree foliage. This will reduce the photosynthetic activity. Based on experience in similar settings, the impact is expected to be localized upto a maximum of 50 to 100 m from the source. In addition, the area experiences rainfall for almost 8 to 9 months in a year. Thus, minimal deposition of dust is expected on flora. Thus, no significant impact is expected on this account.

b) Operation phase

Acquisition of forest land

The total land required for the project is 162 ha of which 76 ha is river body/unclassified state forest (USF) land with or without forest cover. Compensatory afforestation has been recommended as a part of EMP. There are no rare/endangered species reported in the project area.

7.6 IMPACTS ON TERRESTRIAL FAUNA

a) Construction phase

Disturbance to wildlife

The total land required for the project is 162 ha of which 35 ha comes under submergence, (including river bed). The balance (127 ha) land is required for other project appurtenances. Based on the field survey and interaction with locals, it was confirmed that no major wildlife is reported in the proposed submergence area. It would be worthwhile to mention here that most of the submergence lies within the gorge portion. Thus, creation of a reservoir due to the proposed project is not expected to cause any significant adverse impact on wildlife movement. The project area and its surroundings are not reported to serve as habitat for wildlife nor do they lie on any known migratory route. Thus, no impacts are anticipated on this account.

During construction phase, a large number of machinery and construction labour will have to be mobilized. This activity may have some disturbance to the wildlife population. The operation of various construction equipment is likely to generate significant noise, especially during blasting. The noise may scare the fauna and force them to migrate to other areas. Likewise, siting of construction equipment, godowns, stores, labour camps, etc. may generally disturb whatever fauna is left in the area. However, no large-scale fauna is observed in the area. Thus, impacts on this account are not expected to be significant. However, few stray animals sometimes venture in and around the project site. Thus, to minimize any harm due to poaching activities from immigrant labour population, strict anti-poaching surveillance measures need to be implemented, especially during project construction phase. The same have been suggested as a part of the Environmental Management Plan (EMP).

Impacts on migratory routes

The faunal species observed in the project area are not migratory in nature. The proposed submergence area is not the migratory route of wild animals. However, during the course of survey information was gathered through locals in the project area and subsequently discussed with forest

official. It was told that elephants are moving in the area. Normally their route is from Likabali – Boginadi – Singhara – Karinga. Sonajuli, Chassa – Kakori. East Kameng District almost parallel of the inner line (Border of Arunachal and Assam). They cross Kameng river downstream of about 150 km from proposed dam site. The other appurtenances also do not obstruct the migratory route of the elephant. The construction of the proposed Dibbin H.E. project will form a reservoir of about 35 ha, which is also not reported to be on the migratory route of any major faunal species.

Impacts on avi-fauna

The project area and its surroundings are quite rich in avi-fauna. However, water birds are not very common in the area. The main reason for this phenomenon is that water birds generally require quiescent or slow moving water environment. However, in the proposed project area and its surroundings due to terrain conditions, water flow is swift, which does not provide suitable habitat for the growth of water birds. With the damming of the river, a reservoir of an area of about 35 ha will be created, with quiescent/tranquil conditions. The reservoir banks will have wet environment throughout the year which can lead to proliferation of vegetation e.g. grass, etc. along the reservoir banks. Such conditions are generally ideal for various kinds of birds, especially, water birds. This is expected to increase the avi-faunal population of the area.

b) Operation phase

During project operation phase, the accessibility to the area will improve due to construction of roads, which in turn may increase human interferences leading to marginal adverse impacts on the terrestrial ecosystem. Since significant wildlife population is not found in the region, no major adverse impacts are anticipated on this account.

7.7 IMPACTS ON AQUATIC ECOLOGY

Construction phase

Impacts due to excavation of construction material from river bed

During the construction phase a large quantity of construction material like stones, pebbles, gravel and sand would be needed. Significant amount of material is available in the river bed. It is proposed to extract construction material from borrow areas in the river bed. The extraction of construction material may affect the river water quality due to increase in the turbidity levels. This is mainly because the dredged material gets released during one or all the operations mentioned below:

- excavation of material from the river bed.
- loss of material during transport to the surface.
- overflow from the dredger while loading
- loss of material from the dredger during transportation.

The cumulative impact of all the above operations is increase in turbidity levels. Good dredging practices can however, minimize turbidity. It has also been observed that slope collapse is the major factor responsible for increase in the turbidity levels. If the depth of cut is too high, there is possibility of slope collapse, which releases a sediment cloud. This will further move outside the suction radius of dredged head. In order to avoid this typical situation, the depth of cut be restricted to:

$$\gamma H/C < 5.5$$

where,

| | | |
|----------|---|---------------------------|
| γ | - | unit weight of the soil |
| H | - | depth of soil |
| C | - | Cohesive strength of soil |

The dredging and deposition of dredged material may affect the survival and propagation of benthic organisms. The macro-benthic life which remains attached to the stones, boulders etc. gets dislodged and is carried away downstream by turbulent flow. The areas from where construction material is excavated, benthic fauna gets destroyed. In due course of time, however, the area gets recolonized, with fresh benthic fauna. The density and diversity of benthic fauna, will however, be less as compared with the pre-dredging levels.

The second important impact is on the spawning areas of fishes. Almost all the cold water fish breed in the flowing waters. The spawning areas of these fish species are found amongst pebbles, gravel, sand etc. The eggs are sticky in nature and remain embedded in the gravel and subsequently hatch. Any disturbance of stream bottom will result in adverse impacts on fish eggs. Even increase in fine solids beyond 25 ppm will result in deposition of silt over the eggs, which would result in asphyxiation of developing embryo and also choking of gills of young newly emerged fry. Thus, if adequate precautions during dredging operations are not undertaken, then significant adverse impacts on aquatic ecology are anticipated.

Impacts due to discharge of sewage from labour camp/colony

The proposed hydro-power project would envisage the construction of temporary and permanent residential colonies to accommodate labour and staff engaged in the project. This would result in emergence of domestic waste water which is usually discharged into the river. However, it is proposed to commission adequate number of septic tanks for treatment of domestic sewage before its disposal in to the river. Due to perennial nature of river Bichom, it maintains sufficient flow throughout the year which is sufficient to dilute the treated sewage from residential colonies. Therefore, as mentioned earlier, no adverse impacts on water quality are anticipated due to discharge of sewage from labour camp/colony.

Impacts due to human activities

Accumulation of labour force in the project area might result in enhancement in indiscriminate fishing including use of explosives. The use of explosive material to kill fishes in the river in the project area would result in complete loss of fishes and other aquatic life making a river stretch completely barren. Indiscriminate fishing will reduce fish stock availability for commercial and sport fishermen. These aspects have been adequately covered in the Environmental Management Plan (EMP) outlined Separate Volume of this Report.

(b) Operation Phase

Impacts due to damming of river

The damming of river Bichom near village Dibbin will result in creation of 35 ha of submergence area. The dam will change the fast flowing river to a quiescent lacustrine environment. The creation of a pond will bring about a number of alterations in physical, abiotic and biotic parameters both in upstream and downstream directions of the proposed dam site. The micro and macro benthic biota is likely to be most severely affected as a result of the proposed project.

The positive impact of the project will be the formation of a water body which can be used for fish stocks on commercial basis to meet the protein requirement of region. The commercial fishing in the proposed reservoir would be successful, provided all tree stumps and other undesirable objects are removed before submergence. The existence of tree stumps and other objects will hinder the operation of deep water nets. The nets will get entangled in the tree stumps and may be damaged.

The reduction in flow rate of river Bichom especially during lean period is likely to increase turbidity levels downstream of the dam. Further reduction in rate of flow may even create condition of semi-desiccation in certain stretches of the river. This would result in loss of fish life by poaching. Hence, it is essential to maintain minimum flow required for well being of fish life till the disposal point of the tail race discharge.

The field observations made by the Consultant in upstream / downstream of the proposed dam and power house site have shown that the average catch of fish per man hour in one km is 350 g (using standard cast net about 1 m from the shore line). The average width of the stream at the sampling sites was 30 m. Taking into considerations, the average fish catch per man hour in 1 kilometer, the total catch will workout 10.5 kg per km had the fishing done in the whole width of the river. Any adverse conditions of semi-desiccation will result in loss of fish catch, In addition, adverse impacts on young fry and fingerlings of commercially important *Schizothorax* species may occur.

Impacts on migratory fish species

The obstruction created by the dam would hinder migration of certain commercial species especially the Mahseers (from downstream to upper reaches) and *Schizothorax* sp. (from upper reaches to the lower reaches). These fishes undertake annual migration for feeding and breeding. Therefore, fish migration path may be obstructed due to high dam and fishes are expected to congregate below the dam wall. Under this situation poaching activities may increase in the area. Most of the species will shift to the section of the river where they find favourable environment for breeding since the dam is 92 m high construction of fish ladders is not feasible in the proposed dam. However, it is proposed that the artificial seed production in hatchery may be adopted which can be stocked in the river stretches downstream and upstream of the proposed dam.

The *Schizothorax* species are steno-thermal. During winter months, they migrate from upper reaches to near flood plains in search of suitable feeding and breeding grounds. The sampling in river Bichom both on upstream and downstream of the proposed dam site for macro-benthic life gave 5 units/sq.m. of fry of *Schizothorax* sp. This observation further strengthens the fact that *Schizothorax* sp. migrate during winter months. With the onset of summer season, these species migrates upstream. These species from henceforth would congregate in the reservoir. It is expected that in due course of time these species will adapt themselves to the changed habitat.

7.8 IMPACTS ON NOISE ENVIRONMENT

Noise due to Construction Equipment

In a water resource project, the impacts on ambient noise levels are expected only during the project construction phase, due to operation of various construction equipment. Likewise, noise due to quarrying, blasting, vehicular movement will have some adverse impact on the ambient noise levels in the area. The noise level due to operation of various construction equipment is given in **Table-7.8**.

TABLE-7.8
Noise level due to operation of various construction equipment

| Equipment | Sound Level (dBA) |
|----------------------------|-------------------|
| Unsilenced scraper/grader | 94 |
| Unsilenced pneumatic drill | 90 |
| Unsilenced compressor | 85 |
| Cranes | 82 |
| Generator | 82 |

Under the worst case scenario, considered for prediction of noise levels during construction phase, it has been assumed that all these equipment generate noise from a common point. The increases in noise levels due to operation of various construction equipment are given in **Table-7.9**.

TABLE-7.9
Increase in noise levels due to operation of various construction equipment

| Distance (m) | Average Ambient noise levels (dB(A)) | Increased in noise level due to construction activities (dB(A)) | Noise levels due to construction activities (dB(A)) | Increase in ambient noise level due to construction activities (dB(A)) |
|--------------|--------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------------------|
| 100 | 40 | 76 | 76 | 36 |
| 200 | 40 | 70 | 70 | 30 |
| 500 | 40 | 62 | 62 | 22 |
| 1000 | 40 | 56 | 56 | 16 |
| 1500 | 40 | 52 | 52 | 12 |
| 2000 | 40 | 50 | 50 | 10 |
| 2500 | 40 | 48 | 49 | 9 |
| 3000 | 40 | 46 | 47 | 7 |

As per Table-7.9, the increase in noise level shall be of the order of 16 dBA, within 1 km from the project area. However, it would be worthwhile to mention here that in absence of the data on actual location of various construction

equipment, all the equipment have been assumed to operate at a common point. This assumption leads to over-estimation of the increase in noise levels.

It is a known fact that there is a reduction in noise level as the sound wave passes through a barrier. The noise transmission loss values for common construction materials is given in **Table-7.10**.

TABLE-7.10
Noise transmission loss values for various construction materials

| Material | hickness (inches) | Decrease in noise level (dB(A)) |
|----------------|-------------------|---------------------------------|
| Light concrete | 4 | 38 |
| | 6 | 39 |
| Dense concrete | 4 | 40 |
| Concrete block | 4 | 32 |
| | 6 | 36 |
| Brick | 4 | 33 |
| Granite | 4 | 40 |
| Wood Bamboo | | 15 |

The walls of various houses will attenuate at least 15 to 30 dBA of noise. In addition there is attenuation due to the following factors.

- Air absorption
- Rain
- Atmospheric inhomogeneties and atmospheric turbulence.
- Vegetal foliage.

Thus, no increase in noise levels are anticipated as a result of various activities, during the project construction phase. The noise is also generated due to blasting during tunneling operations. However, it is not likely to have any effect on habitations. No major wildlife is observed in and around the project site. Hence, no significant impacts on wildlife is anticipated as a result of blasting activities in the proposed project.

7.9 AIR POLLUTION

In a water resources project, air pollution occurs mainly during project construction phase. The major sources of air pollution during construction phase are:

- Pollution due to fuel combustion in various equipment
- Emission from various crushers
- Fugitive emissions from various sources.
- Blasting Operations
- Pollution due to increased vehicular movement
- Dust emission from muck disposal

Pollution due to fuel combustion in various equipment

The operation of various construction equipment requires combustion of fuel. Normally, diesel is used in such equipment. The major pollutant which gets emitted as a result of combustion of diesel is SO₂. The SPM emissions are minimal due to low ash content in diesel. The short-term increase in SO₂, even assuming that all the equipment are operating at a common point, is quite low, i.e. of the order of less than 1µg/m³. Hence, no major impact is anticipated on this account on ambient air quality.

Emissions from crushers

The operation of the crusher during the construction phase is likely to generate fugitive emissions, which can move even up to 1 km in predominant wind direction. During construction phase, one crusher each is likely to be commissioned near proposed dam and proposed power house sites. During crushing operations, fugitive emissions comprising mainly the suspended particulate will be generated. Since, there are no major settlements close to the dam and power house, hence, no major adverse impacts on this account are anticipated. However, during the layout design, care should be taken to ensure that the labour camps, colonies, etc. are located on the leeward side and outside the impact zone (say about 2 km on the wind direction) of the crushers.

Fugitive Emissions from various sources

During construction phase, there will be increased vehicular movement. Lot of construction material like sand, fine aggregate are stored at various sites, during the project construction phase. Normally, due to blowing of winds, especially when the environment is dry, some of the stored material can get entrained in the atmosphere. However, such impacts are visible only in and around the storage sites. The impacts on this account are generally, insignificant in nature.

Blasting Operations

Blasting will result in vibration, which shall propagate through the rocks to various degrees and may cause loosening of rocks/boulders. The overall impact due to blasting operations will be restricted well below the surface and no major impacts are envisaged at the ground level.

During tunneling operations, dust will be generated during blasting. ID blowers will be provided with dust handling system to capture and generated dust. The dust will settle on vegetation, in the predominant down wind direction. Appropriate control measures have been recommended to minimize the adverse impacts on this account.

Pollution due to increased vehicular movement

During construction phase, there will be increased vehicular movement for transportation of various construction materials to the project site. Similarly, these will be increased traffic movement on account of disposal of muck or construction waste at the dumping site. The maximum increase in vehicle is expected to 50 vehicles per hour. Large quantity of dust is likely to be entrained due to

the movement of trucks and other heavy vehicles. Similarly, marginal increase in Hydrocarbons, SO₂ and NO_x levels are anticipated for a short duration. Modelling studies for hydrocarbon emissions were conducted and the results are given in **Table-7.11**.

TABLE-7.11
Increase in hydrocarbon concentration due to vehicular movement

| Distance (m) | Increase in HC concentration (µg/m ³) |
|--------------|---------------------------------------------------|
| 10 | 5 |
| 20 | 2.50 |
| 30 | 1.67 |
| 40 | 1.25 |
| 50 | 1.00 |
| 60 | 0.83 |
| 70 | 0.71 |
| 80 | 0.63 |
| 90 | 0.56 |
| 100 | 0.50 |

The increase in vehicular density is not expected to significant. In addition, these ground level emissions do not travel for long distances. Thus, no major adverse impacts are anticipated on this account.

Dust emission from muck disposal

The loading and unloading of muck is one of the source of dust generation. Since, muck will be mainly in form of small rock pieces, stone, etc., with very little dust particles. Significant amount of dust is not expected to be generated on this account. Thus, adverse impacts due to dust generation during muck disposal are not expected.

7.10 IMPACTS ON SOCIO-ECONOMIC ENVIRONMENT

Project construction phase

The construction phase will last for about 4 years. The peak labour force and technical staff required is estimated at about 800. The total number of persons inhabiting the area including the service population will be about 2000. The adverse impacts on ecosystem due to congregation of such a large population during the construction phase has been detailed in the respective sections dealing with various disciplines of the environment.

The construction phase of any project is rather an unsettled stage characterized by uncertainties and often disorders. The basic problem relates to management of large population which migrate to the construction area in search of jobs. It has been estimated that about 2,000 persons will inhabit the area during peak construction phase, which is expected to last for about 2 years.

Those who would migrate to this area are likely to come from various parts of the country having different cultural, ethnic and social backgrounds. Such a mixture of population has its own advantages and disadvantages. The advantages include exchange of ideas and cultures between various groups of people which would not have been possible otherwise. Due to longer stay of this population in one place, a new culture, having a distinct socio-economic similarity would develop which will have its own entity.

The benefits however, are always not a certainty and depend on several factors. Often, they are directly related to the way construction phase is handled by the project authorities and their sensitivity to various socio-economic problems that could develop during this phase.

Job opportunities will drastically improve in this area. At present most of the population sustains by agriculture, Jhum cultivation and allied activities.

The availability of infrastructure is generally a problem during the initial construction phase. Though the construction workers can be subsidized for certain facilities like health, education, etc. The facilities of desired quality are often not made available in the initial stages. The adequacy of water supply, sewage treatment, housing, etc. should therefore, be ensured before the commencement of construction and adequate measures would be taken at the very start of the project.

Project operation phase

The proposed project involves acquisition of Jhum lands and other lands. The impacts due to acquisition of these lands have been covered separately in Chapter-5 of this Report. A detailed R&R Plan for Project Affected Families has also been suggested.

7.11 INCREASED INCIDENCE OF WATER-RELATED DISEASES

The construction of a reservoir replaces the riverine ecosystem by a lacustrine ecosystem. The vectors of various diseases breed in shallow water areas not very far from the reservoir margins. The magnitude of breeding sites for mosquitoes and other vectors in the impounded water is in direct proportion to the length of the shoreline. The construction of the reservoir would increase the shoreline by many times as compared to the pre-project shoreline of river Bichom under submergence. Thus, the construction of the proposed reservoir would enhance the potential breeding sites for various diseases vectors. There are chances that incidence of malaria may increase as a result of the construction and operation of the proposed project. In addition to the construction of the reservoir, the following factors too would lead to the increased incidence of malaria in and around the project area:

- aggregation of labour;
- excavation, and
- inadequate facilities in labour camp.

Aggregation of labour

About 500 labourers and technical staff will congregate in the project area during peak construction phase. The total increase in population is expected to be of the order of 2000. Most of the labour would come from various parts of the country. The labourer would live in dormitories provided by the Contractor. Proper sanitary facilities are generally provided. Hence, a proper surveillance and immunization schedule needs to be developed for the labour population migrating into the project area.

Excavations

The excavation of earth from borrow pits etc. is one of the major factor for the increase in prevalence of malaria. After excavation of construction material, the depressions are generally left without treatment where water gets collected. These pools of water, then serves as breeding grounds for mosquitoes. However, in the present case, the borrow areas are within the river bed, which in any case remain under water. Thus, no additional habitat for mosquito breeding is created due to excavation.

The flight of mosquito is generally limited up to 1 to 2 km from the breeding sites. Since, no residential areas are located within 1 km from the reservoir, periphery, increased incidences of malaria are not anticipated. However, labour camps, etc. could be vulnerable to increased incidence of malaria, if proper control measures are not undertaken.

Inadequate facilities in labour camps

Improperly planned labour camps generally tend to become slums, with inadequate facilities for potable water supply and sewage treatment and disposal. This could lead to outbreak of epidemics of water-borne diseases. Adequate measures for supply of potable water and sewage treatment have been recommended as a part of Environmental Management Plan outlined in separate Volume of this Report.

ANNEXURE-II

Drinking water quality standards

| Characteristics | *Acceptable | **Cause for Rejection |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|
| Turbidity (units on JTU scale) | 2.5 | 10 |
| Colour (Units on platinum cobalt scale) | 5.0 | 25 |
| Taste and Odour | Unobjectionable | Unobjectionable |
| pH | 7.0 to 8.5 | <6.5 or >9.2 |
| Total Dissolved Solids (mg/l) | 500 | 1500 |
| Total hardness (mg/l) (as CaCO ₃) | 200 | 600 |
| Chlorides as CD (mg/l) | 200 | 1000 |
| Sulphates (as SO ₄) | 200 | 400 |
| Fluorides (as F) (mg/l) | 1.0 | 1.5 |
| Nitrates (as NO ₃) (mg/l) | 45 | 45 |
| Calcium (as Ca) (mg/l) | 75 | 200 |
| Magnesium (as Mg) (mg/l) If there are 250 mg/l of sulphates, Mg content can be increased to a maximum of 125 mg/l with the reduction of sulphates at the rate of 1 unit per every 2.5 units of sulphates | 30 | 150 |
| Iron (as Fe) (mg/l) | 0.1 | 1.0 |
| Manganese (as Mn) (mg/l) | 0.05 | 0.5 |
| Copper (as Cu) (mg/l) | 0.05 | 1.5 |
| Zinc (as Zn) (mg/l) | 5.0 | 15.0 |

| Characteristics | *Acceptable | **Cause for Rejection |
|-----------------------------------------|--------------------|------------------------------|
| Phenolic compounds (as phenol) (mg/l) | 0.001 | 0.002 |
| Anionic detergents (as MBAS) (mg/l) | 0.2 | 1.0 |
| Mineral Oil (mg/l) | 0.01 | 0.3 |
| Toxic materials | | |
| Arsenic (as As) (mg/l) | 0.05 | 0.05 |
| Cadmium (as Cd) (mg/l) | 0.01 | 0.01 |
| Chromium (as hexavalent Cr) (mg/l) | 0.05 | 0.05 |
| Cyanides (as CN) (mg/l) | 0.05 | 0.05 |
| Lead (as Pb) (mg/l) | 0.1 | 0.1 |
| Selenium (as Se) (mg/l) | 0.01 | 0.01 |
| Mercury (total as Hg) (mg/l) | 0.001 | 0.001 |
| Polynuclear aromatic hydrocarbons (PAH) | 0.2 µg/l | 0.2 µg/l |
| Radio Activity | | |
| Gross Alpha activity | 3p Ci/l | 3p Ci/l |
| Gross Beta activity Pci = pico curie | 30p Ci/l | 30p (Ci/l) |

Notes :-

- *1. The figures indicated under the column 'Acceptable' are the limits upto which water is generally acceptable to the consumers
- **2 Figures in excess of those mentioned under 'Acceptable' render the water not acceptable, but still may be tolerated in the absence of alternative and better source but upto the limits indicated under column "Cause for Rejection" above which are supply will have to be rejected.
- *3. It is possible that some mine and spring waters may exceed these radio activity limits and in such cases it is necessary to analyse the individual radionuclides in order to assess the acceptability or otherwise for public consumption.

ANNEXURE-III**National Ambient Air Quality Standards (Unit : $\mu\text{g}/\text{m}^3$)**

| Pollutants | Time weighted Average | Industrial Area | Residential, Rural and other Areas | Sensitive Area |
|-------------------|---------------------------------|------------------------|-------------------------------------------|-----------------------|
| SO ₂ | Annual Average * 24 hours ** | 80 120 | 60 80 | 15 30 |
| NO _x | Annual * 24 hours ** | 80 120 | 60 80 | 15 30 |
| SPM | Annual * 24 hours ** | 360 500 | 140 200 | 70 100 |
| RPM | Annual * 24 hours ** | 120 150 | 60 100 | 50 75 |

* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/8hourly values should be met 98th percentile of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

NOTE :

1. National Ambient Air Quality Standards: the levels of air quality with an adequate margin of safety, to protect the public health, vegetation and property.

2. Whenever and wherever two consecutive values exceeds the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigation.

Source : S.O. 384 (E), Air (Prevention & Control of Pollution) Act, 1981 dated April 11, 1994 and [EPA Notification : GSR 176 (E), April 2, 1996]

ANNEXURE-IV

Ambient noise standards

| Area Code | Category of Area | Limits in dB(A) Leq | |
|-----------|------------------|---------------------|------------|
| | | Day time | Night time |
| A. | Industrial Area | 75 | 70 |
| B. | Commercial Area | 65 | 55 |
| C. | Residential Area | 55 | 45 |
| D. | Silence Zone | 50 | 40 |

- Note :**
1. Day time 6 AM and 9 PM
 2. Night time is 9 PM and 6 AM
 3. Silence zone is defined as areas upto 100 metres around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by competent authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zone.
 4. Environment (Protection) Third Amendment Rules, 2000 Gazettee notification, Government of India, date 14.2.2000.

ANNEXURE – V

LIST OF PLANT SPECIES REPORTED IN THE STUDY AREA

| Species | Family |
|------------------------------------|-----------------|
| Angiosperms | |
| <i>Ageratum conyzoides</i> | Asteraceae |
| <i>Ailanthus grandis</i> | Simarubaceae |
| <i>Altingia excelsa</i> | Altingiaceae |
| <i>Artemisia nilagirica</i> | Asteraceae |
| <i>Arundinaria</i> sp. | Poaceae |
| <i>Aspidopterys elliptica</i> | Malphigiaceae |
| <i>Begonia</i> sp. | Begoniaceae |
| <i>Betula alnoides</i> | Betulaceae |
| <i>Bidens biternata</i> | Asteraceae |
| <i>Bombax ceiba</i> | Bombacaceae |
| <i>Bridelia</i> sp. | Euphorbiaceae |
| <i>Buddleja asiatica</i> | Loganiaceae |
| <i>Bulbophyllum griffithii</i> | Orchidaceae |
| <i>Callicarpa arborea</i> | Verbenaceae |
| <i>Cardamine hirsuta</i> | Brassicaceae |
| <i>Cassia occidentalis</i> | Fabaceae |
| <i>Castanopsis tribuloides</i> | Fagaceae |
| <i>Centella asiatica</i> | Apiaceae |
| <i>Citrus aurantium</i> | Rutaceae |
| <i>Clematis gouriana</i> | Ranunculaceae |
| <i>Clerodendron colebrookianum</i> | Verbenaceae |
| <i>Colocasia esculanta</i> | Araceae |
| <i>Commelina appendiculata</i> | Commelinaceae |
| <i>Commelina bengalensis</i> | Commelinaceae |
| <i>Cordia dichotoma</i> | Boraginaceae |
| <i>Cynoglossum furcatum</i> | Boraginaceae |
| <i>Cyperus kyllinga</i> | Cyperaceae |
| <i>Cyperus</i> sp. | Cyperaceae |
| <i>Dalbergia rimosa</i> | Fabaceae |
| <i>Desmodium sequax</i> | Fabaceae |
| <i>Dioscorea</i> sp. | Dioscoreaceae |
| <i>Drymaria cordata</i> | Caryophyllaceae |
| <i>Dysoxylum gobara</i> | Meliaceae |
| <i>Elatostemma hookerianum</i> | Urticaceae |
| <i>Equisetum debile</i> | Equisetaceae |
| <i>Eupatorium odoratum</i> | Asteraceae |

| Species | Family |
|--------------------------------|------------------|
| <i>Eupatoriun adenophorum</i> | Asteraceae |
| <i>Eupatoriun cannabinum</i> | Asteraceae |
| <i>Eurya acuminata</i> | Moraceaea |
| <i>Ficus roxburghii</i> | Moraceaea |
| <i>Ficus semicordata</i> | Moraceae |
| <i>Ficus squamata</i> | Moraceae |
| <i>Galinsoga parviflora</i> | Asteraceae |
| <i>Grewia dispernum</i> | Tiliaceae |
| <i>Hedychium concinuum</i> | Zingiberaceae |
| <i>Hedyotis scandens</i> | Rubiaceae |
| <i>Hoya lanceolata</i> | Asclepiadaceae |
| <i>Hydrocotyle asiatica</i> | Apiaceae |
| <i>Impatiens chinensis</i> | Balsaminaceae |
| <i>Indigofera atropurpurea</i> | Fabaceae |
| <i>Inula cappa</i> | Asteraceae |
| <i>Lagerstoemia parviflora</i> | Lythraceae |
| <i>Lilium grande</i> | Liliaceae |
| <i>Litsea monopetala</i> | Lauraceae |
| <i>Lycopodium selago</i> | Lycopodiaceae |
| <i>Macaranga denticulata</i> | Euphorbiaceae |
| <i>Macaranga indica</i> | Euphorbiaceae |
| <i>Maesa chisia</i> | Myrsinaceae |
| <i>Melastoma nepalensis</i> | Melastomataceae |
| <i>Mikania micrantha</i> | Asteraceae |
| <i>Molineria curculigoides</i> | Zingiberaceae |
| <i>Nephrolepis cordifolia</i> | Nephrolepidaceae |
| <i>Osbeckia nutans</i> | Melastomataceae |
| <i>Oxalis corniculata</i> | Oxalidaceae |
| <i>Persea gamblei</i> | Lauraceae |
| <i>Persicaria capitata</i> | Polygonaceae |
| <i>Pinus roxburghii</i> | Taxodiaceae |
| <i>Plantago ovata</i> | Plantaginaceae |
| <i>Pogostemon sp.</i> | Lamiaceae |
| <i>Pouzolzia sanguinea</i> | Urticaceae |
| <i>Pouzolzia sp.</i> | Pouzolziaceae |
| <i>Pouzolzia wednnettiana</i> | Urticaceae |
| <i>Premna latifolia</i> | Verbenaceae |
| <i>Prunus cerasoides</i> | Rosaceae |
| <i>Pseudodrynaria sp.</i> | Drynariaceae |
| <i>Pteridium aquilinum</i> | Pteridaceae |
| <i>Quercus griffithii</i> | Fagaceae |
| <i>Quercus lanuginosa</i> | Fagaceae |
| <i>Quercus spicata</i> | Fagaceae |
| <i>Rhododendron arboreum</i> | Ericaceae |

| Species | Family |
|--------------------------------|------------------|
| <i>Rhus javanica</i> | Anacardiaceae |
| <i>Rivea ornata</i> | Convolvulaceae |
| <i>Rubia cordifolia</i> | Rubiaceae |
| <i>Rubus ellipticus</i> | Rosaceae |
| <i>Rubus mollucanus</i> | Rosaceae |
| <i>Sabia lanceolata</i> | Sabiaceae |
| <i>Saccharum spontaneum</i> | Poaceae |
| <i>Saurauia macrotricha</i> | Saurauiaceae |
| <i>Schefflera venulosa</i> | Araliaceae |
| <i>Senecio scandens</i> | Asteraceae |
| <i>Sida acuta</i> | Boraginaceae |
| <i>Solanum nigrum</i> | Solanaceae |
| <i>Symplocos racemosa</i> | Symplocaceae |
| <i>Syzygium cuminii</i> | Myrtaceae |
| <i>Terminalia belerica</i> | Combretaceae |
| <i>Thysanolaena maxima</i> | Poaceae |
| <i>Toona ciliata</i> | Meliaceae |
| <i>Tridax procumbens</i> | Asteraceae |
| <i>Triumfetta pilosa</i> | Tiliaceae |
| <i>Urena lobata</i> | Malvaceae |
| <i>Urtica dioica</i> | Urticaceae |
| <i>Urtica parviflora</i> | Urticaceae |
| <i>Vitis heyneana</i> | Vitaceae |
| <i>Woodfordia fruticosa</i> | Lythraceae |
| <i>Xanthoxylum armatum</i> | Rutaceae |
| Pteridophytes | |
| <i>Asplenium nidus</i> | Aspleniaceae |
| <i>Equisetum debile</i> | Equisetaceae |
| <i>Lycopodium selago</i> | Lycopodiaceae |
| <i>Nephrolepis cordifolia</i> | Nephrolepidaceae |
| <i>Pteridium aquilinum</i> | Pteridaceae |
| <i>Pteris biaurita</i> | Pteridaceae |
| <i>Selaginella</i> sp. | Selaginellaceae |
| Fungi | |
| <i>Ganoderma lucidum</i> | Ganodermataceae |
| <i>Pseudomertes gibbosa</i> | Polyporaceae |
| <i>Trametes versicolor</i> | Polyporaceae |
| <i>Antrodiella minutispora</i> | Polyporaceae |
| <i>Lycoperdon pyiforme</i> | Lycoperdaceae |
| Algae | |
| <i>Amphora ovalis</i> | Naviculaceae |
| <i>Cytonema</i> sp. | Zygnemaceae |
| <i>Frustulia</i> sp. | Chlorophyceae |
| <i>Navicula</i> sp. | Naviculaceae |

| Species | Family |
|--------------------------------|-------------------|
| <i>Spirogrya</i> sp. | Zygnemaceae |
| <i>Stauroneis</i> sp. | Bacillariophyceae |
| <i>Ulothrix</i> sp. | Ulotrichaceae |
| Bryophytes | |
| <i>Fissidens leptolema</i> | Fissidentaceae |
| <i>Dicranella leptoneura</i> | Dicranaceae |
| <i>Bryum</i> sp. | Bryaceae |
| <i>Fissidens subpulchellus</i> | Fissidentaceae |
| Lichen | |
| <i>Cladonia aggregata</i> | Cladoniaceae |
| <i>Graphis duplicata</i> | Graphidaceae |
| <i>Heterodermia</i> sp. | Physciaceae |
| <i>Leptogonium</i> sp. | Collembataceae |
| <i>Parmelia cirrhata</i> | Parmeliaceae |
| <i>Pheogaphis</i> sp. | Graphidaceae |