MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE, GOVERNMENT OF INDIA

सत्यमेव जयते

CARRYING CAPACITY AND CUMULATIVE IMPACT ASSESSMENT STUDIES FOR HYDROELECTRIC PROJECTS ON THE TRIBUTARIES OF LOHIT RIVER BASIN IN ARUNACHAL PRADESH

VOLUME-I : FINAL REPORT

Prepared by:

WAPCOS LIMITED

(A Government of India Undertaking)

76 C, Sector 18, Gurgaon - 122015, Haryana, INDIA

Tel. +91-124-2397396, Fax. +91-124-2397392

Email: environment@wapcos.co.in

AUGUST 2016

CONTENTS

CONTENTS

CHAPTER-8 PROTECTED AREA

CHAPTER-9 PREDICTION OF IMPACTS

LIST OF FIGURES

CHAPTER-1
INTRODUCTION

CHAPTER-1
INTRODUCTION

1.1 GENERAL

Basin study for any river basin can be defined as its ability to provide optimum support for various natural processes and allow sustainable activities undertaken by its inhabitants. The same is determined in terms of the following:

- Inventorization and analysis of the existing resource base and its production, consumption and conservation levels.
- Determination of regional ecological fragility/sensitivity based on geo-physical, biological, socio-economic and cultural attributes.
- Review of existing and planned developments as per various developmental plans.
- Evaluation of impacts on various facets of environment due to existing and planned development.

The basin study involves assessment of stress/load due to varied activities covering, e.g. exploitation of natural resources, industrial development, population growth which lead to varying degree of impacts on various facet of environment. The basin study also envisages a broad framework of environmental action plan to mitigate the adverse impacts on environment which could be in the form of:

- Preclusion of an activity
- Infrastructure development
- Modification in the planned activity
- Implementation of set of measures for amelioration of adverse impacts.

Thus, basin study is a step beyond the EIA, as it incorporates an integrated approach to assess the impacts due to various developmental projects. The present study basically assesses impacts on terrestrial and aquatic ecology due to development of various hydroelectric projects in the area to be studied as a part of the present study.

1.2 CONCEPT OF SUSTAINABLE MANAGEMENT

Implementation of any developmental project requires sustainable management of natural resources. In order to ensure sustainable management of resources, an inventory of the existing resource base and its production and consumption pattern needs to be studied. This helps in developing conservation strategies for the resources and identification of intervention areas for conservation effort. Sustainable development is also assessed by determining the carrying capacity, which defines the upper limit of growth.

Sustainable development calls for keeping life-supporting ecosystems and interrelated socio-economic systems resilient for avoiding irreversibility, and for keeping the scale and impact of human activities within supportive and assimilative capacities.

Sustainable development is a process in which the utilization of resources, the direction of investments, and institutional changes are all made consistent with future as well as present needs. The sustainable development could be achieved through:

- Carrying capacity based developmental planning process
- Preventive environmental policy
- Structural change in economic sectors
- Enlarged and objective use of tools like
    - Environmental Impact and Risk Assessment
    - Environmental Audit
    - Natural Resource Accounting, and
    - Life Cycle Assessment.

Planning for sustainable development based on the premises of carrying capacity implies adoption of a normative, rationalist approach to planning, wherein planners subject both the ends and means of public policy to rational considerations. Sustainable development requires pragmatic management of natural resources through positive and realistic planning that balances human expectations with the ecosystems carrying capacity. It aims not only at environmental harmony, but also at long term sustainability of the natural resource base with economic efficiency in the utilization of non-renewable resources, and structural shifts to renewable resource utilization in economic processes.

1.3 NEED FOR THE STUDY

The Study of Lohit Basin in Arunachal Pradesh was initiated at the instance of Ministry of Environment & Forests, Government of India while according prior Environmental Clearance to Demwe Lower hydroelectric project and Demwe Upper hydroelectric project being developed by M/s Athena Demwe Power Limited, New Delhi. Subsequently, after series of discussions, Expert Appraisal Committee reccomended the TOR for the Study of Lohit Basin. Subsequently, Basin Study for river Lohit was conducted by WAPCOS Ltd. The scope of this study covered the hydroelectric projects only on the main Lohit river. During the course of evaluation of the Basin study by the Expert Appraisal Committee, it was suggested to conduct Basin Study covering cumulative impacts of hydroelectric on tributaries. The TOR for the Basin Study covering inputs due to hydroelectric projects of river Lohit was approved by EAC in the month of December 2014.

1.4 STUDY AREA

The Basin Study will focus on the various impacts resulting from implementation of hydro power projects in the Lohit basin. A total of 7 (seven) hydroelectric projects are proposed to be developed on the main Lohit river upto Brahmakund in the Indian portion. The Lohit basin map is enclosed as Figure-1.1. The list of the hydroelectric projects covered under Basin Study for main Lohit river and tributaries is given in Tables-1.1 and 1.2 respectively.

Table-1.1: List of hydroelectric projects covered in the Basin Study of river Lohit

S.No	Project Name	Capacity (MW)	Project Proponent
1	Kalai-I HEP	1450	Mountain Fall India Private Limited
2	Kalai-II HEP	1200	Kalai Power Private Limited
3	Hutong-I	750	Project yet to be allotted
4	Hutong-II	1250	Mountain Fall India Private Limited
5	Anjaw HEP	270	Lohit Urja Limited
6	Demwe Upper HEP	1080	Lohit Urja Limited
7	Demwe Lower HEP	1750	Athena Demwe Power Private Limited

Table-1.2: List of hydroelectric projects on river Lohit and tributaries

Project Name	Tributary	Capacity as per approved TOR (MW)	Capacity as per PFR, Project Reports, etc. (MW)	Project Proponent
Gimiliang HEP	Dav	99	88.5	Sai Krishnodaya Industries(P) Ltd.
Raigam HEP	Dalai	96	195	Sai Krishnodaya Industries(P) Ltd.
Tidding- I HEP	Tidding	98	84.5	Sai Krishnodaya Industries(P) Ltd.
Tidding- II HEP	Tidding	68	75	Sai Krishnodaya Industries(P) Ltd.
Kamlang HEP	Kamlang	21	24.9	Sai Krishnodaya Industries(P) Ltd.

Initially the Pre-Feasibility Report of Demwe Upper H.E. Project was proposed with installed capacity (1800 MW), between EL 440.00 m with FRL at EL 584.00 m, almost utilizing the entire allotted reach up to EL 589.00 m with the submergence area of 1440 ha. The free flow river stretch between Demwe Upper HEP and Hutong II HEP was only 500 m at that time.

However, during the site investigations and subsequent interactions with the Government of Arunachal Pradesh officials and local authorities, it was impressed upon by them that Demwe

Upper HE Project which earlier envisaged FRL of EL 584.00 m will lead to submergence of a proposed hospital site of Swami Camp; part of Hayuliang town; some habitat areas and considerable road length of strategic importance. Accordingly, to avoid the large scale submergence as well as optimal utilization of the Power Potential of allotted reach, Project had been planned to be developed in two schemes/stages in consultation with MOEF, namely Demwe Upper HE Project with installed capacity of 1050 MW near Mompani at EL 440.00 m with FRL at EL 525.00 m bringing down submergence area to 749 ha and Anjaw HE Project, a Barrage toe power house scheme at EL 550 m with FRL at EL 580 m. The Ministry of Environment & Forests (MoEF), while granting revised TOR and Scoping approval for 1050 MW Demwe Upper HE Project vide letter dated 22-12-2010, stated that the proposal for harnessing the hydropower potential of the allotted stretch up to EL 589 m wherein the proposal for a Barrage toe power house based project in the upstream reach is envisaged with provision of free flow river stretch of about 2 km between consecutive upstream and downstream projects.

1.5 STATUS OF ENVIRONMENTAL CLEARANCE OF THE PROJECTS IN STUDY AREA

The status of Environmental Clearance of the projects on main Lohit and tributaries is given in Tables-1.3 and 1.4 respectively.

Table-1.3: Status of Environmental Clearance of the projects on Lohit river

S. No.	Project Name	Project Proponent	Status of Environmental Clearance
1	Kalai HEP Stage –1	Mountain Fall India Private Limited	TOR Approved by EAC for River Valley Projects, Ministry of Environment , Forests & Climate Change
2	Kalai HEP Stage -2	Kalai Power Private Limited	EC awarded by MOEF & CC
3	Hutong HEP Stage –1	Project yet to be allotted	Not Applicable
4	Hutong HEP Stage –2	Mountain Fall India Private Limited	TOR Approved by EAC for River Valley Projects, Ministry of Environment , Forests & Climate Change
5	Anjaw HEP	Lohit Urja Limited	TOR Approved by EAC for River Valley Projects, Ministry of Environment, Forests & Climate Change
6	Demwe Upper HEP	Lohit Urja Limited	TOR Approved by EAC for River Valley Projects, Ministry of Environment, Forests & Climate Change
7	Demwe Lower HEP	Athena Demwe Power Private Limited	EC awarded by MOEF & CC

Table-1.4: Status of Environmental Clearance of the projects on tributaries

S. No	Project Name	Capacity as per approved TOR (MW)	Capacity as per PFR, Project Reports, etc. (MW)	Status of Environmental Clearance	Status of Other Clearance
1	Gimiliang HEP	99	88.5	TOR approved by EAC for River Valley projects, MOEF &CC	Hydrology and power potential Approved by CEA
2	Raigam HEP	96	195	TOR approved by EAC for River Valley projects, MOEF &CC	Hydrology and power potential Approved by CEA
3	Tidding- I HEP	98	84.5	Application for Stage-I Forest Clearance is ready for submission. TOR for EIA study to be accorded by EAC for River Valley projects, MOEF &CC	Hydrology and power potential Approved by CEA
4	Tidding- II HEP	68	75	Application for Stage-I Forest Clearance is ready for submission. TOR for EIA study to be accorded by EAC for River Valley projects, MOEF &CC	Hydrology and power potential Approved by CEA
5	Kamlang HEP	21	24.9	EC not required because less capacity is less than 25 MW.	TEC accorded. NBWL clearance has been accorded.

Note:- The Project Proponent for all the projects is Sai Krishnodaya Industries(P) Ltd

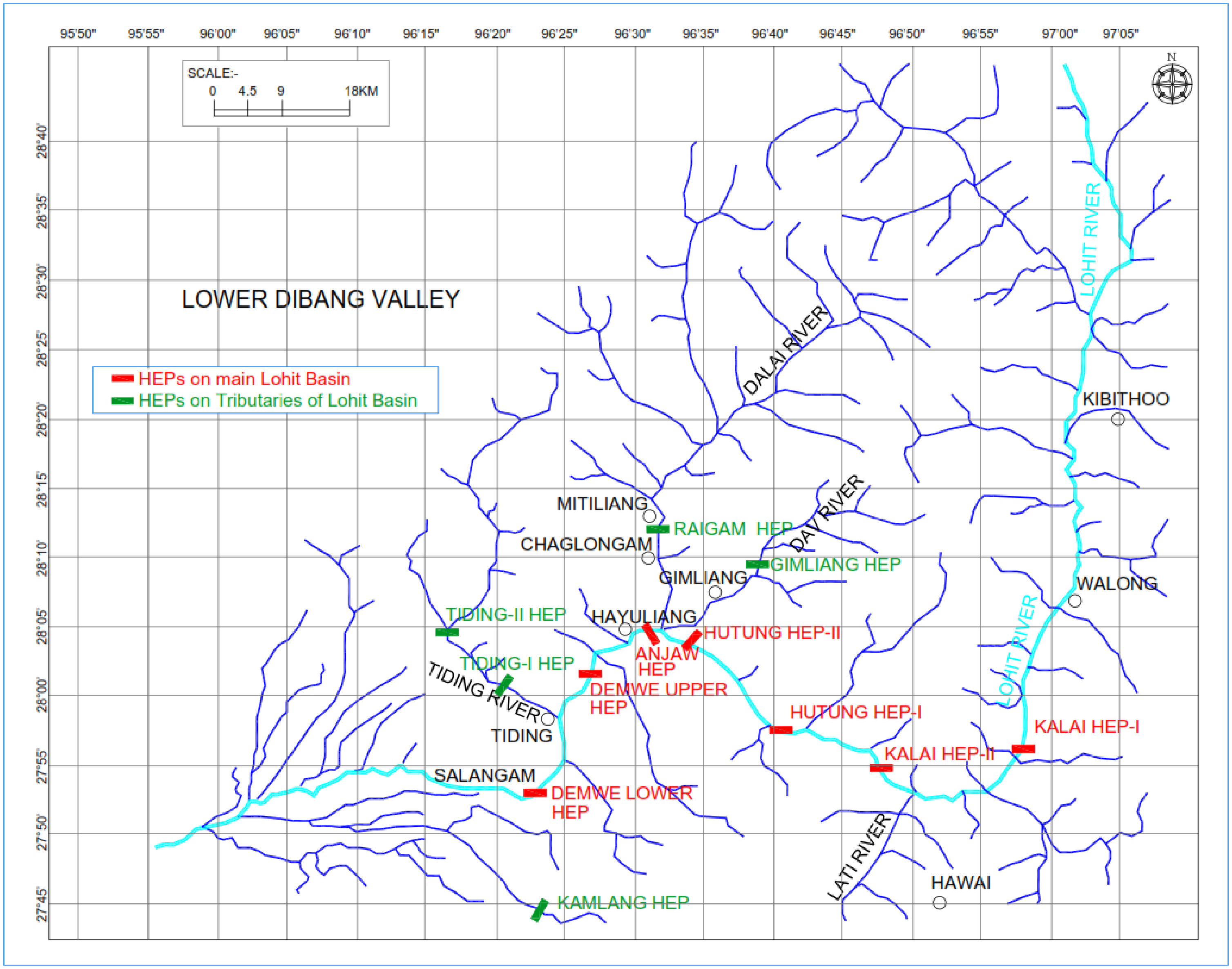


Figure-1.1: Location of HEPs covered as a part of Lohit Basin Study

1.6 OUTLINE OF THE REPORT

The report is presented in two volumes listed as below:

Volume-I : Main Report

Volume-II : Annexures

The outline of Volume-I (Main Report) is given as below:

Chapter-1 covers the need for the basin study, study area to be covered as a part of the study. The scope of work and brief profile of the study area is also summarized in the Chapter.

Chapter-2 gives the profile of Lohit Basin.

Chapter-3 includes description of various projects proposed to be developed in the study area.

Chapter-4 presents information on hydrological aspects of Lohit river Basin.

Chapter-5 presents the findings the terrestrial ecological survey conducted for two seasons as a part of the study for Lohit river and its tributaries. The information collected through secondary sources has also been presented in this chapter.

Chapter-6 presents the information on faunal aspects of the Study Area.

Chapter-7 presents the aquatic ecological aspects of environment. As a part of the basin study, detailed ecological survey was conducted for Lohit river and its tributaries. The findings of the aquatic ecological survey were analysed and ecological characteristics of the study area have been covered in this Chapter.

Chapter-8 gives a brief description of the Protected Areas within the Study Area.

Chapter-9 delineates the prediction of impacts likely to accrue as a result of construction and operation phases of various projects on the tributaries of Lohit Basin.

Chapter-10 delineates an Environmental Management Plan (EMP) for amelioration of anticipated adverse impacts likely to accrue as a result of commissioning of various projects in the study area. The approach adopted for formulation of the Environmental Management Plan (EMP) has been to maximize the positive environmental impacts and minimize the negative ones.

Chapter-11 presents the recommendation of Lohit Basin study alongwith Environmental Flows to be released for sustaining the riverine ecology.

CHAPTER-2

LOHIT RIVER BASIN

CHAPTER-2
LOHIT RIVER BASIN

2.1 INTRODUCTION

The Lohit Basin is the eastern most river basins of India forming part of Brahamputra basin, with its catchment spreading across international border covering part of Tibet. River Lohit is a tributary of river Brahmaputra and originates at an EL 6190 m above mean sea level from the snow clad peaks in Eastern Tibet and enters India through Kibithoo area of the district. River Lohit in the upper reaches is known' as Krawnaon and after flowing westwards, joins tributary called Chalum Susning flowing from Indo-Burma Border. The combined flow is known as Tellu or Lohit river. The Lohit basin lies between latitudes 27° 34’ N and 29° 36’ N and longitudes 95° 38’ E and 97° 44’ E.

River Lohit enters the state of Arunachal Pradesh after traversing through Tibet, and generally flows through Mishmi hills. Rivers Dau, Dalai and Tidding are its major tributaries on the right bank and river Lang is the major tributary on the left bank. After debouching from the gorges of Mishmi hills into the plains near Brahamkund, it flows in a westerly direction. It meets Noa-Dihing, Kamlang, Tabang and Tengapani River on the left bank and Digaru, Balijan and Kundli on the right bank. River Lohit is then joined by river Dibang, another important tributary of river Brahmaputra on its right bank and combined flow confluences with river Dihang near Kobo.

The catchment area experiences mostly tropical wet season and supports dense mixed forest. The area is characterized by hills with steep gorges and deep rugged valleys of dentritic pattern with streams feeding the tributaries of the Lohit river system. The rivers are turbulent with steep gradients. Water falls and rapids are very common in these rivers. The catchment area of river Lohit including Tibet region is 29,487 sq km. The catchment area in Tibet has been estimated as about 15,034 sq km and lies mostly in high altitude region.

River Lohit is perennial in nature, with its main source being snow melts of Himalayan glaciers and other small sreams. During lean season i.e. from November to March every year there is a drop in discharge. River Lohit offers good sites for hydro power development. For the optimal use of head and water, cascade development is envisaged to harness the natural river gradient of river Lohit.

2.2 METEOROLOGY

The climate of Lohit basin is characterized by cool and highly humid conditions at lower elevations and in the valleys and intensively cold weather at higher elevations. The winter season commences from late November and continues up to March followed by monsoon season from May to September.

2.2.1 Precipitation

As substantial portion of the catchment lies in China/Tibet, hydro-meteorological data for this area of the basin is not available. The rainfall in the Raigam catchment is predominantly influenced by the mountain system and occurs due to South-West monsoon and cyclonic rainfall, which generally sets in May and continues till October (CWC- 2a, 1991). A lot of rainfall takes place due to pre-monsoon thunderstorm activity in the months of March and April. The rainfall intensity usually decreases after October. Generally November, December and January are the dry months, with occasional scattered rainfall.

The average annual rainfall recorded in the catchment area region at Chaglongam station is 2554 mm, 2165 mm at Hawai (towards south east), 3790 mm at Hayuliang (towards south from the barrage site), 1204 mm at Kibithoo (towards north east), 4654 mm at Salangam, 4230 mm at Tidding (towards south west) and 1167 mm at Walong (towards south east)

2.2.2 Temperature

Depending on the elevation, the high hills belong to temperate zone while lower hills and valleys are in the sub tropical agro climate zone. The region experiences four seasons viz., the winter (starting from late November and continuing up to March), the Pre-Monsoon (April to beginning of May), South-West Monsoon (May to September) and Post Monsoon (October to beginning of November). The temperature in the region varies generally from a maximum of 25°C to 35°C in summer to a minimum of 1 ° to 10°C in winter. Further, monthly mean minimum and maximum temperatures recorded at Pasighat stations reported by IMD based on data for 35 years (1957-1992) have been furnished in **Table-2.1** and depicted in **Figure-2.1.**

Table-2.1: Maximum and Minimum Temperature received at IMD station, Pasighat

Month	Maximum Temperature (°C)	Minimum Temperature (°C)
May	29.3	21.2
Jun	30.7	23.2
July	30.4	23.5
Aug	31.5	23.8
Sep	30.5	23.0
Oct	29.4	20.6
Nov	27.2	16.6
Dec	24.1	13.3
Jan	22.8	12.3
Feb	23.0	13.9
Mar	26.0	16.7
Apr	27.8	18.9

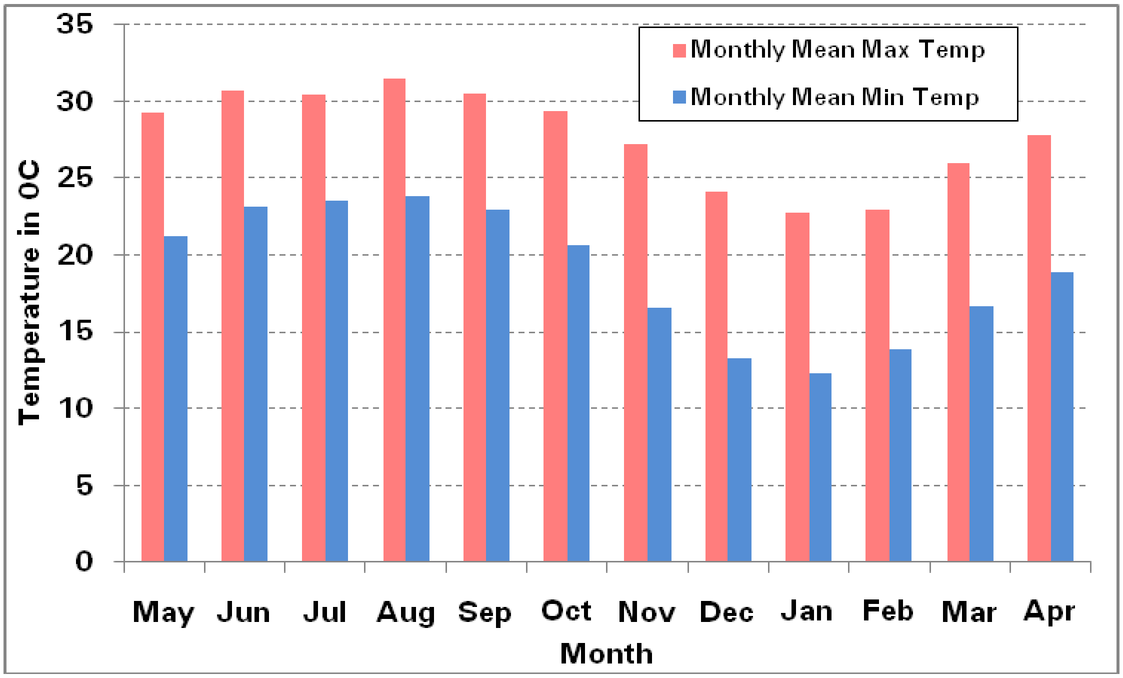


Figure-2.1: Monthly Mean Maximum & Minimum Temperatures at Pasighat

2.3 GEOLOGY

The region in and around Arunachal Pradesh exhibits tectonically distinct geological domains. In this region, two young belts E - W Eastern Himalayas and N - S Indo - Mayanmar mobile belts exist, which meet almost at right angles to each other. The distinctive techno - geological region of Arunachal Pradesh has been divided into four physiographic segments, with major tectonic features lineaments separating each segment as listed below:

- Eastern Himalayan Mobile Belt
- Mishmi Block
- Indo-Myanmar (Burmese) Mobile Belt
- Brahmputra Plain

Eastern Himalayan Mobile Belt

This belt rises abruptly from the Brahmaputra plain and merges with Tibetan plateau in the north. This belt covers about 350 km of Eastern part of Himalayas, known as the Arunachal Himalayas and extends from Eastern Nepal in the west to the West Siang district of Arunachal Pradesh in the east terminating against N - W trending para-metamorphites and diorite - granodiorite complex of Mishmi block of Lohit district of Arunachal Pradesh. The eastern mobile belt embodies a succession of northerly dipping thrust sheets covering almost the whole of Arunachal Pradesh. Deep erosion along these thrust contact brings about the four well known E - W trending physiographic units of the eastern Himalayas namely Sub - Himalayas, Lesser

Himalayas, Higher Himalayas and Tethyan belt or Tibetan Himalayas. North of it lies zone of Indus - Tsangpo suture.

Mishmi Block

The Mishmi block lies adjacent to the Naga - Patkai ranges of Arkan - Youma mountains to the south along another tectonic plate - the Mishmi thrust. The Himalayas at the eastern end gets terminated along the Tidding suture and meets another chain of mountains - the Mishmi hills, which are the part of Mishmi block mobile belt. These mountain ranges, trending NW - SE are said to be a continuation of the hill ranges of northern Mayanmar (Burma), but are also considered to be in continuation of the Laddakh ranges lying to the north of Indus - Tsangpo suture. These are made up of diorite - granodiorite complex with a frontal belt of high grade schists and migmatites, and inner belt of low grade schist with crystalline limestone and serpentinite lenses. The important tectonic activities in this block are Mishmi thrust, Tidding Suture, Lohit thrust and Pochu fault.

Indo - Mayanmar (Burmese Belt) Mobile Belt

The Patkoi - Naga - Manipur - Chil Hills - Arkan Yoma region forms a westerly convex arcuate belt in the eastern part of the Arunachal Pradesh, which is an eastern portion of the Indo - Mayanmar (Burmese) mobile belt and is made up of Paleogene - Neogene sediments.

Brahmaputra Plains

This is an ENE - WSW trending relatively narrow valley bounded by two young mountain belts to the north and south east, Mishmi block to the north east and Meghalaya plateau to the south. The valley is filled by thick alluvium with a few inselbergs of basement rocks from Tezpur west wards. Almost flat lying tertiary shelf sediments overlie the basement whose thickness increases from south to north towards Himalayas.

2.4 SEISMICITY AND TECTONICS

Planar structures developed in the area are schistosity (foliation), joints, shears and thrusts. Out of these, foliation/bedding is the only primary structure and rest are secondary. Bedding is well developed in the limestone and quartzite of Tidding group of rocks. The general trend of this bedding is NW - SE with dip towards NE. Joints are well developed in the limestone at Tidding and along Lohit and Tidding rivers. Three sets of joints were observed, which trend in NW, NE and NS with moderate to steep dips. The rocks of Tidding group and Lohit group are highly sheared and fractured at a number of places.

The major thrusts that are present in the area are Tidding suture and Lohit. The general trend of the thrusts is NW - SE, which becomes almost N - S in the southern part. The area falls under seismic zone–V as per Seismic Zoning Map of the country given in IS 1983 (part I): 2002. The seismic zoning map is enclosed as Figure-2.2. The important structural elements of the area are Lohit thrust, Tidding suture with dismembered ultra - mafic suite which mark the boundary between low grade sediments of Himalayan orogenic belt and moderately reworked metasedimentary belt and Mishmi thrust. These thrust systems trend NW - SE in contrast to NE - SE trend of Naga fold thrust belt. The historical record of important earthquake events in this region are during 1897 (Ms = 8.7) and 1950 (Mb =8.0, Ms = 8.6).

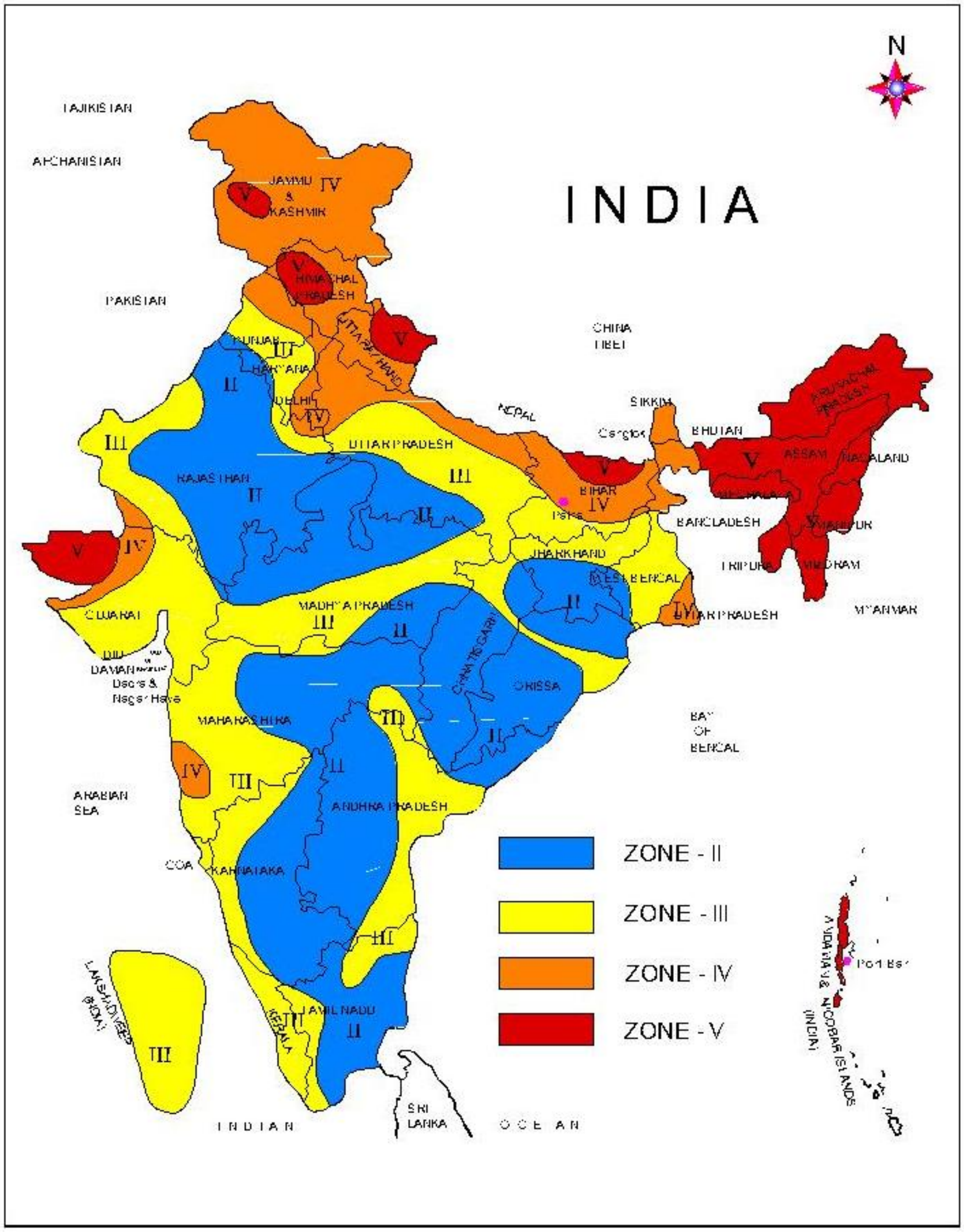


Figure-2.2: Seismic zoning map of India

2.5 PHYSIOGRAPHY

The physiography extent of the basin area ranges from less than 300 m to almost 7000 m. An area of about 4400 sq. km. lies above an elevation of 4500 m (permanent snow line) and accounts for nearly 22% of the total basin area.

2.6 DRAINAGE NETWORK OF RIVER LOHIT

The drainage network in the Lohit basin is complex being controlled by the structural features. Dendritic and rectangular drainage patterns are conspicuous. There are many rapids in the course of Lohit river. The tributaries of Lohit river and their catchment characteristics are given in Table-2.2. The drainage map of the study area is given in Figure-2.3.

Table-2.2: Drainage network of Lohit River in Indian Territory and the physiography of their catchment

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Di Chu	**Kibitoo**	Left bank	-	Upstream of Kibitoo	Upper part of its catchment is covered with grass lands, snowfields and wastelands. Pine forest is in the middle reaches
Tho Chu		Right Bank	-	Kibitoo	It is a small stream. Upper part of its catchment is covered with dense pine forest. Arable lands are on the lower part.
Dunai River		Right Bank	-	Downstream of Kibitoo	This is a small stream the upper par of the catchment is covered with dense pine forest and arable lands are on the lower part.
Meshai River		Left Bank	-	Near Musai	It drains the slopes near Musai. Snowfields and grasslands are in the upper reaches, dense pine forest in the middle reaches and arable lands in the lower reaches.
Karo Ti		Right Bank	-	Downstream of Kibitoo	Originates from lakes. Upper catchment has grasslands and snowfields. Dense pine forests in the middle reaches and arable lands in the lower reaches.

Tributary	**Circle**	**Right Bank/ Left Bank**	**Streams joining the tributary**	**Confluences with Lohit near**	**Catchment Characteristics**
Set Ti	**Walong**	Left Bank	Ir Ti, Yirchik Ti	Dong in the upstream of Walong	It drains the slopes near Dong. Grass lands have wide coverage. Dense forests are on the left bank. Some lands have been subjected to shifting cultivation in the middle part. Arable lands are in lower reaches.
Tamun Ti		Left Bank	-	Tinal in the upstream of Walong	It drains the slopes around Tinal. Originates from snowfields and lakes. Grasslands and thick pine vegetation cover most part of its catchment. Arable lands are on the lower reaches.
Dan Ti		Left Bank	-	downstream Walong	It originates from lakes and snowfields and drains the slopes upstream of Setati camp. Middle and most part of upper catchment is covered with dense forest. Chunks of lands with shifting cultivation in the lower reaches.
Yabak Ti or Yerbi Ti		Right Bank	-	downstream Walong near Bish point L. camp	It originates from snowfields. Grass lands and dense forests are in the middle reaches. In the lower reaches, some lands are under shifting cultivation and others are arable.
Shet Ti		Right Bank	-	Near Setati camp	It drains the slope around Setul. It originates from a lake and passes through a18 m fall. Grasslands are present in the upper catchment and dense mixed forest in the lower and middle reaches.

Tributary	**Circle**	**Right Bank/ Left Bank**	**Streams joining the tributary**	**Confluences with Lohit near**	**Catchment Characteristics**
Sal Ti		Right Bank	-	Near Selti	It is a small stream with headwater regions in the snowfields. The middle reaches are covered with dense mixed vegetation. Shifting cultivation and arable lands are in the lower part.
Klang Ti		Right Bank	-	downstream of Sarti L. Camp	It is a small stream which mostly flows through dense mixed forest.
Chik Ti		Left Bank	-	upstream of Yashong L. Camp	It is a small stream. Its upper catchment is covered with dense mixed forest. Lands with shifting cultivation are in the lower part.
Kamun Ti		Left Bank	-	Near Khampti Pani	Upper part of the catchment is covered with snowfields and waste lands. Dense mixed jungle mainly of pine occurs in middle part and arable lands in the lower part.
Kram Nala		Right Bank	-	Near Krill	Upper part of the catchment is snow covered. Its catchment has dense mixed jungle in the middle part and arable lands in the lower part. There is a 10 m high waterfall in its course.
Chiral Nala	**Hawaii**	Right Bank	-	Near Machong	It is a small stream. The upper catchment is covered with dense mixed forest. Arable lands are in the lower part.
Ghalum or Kulung River		Left Bank	Pungla Ti, Thacechi Ti, Hau Ti, Samblam Ti, Rati River, Kunglung Ti/Nom Ti (Top Ti and Galong Ti), Cha Ti	Hawaii Block	It originates from dense forest and drains the slopes around Matkrong, Hunung and Bhaw. Most part of its catchment is under shifting cultivation. Arable lands are present in the lower reaches.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
See Ti		Left Bank	-	Near Kheyong	It is a small stream. Most part of its catchment is covered with thick vegetation.
La Ti		Left Bank	Dothi Nala, Chenu Nala, Klathi Nala, Tawa Nala, Krang Nala, Lap Ti, Kaithang Ti	upstream Hawaii, near Mla	It originates from snow covered land and flows through dense cane and bamboo forest region and grass lands. Drains the slope around Krosam, Halaikrong, Lapkrong, Kamlat, Nukung, Kunung. In the lower reaches there are patches under shifting cultivation and at the bottom level there are some arable lands.
Samdi Ti		Left Bank	-	Near Chunyu	It is a springfed stream which drains the slopes around Walla, Kamdi and Chegung. Its catchment is covered with dense vegetation.
Wal Nadi		Left Bank	-	Near Perho	It is a springfed stream which drains the slopes around Longling, Marbo and Perho. Its catchment is covered with dense vegetation in the upper part. In the middle and lower reaches shifting cultivation is in practice.
Chowa Ti		Right Bank	-	Near Kalai	It is a springfed stream which drains the slopes of Chowagong, Kritong, Tamblu and Kalai. Shifting cultivation is in practice in its middle and lower reaches.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
Hali R./ Gudun Nala		Right Bank	Kawai Nala, Hali Nala, Sirun Nala. The tributaries of Hali namely Lan Nala, Lang Nala and Gudin Nala are in Manchal circle	Downstream of Lautul	It drains the slopes of Yealiang, Thalla, Tapang and Lautul, There are thick forest and grass lands in the upper catchment. Some of the slopes are subjected to shifting cultivation. There are arable lands in the lower reaches. It confluences with Lohit river at 713 m.
Shangti River	**Manchal**	Left Bank	-	Near Chambab	It is a springfed stream which drains the slopes around Sungung, Loliang, Chamukh, Kanji and Chambab. Dense forest is present in the upper part of its catchment and arable lands are in the lower reaches.
Towang River		Left Bank	Tuiyul Nala	Near Hutong	It is a springfed stream which drains the slopes around Khamblighat, Kherewe, Phanglonglat. Thick pine forest is present in its upper catchment. In the lower reaches arable lands area present along either side of the stream.
Halong Ti		Right Bank	-	Near Changrelang	It is a small springfed stream. Dense forest is present in its upper catchment. The lower catchment near the confluence has arable lands.
Gabgonia nala		Left Bank	-	Near Manchal	It is a small springfed stream which drains the slopes around Gnnog and Manchal. Its upper catchment is covered with dense vegetation. There are extensive arable lands in the lower reaches near its confluence with the Lohit.

Tributary	**Circle**	**Right Bank/ Left Bank**	**Streams joining the tributary**	**Confluences with Lohit near**	**Catchment Characteristics**
Hangam nala		Left Bank	-	Near Kombing	It is a springfed stream which drains the slopes around Ikalang, Kumbing and Gathong. Dense vegetation cover is present in Its upper catchment and arable lands are in the lower reaches.
Ul Nala		Right Bank	Halong Nala, Vaj Nala	Near Plutung	It is a springfed stream which drains the slopes around Long jam, Eliang, Ghowaliang, Pirah, and Plongnung. Its upper catchment is covered with dense mixed forest. In the middle reaches at 1512 m there are clusters of arable lands and settlements. Arable lands are also present in the lower reaches and alongside the Haling Nala.
Tawig Nala		Left Bank	Hotang Nala	Near Kholiang	It is a springfed stream which drains the slopes of Chutong, Kanthuliang, Gong, Qunboo, Khapma, Zong, Chiliang, Krosam, Kundong, Ratong, Chikulang and Kombo. There area arable lands and settlements in the lower reaches.
Dau River	**Goiliang**	Right Bank	Thusbi R.,Changai Nala, Tastor Tasi Nala, Aniyoi Nala, Biringko K, Beri R. (Jang Nala), and Lang N.	Upstream of Hayuliang	It is a springfed and lakefed stream which drains the slopes around Bringkong, Nilang, Room, Challang, Goiliang, Brailiang, Kaniliang, and Goiliang. The lower and middle parts of its catchment have arable lands and settlements where shifting cultivation is in practice.
Dalai River	**Changlangam**	Right Bank	Kalang River, Kazi Miyu, Kayom N.,	Downstream of Hayuliang	It is a snowfed and lakefed stream which drains the slopes around Chaglagam and in lower elevational

Tributary	**Circle**	**Right Bank/ Left Bank**	**Streams joining the tributary**	**Confluences with Lohit near**	**Catchment Characteristics**
			Tamlon River, Kajap river, Katsa R., Duren River, Kuran Machi, Hara Machi, Doring R., Hamang R.		regions like Tablaiko, Chipura, Tegamna, Chaipuliang, Doringko, and Hamangko. Most part of its catchment in the middle and lower reaches is covered with arable lands and settlements. Shifting cultivation is in practice in this stretch.
Nangdh Nala	**Hayuliang**	Left Bank	-	Near Kongra	It is a springfed stream which drains the slopes around Milling. Dense vegetation is present in most part of its catchment.
Din Pong Nala		Right Bank	Am Nala	Near Ampani Camp	It is a springfed stream which drains the slopes around Matiliang, Hoiliang, Chunga and Tafraliang. Most part of its catchment is covered with dense vegetation.
Am Nala		Right bank	Haningklay Nala, Shiv Nala, and Grey Nala, Chikung Nala, and Taku Nala, Dinpong Nala and Cheru Nala	Near Koupe	It is a springfed stream. This valley is spread between 3824 m to 495 m. Most part of its catchment is covered with dense mixed jungle. It confluences with Lohit river near Roupe.
Tallua Nala		Right Bank	-	Near Chirang	It is a small stream which flows from 3558 m and confluences at 490 m. Most part of its headwater region is barren rocky land. Below 1000 m there are numerous small old landslide scars along its tributary streams. It drains the slopes around Chirang. Lower part of its catchment is covered with fairly dense mixed jungle.

Tributary	**Circle**	**Right Bank/ Left Bank**	**Streams joining the tributary**	**Confluences with Lohit near**	**Catchment Characteristics**
Mahui Nala		Left Bank	-	Near Mahikong	It is a small springfed stream which drains the slopes around Huiliang, Chingraliang and Mahikong. Most part of its catchment is covered with dense mixed jungle. It confluences with Lohit river at 480 m.
Mam Nala		Right Bank	-	Near Chillang	It is a small springfed stream. In its headwater region the right bank slopes are barren while the left bank slopes are covered with dense mixed jungle.
Dura nala		Left Bank	-	Near Sapalding	It is a small springfed stream which confluences with Lohit at 470 m near Sapaliong.
Paya Nala		Right Bank	-	Near Tayabjal	It originates on the southeastern slopes of 3220 peak. It drains the slopes around Sagurnla and Takallang and confluences with Lohit river on its right bank at 450 m. There are old landslide scars in the upper reaches of Paya Nala.
Taka Nala		Right Bank	-	Near Paya	It is a small tributary stream. Its catchment is covered with dense mixed jungle.
Mazang Pani		Left Bank	-	Near Namalong	It flows westward from 2901 m peak and confluences with Lohit at 420 m. Most part of its catchment is covered with dense mixed forest. On the southern slope of Lamatong village there are a number of landslide scar. Landslide scars are also on the right bank of one of the tributary streams of Mazang pani.

Tributary	**Circle**	**Right Bank/ Left Bank**	**Streams joining the tributary**	**Confluences with Lohit near**	**Catchment Characteristics**
Tidding River		Right Bank	Ito Nala, Gome Nala, Chakring River, Wa Nadi; Tributaries in Tezu circle are Tinning R., Omane R.	Near Tidding	It is a large tributary stream of Lohit which has its headwater region in moraine fields in Tibet. Its upper catchment is thickly vegetated. Its lower catchment has settlements and arable lands at many places. Shifting cultivation is in practice in this stretch.
Lang River	**Wakro**	Left Bank	Tamblung	Near Lakao	It is a springfed stream which drains the slopes of Kamlang wildlife sanctuary and slopes near Lakao. It drains the dense mixed sal and bamboo forest and grass lands.
Tacha Pani		Left Bank	-	downstream of Dumla	It is a small springfed stream which flows through dense mixed jungle on the northern slope of Shamphu Mamphun ridge. It confluences with Lohit river at 316 m.
Kamlang River		Left Bank	Lai Nala, Krasam	Near Nagar-II, downstream of Wakro	It is a springfed stream which drains the slopes of Kamlang wildlife sanctuary around Kalai, Cherang, Towam, Towan, Kamja, Mining Nagar, Kamlang Nagar, and Wakro.
Digaru River	**Tezu C.D. Block**	Right Bank	Reena River, Tebang River	Near Alubari, downstream of Danglat	It is a springfed streams which drains the slopes around Lohitpur, Tafra Gam, Lolliang and Danglat.
Hazo River		Right Bank	Balljan River	downstream of Sunpura	It is a springfed stream which drains the slopes around Sunpura. Its upper catchment has thick mixed jungle of bamboo.
Tengapani River	**Chowkham**	Left Bank	Champani Nala, Tamba Nala, Ligaun H ka, Mathang H ka, Kalpet	downstream of Chowkham	It is a springfed stream which drains the slopes around Namliang, Guna Nagar-II, and Chawkham. Its upper catchment is covered with dense vegetation.

Tributary	Circle	Right Bank/ Left Bank	Streams joining the tributary	Confluences with Lohit near	Catchment Characteristics
			H Ka, Lunga H ka, Namkahi Nala		
Nao Dihing River	**Namsai**	Left bank	Sanglai H ka, Jamga H ka, Dirak Nala	downstream of Mengkenmiri	It is a springfed stream which drains the slopes around Piyong, Mahadevpur, Kaupata and Lekang. Most part of its upper catchment has thick forest.

Source: CEIA Report, Demwe Lower Hydroelectric Project

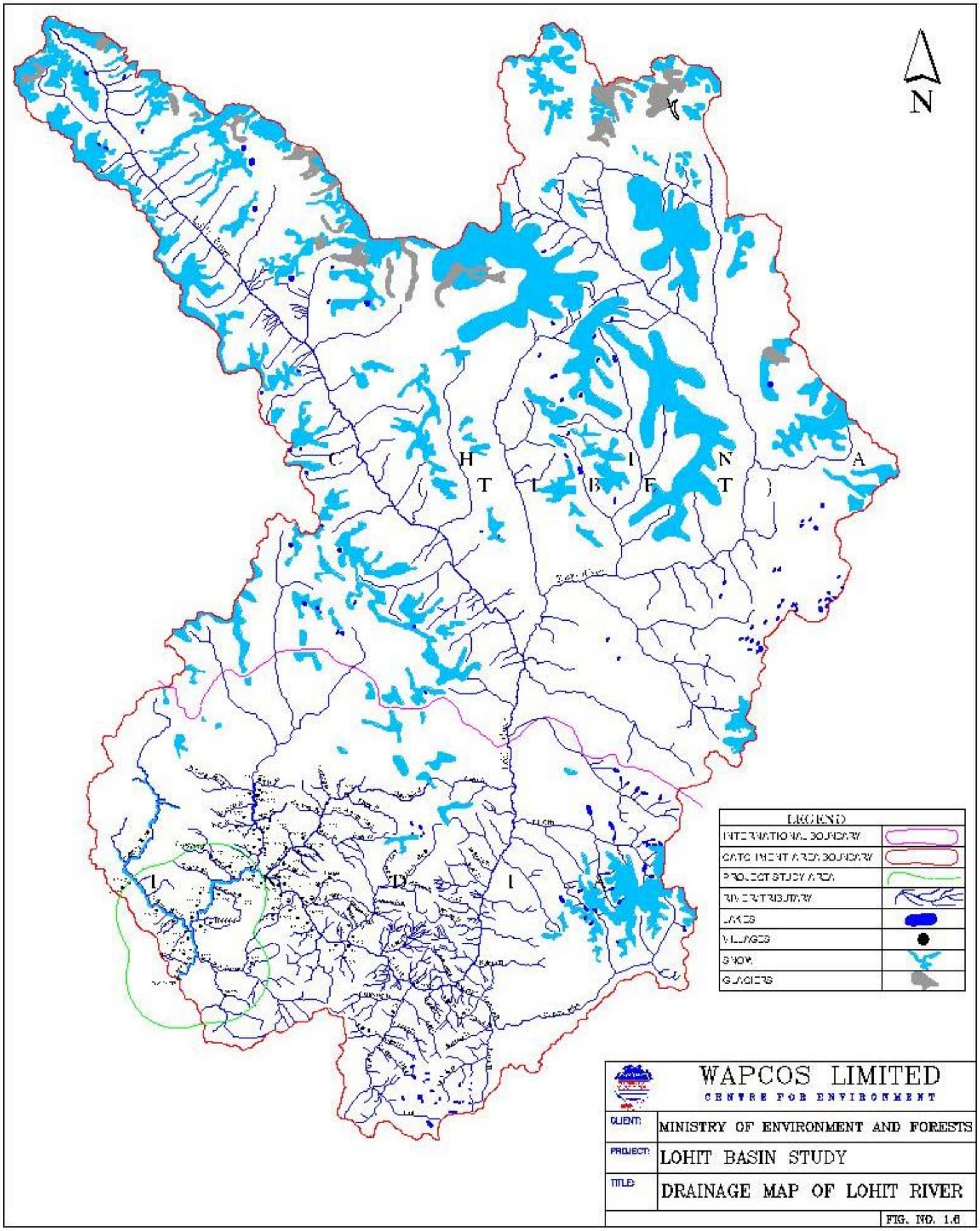


Figure-2.3: Drainage map of the study area

2.7 FOREST TYPES IN LOHIT BASIN

Lohit basin is rich in plant diversity. The major forest types surveyed in the Lohit river basin including the Upstream area are:

- Tropical semi-evergreen forest
- Tropical secondary forest
- Plantation forests
- Montane sub-tropical wet hill forest
- East Himalayan sub-tropical pine forest
- East Himalayan wet lower temperate forest
- East Himalayan wet temperate forest
- East Himalayan coniferous forest.

2.7.1 Tropical semi-evergreen forests

The vertical stratification in these types of forests is clearly distinguishable into emergent, canopy and sub-canopy tree layers, shrub layer and ground flora. The tropical climatic conditions have favored growth of a multitude of plants making these forests resource rich. Patches of primary undisturbed evergreen forests, especially on the left bank of Lohit river are seen, which are dominated by tree species such as *Altingia excelsa, Canarium strictum, Duabanga grandiflora*, *Ficus* spp*.,Terminalia myriocarpa*, *Pterospermum acerifolium, Meliosma simplicifolia,* etc. The shrub layer is rich and includes species like *Acacia pennata, Acacia pruinescen, Boehmeria longifolia, Boehmeria macrophylla, Calamas erectus, Calamus leptospadix, Clerodendron coolebrokianum, Debregessia longifolia* and *Desmodium laxiflorum.* The herbaceous layer consists of *Begonia* sp., *Cyanotis vaga*, *Lygodium flexuosum*, *Ophiopogon intermedius*, *Pilea* sp., *Symethea ciliata* etc. Some species found in the study area are important from conservation point of view such as *Lagerstroemia muniticarpa* which is globally an endangered category of species. Plants of economic importance such as timber, medicinal, edible fruits were common e.g., *Canarium strictum* is a very good incense yielding tree and *Pandanus* species is a fiber yielding tree species.

Such forests are seen all along the river valley and are found in the areas of Kalai stage-1, Kalai stage-2, Hutong stage-1, Hutong stage-2, Upper Demwe, Lower Demwe hydroelectric projects. These forests belong to the following categories of Champion and Seth classification (1968):

2B/C1a Assam alluvial Plains semi-evergreen forests

This is a closed high forest community with varying proportions of evergreen and deciduous trees in the top storey. The important species include *Terminalia myriocarpa,Ailanthus integrifolia, Canarium strictum, Castanopsis indica, Dillenia indica, Dysoxylum procerum, Garuga gamblei, Michelia champaca, Phoebe cooperiana, Pterospermum acerifolium* and

Syzygium cumini. Second storey is represented by trees like *Albizia lucida, Cinnamomum pauciflorum, Dalbergia sissoo, Gynocardia odorata, Magnolia hodgsonii,Meliosma simplicifolia* etc. Understorey is represented by bamboos, canes, and many woody shrubs and climbers. Epiphytes are represented by a few ferns, orchids and lianas that grow on the large tree trunks. Shrubs in these forests are represented by *Boehmeria macrophylla, Calamus leptospadix, Dracaena angustifolia, Oxyspora paniculata, Maotia puya,Phlogacanthus thrysiflorus, Micromelum integerimum, Difflugossa colorata.* The forest floor, wherever disturbed, is covered with herbs and tall grasses like *Ageratum conyzoides, Bidens bipinnata, Eriophorum comosum, Commelina benghalensis, Imperata cylindrica, Pogonatherum paniceum, Saccharum longisetosus* and *S. spontaneum.*

2B/1S1 Sub-Himalayan light alluvial semi-evergreen forest

This is a mixed high forest community which occurs in lower elevation of Lohit basin, particularly along the river banks. The top canopy in these forests consists of many deciduous trees, while the second storey is dense mixed and consists of both evergreen and deciduous tree species. The top canopy comprises *Duabanga grandiflora, Garuga gamblei, Phoebe hainesiana, Artocarpus lokoocha, Spondias pinnata* and *Terminalia myriocarpa.* The second storey is represented by *Callicarpa arborea, Glochidion lanceolarium, Gynocardia odorata, Macaranga denticualata Mallotus roxburghii, Ficus elmerii, Endospermum chinensis,* etc. This type of forest is found in the submergence area of Demwe Lower hydroelectric project. The understorey of these forests is represented by bamboos, canes, palms and shrubs. Shrubby species include *Bambusa pallida, Boehmeria macrophylla, Calamus floribundus, Clerodendrum bracteatum, Costus speciosus, Boehmeria hamiltonii, Micromelumintegerrimum, Oxyspora paniculata* and *Pinanga gracilis.Caryota urens,* a tall palm, makes a noticeable presence in this forest. Climbers are represented by species of *Pegia nitida, Cayratia pedata, Dioscorea pentaphylla, Entada purseatha, Pothosscandens, Raphidophora lancifolia, Stephania hernandifolia, Thunbergia grandiflora,* etc. Some common epiphytes present here are species of *Dendrobium, Pholidota, Eria, Asplenium,Hoya, Lepisorus* and *Microsorium.* The forest floors which are disturbed at many places show gaps and are covered with herbs and grasses like *Polygonum chinensis, Ageratum conyzoides, Alpinia alughas, Bidens bipinnata, Commelina benghalensis, Cyrtococcum accrescens, Digitaria ciliaris, Oplismenus compositus, Saccharum longisetosus, S. spontaneum* and *Thysanolaena maxima.*

2.7.2 Tropical secondary forests

These forests have lesser species diversity and are formed of secondary successional species. The density of plants is low and structure is less complex. The secondary forests have grown along the West bank of the river where primary forests have been cleared in the past for timber or shifting cultivation. The secondary forests are dominated by trees belonging to species *Macaranga denticulate* and *Callicarpa arborea.* The old grown secondary forest, particularly in certain patches along Lohit River gives the impression of an undisturbed primary forest. The herbaceous flora of these forests is mostly of weedy nature. These types of forests are seen along the West bank of the river in all the project sites.

According to Champion and Seth (1968) classification, the following forest type is also found under the secondary forest category.

2SI Secondary moist bamboo brakes

These scattered bamboo brakes occur in areas which are abandoned and cleared for agriculture. *Bambusa pallida, Dendrocalamus Hamiltoni* are the important species under this forest category.

2.7.3 Plantation forests

The plantations have been raised along the left bank of the Lohit river in Lower Demwe where primary forests have been cleared in the past for timber. The plantation is dominated by trees belonging to species *Bombax cieba*, *Emblica officinalis*, *Albiziachinensis* and *Kydia calycina*. Some tree species that grow here are *Bombax ceiba, Macaranga denticulata, Sterculia villosa, stereospermum colais, Spondias pinnata*, etc. and are found growing along the edges of degraded bamboo forests.

2.7.4 Montane Subtropical wet hill forests

This forest type occurs in Lohit basin around upper reaches of Demwe and Zero point. These forests generally occur on hilly terrain between 900-1200 m elevations and are dominated by evergreen species. These forests are undisturbed on the left bank of the river Lohit (opposite bank of the road). One can approach these forests after crossing the hanging bridges across the river. *Alnus nepalensis, Prunus cerasoides, Quercuslamellosa* and *Engelhardtia spicata* are dominant species in this forest.

According to Champion and Seth (1968) classification, the forest falls under 8B/ C I East Himalayan sub-tropical wet hill forests category. A number of deciduous trees also occur in the canopy. The top canopy is comprised of *Alnus nepalensis, Castanopsis hystrix, Cinnamomum glaucesens, Engelhardtia spicata, Phoebe attenuata, Prunus cersoides, Quercuslamellosa, Magnolia campbellil,* etc. The second storey is represented by some medium sized evergreen tree species such as *Brassaiopsis speciosa, Macropanax undulatus, Rhus chinensis, Saurauia roxburghii, Persea gambelii, Symplocos glomerata,* etc. The understorey consists of a number of shrubs and climbers and among shrubs found in these forests are *Boehmeria macrophylla, Chasalia curviflora, Debregeasia longifolia, Eurya acuminata, Medinilla erythrophylla, Oxyspora paniculata,* etc. There are numerous climbers and epiphytes and the species of *Mastersia, Cissus, Pegia, Bauhinia, Clematis, Dioscorea, Smilax, Entada,* etc. constitute important climbers and lianas. The ground flora at many places is disturbed and the canopy shows gaps. These gaps are represented by herbs and grasses viz., *Ageratum conyzoides, Aster mollisculus, Anaphalis busua, Bidens bipinnata, Cardamine hirsuta, Crassocephalum crepidioides, Impatiens* sp*., Persicaria capitata, P. barabata, Setaria glauca, Themeda arundinacea, Thysanolaena maxima, Viola pilosa,* etc.

2.7.5 East Himalayan sub-tropical pine forest

This forest type is not found in Champion and Seth (1968) classification. This forest is dominated by *Pinus merkusii* occurring at an elevational range of 1200 – 1400 m in Chigwinti Walong – Kaho area and before reaching Walong. Although not described by Champion and Seth (1968), it can be categorized as Sub-tropical pine forests.

2.7.6 East Himalayan wet lower temperate forest

This forest type is in continuity with montane subtropical wet hill forest occurring in the elevation range of 1200 -2500 m elevation. The dominant tree species in this forest are *Acer campbellii, Alnus nepalensis, Castanopsis tribuloides, Engelhardtia spicata* and *Quercus lamellose.* According to Champion and Seth (1968) classification, following forest type falls under this category.

11b/C1 East Himalayan Wet temperate forests

These forests are closed evergreen forests of trees of medium height and occur between 1700-2700m in the higher hills. The important trees of the canopy include *Acer campbellii, Alnus nepalensis, Betula alnoides, Exbucklandia populnea, Castanopsistribuloides, Engelhardtia spicata* and *Quercus lamellosa.* The middle storey is represented by some moderate sized tree species such as *Eurya acuminata, Ilexdipyrena, Litsea* sp*., Lyonia ovalifolia, Prunus cerasoides* and *Mahonia pycnophylla*. These forests are found in upper reaches of Khairang and Chigunti areas. Shrubs are represented by the species of *Berberis, Mahonia, Rubus, Sinarundinaria falcata, Viburnume rubescens,* etc. There are only a few climbers, while epiphytes are represented by ferns and orchids. The ground flora is represented by species of *Anaphalis, Cardamine, Campanula, Circium, Fragaria, Plantago, Persicaria, Stellaria* and *Viola.*

2.7.7 East Himalayan coniferous forest

This forest is found on the drier ridges between 2500 m and 2700m elevations. Beyond Kibito, this forest type is encountered. They form the Upstream area of the basin. According to Champion and Seth (1968), this forest belongs to 12/C3 East Himalayan mixed coniferous forests category.

The forests of this zone are dense evergreen, with predominating Hemlocks and firs. Hemlock *(Tsuga dumosa*) makes appearance in the upper reaches as a dominant tree species, At the higher elevations Hemlock gives way to Silver fir (*Abies densa*). Apart from the conifers, some oak mixed deciduous broad-leaved species such as *Acer, Betula, Magnolia* and *Rhododendron* are also found in the forests. The undergrowth is represented by a number of evergreen shrubs such as *Berberis, Cotoneaster, Rhododendron, Salix, Thamnocalamus and Viburnum.* Most of the shrubs are laden with many epiphytic mosses and lichens.

CHAPTER-3

DECRIPTION OF PROJECTS IN THE STUDY AREA

CHAPTER-3

DESCRIPTION OF PROJECTS IN THE STUDY AREA

3.1 GENERAL

A total of 6 projects are envisaged to be covered on main stream of river Lohit. The list of the projects is given as below:

- Kalai hydroelectric project stage-1
- Kalai hydroelectric project stage-2
- Hutong hydroelectric project stage-1
- Hutong hydroelectric project stage-2
- Anjaw hydroelectric project
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project

Hydroelectric projects to be covered as a part of the study on tributaries in Lohit river Basin in the Indian portion upto Parsuram Kund are:

- Gmliang HEP
- Raigam HEP
- Tidding-I HEP
- Tidding-II HEP
- Kamlang HEP

The location of various hydroelectric projects covered as a part of the study is given in Figure-1.1 enclosed in Chapter-1. A brief description of the above referred projects is given in the following sections.

3.2 KALAI HYDROELECTRIC PROJECT STAGE-1

The Kalai hydroelectric Project Stage-1 envisages creation of a storage reservoir on river Lohit, a left bank tributary of river Brahmaputra with a view to flows of river Lohit over large head available for hydro power generation. The coordinates of the dam site are 27° 54' 55" N and 96° 57' 30" E.

The gross and live storage of the Kalai Stage-1 reservoir are 429.31 Mm^3 and 336 Mm^3 respectively. The FRL and Lower Spillway crest level are envisaged as 1065.25 m and 989.25 m respectively. The dam on river Lohit shall be concrete dam with spillway and a separate diversion structure for diverting a regulated discharge of 1033.05 cumec through 4 nos. each 0.75 km long with 8.0 m dia. Head Race Tunnel to the 7.5 m dia vertical shafts bifurcating to 5.3 m dia leading to the turbine generating 1450 MW power (8 x 181.50 MW) in underground power stations located on the right bank of the Lohit river.

A brief description of project components is given in the following paragraphs.

DAM AND RIVER DIVERSION WORKS

The width of the valley at dam site varies from 137 m at the river bed to 379 m at EL 1070.25 m. The average bed level at dam site is EL+ 915.25 m. The FRL is proposed to be fixed at

EL 1065.25 m and MDDL at 1060.25 m keeping in view the inflow of water in Lohit during lean period. The top of the dam has been proposed at EL 1070.25 m and seat of the dam is proposed to be kept at EL 884.25 m after removal of approximately 30 m thick overburden.

The spillway for concrete gravity dam is proposed to be designed for a probable maximum flood (PMF) of 13526 cumecs. Keeping in view large quantum of silt being carried by river Lohit and high PMF, two level spillway are proposed. Five lower level orifice type spillways are proposed with crest at EL 989.25.0 m with an opening of size 7.0 x 11 m. Two upper level orifice type spillways are proposed with crest at 1048.25 m with an opening of size of 10.5 m x 17 m. The total length of the spillway structure is 132 m. Three concrete lined 10.0 m diameter D- shaped, 1200m long diversion tunnel has been proposed on each bank of the river to divert a flood of 3700 cumec of river Lohit.

POWER INTAKES

The power intake systems are proposed on both the banks of river Lohit and consist of 4 nos. power intakes each. The invert level of the intake structure has been kept at EL 1039.25 m taking into consideration the water seal requirement to prevent the vortex formation and air entertainment. The intake structure shall be provided with trash racks to prevent entry of trash in the water conductor system.

HEAD RACE TUNNEL

It is proposed to provide 4 nos. of 8.0 m diameter horse shoe shaped concrete lined tunnels of about 750 m length to pass the design discharge of 1033.05 cumec.

PRESSURE SHAFT

4 nos. of 7.5 m diameter steel lined, vertical, circular pressure shafts are proposed. The above shafts shall be divided into 8 nos. penstocks to feed water to 8 nos. Francis turbines of 181.25 MW each. A separate Valve House cavity of 15 m width and 20 m height shall be provided to accommodate the MIVs. The valve house shall be connected to machine hall cavern through access tunnel.

POWER HOUSE COMPLEX AND TAIL RACE TUNNEL

The underground power house is proposed to utilise the maximum head for generation of power. Based on the power potential studies, installed capacity of 1450 MW (8 nos. machine of 181.25 MW each) has been proposed. The size of the machine hall cavern is 205 m(L) X 22m(W) x 49.6 m(H).

4 nos. 8.0 diameter horse shoe shaped Tail Race Tunnel is proposed in the downstream of draft tube for outfalling the tailrace discharge in river Lohit. The length of tailrace tunnel is 750 m. The invert of the TRT shall be kept at 896.50 m.

The salient features of the Kalai hydroelectric project stage-1 are given in Table-3.1. The project layout map is enclosed as Figure-3.1.

Table-3.1: Salient features of Kalai hydroelectric project stage-1

River	
Name of River	Lohit
Catchment Area	16610 sq.km
Annual Average Inflow	967 cumecs
Reservoir	
Maximum Water Level (MWL)	1065.25 m
Full Reservoir Level (FRL)	1065.25 m
Minimum Drawdown Level	1061.35
Available Drawdown	5.0 m
Sedimentation Level (NZE at 70 yrs)	989.00 m
Gross Storage Capacity	429.31 MCM
Reservoir Area	7.45 sq.km
Dam	
Type	Concrete Gravity Dam
Elevation of Upper Spillway Crest	1048.25 m
Elevation of river bed	915.25 m
Height of Dam (from foundation)	186 m
Length at top of Dam	403 m
Spillway (Lower)	
Design Flood	13526 cumecs
Type	Sluice
Crest Elevation	989.25m
Width of Overflow Crest	56m
Energy Dissipator	Trajectory type
Type of Gate	Radial
Number of Gate	5
Size of Gate	7m (W) x 16m (H)
Intake	
Type	Inclined
Number	4
Elevation of Inlet Sill	1039.25 m
Type of Gate	Fixed Wheel
Number of Gate	4
Size of Gate	6.4m (W) x 7.0m (H)
Headrace Tunnel	
Type	Horse Shoe
Number	4
Max. Discharge	258.3 cumecs
Inner Diameter	8.0 m
Length	0.75 km
Pressure Shaft	
Type	Circular Steel Lined
Number	4
Inner Diameter	7.5 m
Total length	220 m
Powerhouse Cavern	
Type	Underground
Size	205 x 22 x 49.26 m
Transformer Cavern	
Type	Underground
Size	214.6 x 16 x 23.1 m

Development Plan	
Maximum Tail Water Level	904.8m
Gross Head	159.15m
Rated head	156.15m
Maximum Discharge	1033.05 cumec
Number of Unit	8
Installed Capacity	1450 MW (8 x 181.25)
Lean Period Avg. Power	370.57 MW
Turbine/Generator	
Type	Francis
Number	8
Speed	176.47 rpm
Frequency	50 Hz
Voltage	11 kv
Power Factor	0.9
Annual Energy Production	
Total Energy (GWh)	6863
Construction Period	7 years Main Project Components
Project Cost (Rs. in Crores)	
Excluding IDC	5525.28
IDC (Rs. Crores)	1210.41
Total Project Cost (Rs. Crores)	
Including IDC	6735.69

3.3 KALAI HYDROELECTRIC PROJECT STAGE-2

The Kalai-II HE Project envisages utilization of a gross head of about 125m for power generation with an installed capacity of 1200MW. The coordinates of Kalai-II HE Project are Latitude 27^{o} 54’ 20” N and Longitude 96^{o} 48’ 16” E. The catchment area up to the proposed dam site including Tibet region is estimated to be about 15,654 sq. km. The full reservoir level (FRL) is at EL 904.80m. The project involves construction of a concrete gravity dam, upstream & downstream coffer dam, diversion tunnel, intake tunnel, pressure Shafts, underground Powerhouse complex, surge chamber and Tail Race Tunnel etc. The total optimized land requirement for the project including underground structures is 1100 Ha.

A brief description of project components is given in the following paragraphs.

DAM AND RIVER DIVERSION WORKS

The project envisages construction of a 161 m high concrete dam across river Lohit considering 4 to 6 hours of peaking. The reservoir formed by construction of Dam has a gross storage pre-sedimentation capacity for about 315.94 Mcum and live storage capacity of about 108.52 Mcum.

The average bed level at dam site is EL 779.80 m. The top of the dam has been proposed at EL 909.80 m and seat of the dam is proposed to be kept at EL 748.80 m.

The spillway for concrete gravity dam is proposed to be designed for a probable maximum flood (PMF) of 14273 cumecs. Keeping in view large quantum of silt being carried by river

Lohit and high PMF, two level spillway are proposed. Six lower level orifice type spillways are proposed with crest at EL 818.80 m having spillway opening size of 7.0 x 11 m. Two upper level orifice type spillways are proposed with crest at 887.80 m with opening size of 10.5 m x 17 m. The total length of the spillway structure is 121.3 m.

Three concrete lined 10.0 m diameter D-shaped, 1200m long diversion tunnels are proposed on each bank of the river to divert a flood of 3700 cumecs.

POWER INTAKES

The power intake systems are proposed on both the bank of river Lohit and consist of 5 nos. power intakes each. The invert level of the intake structure has been kept at EL 878.80 m.

HEAD RACE TUNNEL

The proposed project envisages 4 nos. of 8.4 m diameter horse shoe shaped concrete lined tunnels of about 750 m length to pass the design discharge of 1158.61 cumecs.

SURGE SHAFT

The restricted orifice type surge tank shall be provided to reduce the height of surge shafts. The top of the surge shaft has been kept at 915 m, keeping adequate freeboard above the maximum upsurge level. The bottom of the surge shaft is 83 below the maximum down surge level.

PRESSURE SHAFT

4 nos. of 7.85 diameter steel lined, vertical, circular pressure shafts are proposed. The above shafts shall be divided into 8 nos. penstocks to feed water to 8 nos. Francis turbines of 150 MW each. A separate Valve House cavity 15 m wide and 20 m high can be created to accommodate the Main Inlet Valve (MIV). The valve house shall be connected to machine hall cavern through access tunnel.

POWER HOUSE COMPLEX AND TAIL RACE TUNNEL

The underground power house is proposed to the maximum head for generation of power. Based on the power potential studies the installed capacity of 1200 MW (8 nos. machine of 150 MW each) has been proposed.

4 nos. 8.4 diameter horse shoe shaped tail race tunnel is proposed downstream of draft tube for disposal of tailrace discharge into Lohit river. The length of tail race tunnel is about 750 m. The salient features of Kalai hydroelectric project stage-2 are given in Table-3.2. The project layout map is enclosed as Figure-3.2.

Table-3.2: Salient features of Kalai hydroelectric Project Stage-2

LOCATION	
State	Arunachal Pradesh
District/town	Anjaw/Hawai
River	Lohit
Location	Latitude: 27^{o} 54’ 20” N Longitude: 96^{o} 48’ 16”
Nearest Airport	Dibrugarh (Assam)

Nearest Rail head	Tinsukia (Assam)
HYDROLOGY	
Catchment area	15654 km^2
Design Flood	24268 m^3/sec
RESERVOIR	
Full Reservoir Level (FRL)	EL904.80 m
Gross Storage	318.88 Mm^3
Live Storage	29.76 Mm^3
DAM	
Type	Concrete Gravity
Top of Dam	EL 908.00 m
Dam Height above river bed level	128.20 m
River Bed Level	EL 779.80 m
DIVERSION **Upstream Cofferdam**	
Top of Coffer Dam	EL 812.2 m
Downstream Cofferdams	
Top of Coffer Dam (Stage I/ Stage II)	EL 797.0/796.0 m
Diversion Tunnel	
No. of tunnels	3 nos. (Left bank) and 2 nos. (Right bank)
Size	Finished Dia 14.4 m
Main Spillway – Sluice (8 Nos)	
Crest Elevation	EL 820.0 m
Auxiliary Spillway –Ogee (2 Nos)	
Crest Elevation	EL 894.80 m
Intake Structures	
Location	On Right abutment
Number of Intake Gates	6 Nos
Design Discharge	1128.06 m^3/sec
INTAKE TUNNEL	
No. of Tunnel	6
Shape	Circular
No. of tunnels, size	1 No. 8.5 m dia, 5 Nos. 7.5m dia
PRESSURE SHAFT	
Type	Underground
Number & Size	5 Nos. 6.5m dia, & 1 No. 7.5m dia
POWER HOUSE	
Structure	
Type	Underground
Size of power house (L x W x H)	250 m x 23.5 m x 54.1 m
Design Head	115.47 m
Installed Capacity	1200 MW incl. auxiliary units of (60+190)MW
Turbine	
Type	Vertical Francis
Number of Units, Capacity	(1x60MW + 6x190 MW) = 1200MW
SURGE CHAMBER	
Type	Underground – D/s Surge Chamber
TAIL RACE TUNNEL	
No. & Size	3 Nos. of 11.2 m dia & 1 No Aux. TRT of 9.5 m dia.

3.4 HUTONG HYDROELECTRIC PROJECT STAGE-1

The Hutong hydroelectric Project Stage-1 envisages creation of a storage reservoir on river Lohit, a left bank tributary of river Brahmaputra with a view to utilize flows of river Lohit over large head available for hydro power generation. The coordinates of the barrage site are 28° 57' 38" N and 96° 43' 40" E.

The gross and live storage of the Hutong hydroelectric project Stage-1 are 6.69 Mm^3 and 0.06 Mm^3, respectively. The FRL is envisaged at El 779.8 m. The reservoir area at FRL is 51 ha. The barrage on river Lohit shall, be of concrete with a separate diversion structure for diverting a regulated discharge of 1423.02 cumec through 3 nos. each 5.75 km long 10.9 m dia Head Race Tunnel to the 7.20 m dia vertical shaft leading to the turbine generating (6 units of 125 MW each) 750 MW in underground power house located on the right bank of river Lohit.

A brief description of project components is given in the following paragraphs.

DAM AND RIVER DIVERSION WORKS

A 124 m high barrage has been proposed as a part of the project across river Lohit considering 4 to 6 hours peaking. The reservoir formed by construction of dam shall have a gross storage pre-sedimentation capacity for about 6.69 Mm^3.

Average bed level at dam site is El $\pm$755.80 m. The FRL and MDDL are proposed at EL 779.80 m and El 777.80 m respectively. The top of the barrage has been proposed at EL 784.80 m.

POWER INTAKES

The power intake systems are proposed on both the banks of river Lohit and consist of 5 power intakes. The invert level of the intake structure has been kept at El 753.8 m. The intake structure shall be provided with trash racks to prevent the entry of trash in the water conductor system.

HEAD RACE TUNNEL

It is proposed to provide 3 nos. 10.9 m diameter horse shoe shaped concrete lined tunnels of approximate 5750 m length to convey the design discharge of 1423.02 cumec.

SURGE SHAFT

A restricted orifice type surge tank shall be provided to reduce the height of surge shafts. The top of the surge shaft has been kept at 860 m keeping adequate freeboard above the maximum upsurge level. The bottom of the surge shaft is 736.8 m below the maximum downsurge level. The proposed diameter of surge shaft and orifice is 26 m and 6 m respectively.

PRESSURE SHAFT

6 nos. of 7.2 diameter steel lined, vertical, circular pressure shafts are proposed. A separate

Valve House cavity 15 m wide and 20 m high shall be created to accommodate the Main Inlet Valves. The valve house shall be connected to machine hall cavern through access tunnel.

POWER HOUSE COMPLEX

The underground power house is proposed to utilize the maximum head for generation of power. Based on the power potential studies the installed capacity of 750 MW (6 nos. machine of 125 MW each) has been proposed. The size of the machine hall cavern is 165 m(L) X 22m(W) x 49.6 m(H).

TAIL RACE DISPOSAL

3 nos. 10.9 diameter horse shoe shaped tail race tunnel are proposed in the downstream of draft tube for conveying tail race discharge into river Lohit. The length of tailrace tunnel is 750 m. The tailrace channel shall be made at the end of the tunnel to check the erosion of the river bed. The invert of the TRT shall be kept at 706.05 m.

The salient features of the Hutong hydroelectric project stage-1 are given in Table-3.3. The project layout map is enclosed as Figure-3.3.

Table-3.3: Salient features of the Hutong Hydroelectric Project Stage-1

River	
Name of River	Lohit
Catchment Area	17968 sq.km
Annual Average Inflow	1046 cumecs
Reservoir	
Maximum Water Level (MWL)	779.8 m
Full Reservoir Level (FRL)	779.8 m
Minimum Drawdown Level	777.8 m
Available Drawdown	2.0 m
Sedimentation Level (NZE at 70 yrs)	
Gross Storage Capacity	6.69 MCM
Reservoir Area	0.51 sq.km
Dam	
Type	Barrage
Elevation of river bed	755.8 m
Height of Dam (from foundation)	24 m
Length at top of Dam	160 m
Spillway (Lower)	
Design Flood	11976 cumecs (SPF)
Type	Sluice
Crest Elevation	756.80 m
Width of Overflow Crest	56m
Energy Discipator	Stilling Basin
Type of Gate	Radial
Number of Gate	6
Size of Gate	15m (W) x 19m (H)

Intake	
Type	Inclined
Number	5
Elevation of Inlet Sill	753.8 m
Type of Gate	Fixed Wheel
Number of Gate	5
Size of Gate	6.4m (W) x 7.0m (H)
Headrace Tunnel	
Type	Horse Shoe
Number	3
Max. Discharge	474.34 cumecs
Inner Diameter	10.9 m
Length	5.75 km
Surge Shaft	
Type	Restricted orifice
Number	3
Size	26 m dia, 6.0 m orifice
Pressure Shaft	
Type	Circular Steel Lined
Number	6
Inner Diameter	7.2 m
Total length	80 m
Powerhouse Cavern	
Type	Underground
Size	165 x 22 x 49.26 m
Annual Energy Production	
Total Energy (GWh)	2977
Construction Period	7 years Main Project Components
Project Cost (Rs. in Crores)	
Excluding IDC	4191.83
IDC (Rs. in Crores)	918.30
Total Project Cost (Rs. in Crores)	
Including IDC	5110.13

3.5 HUTONG HYDROELECTRIC PROJECT STAGE-2

The Hutong hydroelectric Project Stage-2 envisages creation of a storage reservoir on river Lohit, a left bank tributary of Brahmaputra river with a view to utilise flows of Lohit river over large head available for hydro power generation. The coordinates of the dam site are 27° 54' 55" N and 96° 57' 30" E.

The Gross and Live Storage of the Kalai Stage-1 Storage reservoirs are 429.31 Mm^3 and 336 Mm^3 with FRL at El 1065.25 m and Lower Spillway Crest Level at El 989.25 m respectively. The dam on river Lohit shall be concrete dam with spillway and a separate diversion structure for diverting a regulated discharge of 1033.05 cumec through 4 nos. each

0.75 km long 8.4 m dia Head Race Tunnel to the 7.5 m dia vertical shafts bifurcating to 5.3 m dia leading to the turbine generating 1450 MW power (8 x 181.50 MW) in underground power stations located on the right bank of the Lohit river.

A brief description of project components is given in the following paragraphs.

DAM AND RIVER DIVERSION WORKS

The project envisages construction of a 161 m high concrete across river Lohit considering 4 to 6 hours peaking. The reservoir formed by construction of dam shall have a gross storage capacity of about 424.24 Mm^3 and live storage capacity of about 23.04 Mm^3.

The average bed level at dam site is EL$\pm$ 589.50 m. FRL is proposed to be fixed at EL 714.50 m and MDDL at EL 710.88 m keeping in view the inflow of water in Lohit during lean period. The top of the dam has been proposed at EL 719.50 m and seat of the dam is proposed to be kept at EL 558.50 m after removal of approximately 30 m thick overburden. The spillway for concrete gravity dam is proposed to be designed for a probable maximum flood (PMF) of 14635 cumecs.

Keeping in view large quantum of silt being carried by river Lohit and high PMF, two level spillway are proposed. Six lower level orifice type spillways are proposed with crest at EL 628.50 m having spillway opening size of 7.0 x 11 m. Two upper level orifice type spillways are proposed with crest at 697.50 m with opening size of 10.5 m x 17 m. The total length of the spillway structure is 121.3 m.

Three concrete lined 10.0 m diameter D- shaped, 1200m long diversion tunnel has been proposed on each bank of the river to divert a flood of approx 3700 cumecs of river Lohit.

POWER INTAKES

The power intake systems are proposed on both the bank of river Lohit and consist of 4 nos. power intakes each. The invert level of the intake structure has been kept at EL 643.50 m.

HEAD RACE TUNNEL

It is proposed to provide 4 nos of 8.4 m diameter horse shoe shaped concrete lined tunnels of approximate 750 m length to pass the design discharge of 1151.23 cumecs.

SURGE SHAFT

The top of the surge shaft has been kept at 725 m keeping adequate freeboard above the maximum upsurge level. The bottom of the surge shaft is 640 m below the maximum down surge level. The proposed diameter of surge shaft and orifice is 26 m and 6 m respectively.

PRESSURE SHAFT

4 nos. of 7.85 diameter steel lined, vertical, circular pressure shafts are proposed. The above shafts shall be divided into 8 nos. penstocks to feed water to 8 nos. Francis turbines of 156.25 MW. A separate Valve House cavity 15 m wide and 20 m high can be created to accommodate the Main Inlet Valves. The valve house shall be connected to machine hall

cavern through access tunnel.

POWER HOUSE COMPLEX AND TAIL RACE TUNNEL

Based on the power potential studies the installed capacity of 1250 MW (8 nos. machine of 156.25 MW each) has been proposed. 4 nos. 8.4 diameter horse shoe shaped tail race tunnel is proposed in the downstream of draft tube for discharge of tail race outfall in river Lohit. The length of tail race tunnel shall be about 750 m.

The salient features of Hutong hydroelectric project stage-2 are given in Table-3.4. The project layout map is enclosed as Figure-3.4.

Table-3.4: Salient features of Hutong Hydroelectric Project Stage-2

River	
Name of River	Lohit
Catchment Area	18450 sq.km
Annual Average Inflow	1071 cumecs
Reservoir	
Maximum Water Level (MWL)	714.5 m
Full Reservoir Level (FRL)	714.5 m
Minimum Drawdown Level	710.5
Available Drawdown	3.62 m
Sedimentation Level (NZE at 70 yrs)	629.5 m
Gross Storage Capacity	424.24 MCM
Reservoir Area	6.51 sq.km
Dam	
Type	Concrete Gravity Dam
Elevation of Upper Spillway Crest	697.5 m
Elevation of river bed	589.5 m
Height of Dam (from foundation)	161 m
Length at top of Dam	675 m
Spillway (Lower)	
Design Flood	14635 cumecs
Type	Sluice
Crest Elevation	638.50 m
Energy Dissipator	Trajectory type
Type of Gate	Radial
Number of Gate	5
Size of Gate	7m (W) x 16m (H)
Intake	
Type	Inclined
Number	4
Elevation of Inlet Sill	643.50 m
Type of Gate	Fixed Wheel
Number of Gate	4
Size of Gate	6.4m (W) x 7.0m (H)
Headrace Tunnel	
Type	Horse Shoe
Number	4
Max. Discharge	287.8 cumecs
Inner Diameter	8.4 m
Length	0.75 km
Surge Tank	

Type	Restricted Orifice
Number	4
Size	26 m dia, 6.0 m orifice
Pressure Shaft	
Type	Circular Steel Lined
Number	4
Inner Diameter	7.85 m
Total length	250 m
Powerhouse Cavern	
Type	Underground
Size	205 x 22 x 49.26 m
Annual Energy Production	
Total Energy (GWh)	5905
Construction Period	7 years Main Project Components
Project Cost (Rs.in Crores)	
Excluding IDC	6259.30
IDC (Rs. in Crores)	1371.21
Total Project Cost (Rs. in Crores)	
Including IDC	7630.51

3.6 ANJAW HYDRO ELECTRIC PROJECT

Anjaw HEP is proposed on Lohit River in the Anjaw District of Arunachal Pradesh at latitude 28^0 02' 31'' N and longitude 96^0 35' 04'' E. The river bed level at the Barrage site is about at EL 550.00 m and FRL is proposed at EL 580.00 m. The catchment area of Lohit River at the barrage site is 16430 sq km. The gross storage at FRL and live storage of the project reservoir will be 10 MCM and 1.17 MCM respectively. The FRL and MDDL are envisaged as 580 m and 578 m respectively. The diversion structure on Lohit River for Anjaw project shall be barrage with height of 26 m above the crest level. The surface power house is proposed on right bank of river with net design head of 27.04 m.

The Salient features based on DPR of Anjaw HEP are given in Table-3.5. The project layout is enclosed as Figure-3.5.

Table-3.5 Salient Features of the Anjaw Hydroelectric Project

Location	
State	Arunachal Pradesh
District	Anjaw
Village	Supliyang
Access	
Airport	Dibrugarh - around 335 km (Guwahati to Dibrugarh = 550 km)
Rail Head	Tinsukia - around 285 km
Road Head	Brahmakund - Hayuliang road – 0 km
Geographical co-ordinates	
Latitude (N)	28^0 02' 31''
Longitude (E)	96^0 35' 04''
Map reference	Survey of India topo-sheet 91D/12
Meteorology	
Average Rainfall	3000 mm

Atmospheric Temperature	
Average Maximum Temp.	39^{0}C (at Tezu)
Average Minimum Temp.	3^0 C (at Tezu)
Hydrology	
Catchment Area	16430 sq. km
Design Flood	12944 Cumecs (1 in 100 years)
Reservoir	
Maximum Water Level	580.00 m
Full Reservoir Level	580.00 m
Minimum Drawdown Level	578.00 m
Water Spread at FRL	115 Hectare
Storage at FRL	10 MCM
Storage at MDDL	8.83 MCM
Live Storage	1.17 MCM
Diversion Structure	
Type	Barrage
Barrage bridge deck level	EL. 582.0 m
Height of the Barrage above crest level	26 m
Overall width of barrage(between NOF and divide wall)	121.0 m
River Bed Level (average)	EL. 550.00 m
Barrage Bay	
Crest Elevation	EL. 556.0 m
Capacity	12944 Cumecs (1 in 100 Year Flood)
No. of Gates	7 Nos.
Size of Gates	13.0 m (W) X 24.0 m (H)
Total Floor Length	214.0 m
Penstock	
Nos., Diameter	7 Nos. and 7 m Diameter ,steel lined
Length	Each of 48.5 m (approx)
Power House	
Type and Location	Surface powerhouse on right bank
Design Head	25.64 m (net)
Machine Hall	
Size	25 m (W) x 168.15 m (L) x 50 m (H)
Type of Turbine and no. of units	Vertical Kaplan, 7 units of 38.57 MW each
Installed Capacity	270 MW
Service Bay Level	EL. 559.30 m
Minimum Tail Water Level	EL. 550.90 m
Transformer Hall	
Facilities	Transformer
Size	18 m (W) x 168.15 m (L) x 15.2 m (H)
Floor Level	EL 559.30m
Service Bay	
Size	25 m (W) x 40 m (L) x 20.70 m (H)
Tailrace Channel	
Details	163.6 m wide and 165 m long rectangular Tailrace Channel
Electro-Mechanical Equipments	
Turbine	
No. and Type	7 nos. Vertical Kaplan, rated at 38.57 MW
Generator	

Out put	44.44 MVA
Power factor	0.9 lagging
Voltage	11 kV
Power Generation	
Design discharge	1184.55 Cumecs
Rated net head at Design Discharge	25.64 m
Installed Capacity	7 x 38.57 MW = 270 MW
Design Energy in 90% Dependable Year	1064.44 Million Units

3.7 DEMWE UPPER HYDROELECTRIC PROJECT

As discussed in Chapter – 1 to avoid the submergence of proposed hospital site of Swami Camp; part of Hayuliang town; some habitat areas and considerable road length of strategic importance, the project is being developed in two stages i.e. Demwe Upper Hydroelectric Project with installed capacity of 1080 MW near Mompani at EL 440.00 m with FRL at EL 525.00 m and Anjaw Hydroelectric Project a Barrage toe power house scheme at EL 550 m with FRL at EL 580 m.

1080 MW Demwe Upper H.E. Project has been contemplated as a Run-of-River scheme with diurnal pondage situated in the Anjaw district of Arunachal Pradesh. Dam site is located on Lohit river at about 12.8 km d/s of confluence of Delai river with Lohit River.

Demwe Upper hydroelectric project is proposed on river Lohit at Mompani, at EL -440 with FRL at 525 m. The coordinates of the dam site are 28° 01' 56" N and 96° 27' 0" E. The gross and live storage of the Demwe Upper Storage reservoir are 216 Mm^3 and 99 Mm^3. The FRL and MDDL are envisaged as 525.0 m and 512 m respectively. The water spread shall be 749 ha at FRL. The dam on river Lohit shall be concrete dam with a height of 162.03 m from deepest foundation level. The dam-toe, underground cavern powerhouse is proposed to be located at about 100 m downstream of dam axis in the right bank of Lohit river. The power generation envisaged is 1080 MW.

The salient features of Demwe Upper hydroelectric project are given in Table-3.6. The project layout map is enclosed as Figure-3.6.

Table-3.5: Salient features of Demwe Upper Hydroelectric Project

Location	
State	Arunachal Pradesh
District	Anjaw
Village	Mompani
Access	
Airport	Dibrugarh - around 300 km (Guwahati to Dibrugarh = 550 km)
Rail Head	Tinsukhia - around 250 km
Road Head	Brahamkund - Hayuliang road
Geographical co-ordinates	
Latitude (N)	28^0 01’ 51’’

Longitude (E)	96^0 27' 01''
Meteorology	
Average Rainfall	3800 mm
Maximum Rainfall	4996 mm
Minimum Rainfall	2519 mm
Atmospheric Temperature	Min average- 12.3^o C Max average- 30.7^o C
Hydrology	
Catchment Area	18947 sq km
Design Flood	27500 (PMF) + 3989 (GLOF) Cumecs
Reservoir	
Maximum Water Level (MWL)	525.0 m
Full Reservoir Level (FRL)	525.0 m
Minimum Drawdown Level (MDDL)	512.0 m
Water Spread at FRL	749 ha
Storage at FRL	216 MCM
Storage at MDDL	129 MCM
Live Storage	87 MCM
Dam	
Type	Concrete Gravity Dam
Length at top	360.7 m
Overflow	186.0 m
Non-overflow	174.7 m
Top Width	6.0 m
Top Elevation	EL. 527.0 m
Maximum Height above deepest foundation	186.5 m (EL. 340.5 - EL.527.0)
River Bed Level (average)	EL. 440.00 m
Spillway	
Type	Sluice Type
	Surface Spillway
Capacity	(30346.26+116.04) = 31509.3 Cumecs > 31489 Cumecs (PMF+GLOF)
No. of Gates	12 Nos. of Sluice Spillway controlled by Radial Gates (Two Tier) Sluice Spillway Size: 8 (W) x 12 (D) m
	1 No. of Surface Spillway Size: 12 (W) m x 15 (D) m
Crest Level	Sluice Spillway - EL. 465.0 m
	Surface Spillway - EL. 510.0 m
Coffer Dam	
Upstream Coffer Dam	
Maximum Height above deepest foundation Average Height of Coffer Dam	45.0 m 30.0 m
Type	Rock-fill with upstream concrete face with two

	Rows of Jet-Grouting
Top Width	6.0 m
Downstream Coffer Dam	
Maximum Height	13.0 m (above deepest foundation)
Type	Rock-fill with concrete face with one Row of Jet-Grouting
Top Width	4.0 m
Diversion Tunnels	
Nos, Size & Shape	5 Nos., 14.0 m dia Horse shoe
Length	Length of Tunnels varying from 873.12m to 1328.29m
Discharge	12,011 Cumecs (1 in 25 Year Return Period Flood)
Invert Level at Tunnel Inlet	EL 455.00 m
Invert level at Tunnel outlet	EL 435.00 m
Power Intake	
Type and Location	Rectangular forebay type with inclined trash rack on right bank of Lohit River
Size	125 m long and 37.7 m high
Pressure Shaft	
Nos., Diameter and type	5 Nos. of 10.0 m ϕ, underground with a vertical shaft and reduced to 7.1 m ϕ near power house and 1 bifurcated Pressure shaft of 5.1 m.
Length	Length of five Pressure Shafts varying from 153.90 m to 284.89 m and the average length is 219.40 m
Liner	Steel liner thickness of 34 mm
Power House	
Type and Location	Underground powerhouse on right bank of Lohit River about 100m downstream of dam axis
Discharge at Design Head	1608.26 Cumecs
Design Head	73.61 m (Net)
Size	Power House Hall: 228.17 m (L) x 23 m (W) x 63.72 m (H) Transformer Cavern: 203 m (L) x 16 m (W) x 28 m (H)
Type of Turbine and no. of units	Vertical Francis, 5units of 200 MW each and 1unit of 80 MW =1080 MW
Turbine Centre Line Level for 206 MW main Units	EL. 437.94 m
Turbine Centre Line Level for 50 MW Units	EL. 427.75 m
Service Bay Level	EL. 452.94 m
Tail water level (All machines running at MDDL)	EL. 446.13 m
Minimum Tail Water Level (At 50% of 1 unit discharge)	EL. 443.44 m

Tailrace Tunnel System	
Details	Four Tunnels of 13.0 m ϕ Horse Shoe shaped, Length varying from 273.3 m to 488.4 m
Downstream Surge Chamber Size	15.0 m width, 160.0 m length and 60.33 m height
Electro-Mechanical Equipments	
Turbine	
No. and Type	5(Five) Nos. Vertical Francis, rated at 206MW and 1 (One) No. of Vertical Francis Turbine rated at 50MW
Generator	
Out put	333.33 MVA for 200 MW Units 55.60 MVA for 80 MW Units
Power factor	0.9 lagging
Voltage	15 kV for 200 MW Units 11Kv for 80 MW Unit
Power Generation	
Design discharge	1608.26 Cumecs
Rated net head at Design Discharge	73.61 m (Net)
Installed Capacity	5X 200 MW + 1X80 MW = 1080 MW
Design Energy in 90% Dependable Year and at 95% plant availability	4013.76 Million Units

3.8 DEMWE LOWER HYDROLECTRIC PROJECT

The project is located at the foothill of Lohit basin. The project is located about 800m upstream of Brahamkund bridge on NH 52 and falls in Lohit district with reservoir extending into Anjaw district of the state of Arunachal Pradesh. The project area can be accessed from Dibrugarh airport, which is about 550 km from Guwahati airport. The project site is about 215 km from Dibrugarh and about 160 km from Tinsukia, the nearest rail head. The district head quarter Tezu is about 40 km on hill road from the project site. The project Demwe Upper HEP, a cascade development of Demwe HEP is located about 80 km upstream of proposed Demwe Lower HE Project.

After approval from CEA/CWC for the Water Availability Studies in July, 2008, M/s ADPPL approached MOEF for continuance of same ToR for EIA/EMP studies with an installed capacity of 1630 MW and received approval from MOEF vide letter dated 12-1-2009. Subsequently, M/s ADPPL finalized Detailed Project Report (DPR) and submitted to CEA for Techno-economic appraisal. During appraisal CEA recommended that the FRL and MWL of Demwe Lower should be kept at EL 424.8m as against the earlier considered FRL of EL 420m and MWL of EL 423.5m respectively. This change in elevation levels has resulted in enhancement of installed capacity to 1750 MW for which the MOEF has also accorded approval with the same TOR as earlier approved during the appraisal for 2 stage development (i.e Demwe Lower and Demwe Upper HEP)s. The project has obtained

Techno-Economic Clearance from Central Electricity Authority in November-2009, Environment Clearance from Ministry of Environment & Forests in February-2010.

Demwe Lower HE Project envisages construction of concrete gravity dam of 163.12 m height above deepest foundation level, the maximum water level and full reservoir level of the project are proposed at an elevation of 424.8 m and the Minimum drawdown level will be at elevation 408 m with live storage of about 171.20 Mcum. A surface power house is proposed on the right bank of Lohit river to accommodate five numbers of vertical Francis turbines of 342 MW each to generate 1710 MW power and one unit of 40 MW to generate total installed capacity of 1750 MW. The water after power generation will be discharged at an elevation of 297.9 m in the main course of river through a 130m long tail race channel. The design discharge of the project is 1729 cumec with a design head of 112.00m. The project will generate 6322 million units in a 90% dependable year at 95% machine availability.

The Layout plan of Demwe Lower is given as Figure-3.7. The salient features of the project are given in Table-3.7.

Table-3.7: Salient Features of the Demwe Lower Hydroelectric Project

Location	
State	Arunachal Pradesh
District	Lohit
River	Lohit
Access	
Airport	Dibrugarh - 215 km (Guwahati to Dibrugarh = 550 Km)
Rail Head	Tinsukia - 160 km
Road Head	Parasuram Kund – 1 km
Co-ordinates of the Dam Site	
Latitude (N)	27^0 52’ 48’’
Longitude (E)	96^0 22’ 39’’
Map reference	Survey of India topo-sheet 92A/5
Meteorology	
Average Rainfall	3000 mm
Maximum Rainfall	5000 mm
Minimum Rainfall	2500 mm
Atmospheric Temperature	
Average Maximum Temp.	39^0C (at Tezu)
Average Minimum Temp.	8^0 C (at Tezu)
Hydrology	
Catchment Area	20,174 sq. km
PMF	28,500cumecs
Reservoir	
Maximum Water Level	424.80 m
Full Reservoir Level	424.80 m

Minimum Drawdown Level	408.00 m
Water Spread at FRL	1131 ha
Storage at MWL	516.38 MCM
Storage at FRL	516.38 MCM
Storage at MDDL	345.18 MCM
Live Storage	171.20 MCM
Dam	
Type	Concrete Gravity
Length at top	474.35 m
Overflow	219.70 m
Non-overflow	254.65 m
Top Width	6.00 m
Top Elevation	426.80 m
Maximum Height above deepest foundation	163.12 m
Spillway	
Type	Sluice /Surface Ogee spillway type
Capacity	32300.00cumecs
No. Of Gates	Surface Ogee type– 1No. Sluice spillway – 12 Nos.
Size of Gates	Surface Ogee -12.5m(W)X18.0 m(H) Sluice spillway -8.6m (W) X 11.0 m(H)
Crest Level	Surface Ogee type -406.80 m Sluice spillway -360.00 m
Diversion Tunnels	
Nos, Size & Shape	5Nos.-14.0 m Horse Shoe shaped on right bank and 1No.-6.00m Horse Shoe shaped on left bank,
Length	14.0 m – average length of 1025 m 6.0 m – 900 m length
Design Discharge	12600.00 cumecs
Invert Level at Tunnel Inlet	EL 300.00 m
Power Intake	
Type and Location	Rectangular forebay type with inclined trash rack on right bank of Lohit River inclined at 105° to dam axis
Size	160 m long, 32.57m wide and 48.8 m high
Design Discharge	2085 cumec during monsoon
Pressure Shafts	
Nos., Diameter and type	5 Nos. 10.0 m Dia, underground parallel @ 36m c/c
Length	Length varying from 550.0 m to 640.0 m and the average length is 602.0 m
Liner	Steel liner of varying thickness of 28 mm to 36 mm
Power House	

Type and Location	Surface powerhouse on right bank of Lohit River about 650 m downstream of dam axis
Design Discharge	1729 cumec at design head
Design Head	112.00 m (net)
Size	PH Hall: 200.57 m (l) x 28m (w) x 50 m (h)
Type of Turbine and no. of units	Vertical Francis, 5 units of 342 MW each + 1 unit of 40.0 MW
Installed Capacity	1750 MW
Turbine Centre Line Level	El. 291.90 m
Service Bay Level	El. 306.60 m
Minimum Tail Water Level	El. 297.90 m
Tailrace	
Details	Open channel, 165.0 m wide, 130 m long
Power Generation	
Installed Capacity	5 X 342 MW +1 X 40 MW = 1750 MW
Design Energy: Annual generation in 90% Dependable Year at 95% plant availability	6322 Million Units

3.9 GIMLIANG HYDRO ELECTRIC PROJECT

M/s Sai Krishnodaya Industries (P) Ltd (SKIL) has signed a Memorandum of Agreement (MOA) with the Government of Arunachal Pradesh on 26th February, 2009 to develop the proposed Gimliang Hydro Electric Project (99 MW) on river Dav, a right bank tributary of Lohit river in Anjaw District of Arunachal Pradesh on Build, Own, Operate and Transfer (BOOT) basis.

The project is located near Hayuliang town in the Anjaw District of Arunachal Pradesh and is about 250 km from Tinsukhia. The project site is located about 300 km from Dibrugarh. The project is approachable by National Highway No. 52 from Dibrugarh to Tinsukhia and other road from Tinsukhia to Hayuliang.The broad gauge railway station is at Tinsukia which is about 275 km from the Barrage site. Gimliang H.E Project is a run- of- the river project located on the Dav River, a major right bank tributary of Lohit River in the Anjaw district of Arunachal Pradesh. The run- of-the river plant with a design head of 345.90 m has three units with unit capacity of 29.5 MW each giving a total installed capacity of 88.5 MW. From the intake on the right bank of the river, a 9.537 km long headrace tunnel leads to a surface power house on the right bank of the river Dav. The Full Reservoir Level (FRL) and Minimum Drawdown Level (MDDL) is at an elevation of 942 m and 939 m respectively.

The major components of the Gimiliang HEP project are listed as below:

- A concrete Barrage 75.5 m long & 10 m high above river bed level, with 5 nos. of bays with crest level at EL. 934.00 m.
- A Power Intake on the right bank aligned 90^0 to the river flow with invert level at EL. 936.00 m.

- A 3.8 m dia finished D-shaped head race tunnel about 9.537 km long.
- A 8 m dia, 112.30 m high restricted orifice type underground surge shaft with a dome at the top ;
- A 2.8 m dia, 1123 m long steel lined pressure shaft with 3Nos. 2.0 m dia steel penstocks each of length 41 m will be taking from it for feeding the turbines;
- 68.70 m (l) x 16.5 m (w) x 38.0m (h) surface powerhouse with three vertical Francis type units of 29.5 MW each;
- Switch yard of dimension 41.5 m (W) x 65 (L).
- A 20m (W) x 45m (L) x 6m (H) long tail race chnnel connected to the river
- Design energy shall be 338.28 million units (MU) in a 90% dependable year at 95% plant availability.
- Power generated would be taken through a 220kV Double Circuit line having zebra ACSR or equivalent AAAC conductor from 220kV pothead yard of Gimliang HE Project to proposed pooling station at Tezu with line length of approx. 55 km.

The project components are briefly described in the following paragraphs

Barrage

A Barrage of 20.1 m height from the deepest river bed and top length of 75.5 m is proposed across the river downstream of Goiliang village. 5 bays of size 11.5 m X18.1 m is provided with a discharging capacity of 5555 m^3/s (SPF). 135 m floor length with 3.0 m deep upstream cut-off and 10.0 m downstream cut-off has been proposed for a design discharge of 3510 m^3/s (100 year Design flood) considering the crest at EL.934 m. A stilling basin of 90 m length at the Floor level of 923 m and end sill at 934 m has been provided to dissipate the energy at downstream during flood.

Water Conductor System

The power intake is proposed to be located about 25 m upstream of the barrage axis and the water conductor system is located on the right bank of the river. MDDL has been kept at 939 m.The water conductor system has been designed for a total design discharge of 28.17 cumec. The size of the HRT has been kept as 3.8 m finished dia. A restricted orifice type, all underground surge shaft of dia 8.0m is proposed and 2.8 m dia pressure shaft emanate from the circumference of the surge shaft.

Power Plant Civil Works

The surface power house of size 68.5 m (L) x 16.5 m (W) x 38 m (H), units is spaced at 15.5 m c/c. The 20m long service bay is located at the left end and the 12 m long Control Block is located at the right end of the machine hall. The centerline of machines is set at El.621.2m.

An open Tail Race Channel of size 20 m (W) x 6 m (H) and 45 m (L) has been proposed to convey discharge from the units in the powerhouse to Dav river at an elevation of 574.0 m.

Power Plant and Electro-Mechanical System

Gmliang Powerhouse envisages installation of 3 units of 29.5 MW, vertical axis Francis turbines with unit auxiliaries, two hydro generators and 3 phase generator step-up transformers, 220 kV GIS & 220 kV XLPE cables and 220 kV Transmission line.

The salient features of the Gimliang Hydroelectric project are given in Table-3.8. The general layout of the Project is presented in Figure-3.8.

Table-3.8: Salient features of Gimliang Hydro Electric Project

Project Components	Unit	Details
LOCATION OF THE PROJECT		
State		Arunachal Pradesh
District		Anjaw
River Basin/sub-basin		Brahmaputra, Sub- basin Lohit
Barrage		
Latitude		28° 08' 25.05" N
Longitude		96° 38' 03.29" E
Power House		
Latitude		28° 05' 1" N
Longitude		96° 33' 42.32" E
HYDROLOGY AND CLIMATE		
Catchment area up to barrage	km²	371.4
Rainfed Catchment area	km²	370.6
Snowfed catchment area	km²	0.86
90% dependable water year		2002-03
50% dependable water year		1995-96
Average annual yield	Mcum	906
Maximum/ Minimum yield	Mcum	1323/382
Average maximum temperature	ºC	26
Average minimum temperature	ºC	18
Environmental Release		
During monsoon (Jun-Sep)		30% of inflow
During non-lean, non-monsoon		25% of inflow
(Oct-Nov and Apr-May)		
Minimum environmental release		20% of average inflow of 4 consecutive leanest months
(lean season, Dec –Mar)		
Diversion Flood		
River diversion flood for 25 year return period non- monsoon flood during construction of the project (Period: October- to April)	m³/s	390
Design flood (SPF) for barrage height (i.e. calculation of free board)	m³/s	5555
RESERVOIR		
FRL	m	942
MDDL	m	939
River Bed Level at barrage axis	m	934

Gross storage	mcm	0.035
Submergence area at FRL	m²	10445
DIVERSION STRUCTURE		
Type of structure		Barrage
RIVER DIVERSION		
Diversion Arrangement		Through DT
HEAD RACE TUNNEL		
Location		Right Bank
Finished shape		D-Shape
Finished diameter	m	3.8
Number of tunnel	No.	One
Length (from Intake to SS)	m	9537
SURGE SHAFT		
Type		Restricted orifice
PRESSURE SHAFT & STEEL LINER		
Type		
Discharge	m^3/s	28.1
Internal diameter	m	2.8
Length of pressure shaft (up to trifurcation)	m	1123
Number of pressure shaft	No.	1
Number of units	No.	3
POWERHOUSE		
Type		Surface
Installed capacity	MW	88.5
Number of units	No.	3
Gross head (maximum)	m	365
Net head	m	360
Energy		
Design energy – in 90% dependable year	MU	338.2
Plant Load Factor in 90% dependable year	%	43.6
Energy in a 50% dependable year	MU	481.1
Energy in a 50% dependable year+10% over loading	MU	549.4
CONSTRUCTION PERIOD	Year	5
Estimated Cost (at January 2014 price level)		
Civil Work	Rs. crore	363.61
E & M Works excluding Transmission Line	Rs. crore	165.57
Other Direct & Indirect Charges	Rs. crore	108.26
Total Cost	Rs. crore	637.155
Estimated Cost		
Escalation on Civil Works	Rs. crore	55.64
Escalation on E&M Works	Rs. crore	25.36
Interest During Construction	Rs. crore	129.54
Financing Charges	Rs. crore	6.1
Project Cost Including escalation, IDC & FC	Rs. crore	870.39

3.10 RAIGAM HYDRO ELECTRIC PROJECT

M/s Sai Krishnodaya Industries (P) Ltd (SKIL) has signed a Memorandum of Agreement (MOA) with the Government of Arunachal Pradesh on 26th February, 2009 to develop the proposed Raigam Hydro Electric Project (96 MW) on river Dalai, a major right bank tributary of Lohit river in Anjaw District of Arunachal Pradesh on Build, Own, Operate and Transfer (BOOT) basis.

The project is located near Hayuliang town in the Anjaw District of Arunachal Pradesh and is about 250 km. from Tinsukhia. The project site is about 300 km from Dibrugarh. The project is approachable by National Highway No. 52 from Dibrugarh to Tinsukhia and Tinsukhia to Hayuliang.The broad gauge main railway station is at Tinsukia station which is about 265 km from the Barrage site.

Raigam H.E Project is a run- of- the river project located on the Dalai River, a major right bank tributary of Lohit River in the Anjaw district of Arunachal Pradesh.

The run- of-the river plant with a design head of 186.33 m has three units with unit capacity of 65 MW each giving a total installed capacity of 195 MW. From the intake on the left bank of the river, a 10.375 km long headrace tunnel leads to an Under ground powerhouse on the left bank of the river Dalai. The Full Reservoir Level (FRL)/ Minimum Drawdown Level (MDDL) is at an elevation of EL 723.0 m.

The major components of the Raigam Hydro electric project are listed in the following paragraphs:

- A concrete Barrage 172 m long & 22 m high above deepest foundation level, with 11 nos. of bays each 10.5m(W) x 14m(H) including one bay as inoperative, with crest level at EL. 710.0m (at river bed level) .
- A Power Intake on the left bank aligned 90^0 to the river flow with invert level at EL.712.5 m.
- 7 m dia finished modified horse shoe-shaped head race tunnel 10.375 km long.
- A 22 m dia, 77.82 m high restricted orifice type Underground Surge shaft.
- A 5.4 m dia, 675 m long steel lined pressure shaft with three 3.20 m dia steel lined Unit Pressure shaft of length 45m/58m/72m will be taking from it for feeding the turbines;
- 89.6 m (l) x 18 m (w) x 38 (h) Surface Powerhouse with three vertical Francis type units of 65 MW each;
- GIS Switchyard of dimensions 56.6 m (l) x 65 m (w)
- A 40m wide and 75 m long tail race channel connected to the river and Pothead yard
- The design energy shall be 761.65 million units (MU) in a 90% dependable year at 95% plant availability.
- Power generated would be taken through a 220kV Double Circuit line having zebra ACSR or equivalent AAAC conductor from 220kV switchyard of Raigam HE Project to proposed pooling station at Tezu with line length of approx. 50 km. Double circuit line is proposed for redundancy.

The project components are briefly described in the following paragraphs

Barrage

A Barrage of 22 m height from the deepest foundation level and top length of 172 m is proposed across the river upstream of Teepani village. 11 bays of size 10.5 m X14 m is provided with a discharging capacity of 11600 m^3/s (SPF) including one bay as inoperative. 121.75m floor length with 4.0 m deep upstream cut-off and 6.0 m downstream cut-off has been proposed for a design discharge of 7480 m^3/s (Design flood) considering the crest at EL.710.0m. A stilling basin of 85 m length at the Floor levelof 705.0 m and end sill at 709.5 m has been provided to dissipate the energy at downstream during flood.

Water Conductor System

The power intake and the water conductor system are located on the left bank. In order to ensure proper hydraulics of the system, the intake is aligned in such a way that the front face of the intake wall is almost parallel to the general bank line.

Three feeder tunnels of 4 m (w) x 3.5m (h) D-shaped tunnel off-take from the intake well. The water conductor system has been designed for a total design discharge of 123.43 cumec. The three feeder tunnels join to form a single head race tunnel (HRT) of 7.0m diameter 10375m Long. The size of the HRT has been finalized through an optimization study. An orifice type, all underground surge shaft of dia 22.0m is provided and 5.4 m dia pressure shaft emanate from the circumference of the surge shaft.

Power Plant Civil Works

The Surface power house of size 56.6m (L) x 18.0m (W) x 38m (H). Units are spaced at 16 m c/c. The 21m long service bay is located at the right end and the 12m long Control Block is located at the left end of the machine hall. The centreline of machines is set atEl.565.80m.An open tail race channel 40m (W) x 75m (L) will discharge back to the river.

Power Plant and Electro-Mechanical System

Raigam powerhouse envisages installation of 3 units of 65 MW, vertical axis Francis turbines with unit auxiliaries, three hydro generators and 3 phase generator step-up transformers, 220 kV GIS & 220 kV XLPE cables and 220 kV Transmission line.

The salient features of the Raigam Hydroelectric project are given in Table-3.9. The general layout of the Project is presented in Figure-3.9.

Table-3.9: Salient features of the Raigam Hydroelectric project

Location	
State	Arunachal Pradesh
District	Anjaw
District Head Quarter	Tezu
River/Stream	Brahmaputra, Sub-basin Lohit
Location of Intake Structure	28° 10’ 42.56” N
	96° 31’ 19.56” E
Geographical Co-ordinates of Project Area	

Latitude	280 10' 42.56" N
Longitude	960 31' 19.56" E
Altitude	710.0 m (At barrage Location)
Access to the Project	Site 250 km from Tinsukia rail head and 300 km from Dibrugarh Airport and approchable by NH-52 from Dibrugarh to Tinsukia and than Hualiang.
Nearest Rail head	Tinsukia, ASSAM
Nearest Airport	Dibrugarh
Hydrology	
Catchment area	1697.45 km^2
Annual Average Rainfall	2500-5000 mm
Average annual yield	4034 Mcum
90% Dependable yield	2392.26 Mcm
Flood corresponding to 100-yearreturn period at diversion site of u/s project	7480 Cumecs
SPF at diversion site of u/s project	11600 m^3/s
Power Intake	
No. of Openings	3Nos.
Size & Shape	4.0 (W) x 3.5 (H), Rectangular Bellmouth
Invert Level of Intake	712.5.0 m
Type of Gates	Vertical Lift Gates, Rope Drum Hoist Arrangement
Intake Stop Log	3Nos. 4.0 (w) x 3.5 (h)
Intake Service Gate	3Nos. 4.0 (w) x 3.5 (h)
Head Race Tunnel	
Type	Modified Horse Shoe
Diameter	7 m finished
Total Plan Length	10.375 km
Slope	1 in 200
Design Discharge	123.43 m^3 /s
Velocity	3.4 m/s
Surge Shaft	
Type	Restricted Orifice
Size	22 m
Height	95.50 m
Orifice size	3.6
Level of Intersection with HRT	680.55m
Top Level	758.37 m
Maximum Up Surge level	743.68 m
Minimum Down Surge level	695.0 m
Adit-1 (Lenght/Size/Shape)	238.0 m, 6.0 m Dia., D-Shape
Adit-2 (Lenght/Size/Shape)	223.0 m, 6.0 m Dia., D-Shape,
Adit-3 (Lenght/Size/Shape)	196.0 m, 6.0 m Dia., D-Shape,
Pressure Shaft	
Type	Circular Steel Lined.
Nos.	1
Diameter	5.40 m
Length	675.0 m
Length of Unit Pressure Shafts after	UPS-1 = 32.9 m, UPS-2 = 26.92,

trifurcation	UPS-3 = 45.90
Dia. Of Unit Pressure Shaft	3.20 m
Power House Complex	
Type of Power House	Surface power house
Installed Capacity	195 (3x65) MW
Normal Tail Water Level	538.0 m
Rated Head	186.33 m
Design Discharge	123.43 m^3/s
Size of Power House (including Service Bay)	89.6 (L)x 18 (W) 38 (H) m. Surface structures.
Size of Switchyard	Switchyard (56.6 x 65 m)
Tail Race tunnel	
Shape	Open channel
Size & Shape	40 m Wide, 75 m long, 8 m High
Min. Tail Water Level	536.5 m
E&M Equipment	
Turbines	3
Type	Vertical Fransis
No. & Capacity	3 x 65 MW
Rated head	173.93 m
Rated Discharge	123.43 Cumecs
Over loading	10%
Generators	
No. & Capacity	3Nos. Generators, 71.5 MVA, 11 kV
Power factor	0.9
Overloading	10% continuous overloading
Transformer	
Type and Numbers	3Nos. 78.66 MVA, 11/220 kV, 3Φ phase generator step-up (GSU) transformers.
Power Generation	
Installed Capacity	195 MW
Design Energy (in 90% dependable year with 95% M/c availability)	761.65 MU
Estimated Cost (at January 2014 price level)	
Civil Work	590.9 Cr.
E & M Works excluding Transmission Line	411.57 Cr.
Other Direct & Indirect Charges	178.86 Cr.
Total Cost	1181.34 Cr.
Estimated Cost- For Tariff Calculations	
Escalation on Civil Works	94.28 Cr.
Escalation on E&M Works	65.72 Cr.
Interest During Construction	228.29 Cr.
Financing Charges	11.25 Cr.
Project Cost Including escalation, IDC & FC	1609.38 Cr.
Financial Aspects	
Levellized Tariff	6.09
Tariff For Block of 1st Five Years	5.16
Construction Period	
Construction period excluding infrastructure work	5

3.11 TIDDING-I HYDRO ELECTRIC PROJECT

The SKIL Group has planned to develop the 98 MW Tidding -I Hydro Electric Power Project as a run of the river scheme by utilizing water from the River Tidding, a tributary of the River Lohit in Arunachal Pradesh. The River Lohit is a major right bank tributary of the River Bhahmaputra.

Tidding-I HE project is a run off the river scheme proposed on Tidding river, a right bank tributary of Lohit river in Arunachal Pradesh. The total catchment area at the diversion site is about 614.53 sq.km out of which snowfed catchment area above permanent snow line of 4500 m is about 1.69 sq.km. The project envisages construction of a diversion structure.Proposed barrage Site on River Tidding is located at Latitude 28°0'55.79" North and Longitude 96°19'34.24" East. The proposed power house is located at Latitude 27°59'25.41" North and Longitude 96°23'24.42" East, about 8.17 km downstream of the barrage site. The catchment area of River Tidding up to the barrage site of Tidding-I HEP extends between Latitudes 28°0'18.13" and 28°25'38.76" North and Longitudes 96°11'43.47" and 96°25'44.74" East. The layout of the Project is presented in Figure-3.10.The salient features of the Tidding-I Hydroelectric project are given in Table-3.10.

Table-3.10.: Salient features of the Tidding-I Hydroelectric Project

Project Components	Unit	Tidding I (IC84MW)
LOCATION OF THE PROJECT		
State		Arunachal Pradesh
District		Anjaw
River Basin/sub-basin		Brahmaputra, Sub-basin Lohit
Barrage		
Latitude		28° 0' 55.79"
Longitude		96° 34' 34.24"
Power House		
Latitude		27° 59' 25.41"
Longitude		96°23' 24.42"
HYDROLOGY & CLIMATE		
Catchment area up to barrage	km^2	614.5
Rainfed Catchment area	km^2	612.8
Snowfed catchment area	km^2	1.68
90% dependable water year		2002-03
50% dependable water year		1995-96
Average annual yield	Mcum	1872.7
Maximum/ Minimum yield	Mcum	2734.7/788.7
Average maximum temperature	°C	26.5
Average minimum temperature	°C	14.6
Environmental Release		
During monsoon (Jun-Sep)		30% of inflow
During non-lean, non-monsoon (Oct-Nov and Apr-May)		25% of inflow
Minimum environmental release(lean season, Dec -Mar)		20% of average inflow of 4 consecutive months

Diversion Flood		
River diversion flood for 25 year return period non-monsoon flood during construction of the project (Period: October- to April)	m^3/s	650
Design flood (SPF) for barrage height (i.e. calculation of free board)	m^3/s	5225
RESERVOIR		
FRL	m	642
MDDL	m	640
River Bed Level at barrage axis	m	616
Gross storage	mcm	
Submergence area at FRL	m^2	
DIVERSION STRUCTURE		
Type of structure		Barrage
RIVER DIVERSION		
Diversion arrangement		Through DT
HEAD RACE TUNNEL		
Location		Left Bank
Finished shape		Modified Horse Shoe
Finished diameter	m	4.7
Number of tunnel	no	One
Length (from Intake to SS)	m	6600
SURGE SHAFT		
Type		
PRESSURE SHAFT & STEEL LINER		
Type		
Discharge	m^3/s	55.9
Internal diameter	m	3.9
Length of pressure shaft (up to trifurcation)	m	860
Number of pressure shaft	no	1
Number of units	no	3
POWERHOUSE		
Type		Surface
Installed capacity	MW	84
Number of units	no	3
Gross head (maximum)	m	180.7
Net head	m	165.4
Energy		
Design energy - in 90% dependable year	MU	327
Plant Load Factor in 90% dependable year	%	44.45
Energy in a 50% dependable year	MU	492.6
Energy in a 50% dependable year + 10% over loading	MU	526.5
CONSTRUCTION PERIOD	Year	4

3.12 TIDDING-II HYDRO ELECTRIC PROJECT

The SKIL Group has planned to develop the 68 MW Tidding II Hydro Electric Power Project as a run of the river scheme by utilizing water from the perennial River Tidding, tributary of the River Lohit in Arunachal Pradesh. The River Lohit is a major right bank tributary of the River Bhahmaputra.

Tidding-II HE project is a run off the river scheme proposed on Tidding river, a right bank tributary of Lohit river of Arunachal Pradesh. The total catchment area at the diversion site is about 525.70 sq.km out of which snowfed catchment area above permanent snow line of 4500 m is about 1.69 sq.km. The project envisages construction of a diversion structure. Proposed barrage Site on River Tidding is located at Latitude 28°05'0.45" North and Longitude 96°16'41.09" East. The proposed power house is located at Latitude 28°02'15.94" North and Longitude 96°18'53.68" East, about 8.03 km downstream of the barrage site. The catchment area of River Tidding up to the Tidding-II barrage site extends between Latitudes 28°04'04.70" and 28°25'38.76" North and Longitudes 96°11'50.19" and 96°25'44.74" East. The general layout of the Project is presented in Figure-3.11. The salient features of the Tidding-II Hydroelectric project are given in Table-3.11.

Table-3.11: Salient features of the Tidding-II Hydroelectric Project

Project Components	**Unit**	**Tidding II (IC75MW)**
LOCATION OF THE PROJECT		
State		Arunachal Pradesh
District		Anjaw
River Basin/sub-basin		Brahmaputra, Sub-basin Lohit
Barrage		
Latitude		28° 5' 0.45"
Longitude		96° 16' 41.09"
Power House		
Latitude		28° 02' 15.94"
Longitude		96°18' 53.68"
HYDROLOGY & CLIMATE		
Catchment area up to barrage	km^2	525.6
Rainfed Catchment area	km^2	524
Snowfed catchment area	km^2	1.68
90% dependable water year		2002-03
50% dependable water year		1995-96
Average annual yield	Mcum	1499.4
Maximum/ Minimum yield	Mcum	2189.7/631.5
Average maximum temperature	°C	26.5
Average minimum temperature	°C	14.6
Environmental Release		
During monsoon (Jun-Sep)		30% of inflow
During non-lean, non-monsoon (Oct-Nov and Apr-May)		25% of inflow
Minimum environmental release(lean season, Dec -Mar)		20% of average inflow of 4 consecutive months

Diversion Flood		
River diversion flood for 25 year return period non-monsoon flood during construction of the project (Period: October- to April)	m^3/s	575
Design flood (SPF) for barrage height (i.e. calculation of free board)	m^3/s	4760
RESERVOIR		
FRL	m	865
MDDL	m	863
River Bed Level at barrage axis	m	840
Gross storage	mcm	
Submergence area at FRL	m^2	
DIVERSION STRUCTURE		
Type of structure		Barrage
RIVER DIVERSION		
Diversion arrangement		Through DT
HEAD RACE TUNNEL		
Location		Left Bank
Finished shape		Modified Horse Shoe
Finished diameter	m	4.5
Number of tunnel	no	One
Length (from Intake to SS)	m	6282
SURGE SHAFT		
Type		
PRESSURE SHAFT & STEEL LINER		
Type		
Discharge	m^3/s	46.1
Internal diameter	m	3.6
Length of pressure shaft (up to trifurcation)	m	835
Number of pressure shaft	no	1
Number of units	no	3
POWERHOUSE		
Type		Surface
Installed capacity	MW	75
Number of units	no	3
Gross head (maximum)	m	192.3
Net head	m	178.8
Energy		
Design energy - in 90% dependable year	MU	284.1
Plant Load Factor in 90% dependable year	%	43.25
Energy in a 50% dependable year	MU	432.6
Energy in a 50% dependable year + 10% over loading	MU	461.8
CONSTRUCTION PERIOD	Year	4

3.13 KAMLANG SMALL HYDRO ELECTRIC PROJECT

Kamlang SHP project is proposed on river Kamlang, a tributary of river Lohit having catchment area of 520 sq.km upto the proposed diversion site. The project site is located near Wakro town in Lahit district of Arunachal Pradesh. The scheme envisages to generate 24.9 MW power by utilizing 45 m of gross head with the design discharge of 68.02 cumecs. At design head of 41.28 m, it is proposed to install three vertical Francis Turbines of 8.3 MW each with a surface power house. The annual generation is estimated 133.77 Million kWh in 75% dependable year and 167.52 Million kWh in 50% dependable year.

M/s Sai Krishnodaya Industries (P) Ltd. has been allotted Kamlang Small Hydropower Project by the Government of Arunachal Pradesh in Lohit District, for preparing the DPR and development of the project.

The major components of the Kamlang SHEP project are listed as below:

- 74 m long barrage as diversion structure.
- Intake structure comprising two bays of 5.10 m (W) x 4.80 m (H) each.
- 97.00 m long feeder channel of size 11.70 m (W) x 10.10 m (H) with design discharge of 85.03 cumec.
- A 102.0 m long desilting tank having 2 chambers of 14.75 m width.
- 10.20 m wide and 115.54 m long approach channel carrying water from desilting chamber to HRT.
- 2167 m long HRT of modified horse shoe section of 5.60 m dia.
- 23.85 m high restricted orifice type surge chamber.
- 72.55 m long main penstock of 4600 mm diameter trifurcated into 3 unit penstocks.
- Power house building of size 68.0 m x 18.00 m (W) x 32.27 m (H).
- 36.58 m long tail race channel having bed width of 32.20 m.

The project components are briefly described in the following paragraphs

Barrage

The concrete gated barrage structure is proposed having five radial gates of size 11.0 m wide and 11.30 m height with retaining wall both on left & right bank in the upstream and downstream. The width of gated barrage across the river is 74.00 m. The bed level of the barrage structure in the upstream corresponds to the average river bed level of El. 408.30 m and the pond level has been kept at El. 419.60 m. The bridge deck slab has been proposed at El. 422.60 m. The top most elevation of the barrage structure is at El. 424.10 m.

Intake

A power intake arrangement has been proposed with fixed wheel vertical lift service gates. The power intake consists of 2 openings of size 5.10 m (W) x 4.80 m (H) with a central pier of width 1.5 m separating them. There is a provision of emergency gates of equivalent size in the upstream of service gates. The length of power intake structure is 22.10 m. The invert level of intake structure is kept at El. 410.30 m, which is 2.0 m above the barrage crest, so as to prevent the entry of rolling debris in the intake. The power intake is located on left bank and its centreline is 20.09 m upstream of barrage axis. A power intake trash rack arrangement has been proposed at El. 410.30 m having four numbers of bays each of size 3.225 m (W) x 12.30 m (H). The arrangement appears to be in order.

Trash Rack & Approach Channel

Trash rack cleaning machine (TRCM) arrangement has been proposed to facilitate removal of the deposited floating debris in front of the power intake. A 97 m long approach channel is provided to carry water from power intake to desilting chamber

Desilting Chamber

Twin chambered Hopper type surface desilting chamber of size 14.75 m (W) x 15.00 m (H) x 102.00 m (L) has been proposed to remove suspended sediments of size 0.30 mm and above. 58.50 m long upstream and 29.5 m long downstream transitions have been proposed. A flushing arrangement with 140.0 m long silt flushing conduit of size 2.0 m x 2.0 m has been provided.

Head Race Tunnel

A 2167.10 m long, modified Horse-shoe shaped head race tunnel of 5.6 m diameter starts downstream of approach channel and terminates at the surge shaft. The design discharge of HRT is 68.02 cumec. Concrete lining of thickness 300 mm has been proposed for the HRT. The alignment of HRT has been so chosen to provide adequate rock cover throughout its alignment. One 94.45 m long, D-shaped Adit, having 6.0 m diameter has been proposed for the HRT

Surge Shaft

A 23.85 m high restricted orifice type, open to air surge shaft having 21.5 m diameter has been proposed at the end of HRT to withstand the water hammer pressure in case of sudden load rejection and also facilitate additional water requirement in case of sudden load acceptance. The maximum upsurge and minimum down surge level in the surge shaft are El. 425.85 m and El. 410.80 m respectively. The steady level in the surge shaft shall be at El. 417.025 m

Pressure Shaft (Penstock)

The water will be conveyed to the turbines installed in the power house through a pressure shaft duly lined with steel penstock having 4600 mm diameter and 16 mm thickness. The penstock shall be trifurcated into three unit penstocks of 2600 mm dia each before entering the upstream wall of the power house. Total length of main penstock upto the point of trifurcation is 92.55 m.

Power House

The surface power house site is located on left bank of Kamlang river. A surface power house having installed capacity of 24.9 MW (3 x 8.3 MW) is proposed for the project. The power house is located 2 kms from Wakro village where a flat terrace at an average elevation of el. 383.00 m on left bank of the river is available. The overall size of the power house is 68.0 m (L) x 18.0 m (W) x 32.27 m (H). Maximum gross head of 45.21 m has been utilized for power generation. The turbine floor is at El. 373.00 m and the centre line of the turbines is at El. 371.34 m. Power house is provided with an EOT crane of 40/5 MT capacity.

Tail Race Channel

A 36.58 m long rectangular tail race channel having a width of 32.20 m with a reverse slope of 6.0 H:1V has been proposed to convey discharge from the power house back to Kamlang river. The crest level of the sill at the confluence has been kept at El. 374.00 m to prevent entry of debris from the Kamlang river into the tail pool downstream of powerhouse

The layout of the Project is presented in Figure-3.12. The salient features of the Kamlang Small Hydroelectric project are given in Table-3.12.

Table-3.12: Salient features of the Kamlang Small Hydroelectric project

LOCATION	
State	Arunachal Pradesh
District	Lohit
Tehsil	Wakro
Latitude	27°44'38.57"N
Longitude	96°22'47.98"E
Nearest Rail head	Tinsukia (110 km)
Nearest Airport / Approach	Dibrugarh (155 km)
Name of River / Tributary	Kamlang (tributary of Lohit)
Name of River Basin	Brahamputra River Basin
HYDROLOGY AND CLIMATE	
Catchment Area up to head works (km^2)	520
Average annual Yield (Mm^3)	3081
Maximum / Minimum Annual Yield (Mm^3)	3855 / 2346
Design Flood (m^3/s)	2100 (1 in 100 yr.)
Maximum temperature	35°C
Minimum temperature	1° C
Design Horizontal Seismic Coeff.	0.23g
Design Vertical Seismic Coeff.	0.15g
DIVERSION STRUCTURE	
Type of Structure	Barrage
Av. River Bed Level at Barrage Axis	EL 408.30 m
Deepest River Bed Level	EL 407.965 m
Deepest Foundation Level	EL 400.25 m
Length of Barrage at top (m)	74.00
FRL	EL 419.60 m
MDDL	EL 419.60 m
MWL	EL 421.75 m
Crest Level of the Barrage	EL 408.30 m
Elevation of Barrage Deck Slab	EL 422.60 m

Elevation at top of Barrage Pier	EL 424.10 m
Downstream Cistern Level	EL 402.80 m
Length of the Cistern (m)	45.00
Maximum height above deepest foundation (m)	23.85
No. & size of gates **(**Vertical gates)	5 Nos. – 11.00m (W) x 11.60m (H)
Type of Gate	Radial
RIVER DIVERSION ARRANGEMENT	
Type of flow	Free flow (Open Channel)
Construction Flood (m^3/s) (1 in 25yr)	425(Lean Period Discharge)
Stage 1	
Max. Height of Coffer Dam (m)	8.25
Bottom Width (m)	5.10
Length (m)	231.15
Top Elevation of Coffer Dam (U/s)	EL 410.50 m
Top Elevation of Coffer Dam (D/s)	EL 410.50 m
Stage 2	
Max. Height of Coffer Dam (m)	3.30
Bottom Width (m)	3.145
Length (m)	208.66
Top Elevation of Coffer Dam (U/s)	EL 411.60 m
Top Elevation of Coffer Dam (D/s)	EL 406.10 m
POWER INTAKE	
Type	Surface with breast wall
Number of Inlet	02
Size of opening	5.10m (W) x 4.8m (H)
Length of Power Intake (m)	22.10
Invert level of Intake	EL 409.80
No. of gates	(1) Emergency Gate - 01 no. (2) Service Gate - 01 no.
Design Discharge (m^3/s)	85.03
Flow Through Velocity in Trash rack (m/sec)	1.5
Trash Rack Arrangement	Yes
Type of cleaning	Mechanical (TRCM)
Angle with vertical	12^o
Top Level of Trash Rack	422.60
UPSTREAM APPROACH CHANNEL	
Length (m)	97.00
Size	11.70m (W) x 10.10m (H)
Design Discharge (m^3/s)	85.03
FSL at start of Channel	El 419.357 m
Invert Level at start of Channel	El 409.80 m
DESILTING CHAMBER	
No. of Chambers	02
Width (m)	14.75
Height including Hoppers (m)	15.00
Design Discharge (m^3/s)	85.03
Length of U/S Transition (m)	58.50
Length of Horizontal Portion (m)	102.00
Length of D/S Transition (m)	29.50

Flushing Discharge (m^3/s)	17.00
Size of Silt Flushing Conduit (m)	2.0m x 2.0m
Silt Flushing Conduit Length (m)	140.0
Excavated Open Channel (m)	360.0
DOWNSTREAM APPROACH CHANNEL	
Length (m)	115.54
Size	10.20m (W) x 11.80m (H)
Design Discharge (m^3/s)	68.02
FSL at start of Channel	El 419.251 m
Invert Level at start of Channel	El 408.10 m
HEAD RACE TUNNEL	
Number of Tunnel	01
Shape of Tunnel	Modified Horse-Shoe
Length of Tunnel (m)	2167.10
Invert level at HRT Start	EL 408.10
Diameter (m)	5.6 m (finished)
Design discharge (m^3/s)	68.02
Lining Thickness (m)	0.30
Bed Slope	1 in 268
Design Velocity (m/sec)	2.67
No. of Bends	03
Bend-1 (Chainage in m from HRT start)	81.97
Bend-2 (Chainage in m from HRT start)	494.84
Bend-3 (Chainage in m from HRT start)	1167.92
ADITS	
Number of Adits	01
Location of Construction Adit (Chainage in m from HRT start)	2075.83
Length of Adit (m)	95.45
Shape of Adit	D- Shaped
Diameter (m)	6.0 (finished)
Adit Plug	Adit No.-1
Type & Number	Hinge Type, 01 no.
Size of Plug Gate	2.5m x 2.5m
SURGE SHAFT	
Type	Restricted Orifice (Open-to-air)
Shape	Circular
Diameter on main Surge Shaft (m)	21.50 m
Diameter on Orifice (m)	2.50 m
Height (m)	23.85 m
Maximum Upsurge	EL 425.85 m
Minimum Upsurge	EL 410.80 m
Steady State Level	EL 417.025 m
Top Elevation	EL 428.85 m (Top of Surge Shaft)
Center Line of HRT at Surge Shaft	EL 402.45 m
Overt Level of HRT at Surge Shaft	EL 405.00 m
Sill Level of HRT at Surge Shaft	EL 399.90 m
Thickness of Orifice slab (m)	2.0
PRESSURE SHAFT / PENSTOCK	
Type of Pressure Shaft	Steel Lined
Shape of Pressure Shaft	Circular
Number of Pressure Shafts	One

Number of Unit Pressure Shaft	Three
Normal discharge through pressure shaft / penstock (m^3/s)	68.02
Internal Diameter of Pressure Shaft (m)	4.6
Maximum Velocity through Pressure Shaft/ Penstock (m/sec)	4.09
Length of Main pressure shaft (m)	92.55
Length of Unit Pressure shaft after trifurcation (PS1/PS2/PS3) in (m)	PS1-63.57/ PS2-52.34/ PS3-41.11
Internal Diameter of Unit Pressure Shaft (m)	2.6
Total Length of trifurcated Pressure Shaft (m)	157.02
Pressure Shaft Gate at Surge Shaft	1 no.
Size	5.4m (W) x 5.4m (H)
Main Inlet valve, if any (type & diameter)	3 Nos, 1.90 m (Butterfly Valve)
SURFACE POWERHOUSE	
Type	Surface
Latitude	27^{o}45'17.75"N
Longitude	96^{o}21'33.19"E
Location	Near Wakro Bridge
Number of Units	03
Installed Capacity Per Unit (MW)	8.3
Efficiency of Turbine	92.5%
Rated Output of Turbine	8.469 MW
Installed capacity (MW)	3 x 8.3 MW = 24.9 MW
Maximum Average Gross Head – One unit running (m)	45.26
Maximum Average Gross Head – All unit running (m)	44.46
Total Head Loss (corresponding to all Three units running at rated load)- (m)	3.18
Total Head Loss (corresponding to one units running at rated load)- (m)	0.34
Maximum net head, when one unit is running at FRL	44.92
Design Head (m)	41.28
Type of turbine	Vertical Francis
Center Line of Turbine	EL 371.34 m
Maximum Tail Water Level (In River)	EL 377.66 m
Normal Tail Water Level (In TRC)	EL 375.14 m
Minimum Tail Water Level (one m/c at full load)	EL 374.39 m
Minimum Tail Water Level (one m/c at 50% load)	EL 374.34 m
Turbine Floor Level	EL 373.00 m
Rated Discharge through each unit (m^3/s)	22.67
Rotational Speed	333.33 rpm
For Generator	
- Type	Synchronous
- Rated capacity	8.3 MW
Efficiency of Generator	98%

- Overloading	10%
- Power factor, generator terminal voltage (kV)	0.9 (lagging),11 kV
- Voltage/Frequency (kV/Hz)	11.0/50
- Excitation system (type)	Static
Size of power house (including service bay)	68.025m (L) x 18.00m (W) x 32.27m (H)
Spacing of Units (m)	14.0
No. of Transformers	03
Generator Floor Level	El 377.00 m
Transformer Floor Level	El 381.50 m
Power House EOT Cranes	
- Nos.	1
- Capacity	40/5 MT
TAILRACE CHANNEL	
Type of Tailrace Channel	Rectangular
Length of Tailrace Channel (m)	36.58 m(between A-Line and end of TRC)
Width of Tailrace Channel (m)	32.20 m
Slope of Tailrace Channel	1 in 6
Nominal Discharge (m^3/s)	68.02
Sill level at confluence with Kamlang River	EL 374.00 m
SUBSTATION/SWITCHYARD	
Type of Switchyard (GIS/Outdoor)	Outdoor
Size	58.20 m x 45.00 m
Voltage	132 kV
POWER BENEFITS	
Design Energy (GWh/annum)	133.77
Secondary Energy (GWh/annum)	51.10
PLF (%)	61.33
TOTAL CONSTRUCTION PERIOD	03 years (36 Months)
COST ESTIMATES (Rs. in Crores)	
Civil & H-M Works	119.04
Electro- Mechanical Works	65.59
Other Direct & Indirect Cost	26.55
Total Hard Cost	211.18
IDC & FC	31.18
Total Cost with IDC & Front End Fee and without escalation	242.37
Total Cost with IDC & Front End Fee and with escalation	267.84
Cost per MW of Installed Capacity	10.75

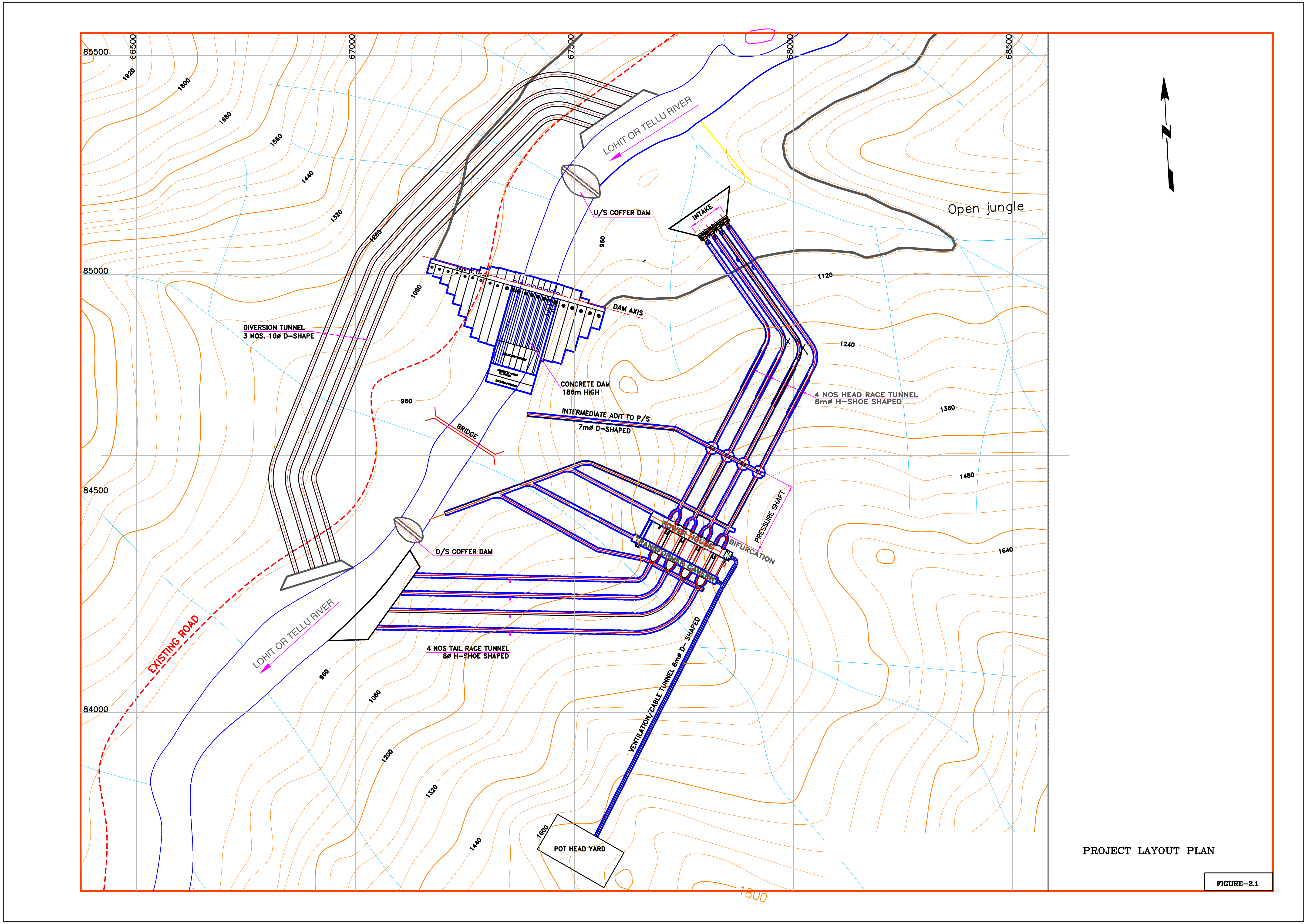


Figure-3.1: Kalai-I hydroelectric project stage

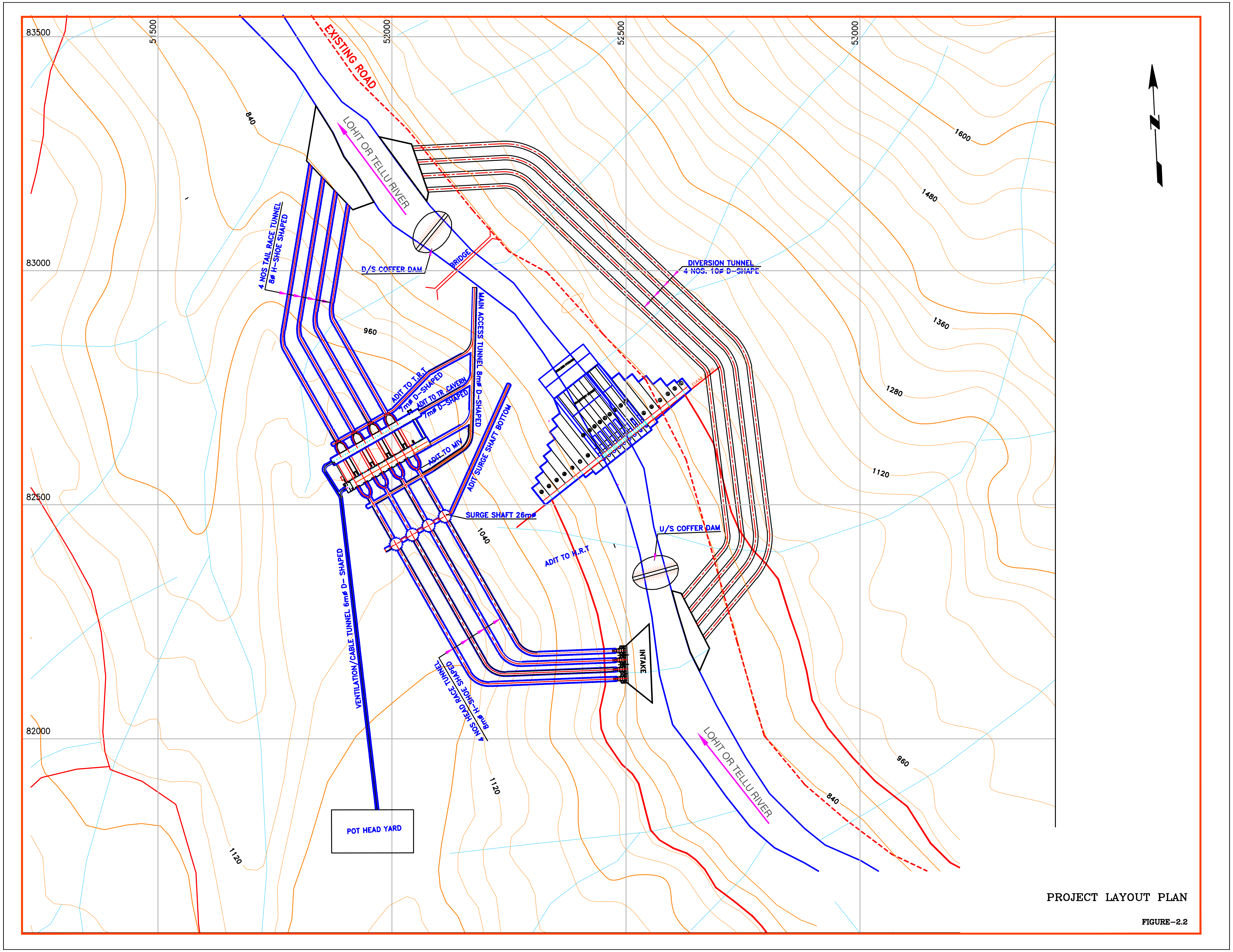


Figure-3.2: Kalai-II hydroelectric project stage

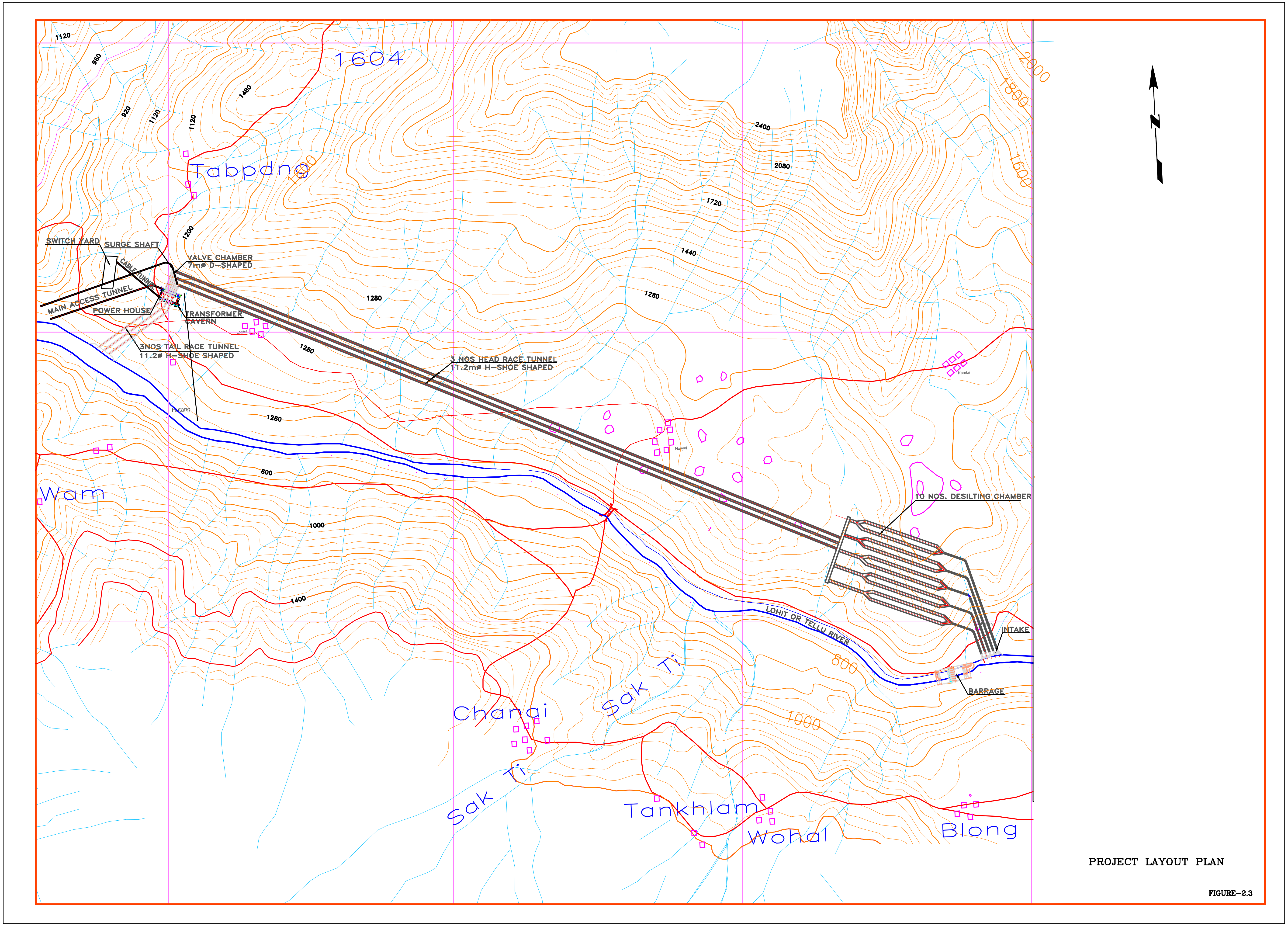


Figure-3.3: Hutong hydroelectric project stage-1

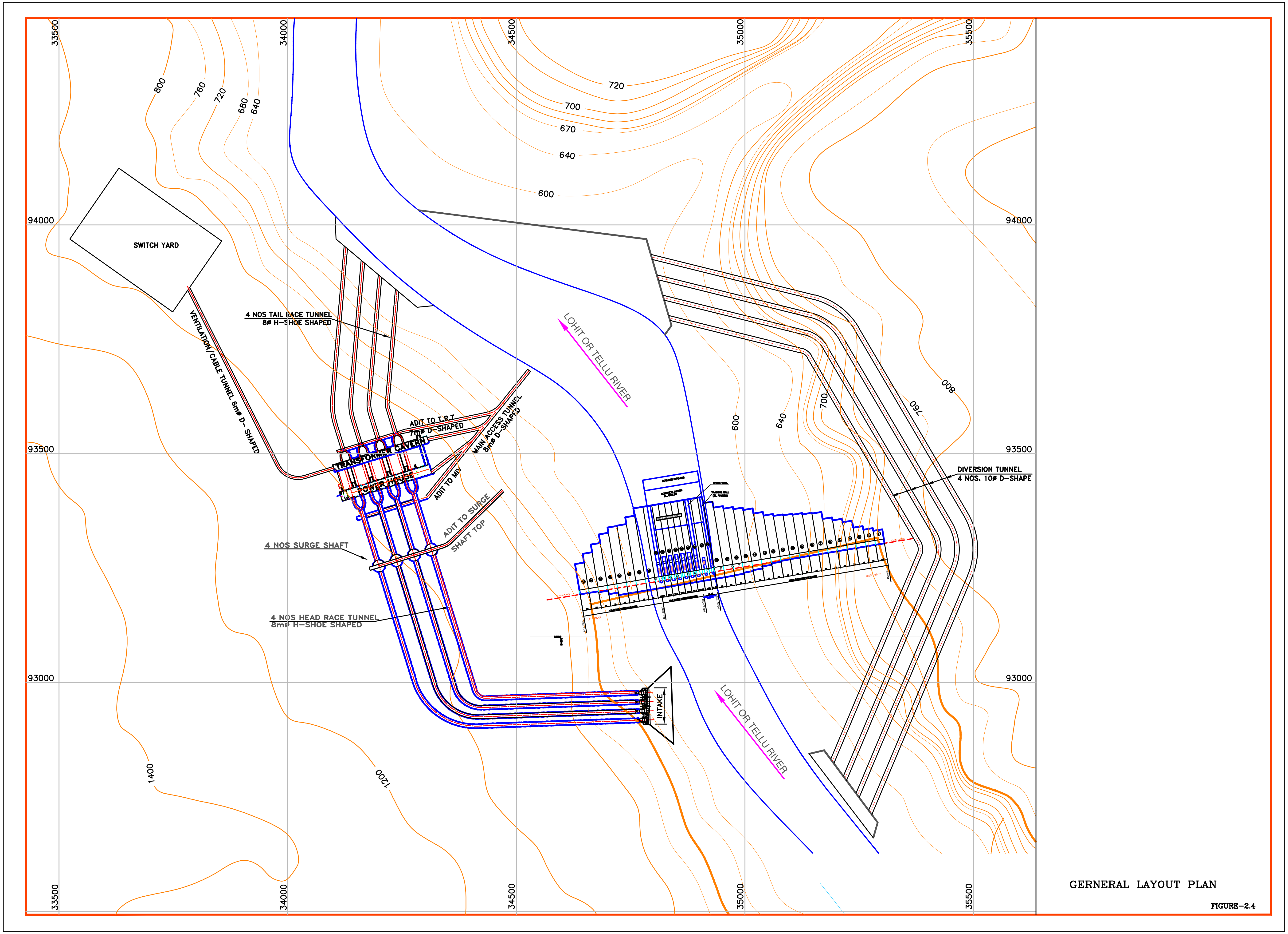


Figure-3.4: Hutong hydroelectric project stage-II

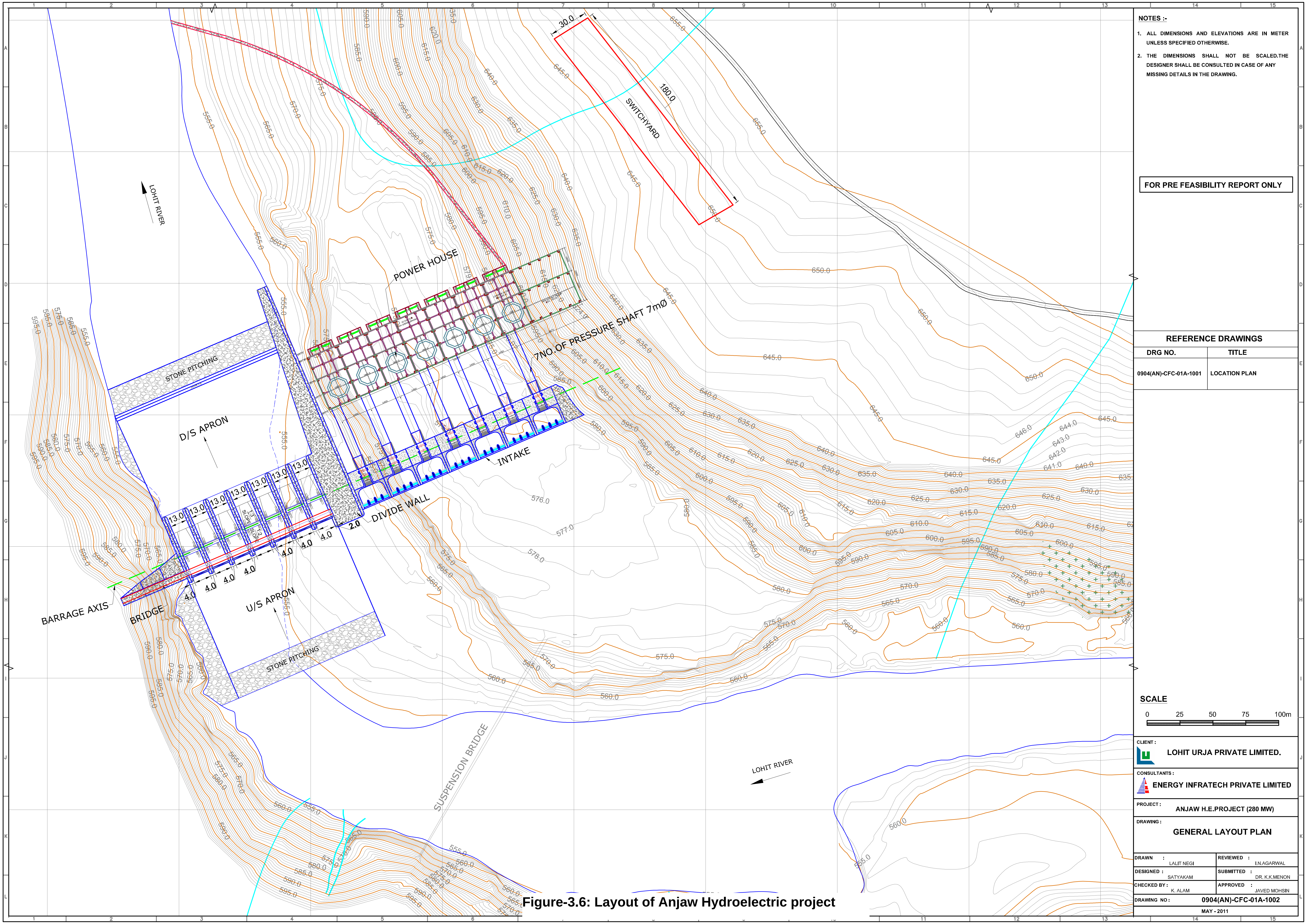


Figure-3.6: Layout of Anjaw Hydroelectric project

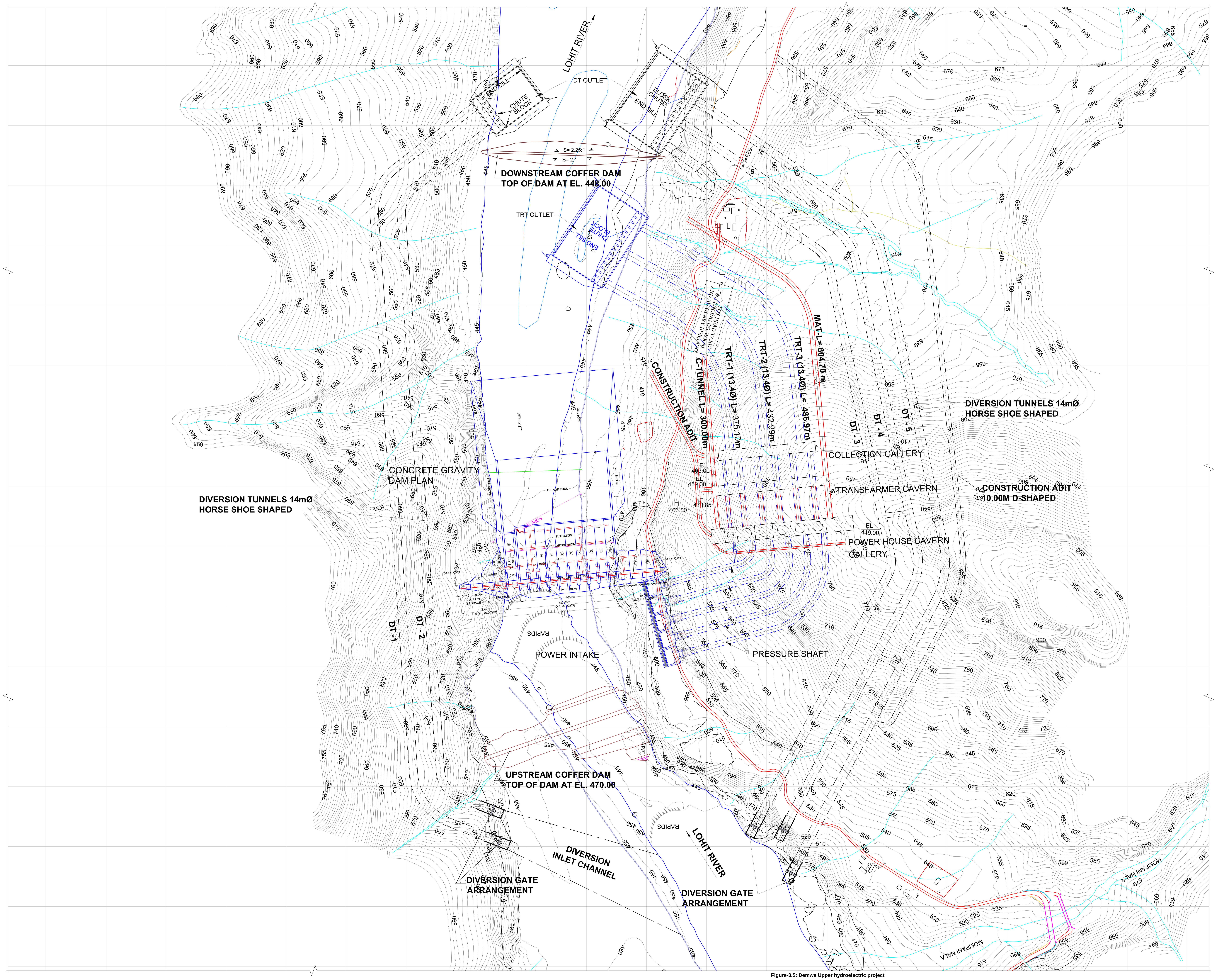


Figure-3.5: Demwe Upper hydroelectric project

NOTES :-

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METER UNLESS SPECIFIED OTHERWISE.
2. THE DIMENSIONS SHALL NOT BE SCALED.THE DESIGNER SHALL BE CONSULTED IN CASE OF ANY MISSING DETAILS IN THE DRAWING.

FOR FEASIBILITY REPORT ONLY

SCALE

0 60 120 180 240m

CLIENT : ATHENA DEMWE POWER LIMITED.

PROJECT : DEMWE UPPER H. E. PROJECT (1050 MW)

CONSULTANTS : ENERGY INFRATECH PRIVATE LIMITED

DRAWING : GENERAL LAYOUT- PLAN

DRAWN : HARPREET	REVIEWED : I.N.AGARWAL
DESIGNED : SOURAV	SUBMITTED : DR. K.K.MENON
INSPECTED BY : I.N.AGARWAL	APPROVED : JAVED MOHSIN
DRAWING NO :	EIPL/DU/FR/03

OCTOBER - 2010

Figure-3.7: Layout of Demwe Lower hydroelectric project

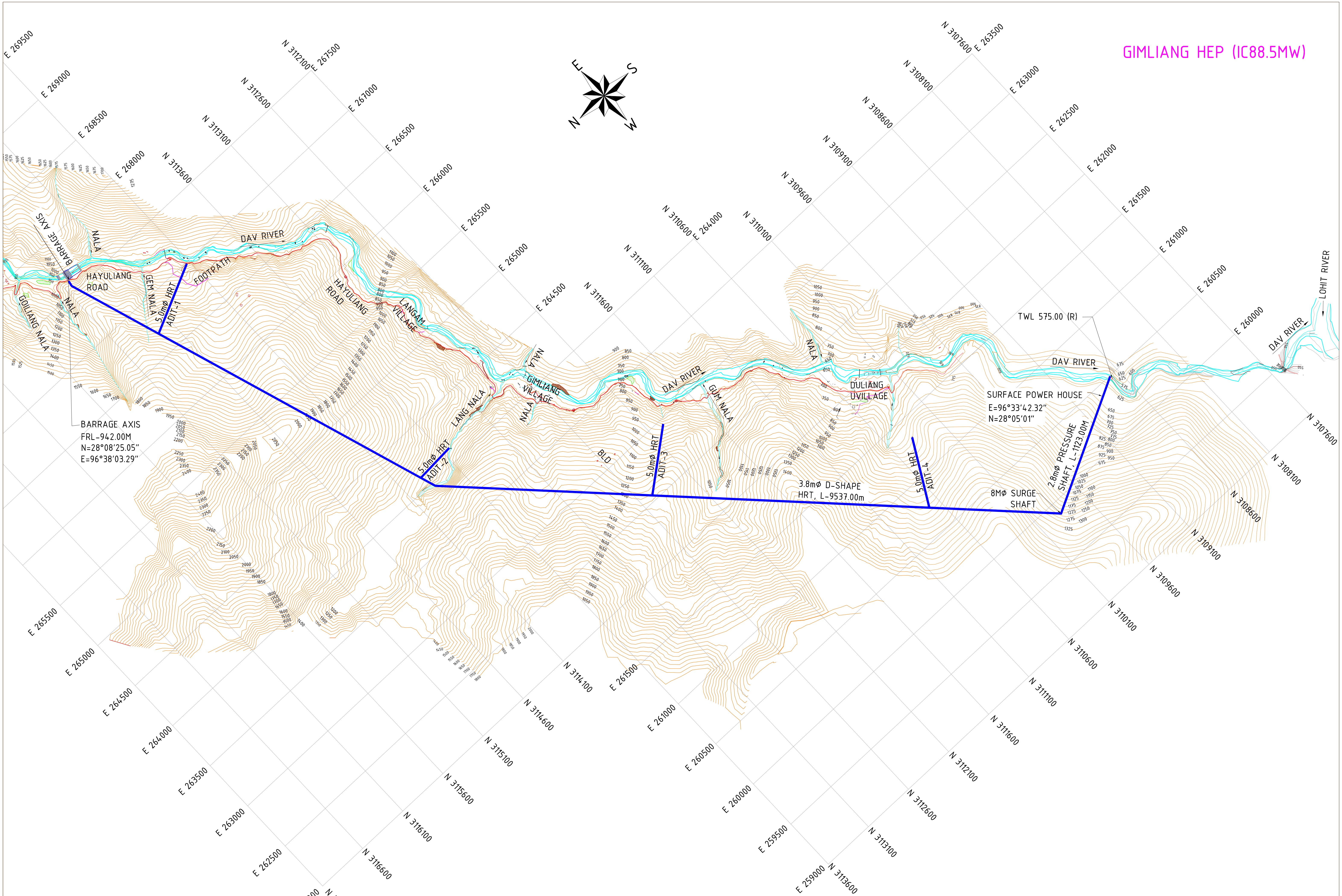


Figure-3.8: Layout of Gimiliang Hydro Electric Project

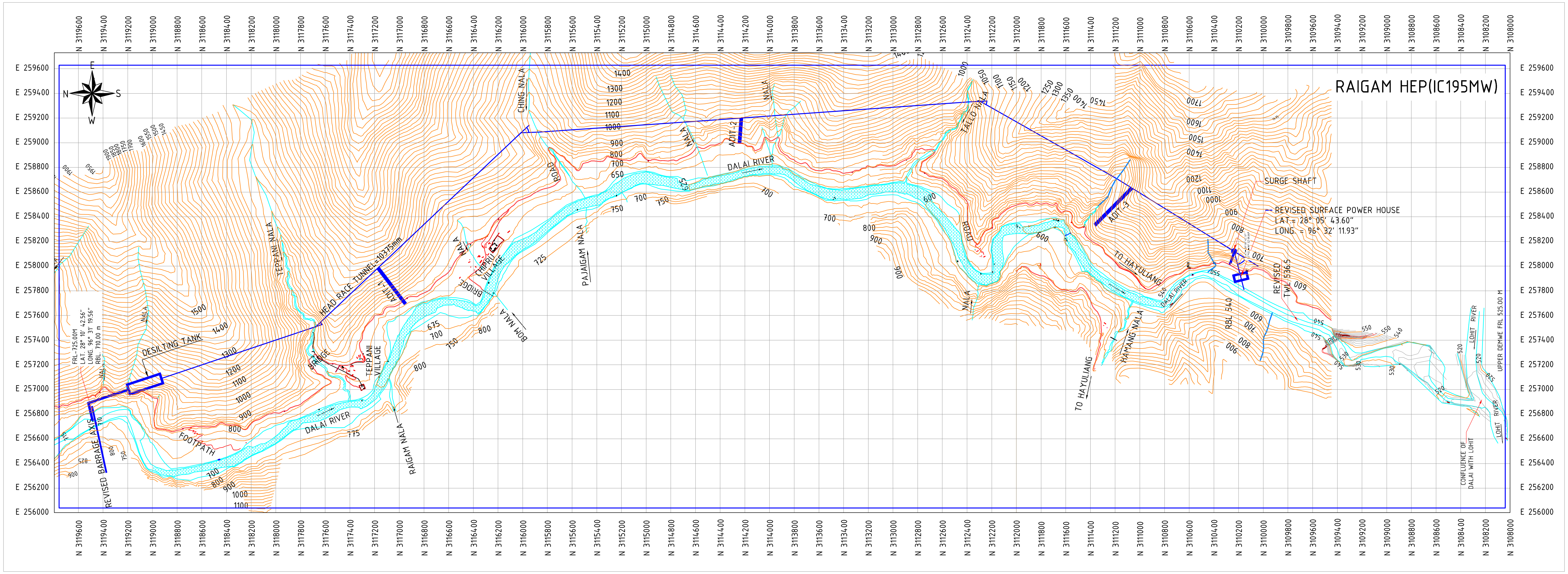


Figure-3.9: Layout of Raigam Hydro Electric Project

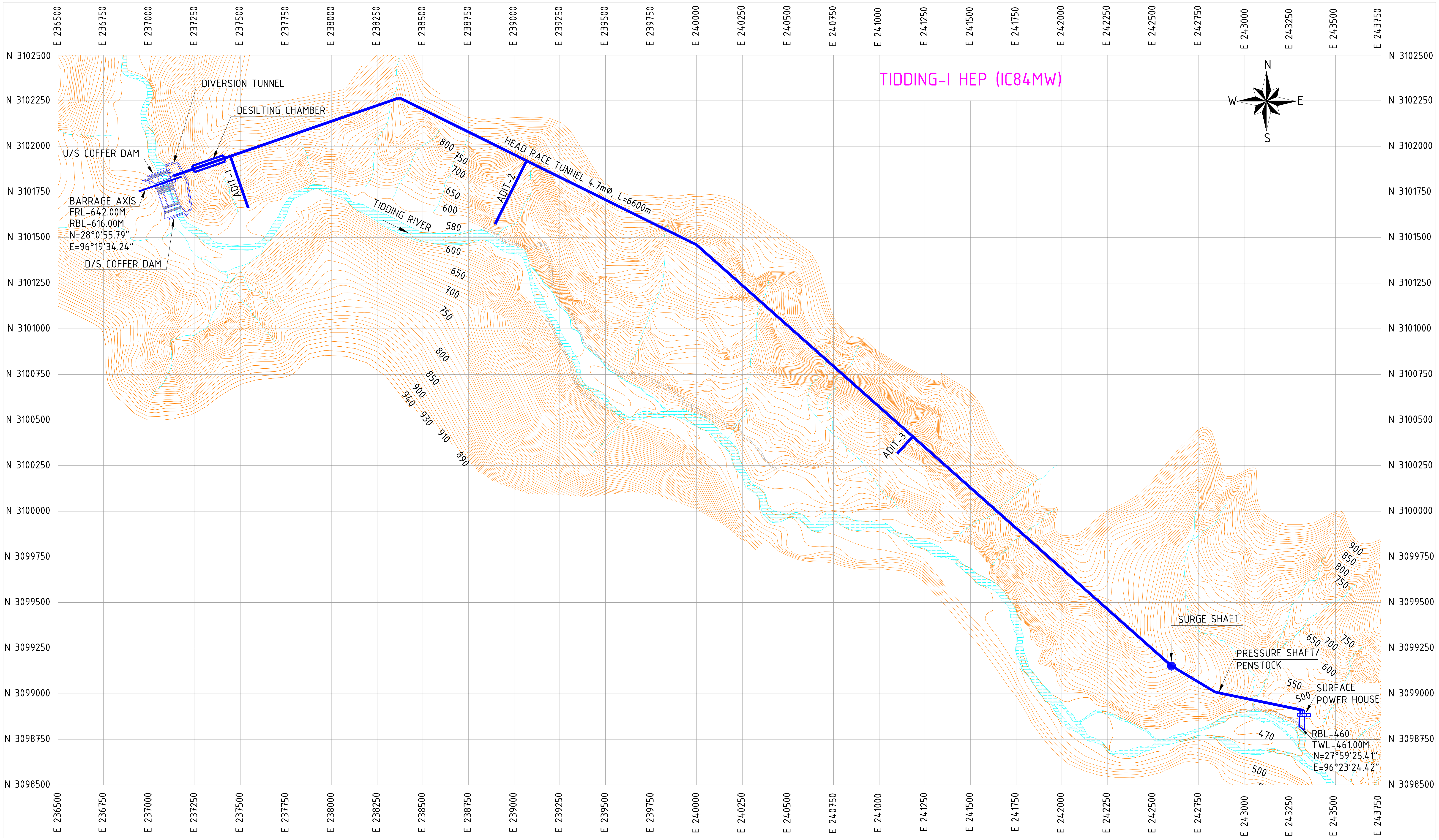


Figure-3.10: Layout of Tidding-I Hydro Electric Project

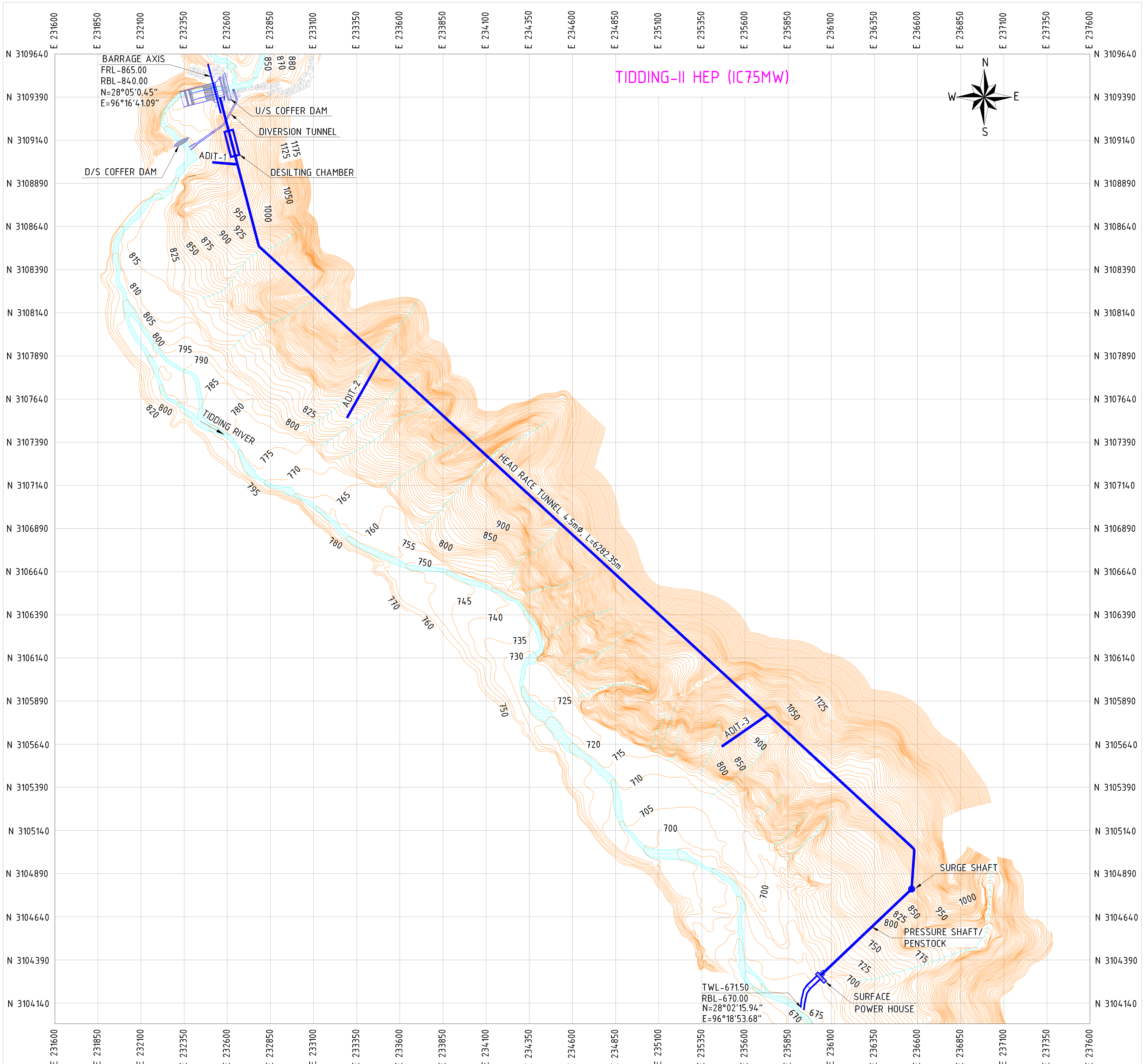
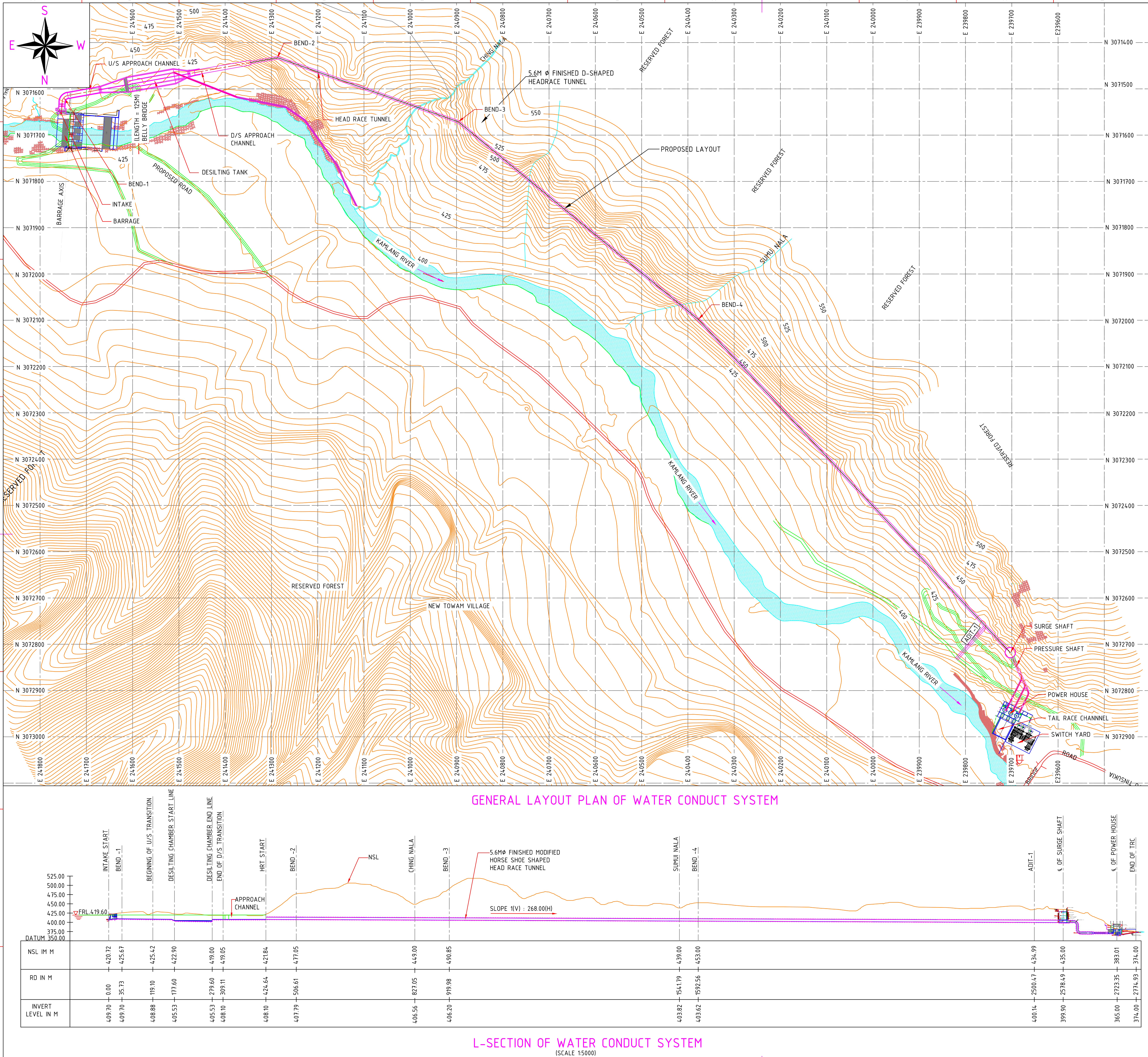


Figure-3.11: Layout of Tidding-II Hydro Electric Project



	INTAKE START	BEND-1	BEGINNING OF U/S TRANSITION	DESILTING CHAMBER START LINE	DESILTING CHAMBER END LINE	END OF D/S TRANSITION	HRT START	BEND-2	CHING NALA	BEND-3	SUMUI NALA	BEND-4	ADIT-1	℄ OF SURGE SHAFT	℄ OF POWER HOUSE	END OF TRC
NSL IM M	420.72	425.67	425.42	422.90	419.00	419.05	421.84	477.05	449.00	490.85	439.00	453.00	434.99	435.00	383.01	374.00
RD IN M	0.00	35.73	119.10	177.60	279.60	309.11	424.64	506.61	827.05	919.98	1541.79	1592.56	2500.47	2578.49	2723.35	2774.93
INVERT LEVEL IN M	409.70	409.70	408.88	405.53	405.53	408.10	408.10	407.79	406.56	406.20	403.82	403.62	400.14	399.90	365.00	374.00

NOTES

1. ALL DIMENSIONS ARE IN MILLIMETERS, CONTOURS, COORDINATES & ELEVATIONS ARE IN METERS, UNLESS OTHERWISE SPECIFIED.
2. DO NOT MEASURE DIMENSIONS ON THE DRAWING, ONLY WRITTEN DIMENSION SHOULD BE FOLLOWED.
3. SLOPE 1 IN 100 SHALL BE MAINTAINED AT THE FLOOR OF SETTLING BASIN TOWARDS SILT COLLECTION CHAMBER BOTH LONGITUDINALLY & TRANSVERSELY.

KAMLANG H.E. PROJECT (24.90MW) SILENT FEATURES

BARRAGE
BARRAGE WIDTH =74.00M
TOP OF BARRAGE EL.424.10M

APPROACH CHANNEL
U/S APPROACH CHANNEL=97.0M
D/S APPROACH CHANNEL=115.54M

DESILTING CHAMBER
LENGTH = 102 WIDTH = 30
U/S TRANSITION=58.5M
D/S TRANSITION=29.05M

HRT
5.6Φ FINISHESD MODIFIED HORSE SHOE
LENGTH = 2167.10M

CONSTRUCTION ADIT
6.0 MΦ D-SHAPED
LENGTH = 95.45M

SURGE SHAFT
21.5MΦ CIRCULAR SHAPE
TOP EL.428.85

PRESSURE SHAFT
4.6MΦ CIRCULAR SHAPE
LENGTH=92.55

UNIT PENSTOCK
NO. OF UNIT PENSTOCK-3.0
DIAMETER OF UNIT PENSTOCK - 2.6M
LENGTH OF PS1/PS2/PS3=63.57/52.35/41.11

SURFACE POWER HOUSE
LENGTH=68.025M, WIDTH=18M, HEIGHT=32.27M,
SERVICE BAY EL. 381.50M

BASED ON DRAWING / DOCUMENTS

DRG./DOCUMENT NO.	SUBJECT

REFERENCE DRAWINGS

DRG. NO.	SUBJECT

SCALE 0 40 100 200 400 M

Autocad release : 2008

DETAILED PROJECT REPORT ONLY

REV. No.	DATE	STAGE	DESCRIPTION	CIVIL	HM	E&M
-	-	-	-	-	-	-
01	31.12.12	DPR	HRT ALIGNMENT CHANGED, DESILTING CHAMBER ADDED AND SURGE SHAFT POSITION CHANGED	-	-	-
				CHECKED		

CLIENT SAI KRISHNODAYA INDUSTRIES (P) LTD.

LAHMEYER INTERNATIONAL INDIA

LAHMEYER INTERNATIONAL (INDIA) PVT. LTD.
CONSULTING ENGINEERS, GURGAON

	NAME	SIGN
DRAWN BY	VNP/NKS	
DESIGNED BY	MGH/SWG	
CHECKED BY	BCJ	
APPROVED BY	AKJ	
DATE:-	20-02-2012	
SHEET SIZE	A1	SCALE 1:4000

PROJECT KAMLANG H.E. PROJECT (3X8.3 MW)

DRAWING TITLE GENERAL LAYOUT PLAN AND L-SECTION OF WATER CONDUCT SYSTEM

DRG NO. 11107-H-20301-A01 | REV. 01 | SHEET 1 OF 1

Figure-3.12: Layout of Kamlang Hydro Electric Project

CHAPTER-4
HYDROLOGY

CHAPTER-4
HYDROLOGY

4.1 INTRODUCTION

The Lohit river basin is the easternmost river basin of India in Arunachal Pradesh with its catchment spreading across international border covering part of Tibet and India. The basin is bounded by China and part of Dibang valley district of Arunachal Pradesh in the north, Changlang district (Burhi Dibang sub basin) in the south, China and hills of Myanmar in the east and Assam state in the west. The Lohit basin is situated between latitude 27˚ 34’ 00” N and 29 36’ 00” N and longitude 95˚ 38’ 00” E and 97˚ 44’ 00” E. Lohit river passes through deep valleys, narrow gorges and deep green lush forest with high hydropower potential. It is a major component of the Brahmaputra river system. It rises from the snow covered peaks in the eastern Tibet at elevation of 6190 m above msl and has a total length of about 413 km from its source in Tibet to its confluence point with Siang/Dihang near Kobo (WAPCOS, 2005).

4.2 REVIEW OF AVAILABLE INFORMATION

The following reports/ documents were reviewed and the data as reported in these reports was used as basis for the present report:

- Preliminary feasibility report for Kalai H.E. Project stage I.
- Detailed Project Report for Kalai H.E. Project stage II.
- Preliminary feasibility report for Hutong H.E. Project stage I (750 MW).
- Preliminary feasibility report for Hutong H.E. Project stage II (1250 MW).
- Pre-feasibility report for Anjaw Hydro Electric Project. Arunachal Pradesh
- Pre-feasibility report for Demwe Upper Electric Project. Arunachal Pradesh
- Detailed Project Report for Demwe Lower Hydro Electric Project.
- Detailed Project Report for Gimliang Hydro Electric Project.
- Detailed Project Report for Raigam Hydro Electric Project.
- Detailed Project Report for Tidding-I Hydro Electric Project.
- Detailed Project Report for Tidding-II Hydro Electric Project.
- Detailed Project Report for Kamlang small Hydro Electric Project.

4.3 DATA AVAILABILITY

The long term gauge & discharge (G&D) observations were collected from two sites: Hayuliang and Mompani. Hayuliang G&D site is located 67 km downstream of Kalai HEP Stage-1 and 18 km downstream from Hutong HEP Stage-2 site. At this site, the observed ten daily flows are available from 1984-85 up to 1994-95 (11 years). Mompani G&D site is located 98 km downstream of Kalai HEP Stage-1 and 49 km downstream from Hutong HEP

Stage-2 site and the observed ten daily flows are available from 1984-85 up to 2002-03 (19 years). The location of proposed project sites along Lohit River and the G&D stations is shown in Figure-4.1. In both G&D stations, data available is “Ten daily data”, with some missing values in different years. The gaps were filled by interpolation from the discharges for the adjacent 10-daily data for the same month. The consistency of data was checked based on double mass curve technique on annual basis. Correlation studies between these two sites and the data was found to be consistent (WAPCOS, 2005).

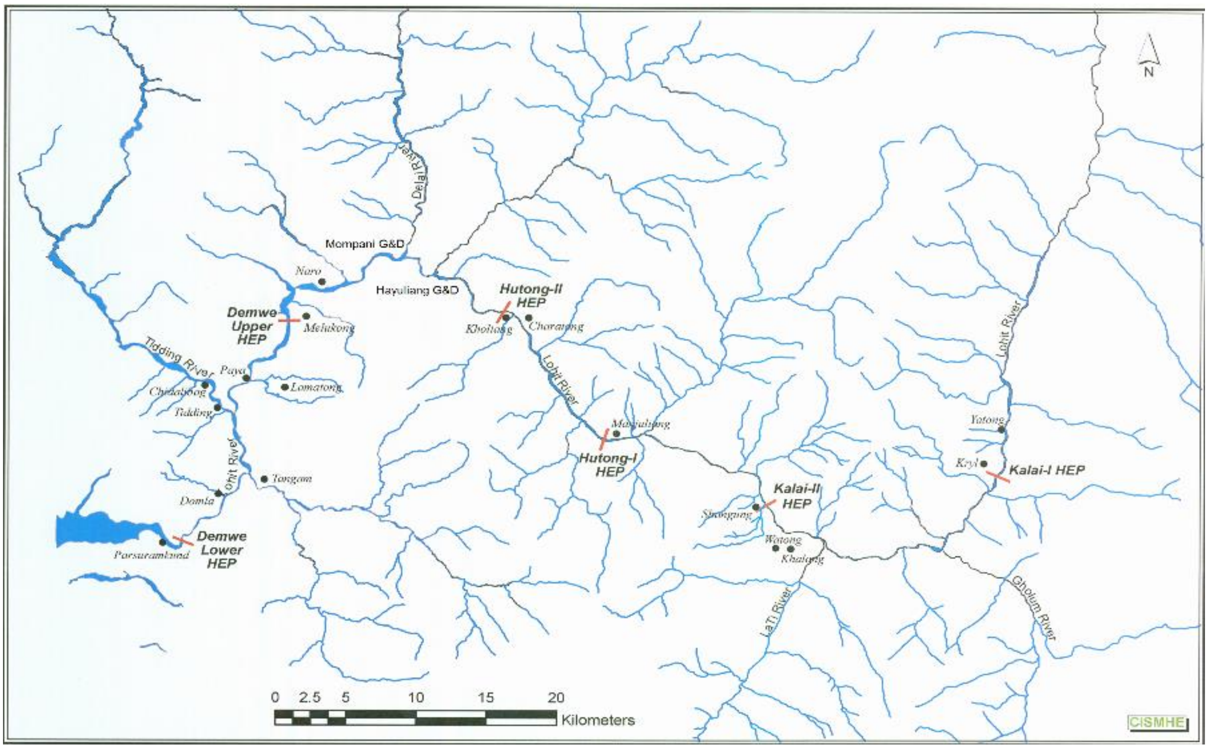


Figure-4.1: Location of proposed project sites along Lohit River and G&D stations

4.4 DATA GENERATION

In order to have stage discharge data at all the sites for a uniform period of time, following interpolations were carried out:

For Discharge data at Kalai & Hutong Projects

Hayuliang G&D station is nearest to these places. However, it has only 11 years (1984-85 to 1994-95) of records. In order to have data for 19 years, a series having the observed data from Hayuliang G & D site and data derived from 1995-96 to 2002-03 using observed data at Mompani G & D site, is prepared. This integrated series is used for preparing series of discharges at Kalai and Hutong projects is shown in Figure-4.2. The series of data for Kalai HEP Stage-1, Kalai HEP Stage-2, Hutong HEP Stage-1 and Hutong HEP Stage-2 are prepared using catchment area-proportion technique from May 1984 to April 2003.

For Discharge data at Demwe Projects

The observed discharge data of Mompani G & D site, which is available from 1984-85 to 2003-04 with some missing months, is used for these projects. For this site, the continuous data available is from 1987-88 to 2003-04 with some interpolated filled up data. In order to estimate the rainfed contribution in Mompani data, snow melt by a rate of 5 mm/day for the period of April to September is subtracted. After this, a new reduction was made to the entire series using a correction factor of 0.8275 in order to take care of the area proportion.

In order to obtain the discharge at Demwe upper project site, snow melt contribution is added to the previously calculated discharge data. The schematic form the process of data generation is enclosed as Figure-4.2.

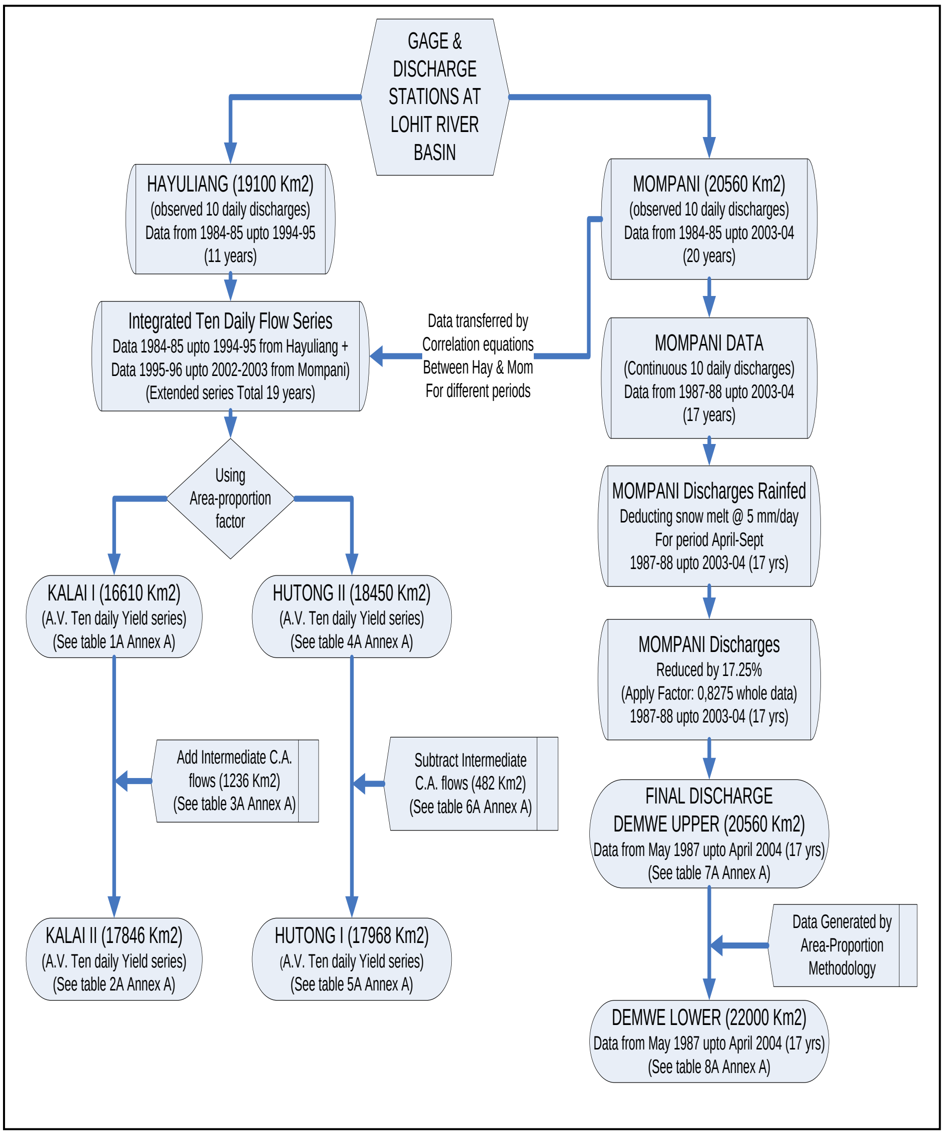


Figure-4.2 Data generation from different sites

4.5 DATA ANALYSIS

Data at different sites do not have the same base years. Hence, data analysis for three different cases was carried out. These are listed in the following paragraphs.

CASE I: Dependable flow analysis using flow series without any arrangement. That means data series with different length of years. For example, Kalai HEP Stage-1, Kalai HEP Stage-2, Hutong HEP Stage-1 and Hutong HEP Stage-2 data for 19 years (instead of 20 as 2003-04 data is not complete) has been used. For Demwe Upper and Demwe Lower Hydroelectric project sites, 17 years data is used.

CASE II: Data series with common years (1987-1988 to 2002-2003) and 16 years only was used.

CASE III: This case consider the data series for 20 years (from 1984-1985 to 2003-2004) in all proposed hydroelectric projects. The series are extended using area-proportion method.

In all three cases, using these 10-daily flow values, following is estimated:

- 10 daily average, maximum, minimum, and corresponding standard deviation values are estimated.
- Annual average (cumec-day) and Annual volume (MCM).
- Total Annual Average discharge in cumec.

The summary of this information for the three cases is given in Tables-4.1 to 4.3 respectively.

Table-4.1: Total Annual Average Discharge at proposed sites (Case I)

Proposed Site	C.A. (km^2)	Total Annual Average Discharge (cumec)	Maximum Discharge (cumec)	Minimum Discharge (cumec)	Standard Deviation of Discharge (cumec)
Kalai HEP Stage-1	16610	967	3603	156	360
Kalai HEP Stage-2	17846	1039	3871	176	386
Hutong HEP Stage-1	17968	1046	3897	169	389
Hutong HEP Stage-2	18450	1074	4002	173	400
Demwe Upper HEP	18947	1176	4070	251	417
Demwe Lower HEP	20174	1234	4273	263	438

Table-4.2: Total Annual Average Discharge at proposed sites(Case II)

Proposed Site	C.A. (km^2)	Total Annual Average Discharge (cumec)	Maximum Discharge (cumec)	Minimum Discharge (cumec)	Standard Deviation of Discharge (cumec)
Kalai HEP Stage-1	16610	1024	3603	156	346
Kalai HEP Stage-2	17846	1100	3871	176	371
Hutong HEP Stage-1	17968	1107	3897	169	374
Hutong HEP Stage-2	18450	1137	4002	173	384
Demwe Upper HEP	18947	1206	4070	251	408
Demwe Lower HEP	20174	1266	4273	263	429

Table-4.3: Total Annual Average Discharge at proposed sites(Case III)

Proposed Site	C.A. (km^2)	Total Annual Average Discharge (cumec)	Maximum Discharge (cumec)	Minimum Discharge (cumec)	Standard Deviation of Discharge (cumec)
Kalai HEP Stage-1	16610	947	3603	156	363
Kalai HEP Stage-2	17846	1017	3871	176	390
Hutong HEP Stage-1	17968	1024	3897	169	393
Hutong HEP Stage-2	18450	1051	4002	173	404
Demwe Upper HEP	18947	1122	4070	239	425
Demwe Lower HEP	20174	1180	4273	254	445

4.6 DEPENDABILITY OF FLOW

Further, in order to know the dependability of flow, the following exercises were carried out for the three cases being studied as a part of the study:

- 90% dependability year among corresponding years.
- 90% dependable flow from 90% dependable year.
- Flow duration curve with the original data series for each proposed site

4.6.1 CASE-I: Dependable flow analysis using flow series without any arrangement

The Dependability years for Case-I for Kalai HEP Stage-1 and Stage-2 are given in Table-4.4.

Table-4.4: Dependability year for Kalai HEP Stage-1 and Stage-2 (Case I)

Rank	Year	Calcs for 90% Dependable year Kalai I		Calcs for 90% Dependable year Kalai II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	423	95	455	95
2	2002-03	553	90	594	90
3	1992-93	701	85	753	85
4	1984-85	759	80	816	80
5	1985-86	812	75	872	75
6	2001-02	812	70	872	70
7	1994-95	885	65	951	65
8	1987-88	934	60	1003	60
9	1990-91	964	55	1036	55
10	1989-90	967	50	1039	50
11	1991-92	1023	45	1099	45
12	1993-94	1034	40	1111	40
13	1995-96	1091	35	1172	35
14	1999-00	1151	30	1237	30
15	1988-89	1185	25	1273	25
16	1998-99	1189	20	1278	20
17	2000-01	1239	15	1331	15
18	1997-98	1285	10	1380	10
19	1996-97	1368	5	1470	5

The Dependability years for Case-I for Hutong HEP Stage-1 and Stage-2 are given in Table-4.5.

Table-4.5: Dependability year for Hutong HEP Stage-1 and Stage-2 (Case I)

Rank	Year	Calcs for 90% Dependable year Hutong I		Calcs for 90% Dependable year Hutong II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	458	95	470	95
2	2002-03	598	90	615	90
3	1992-93	758	85	778	85
4	1984-85	821	80	843	80
5	1985-86	878	75	902	75
6	2001-02	878	70	902	70
7	1994-95	958	65	983	65
8	1987-88	1010	60	1037	60
9	1990-91	1043	55	1071	55
10	1989-90	1046	50	1074	50
11	1991-92	1107	45	1136	45
12	1993-94	1119	40	1149	40
13	1995-96	1180	35	1212	35
14	1999-00	1246	30	1279	30
15	1988-89	1282	25	1316	25
16	1998-99	1287	20	1321	20
17	2000-01	1340	15	1376	15
18	1997-98	1390	10	1427	10
19	1996-97	1479	5	1519	5

The Dependability years for Case-I for Demwe Upper HEP and Demwe Lower HEP are given in Table-4.6.

Table-4.6: Dependability year for Demwe Upper HEP and Lower HEP (Case I)

Rank	Year	Calcs for 90% Dependable year Demwe Upper		Calcs for 90% Dependable year Demwe Lower	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	2002-03	666	94.44	699	94.44
2	2003-04	689	88.89	724	88.89
3	1994-95	846	83.33	888	83.33
4	1992-93	942	77.78	989	77.78
5	2001-02	960	72.22	1008	72.22
6	1987-88	1071	66.67	1125	66.67
7	1989-90	1141	61.11	1198	61.11
8	1995-96	1159	55.56	1217	55.56
9	1993-94	1160	50.00	1218	50.00
10	1990-91	1245	44.44	1307	44.44
11	1988-89	1360	38.89	1428	38.89

Rank	Year	Calcs for 90% Dependable year Demwe Upper		Calcs for 90% Dependable year Demwe Lower	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
12	1991-92	1365	33.33	1433	33.33
13	1999-00	1368	27.78	1437	27.78
14	2000-01	1441	22.22	1513	22.22
15	1998-99	1445	16.67	1518	16.67
16	1997-98	1504	11.11	1579	11.11
17	1996-97	1622	5.56	1703	5.56

The summary of Dependability years for Case-I for the six hydroelectric projects in the study area are given in Table-4.7.

Table-4.7: Different flow dependability at each proposed site for Case-I

Proposed Site	Flow for different dependability (cumec)		
	90 %	75 %	50 %
Kalai HEP Stage-1	301	401	693
Kalai HEP Stage-2	323	430	744
Hutong HEP Stage-1	325	433	753
Hutong HEP Stage-2	334	445	770
Demwe Upper HEP	371	512	918
Demwe Lower HEP	389	537	964

4.6.2 CASE II: Data series with common years (1987-1988 to 2002-2003)

The Dependability years for Case-II for Kalai HEP Stage-1 and Stage-2 are given in Table-4.8.

Table-4.8: Dependability year for Kalai HEP Stage-1 and Stage-2 (Case -II)

Rank	Year	Calcs for 90% Dependable year Kalai I		Calcs for 90% Dependable year Kalai II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	2002-03	553	94.12	594	94.12
2	1992-93	701	88.24	753	88.24
3	2001-02	812	82.35	872	82.35
4	1994-95	885	76.47	951	76.47
5	1987-88	934	70.59	1003	70.59
6	1990-91	964	64.71	1036	64.71
7	1989-90	967	58.82	1039	58.82
8	1991-92	1023	52.94	1099	52.94
9	1993-94	1034	47.06	1111	47.06
10	1995-96	1091	41.16	1172	41.16
11	1999-00	1151	35.29	1237	35.29
12	1988-89	1185	29.41	1273	29.41
13	1998-99	1189	23.53	1278	23.53

Rank	Year	Calcs for 90% Dependable year Kalai I		Calcs for 90% Dependable year Kalai II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
14	2000-01	1239	17.65	1331	17.65
15	1997-98	1285	11.76	1380	11.76
16	1996-97	1368	5.88	1470	5.88

The Dependability years for Case-II for Hutong HEP Stage-1 and Stage-2 are given in Table-4.9.

Table-4.9:Dependability year for Hutong HEP Stage-1 and Stage-2 (Case -II)

Rank	Year	Calcs for 90% Dependable year Hutong I		Calcs for 90% Dependable year Hutong II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	2002-03	598	94.12	615	94.12
2	1992-93	758	88.24	778	88.24
3	2001-02	878	82.35	902	82.35
4	1994-95	958	76.47	983	76.47
5	1987-88	1010	70.59	1037	70.59
6	1990-91	1043	64.71	1071	64.71
7	1989-90	1046	58.82	1074	58.82
8	1991-92	1107	52.94	1136	52.94
9	1993-94	1119	47.06	1149	47.06
10	1995-96	1180	41.16	1212	41.16
11	1999-00	1246	35.29	1279	35.29
12	1988-89	1282	29.41	1316	29.41
13	1998-99	1287	23.53	1321	23.53
14	2000-01	1340	17.65	1376	17.65
15	1997-98	1390	11.76	1427	11.76
16	1996-97	1479	5.88	1519	5.88

The Dependability years for Case-II for Demwe Upper HEP and Demwe Lower HEP are given in Table-4.10.

Table-4.10: Dependability year for Demwe Upper HEP and Lower HEP (Case-II)

Rank	Year	Calcs for 90% Dependable year Demwe Upper		Calcs for 90% Dependable year Demwe Lower	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	2002-03	666	94.12	699	94.12
2	1994-95	846	88.24	888	88.24
3	1992-93	942	82.35	989	82.35
4	2001-02	960	76.47	1008	76.47
5	1987-88	1071	70.59	1125	70.59

Rank	Year	Calcs for 90% Dependable year Demwe Upper		Calcs for 90% Dependable year Demwe Lower	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
6	1989-90	1141	64.71	1198	64.71
7	1995-96	1159	58.82	1217	58.82
8	1993-94	1160	52.94	1218	52.94
9	1990-91	1245	47.06	1307	47.06
10	1988-89	1360	41.16	1428	41.16
11	1991-92	1365	35.29	1433	35.29
12	1999-00	1368	29.41	1437	29.41
13	2000-01	1441	23.53	1518	23.53
14	1998-99	1445	17.65	1579	17.65
15	1997-98	1504	11.76	1579	11.76
16	1996-97	1622	5.88	1703	5.88

The summary of Dependability years for Case-II for the six hydroelectric projects in the study area are given in Table-4.11.

Table-4.11: Different flow dependability at each proposed site (Case II)

Proposed Site	Flow for different dependability (cumec)		
	90 %	75 %	50 %
Kalai HEP Stage-1	317	413	776
Kalai HEP Stage-2	340	443	819
Hutong HEP Stage-1	343	446	839
Hutong HEP Stage-2	352	458	862
Demwe Upper HEP	378	518	981
Demwe Lower HEP	397	544	1030

4.6.3 CASE-III: data series for 20 years (from 1984-1985 to 2003- 2004)

The Dependability years for Case-III for Kalai HEP Stage-1 and Stage-2 are given in Table-4.12.

Table-4.12: Dependability year at Kalai sites (Case III)

Rank	Year	Calcs for 90% Dependable year Kalai I		Calcs for 90% Dependable year Kalai II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	423	95.24	455	95.24
2	2002-03	553	90.48	594	90.48
3	2003-04	557	85.71	598	85.71
4	1992-93	701	80.96	753	80.96
5	1984-85	759	76.19	816	76.19
6	1985-86	812	71.43	872	71.43
7	2001-02	812	66.69	872	66.69

Rank	Year	Calcs for 90% Dependable year Kalai I		Calcs for 90% Dependable year Kalai II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
8	1994-95	885	61.90	951	61.90
9	1987-88	934	57.14	1003	57.14
10	1990-91	964	52.38	1036	52.38
11	1989-90	967	47.62	1039	47.62
12	1991-92	1023	42.86	1099	42.86
13	1993-94	1034	38.10	1111	38.10
14	1995-96	1091	33.33	1172	33.33
15	1999-00	1151	28.57	1237	28.57
16	1988-89	1185	23.81	1273	23.81
17	1998-99	1189	19.05	1278	19.05
18	2000-01	1239	14.28	1331	14.28
19	1997-98	1285	9.52	1380	9.52
20	1996-97	1368	4.76	1470	4.76

The Dependability years for Case-III for Hutong HEP Stage-1 and Stage-2 are given in Table-4.13.

Table-4.13: Dependability year at Hutong sites (Case III)

Rank	Year	Calcs for 90% Dependable year Hutong I		Calcs for 90% Dependable year Hutong II	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	458	95.24	470	95.24
2	2002-03	598	90.48	615	90.48
3	2003-04	602	85.71	618	85.71
4	1992-93	758	80.96	778	80.96
5	1984-85	821	76.19	843	76.19
6	1985-86	878	71.43	902	71.43
7	2001-02	878	66.69	902	66.69
8	1994-95	958	61.90	983	61.90
9	1987-88	1010	57.14	1037	57.14
10	1990-91	1043	52.38	1071	52.38
11	1989-90	1046	47.62	1074	47.62
12	1991-92	1107	42.86	1136	42.86
13	1993-94	1119	38.10	1149	38.10
14	1995-96	1180	33.33	1212	33.33
15	1999-00	1246	28.57	1279	28.57
16	1988-89	1282	23.81	1316	23.81
17	1998-99	1287	19.05	1321	19.05
18	2000-01	1340	14.28	1376	14.28
19	1997-98	1390	9.52	1427	9.52
20	1996-97	1479	4.76	1519	4.76

The Dependability years for Case-II for Demwe Upper HEP and Demwe Lower HEP are given in Table-4.14.

Table-4.14: Dependability year for Demwe Upper HEP and Lower HEP (Case-III)

Rank	Year	Calcs for 90% Dependable year Demwe Upper		Calcs for 90% Dependable year Demwe Lower	
		A.V.Discharge (cumec)	% Time	A.V.Discharge (cumec)	% Time
1	1986-87	524	95.24	558	95.24
2	2002-03	666	90.48	699	90.48
3	2003-04	689	85.71	724	85.71
4	1994-95	846	80.96	888	80.96
5	1984-85	940	76.19	989	76.19
6	1992-93	942	71.43	996	71.43
7	2001-02	960	66.69	1008	66.69
8	1985-86	1000	61.90	1065	61.90
9	1987-88	1071	57.14	1125	57.14
10	1989-90	1141	52.38	1198	52.38
11	1995-96	1159	47.62	1217	47.62
12	1993-94	1160	42.86	1218	42.86
13	1990-91	1245	38.10	1307	38.10
14	1988-89	1360	33.33	1428	33.33
15	1991-92	1365	28.57	1433	28.57
16	1999-00	1368	23.81	1437	23.81
17	2000-01	1441	19.05	1513	19.05
18	1998-99	1445	14.28	1518	14.28
19	1997-98	1504	9.52	1579	9.52
20	1996-97	1622	4.76	1703	4.76

The summary of Dependability years for Case-II for the six hydroelectric projects in the study area are given in Table-4.15.

Table-4.15: Different flow dependability at each proposed site (Case III) considering all years (1984-85 to 2003-04)

Proposed Site	Flow for different dependability (cumec)		
	90 %	75 %	50 %
Kalai HEP Stage-1	297	393	659
Kalai HEP Stage-2	319	422	708
Hutong HEP Stage-1	322	425	713
Hutong HEP Stage-2	330	437	732
Demwe Upper HEP	355	487	817
Demwe Lower HEP	373	511	860

4.7 SUMMARY OF ANALYSIS

The summary of annual average flow (considering total years) for all the three cases is shown in Table-4.16.

Table-4.16: Annual Average Flow (AAF), Q_{90}, Q_{75}, Q_{50} (based on 1984-85 to 2003-04) for Proposed Sites

Site	CASE I				CASE II				CASE III			
	AAF	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$	AAF	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$	AAF	$Q_{90\%}$	$Q_{75\%}$	$Q_{50\%}$
Kalai HEP Stage-1	967	301	401	693	1024	317	413	776	947	297	393	659
Kalai HEP Stage-2	1039	323	430	744	1100	340	443	819	1017	319	422	708
Hutong HEP Stage-1	1046	325	433	753	1107	343	446	839	1024	322	425	713
Hutong HEP Stage-2	1074	334	445	770	1137	352	458	862	1051	330	437	732
Demwe Upper HEP	1176	371	512	918	1206	378	518	981	1122	355	487	817
Demwe Lower HEP	1234	389	537	964	1266	397	544	1030	1180	373	511	860

Note: All values are in cumec.

It may be observed that in all the three cases of analysis, the total annual flow is increasing with increasing basin area. That means the recorded data has a logic sequence. The values of annual average flow are of same order in cases I & III. Also, values of Q_{90}, Q_{75} and Q_{50} from Flow Duration Curve (FDC) are similar in these two cases (Table-4.16). The higher value of AAF occurs in case II, where only 16 years of data is considered (from 1987-1988 upto 2002-2003). After observing the original data, it is seen that years corresponding to 1986-87 and 2003-04 are very dry years, and these years are excluded in case II, that is why the average values are greater in this case.

4.8 DEPENDABILITY YEAR

From hydropower development point of view, the availability of water for a given percentage of time is important. Generally, 90 % dependable flow of 90% dependable year is considered for reliable power production. The analysis has been carried out to estimate the 90% dependable flow for 90 % dependable year for all the three cases and is shown in Table-4.17.

Table-4.17: 90 % Dependable Year, AAF, and $Q_{90\%}$ for different proposed sites

Site	CASE-I			CASE-II			CASE-III		
	90% Dep Yr	AAF	Q90	90% Dep Yr	AAF	Q90	90% Dep Yr	AAF	Q90
Kalai HEP Stage-1	2002-03	553	297	1992-93	701	187	2003-04	557	258
Kalai HEP Stage-2	2002-03	594	319	1992-93	753	201	2003-04	598	278
Hutong HEP Stage-1	2002-03	598	322	1992-93	758	202	2003-04	602	279
Hutong HEP Stage-2	2002-03	615	330	1992-93	778	208	2003-04	618	287
Demwe Upper HEP	2003-04	689	320	1994-95	846	338	2002-03	666	338
Demwe Lower HEP	2003-04	724	336	1994-95	888	355	2002-03	699	355

It may be noticed that the dependability year is changing depending of the case of analysis and also change with site. For example, in case I, the 90% dependable year corresponds to 2002-03 in Kalai & Hutong sites, but in Demwe, it is corresponding to 2003-04. In case II, the 90% dependable year corresponds to 1992-93 in Kalai & Hutong sites, but in Demwe, it is corresponding to 1994-95. For case III, the 90% dependable year corresponds to 2002-03 for Upper Demwe and Lower Demwe hydroelectric projects and 2003-04 for other four projects being considered as a part of the study. For 75% dependability, the year is 1985-86 for Kalai I & II, Hutong I & II. However for Demwe upper it is 1992-93 and for Demwe Lower it is 1984-85. Further, it may be noticed that 50% dependable year in all cases is 1996-97. The tables 4.12 to 4.14 show the corresponding Average Annual Flows.

As case III takes in to account data for larger duration, it is considered as representative for further analysis. The Average Annual flow on the basis of all years flow, dependable year, Average Annual Flow, and corresponding 90 % dependable flow for 90 % dependable year for various sites for this case is shown in Table 4.18.

Table-4.18: AAF, 90 % dependable flow ($Q_{90\%}$) for 90 % dependable year, and AAF for 90% and 50 % dependable years

Site	Av. Annual Flow (1984-85 to 2003-04)	90 % dependable year	90 % dependable Flow ($Q_{90\%}$) (2003-04)	Av. Annual Flow for 90 % dependable year (2003-04)	Av. Annual Flow for 50 % dependable year (1996-97)
Kalai HEP Stage-1	947	2003-04	258	557	1368
Kalai HEP Stage-2	1017	2003-04	278	598	1470
Hutong HEP Stage-1	1024	2003-04	279	602	1479
Hutong HEP Stage-2	1051	2003-04	287	618	1519
Demwe	1122	2002-03	338	666	1141

Site	Av. Annual Flow (1984-85 to 2003-04)	90 % dependable year	90 % dependable Flow ($Q_{90\%}$) (2003-04)	Av. Annual Flow for 90 % dependable year (2003-04)	Av. Annual Flow for 50 % dependable year (1996-97)
Upper HEP					
Demwe Lower HEP	1180	2002-03	355	699	1198

4.9 FLOW DURATION CURVES

The Flow Duration Curves for total data in case III (1984-85 upto 2003-04) and for 90% dependable year (2003-04) for all the six proposed sites in Lohit river basin are shown in Figures 4.3 to 4.8 respectively. The summary of flow duration curve data for various hydroelectric projects is given in Tables-4.19 to 4.24.

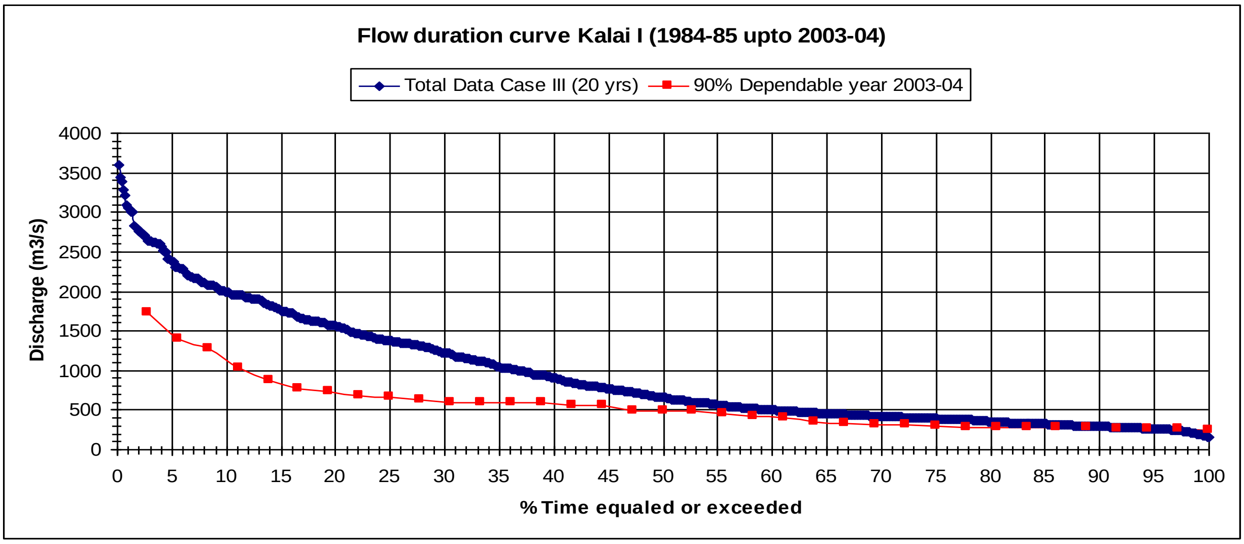


Figure -4.3: Flow Duration Curve at Kalai HEP Satge-1 with Total Data Case III and 90% Dependable year

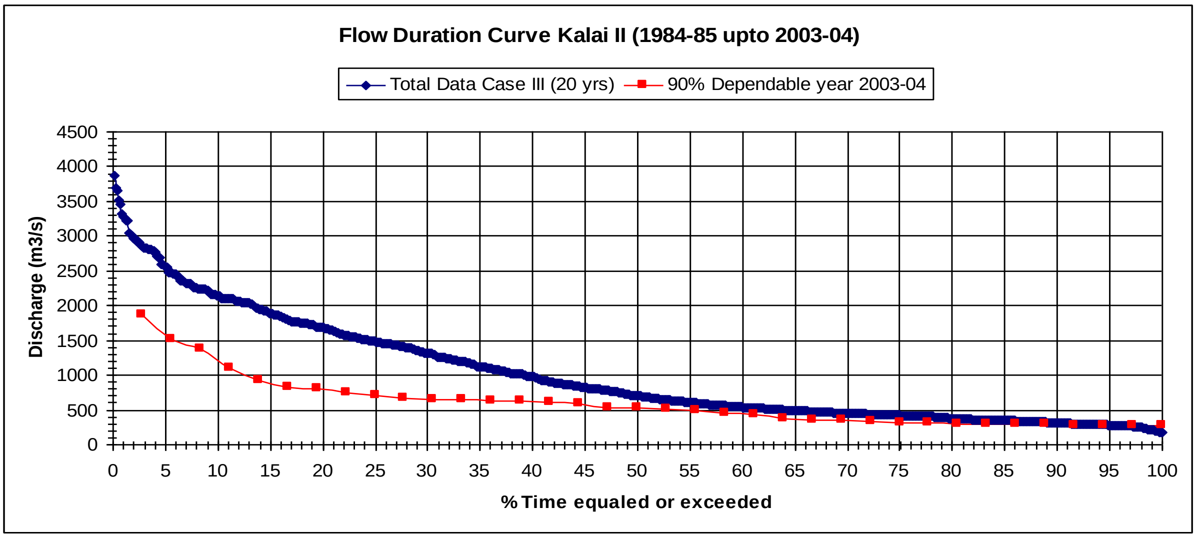


Figure-4.4 Flow Duration Curve at Kalai HEP Stage-2 with Total Data Case III and 90% Dependable year

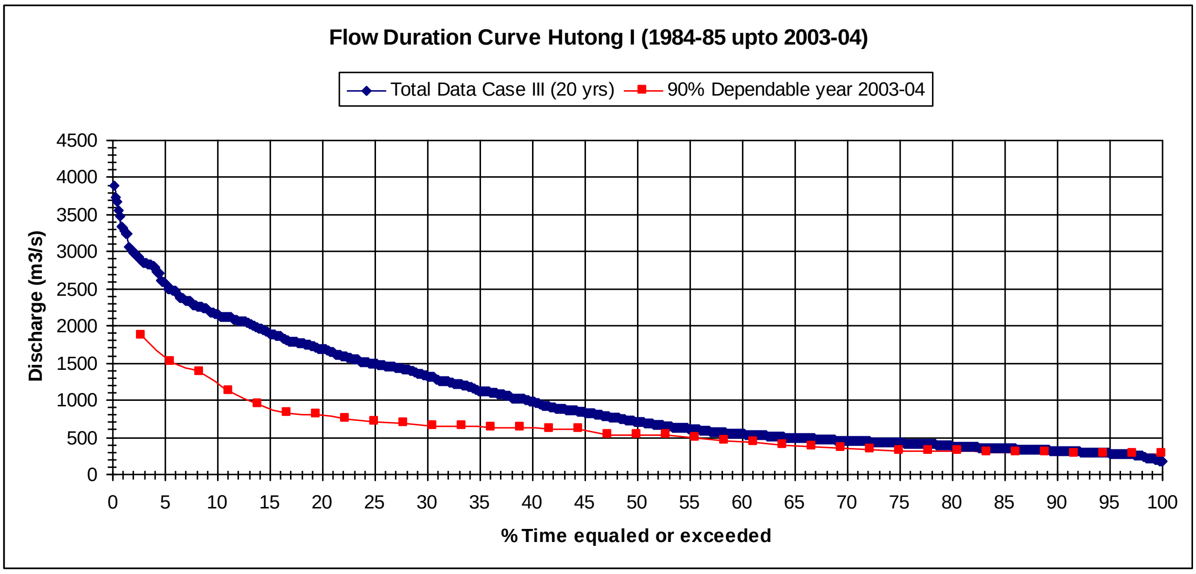


Figure-4.5 Flow Duration Curve at Hutong HEP Satge-1 with Total Data Case III and 90% Dependable year

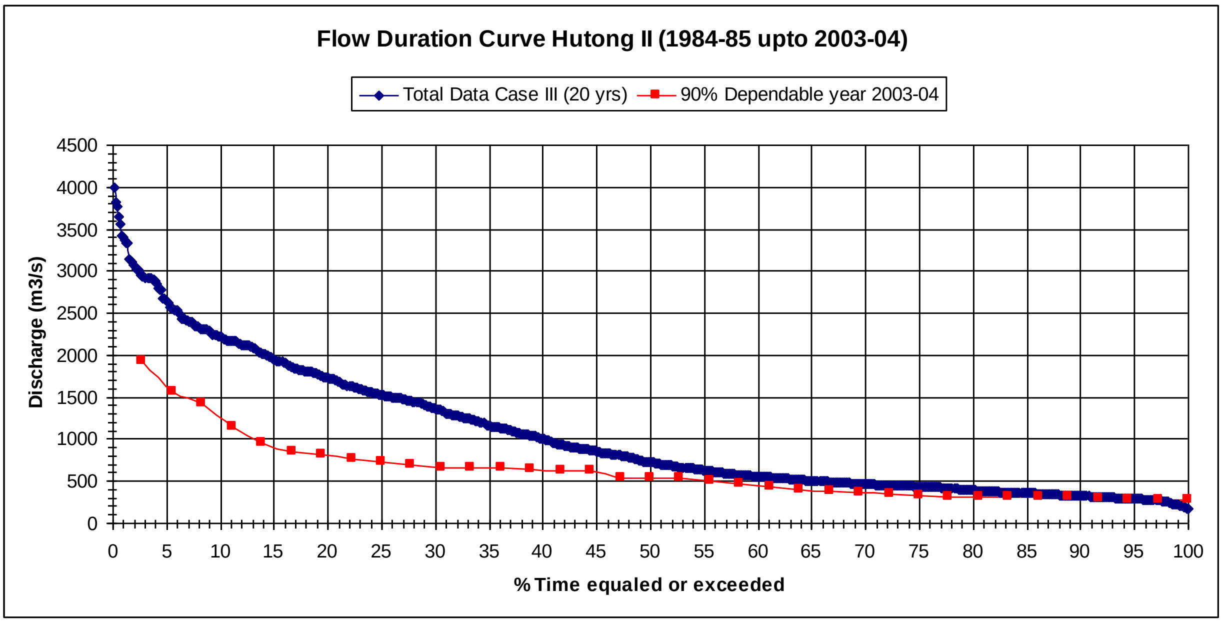


Figure-4.6 Flow Duration Curve at Hutong HEP Stage-2 with Total Data Case III and 90% Dependable year

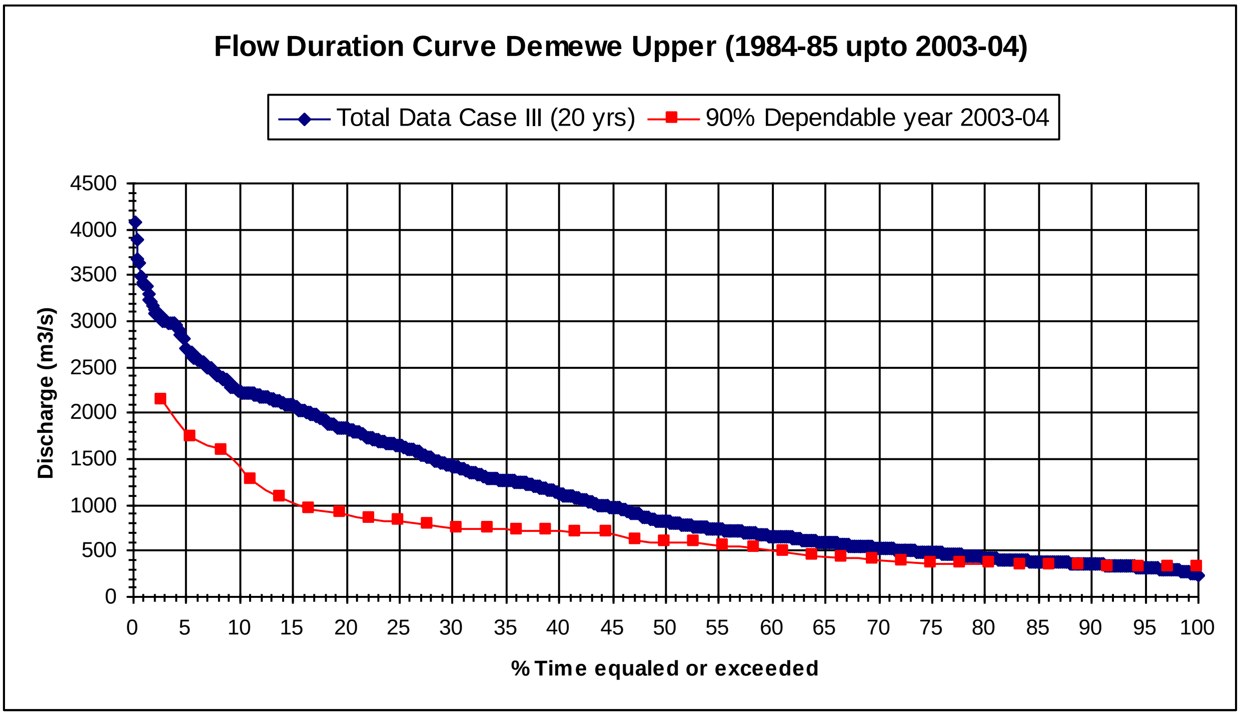


Figure-4.7 Flow Duration Curve at Demwe Upper HEP with Total Data Case III and 90% Dependable year

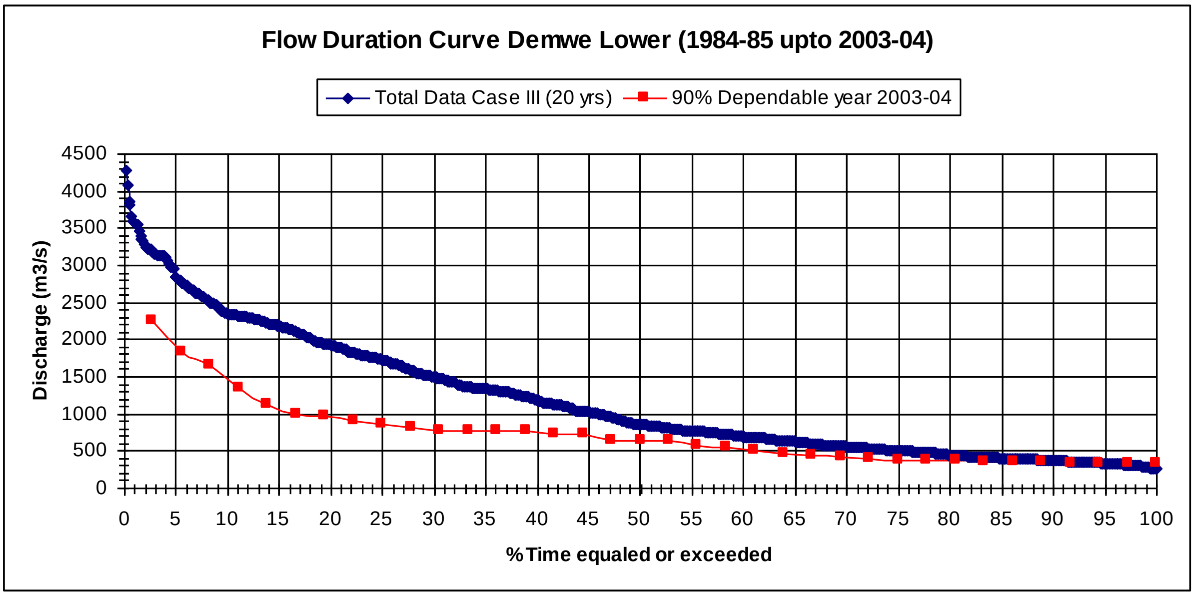


Figure-4.8 Flow Duration Curve at Demwe Lower HEP with Total Data Case III and 90% Dependable year

Table-4.19: Summary Flow Duration Curve data for Kalai-HEP Stage-1

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	659	486
Q75	393	295
Q90	297	258
Q95	263	254
Q98	231	254
Q100	156	250

Table -4.20: Summary Flow Duration Curve data for Kalai-HEP Stage-2

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	714	522
Q75	422	317
Q90	320	278
Q95	283	273
Q98	248	272
Q100	176	269

Table -4.21: Summary Flow Duration Curve data for Hutong-HEP Stage-1

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	711	525
Q75	424	319
Q90	322	279
Q95	285	275
Q98	250	274
Q100	169	271

Table -4.22: Summary Flow Duration Curve data for Hutong-HEP Stage-2

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	732	539
Q75	437	327
Q90	330	287
Q95	293	282
Q98	257	282
Q100	173	278

Table -4.23:Summary Flow Duration Curve data for Demwe Upper HEP

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	817	601
Q75	487	365
Q90	355	320
Q95	316	315
Q98	286	314
Q100	239	310

Table -4.24:Summary Flow Duration Curve data for Demwe Lower HEP

% Dependability	Case III (cumec)	2003-04 (cumec)
Q50	810	631
Q75	511	383
Q90	373	336
Q95	336	330
Q98	300	330
Q100	254	325

4.10 ANJAW HYDROELECTRIC PROJECT

The 10 daily flow series for 90% dependable year (2002-03) as per the discharge series approved by CWC is given in Table-4.25.

Table-4.25: 10 daily discharges for 90% dependable year for Anjaw HEP

Month		Discharge (cumec)
June	I	696
	II	805
	III	788
July	I	809
	II	1157
	III	1238
August	I	877
	II	879
	III	579
September	I	484
	II	444
	III	1022
October	I	765

Month		**Discharge (cumec)**
	II	431
	III	394
November	I	403
	II	375
	III	346
December	I	332
	II	320
	III	305
January	I	291
	II	271
	III	283
February	I	288
	II	290
	III	292
March	I	284
	II	321
	III	312
April	I	360
	II	376
	III	388
May	I	506
	II	773
	III	797

4.11 GIMLIANG HYDRO ELECTRIC PROJECT

The catchment area of the Dav River up to the proposed barrage site is 371.46 km^2. The agriculture mainly depends on monsoon rainfall.

4.11.1 River Characteristics

Dav is a major right bank tributary of Lohit River, originating at an elevation of about 3330m and passes near Lanchomk, khaliong, Glotongla, Chirangla, Nilonglat and Tamlovagam town, reaching an elevation of 931m at the proposed barrage site. It is snow fed and rain fed streams. The river Davoriginates from morainic landform and passes through dense pine forests in its higher reaches. Both the left and right bank slopes of Dav River are covered with settlement and cultivable terraces below 1000 m elevation. It is fed by streams TataiNala, AppauNala, ChangaiNala, Tsai Nala, BringkoNala, AnagongNala, TapangNala, Long Nala, NarangdakungNala, Kanda Nala Gam Nala and Machu Nala from the right and Thushi River, AniyolNala, KasangNala, Brei River, YatNala, HaliNala and ChiprongNala from the left. The river network is trellis type and its tributaries are sub-parallel in nature which shows presence of structural control and flows the geomorphological trends of the hills and mountains. In the hilly terrain, the river have deep gorge along their courses. The total length of the river up to the Barrage site is 34 km and the statistical mean slope is 70 m/km. The bed level of Dav River at proposed Barrage site of Gimliang Hydroelectric Project is 934m.

4.11.2 Catchment Area

The catchment area up to the proposed Barrage site. The catchment is more or less Fan-shaped having a length of 23 km and a width of 19 km and spread between Latitudes 28° 4' 49.11" and 28° 17' 10.97" N and Longitudes 96° 35' 44.52" and 96° 53' 7.98" E. The highest elevation in the catchment is 4698m. Catchment area has been furnished in Figure-4.9,which also shows the distribution of catchment area under different elevation zones.

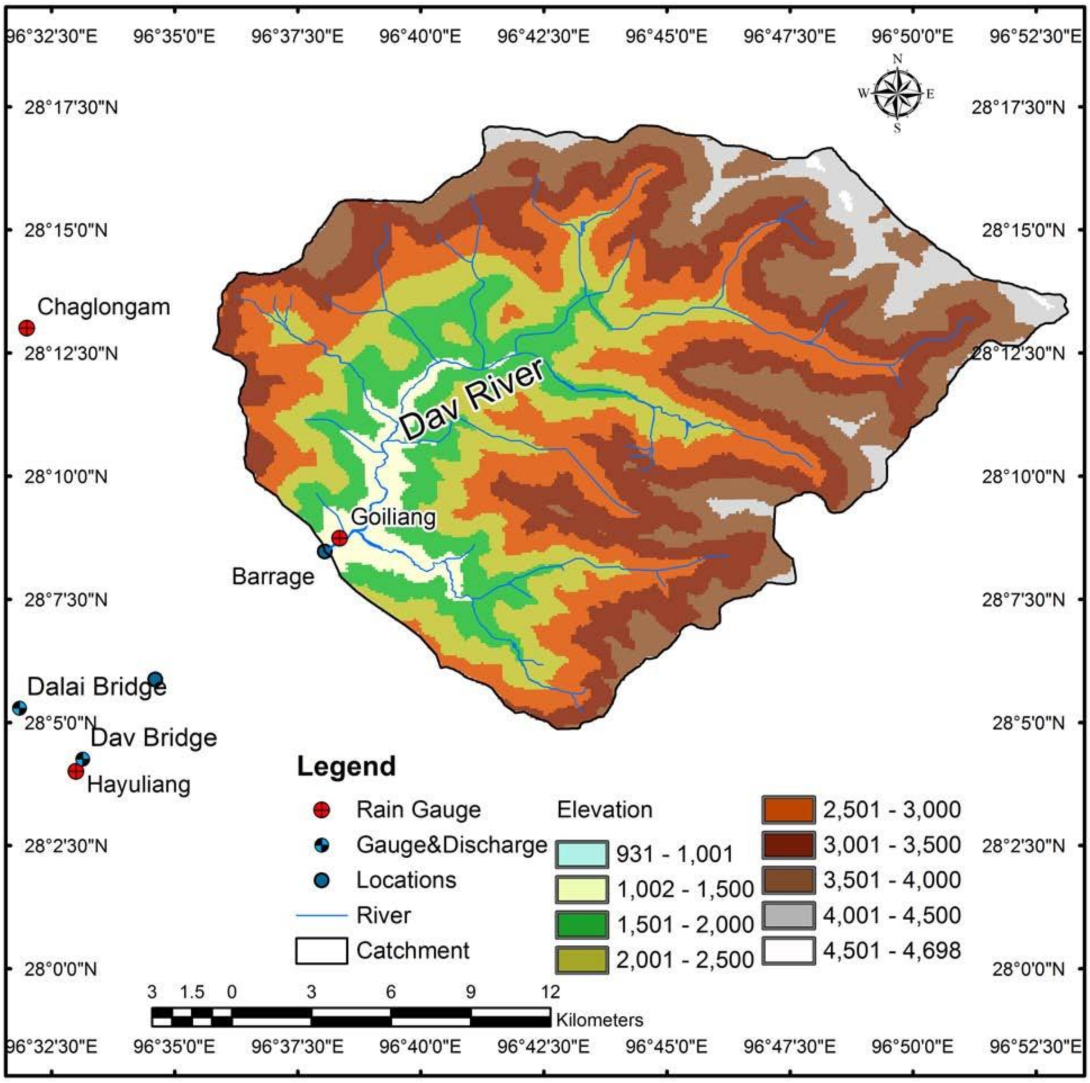


Figure-4.9: Catchment Area Map of Gimliang HEP

4.11.3 Water availability

The discharge data near Dav bridge site is available for the period October 2008 to August 2011 only, which is not sufficient to arrive at the water availability series for the project. Hence, the water availability series for Gimliang HE Project has been worked out on the basis of approved water availability series of Kalai-I HE Project proposed on Lohit river. The total catchment area at Kalai-I HE Project is 14168 sq.km out of which snow fed catchment area is about 4444 sq.km for permanent snow line at EL 4500 m. The snow melt contribution of Kalai-1 catchment has been deducted from approved series of Kalai-I and series thus obtained at Kalai-I has been transferred to Gimliang HE Project site in rainfed catchment area proportion. The snow melt contribution of Gimliang catchment has been added in the above series to get the 19 years 10-daily water availability series for the Gimliang HE Project for the period 1985-86 to 2003-04. The average annual flow and average annual yield of the series thus obtained at Gimliang HE Project site is about 906 MCM and 2438 mm respectively.

The 10-daily water availability series for Gimliang HE Project for the period 1985-86 to 2003-04 with average annual flow of 906 MCM (2438 mm) is generally in order. The same enclosed at Table-4.26, has been adopted for planning purpose of the project.

4.11.4 Design flood

The design flood study has been carried out using hydro-meteorological approach. The 1-day SPS value as supplied by IMD has been taken as 360 mm. The clock hour correction has been considered as 15%. As the time base of unit hydrograph is about 12 hours, the 12 hour rainfall using the hourly distribution coefficient of 12 hour rainfall as per FER-2(a) has been used for design flood computations. The unit hydrograph has been worked out as per FER-2(a). The loss rate of 2.4 mm/hr and base flow of 0.05 cumec/km^2 have been adopted. The snowmelt contribution has been computed as per WMO formula. The study recommends a design flood (SPF) value of 5555 cumec.

4.12 RAIGAM HYDROELECTRIC PROJECT

4.12.1 River Characteristics

Dalai is a major right bank tributary of Lohit River, originating at an elevation of about 3866m and passes near Tajobum, Plongllang and Minutang town, reaching an elevation of 691 m at the proposed barrage site. It is snow fed and lackfed streams which flows mainly southwards till the proposed Barrage site. Tributary of Lohit originates from morainic landform and passes through dense pine forests in its higher reaches. Both the left and right bank slopes of Dalai River are covered with settlement and cultivable terraces below 1000 m elevation. It is fed by streams Tasha Nala, Rai/RaigamNala, BomNala, PajaiNala, TalaiNala, BaziNala, KhaNala, ZuNalaand HemangNala from the right and TeepaniNala, ChingNalaand TalloNala from the left. The river network is dendritic to sub-parallel in nature and flows the geomorphological trends of the hills and mountains. In the hilly terrain, the river have deep gorge along their courses, with an average basin slope of about 1:31. The total length of the river up to the Barrage site is 72km and the mean slope is 33.47m/km. The bed level of Dalai River at proposed Barrage site of Raigam Hydroelectric Project is 691 m.

Table-4.26: 10-daily discharge series for Gmliang HEP

		1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
May	**I**	31.12	11.03	22.35	31.31	31.58	35.65	41.98	30.01	39.08	22.05	47.16	49.3	19.00	43.43	37.48	70.14	28.41	17.55	19.53
	II	25.17	13.66	30.01	45.03	31.58	34.59	66.83	36.83	41.68	18.92	58.25	62.67	19.23	40.61	28.41	76.32	30.09	24.72	18.43
	III	42.48	15.11	32.57	69.50	47.62	41.10	42.78	31.58	37.22	30.32	67.74	56.84	23.72	69.12	60.08	83.94	44.72	25.36	21.55
June	**I**	76.54	14.53	44.22	54.78	49.36	62.25	39.45	32.52	47.19	47.19	57.82	57.02	59.12	58.47	37.43	80.2	59.27	21.85	26.99
	II	54.43	17.08	40.87	55.08	59.92	51.31	55.54	38.43	44.37	57.41	52.3	59.31	63.05	76.61	36.52	79.7	59.43	24.74	41.17
	III	56 57	25.96	48.94	48.14	54.43	52.26	66.06	43.91	45.48	48.72	53 94	91.9	60.49	81.00	61.03	105.88	58.13	24.32	45.59
July	**I**	67.07	20.65	53.01	85.37	89.18	54.00	67.11	47.79	80.56	38.11	66.61	82.05	93.83	87.39	57.09	71.38	50.65	26.56	58.65
	II	63.34	19.39	43.86	50.72	61.51	67.8	69.28	42.37	62.50	34.83	47.1	112.58	100.34	74.08	70.35	67.45	52.78	35.9	34.45
	III	61.47	16.65	50.11	64.82	58.31	69.78	53.12	43.37	60.52	39.21	32.73	86.05	88.34	68.44	66.35	68.52	60.33	38.07	24.42
August	**I**	50.3	13.71	56.32	38.67	49.53	49.00	50.91	37.76	52.7	32.38	24.34	81.01	92.41	63.18	57.65	82.58	51.10	26.36	17.52
	II	43.24	12.11	61.58	43.74	49.65	48.24	49.91	33.03	50.75	29.52	53.53	78.23	94.35	72.21	72.51	67.86	31.89	26.4	15.92
	III	41.95	12.53	55.78	104.45	42.83	39.74	44.16	31.89	46.71	29.52	33.95	69.28	80.37	69.92	79.76	62.34	34.29	18.36	16.95
Septembei	**I**	18.94	12.27	51.87	61.01	48.78	35.97	39.29	23.51	38.22	29.23	29.91	64.14	80.41	99.62	77.78	59.49	31.78	16.23	17.37
	II	13.37	18.9	43.10	37.84	42.18	42.41	36.51	21.11	34.45	27.59	32.5	54.88	83.12	53.66	71.45	59.11	22.56	15.16	16.54
	III	21.22	6.74	57.54	45.84	38.98	35.55	34.03	17.72	35.13	24.46	48.44	52.02	89.33	43.37	49.39	44.36	20.31	30.64	13.83
October	**I**	20.48	10.23	35.76	67.7	44.26	42.28	29.02	13.43	34.7	21.93	21.97	57.56	44.23	32.75	39.23	26.43	26.05	24.48	14.5
	II	16.4	10.19	28.41	64.69	36.6	28.87	30.31	17.51	28.22	18.92	19.38	47.77	29.44	35.99	46.85	19.57	19.68	15.53	13.7
	III	15.95	7.9	23.61	26.77	24.9	19.8	26.96	13.28	22.96	17.62	17.62	43.08	21.82	47.43	35.38	17.05	15.56	14.54	12.74
November	**I**	15.55	9.80	20.78	31.64	19.78	16.09	22.61	9.27	20.17	13.19	13.19	30.65	15.17	18.72	20.05	12.43	12.43	11.82	10.37
	II	13.61	9.72	14.91	26.23	16.66	13.99	18.98	8.12	18.53	12.35	12.35	26.38	14.33	14.72	15.25	11.97	11.71	11.02	9.95
	III	12.47	8.73	12.96	23.6	13.12	14.11	17.04	7.59	17.23	11.21	11.21	22.53	13.88	16.51	14.11	11.40	10.9	10.14	9.57
December	**I**	11.78	7.7	11.28	21.92	10.98	11.28	22.15	7.05	16.09	10.87	10.87	17.88	13.72	14.37	15.90	10.48	10.29	9.72	9.26
	II	10.90	7.28	10.37	18.6	9.87	8.31	16.77	6.44	15.25	10.64	10.64	16.51	13.53	12.35	14.56	10.03	9.84	9.38	8.92
	III	10.45	8.65	9.11	16.24	9.15	8.08	13.38	5.95	14.56	10.48	10.48	15.51	12.47	11.17	12.69	9.76	9.23	8.92	8.65
January	**I**	9.53	4.92	8.31	15.47	8.46	9.79	11.47	6.02	7.36	8.99	9.57	14.67	11.62	10.48	11.78	9.57	8.8	8.54	8.46
	II	8.77	4.61	7.77	14.86	8.04	9.64	9.64	6.06	7.28	8.42	9.3	13.57	11.36	10.18	11.59	9.19	8.88	7.93	8.46
	III	8.35	4.5	7.58	14.22	8.77	9.91	8.88	5.53	7.74	7.85	9.68	12.92	10.94	9.79	11.74	9.15	9.11	8.27	8.46
February	**I**	8.77	4.46	7.47	13.42	9.15	9.64	8.80	5.41	7.66	7.36	11.36	12.27	10.98	9.57	11.62	9.30	8.69	8.42	7.97
	II	8.54	4.61	8.12	13.11	9.15	9.83	8.80	7.13	7.39	8.12	11.89	13.22	11.28	9.49	11.47	9.19	8.92	8.5	7.85
	III	8.61	4.92	11.62	13.57	8.46	10.67	8.77	7.55	7.77	9.19	12.81	13.00	11.28	9.49	11.01	9.41	8.88	8.54	8.08
March	**I**	7.89	5.37	14.29	13.64	8.69	12.35	9.53	9.45	7.97	9.57	13.57	14.18	13.07	10.4	12.54	9.57	9.3	8.31	8.73
	II	12.04	6.36	20.01	13.53	8.54	13.26	10.48	11.62	11.89	9.76	20.54	17.84	13.87	11.85	13.26	9.49	8.96	9.41	7.97
	III	11.09	7.43	19.48	16.81	13.03	14.9	16.54	13.00	26.45	10.98	26.03	17.15	18.03	11.74	15.17	15.17	10.1	9.11	13.53
April	**I**	13.21	26.43	19.91	15.23	16.48	23.08	22.54	23.08	14.27	11.68	25.1	14.73	16.41	15.23	25.02	16.6	10.39	10.5	12.52
	II	20.37	26.66	22.96	24.41	30.24	26.05	25.59	23.76	14.16	15.72	27.16	12.18	22.93	13.66	19.46	20.14	16.33	11.00	16.75
	III	11.83	24.34	22.54	32.61	34.82	19.65	16.56	29.33	15.8	21.93	33.41	12.25	24.18	26.09	26.2	22.54	15.68	11.34	19.3

4.12.2 Catchment Area

The catchment of Dalai River in upper reach extends over an area of 689.44 km^2 in Tibet (China). The Indian part of this catchment up to the proposed Raigam Barrage site is 1013.97 km^2. The total catchment area up to the proposed Barrage site ofthe Raigam HEP is 1703.41 km^2 out of which snowfed catchment area above permanent snow line of 4500 m above mean sea level (a.m.s.l.) is about 59.8 km^2 (3.5%). The catchment is more or less leaf-shaped having a length of 58.12km and a width of 52.14 km and spread between Latitudes 28° 09' 12.18" and 28° 41' 44.57" North and Longitudes 96° 21' 58.35" and 96° 53' 30.17" East. The distribution of catchment area under different elevation zones is depicted in Figure-4.10.

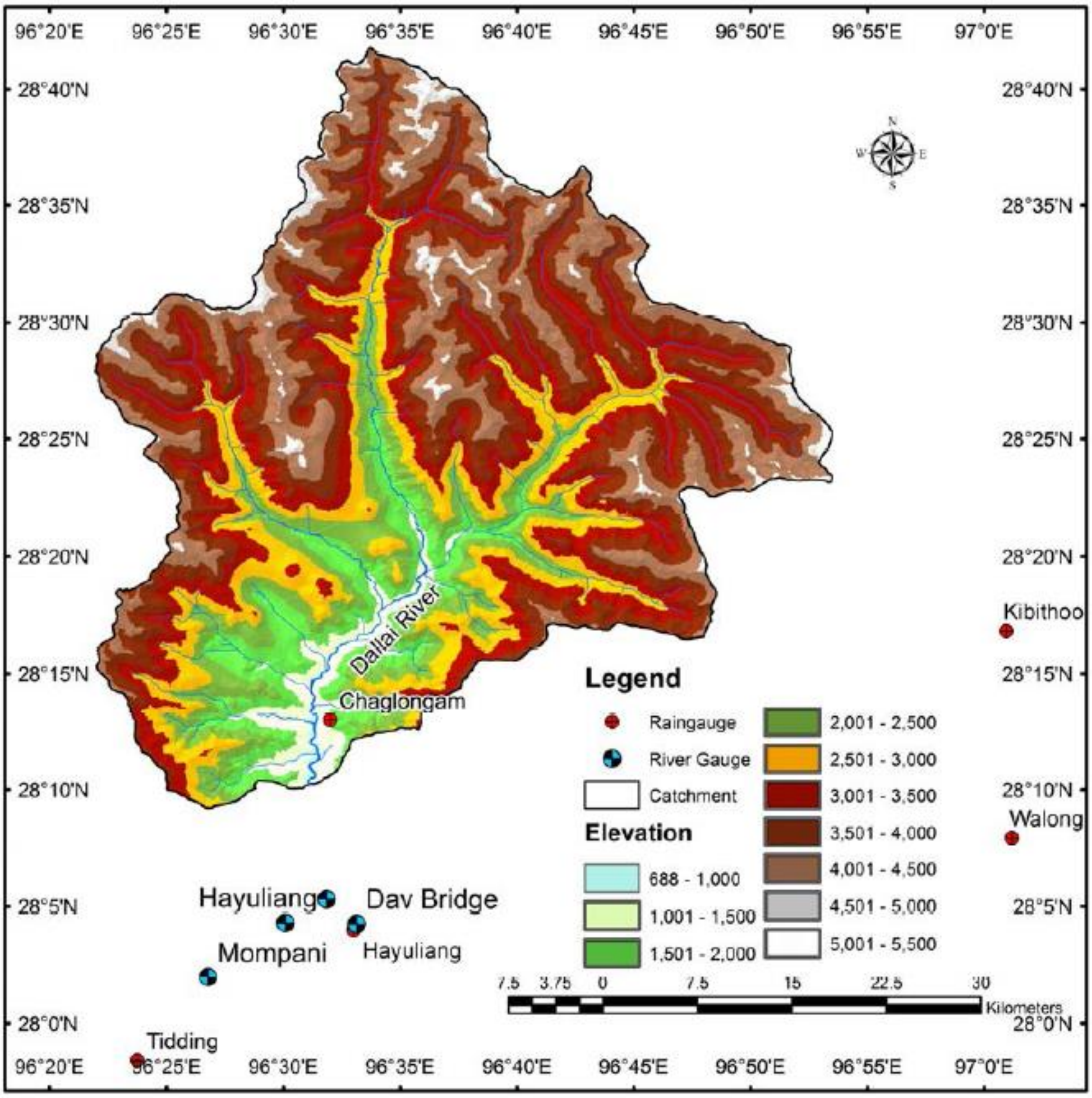


Figure-4.10: Catchment Area Map of Raigam HEP

4.12.3 Water availability

The discharge data at Raigam bridge site is available for the period October 2008 to July 2011 only, which is not sufficient to arrive at the water availability series for the project. Hence, the water availability series for Raigam HE Project has been worked out on the basis of approved water avialability series of Kalai-I HE Project proposed on Lohitriver. The total catchment area at Kalai-I HE Project is 14168 sq.km out of which snow fed catchment area is about 4444 sq.km for permanent snow line at EL 4500 m. The snow melt contribution of Kalai-I catchment has been deducted from approved series of Kalai-I and series thus obtained at Kalai-I has been transferred to Raigam HE Project site in rainfed catchment area proportion. The snow melt contribution of Raigam catchment has been added in the above series to get the 19 years 10-daily water availability series for the Raigam HE Project for the period 1985-86 to 2003-04. The average annual flow and average annual yield of the series thus obtained at Raigam HE Project site is about 4034 MCM and 2368 mm respectively. The details are given in Table-4.27.

Table-4.27: 10-daily discharge series for Raigam HEP (CA-1703.4 sq.km)

		1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
May	**I**	138.62	49.55	99.75	139.47	140.65	158.74	186.79	133.72	173.95	98.39	209.78	219.25	84.87	193.22	166.85	311.70	126.62	78.45	87.24
	II	112.25	61.21	133.72	200.32	140.65	154.00	297.00	163.98	185.44	84.53	258.97	278.57	85.89	180.71	126.62	339.09	134.06	110.23	82.34
	III	188.99	67.63	145.04	308.83	211.81	182.91	190.34	140.65	165.67	135.07	301.05	252.71	105.83	307.14	267.08	372.89	198.96	113.10	96.2
June	**I**	340.73	65.72	197.39	244.21	220.21	277.34	176.26	145.5	210.58	210.58	257.73	254.18	263.48	260.61	167.31	356.95	264.16	98.17	120.99
	II	242.69	77.05	182.52	245.56	267.03	228.83	247.59	171.70	198.07	255.87	233. 23	264.33	280.89	341.06	163.25	354.75	264.83	111.02	183.87
	III	252.16	116.43	218.35	214.80	242.69	233.06	294.24	196.04	202.97	217.34	240.49	433.84	269.57	360.50	271.93	470.87	259.09	109.16	203.48
July	**I**	298.89	93.02	236.52	380.02	396.92	240.91	299.06	213.36	358.72	170.43	296.86	365.31	417.54	388.98	254.60	317.99	226.04	119.21	261.53
	II	282.32	87.44	195.95	226.38	274.21	302.1	308.69	189.36	278.60	155.89	210.32	500.7	446.45	329.99	313.42	300.58	235.5	160.63	154.20
	III	274.04	75.27	223.67	288.92	260.01	310.89	237.02	193.75	269.82	175.33	146.60	383.06	393.2	304.97	295.68	305.31	253 07	170.26	109.75
August	**I**	224.55	62.29	251.26	173.00	221.17	218.81	227.26	168.94	235.20	145.11	109.45	360.79	411.32	281.68	257.17	367.72	228.1	118.40	79.19
	II	193.28	55.19	274.58	195.48	221.68	215.42	222.86	147.98	226.58	132.43	238. 92	348.45	419.95	321.74	323.09	302.47	142.91	118.57	72 09
	III	187.54	57.05	248.89	464.74	191.42	177.73	197.34	142.91	208.66	132.43	152.04	308.73	357.91	311.60	355.21	277.96	153.56	82.91	76.66
September	**I**	85.10	55.52	231.14	271.70	217.44	160.65	175.36	105.38	170.62	130.73	133.78	285.56	357.74	442.92	346.07	264.94	142.06	73.10	78.17
	II	60.42	84.93	192.26	168.93	188.20	189.22	163.02	94.73	153.89	123.47	145.27	244.49	369.74	239.08	318.01	263.25	101.16	68.36	74.45
	III	95.24	31.01	256.32	204.43	174.01	158.79	152.03	79.69	156.93	109.61	215.92	231.81	397.29	153.44	220.15	197.84	91.18	136.99	62.45
October	**I**	91.33	45.86	159.11	300.75	196.80	188.01	129.19	60.06	154.37	97.75	97.92	255.79	196.63	145.75	174.49	117.7	116.01	109.08	64.79
	II	73.24	45.69	126.48	287.40	162.83	128.51	134.94	78.14	125.64	84.40	86.43	212 35	131.05	160.12	208.29	87.27	87.78	69.35	61.24
	III	71.21	35.55	105.19	119.22	110.93	88.29	120.06	59.38	102.31	78.65	78.65	191.56	97.24	210.83	157 42	76.12	69.52	64.96	57.02
November	**I**	68.96	43.44	92.12	140.29	87.73	71.33	100.23	41.07	89.42	58.48	58.48	135.9	67.27	82.99	88.91	55.10	55.10	52.4	45.98
	II	60.34	43.10	66.09	116.29	73.87	62.03	84.18	36.00	82.15	54.77	54.77	116.97	63.56	65.25	67.61	53.08	51.89	48.85	44.12
	III	55.27	38.71	57.47	104.63	58.15	62.54	75.56	33.64	76.40	49.70	49.70	99.9	61.53	73.19	62.54	50.54	48.34	44.96	42.43
December	**I**	52.23	34.14	50.03	97.19	48.68	50.03	98.20	31.27	71.33	48.17	48.17	79.27	60.85	63.72	70.48	46.48	45.64	43.1	41.07
	II	48.34	32.28	45.97	82.48	43.78	36.85	74.37	28.57	67.61	47.16	47.16	73.19	60.00	54.76	64.57	44.45	43.61	41.58	39.55
	III	46.31	38.37	40.40	72.00	40.57	35.83	59.33	26.37	64.57	46.48	46.48	68.79	55.27	49.52	56.29	43.27	40.9	39.55	38.37
January	**I**	42.26	21.80	36.85	68.62	37.52	43.44	50.88	26.71	32.62	39.89	42.43	65.07	51.55	46.48	52.23	42.43	39.04	37.86	37 52
	II	38.88	20.45	34.48	65.92	35.66	42.76	42.76	26.87	32.28	37.35	41.24	60.17	50.37	45.13	51.38	40.74	39.38	35.16	37.52
	III	37.02	19.94	33.64	63.05	38.88	43.95	39.38	24.51	34.31	34.82	42.93	57.3	48.51	43.44	52.06	40.57	40.4	36.68	37.52
February	**I**	38.88	19.78	33.13	59.50	40.57	42.76	39.04	24.00	33.97	32.62	50.37	54.43	48.68	42.43	51.55	41.24	38.54	37.35	35.33
	II	37.86	20.45	36.00	58.14	40.57	43.61	39.04	31.61	32.79	36.00	52.74	58.65	50.03	42.09	50.88	40.74	39.55	37.69	34.82
	III	38.20	21.80	51.55	60.17	37.52	47.33	38.88	33.47	34.48	40.74	56.79	57.64	50.03	42.09	43.35	41.75	39.38	37.86	35.83
March	**I**	35.01	23.86	63.41	60.54	38.56	54.79	42.28	41.94	35.35	42.45	60.2	62.9	58.00	46.17	55.64	42.45	41.27	36.87	38.73
	II	53.44	28.25	88.76	60.03	37.89	58.85	46.51	51.58	52.76	43.30	91.13	79.13	61.55	52.59	58.85	42.11	39.75	41.78	35.35
	III	49.21	32.99	86.40	74.57	57.83	66.11	73.38	57.66	117.33	48.71	115.47	76.09	79.97	52.09	67.30	67.3	44.82	40.42	60.03
April	**I**	58.83	117.48	88.58	67.79	73.37	102.61	100.24	102.61	63.56	52.07	111.57	65.59	73.03	67.79	111.23	73.87	46.32	46.83	55.79
	II	90.61	118.50	102.10	108.52	134.38	115.79	113.76	105.65	63.06	69.99	120.69	54.27	101.93	60.86	86.55	89.59	72.69	49.03	74.55
	III	52.75	108.19	100.24	144.86	154.67	87.4	73.70	130.33	70.32	97.54	148.41	54.6	107 51	115.96	116.47	100.24	69.82	50.55	85.87

4.12.4 Design flood

The design flood study has been carried out using hydro-meteorological approach. The 1-day SPS value as supplied by IMD has been taken as 326 mm. The clock hour correction has been considered as 15%. The unit hydrograph has been worked out as per FER-subzone-2(a). The loss rate of 2.4 mm/hr and base flow of 0.05 cumec/km^2 have been adopted. The snowmelt contribution has been computed as per WMO formula. The study recommends a design flood (SPF) value of 12227 cumec.

4.13 TIDDING-I HYDROELECTRIC PROJECT

4.13.1 River Characteristics

Tidding is a fast flowing perennial river. In the stretch from its source up to the proposed barrage site, the Tidding River drops by about 4067 m. The total length of the river up to the barrage site is 66.908 km, delineated using ASTER GDEM. The bed level of Tidding River at the proposed barrage site of Tidding-I Hydroelectric Project is about 617 m. This was obtained from SRTM DEM with a spatial resolution of about 90 m, after slight modification to match with the level measured at site.

4.13.2 Catchment Area

The Tidding-I barrage catchment is covered under Survey of India (SOI) topographic maps of 1:50,000 scale Numbered 91D/3, 91D/4, 91D/7 and 91D/8. The catchment area up to the proposed barrage site is 614.526 km^2,delineated from ASTER GDEM. About 1.689 km^2 (0.27%) of the catchment area lies above the permanent snowline, considered at an elevation of 4500 m above mean sea level (a.m.s.l.). Catchment area map prepared with SRTM DEM has been furnished in Figure 4.12, which also shows the distribution of catchment area under different elevation zones.

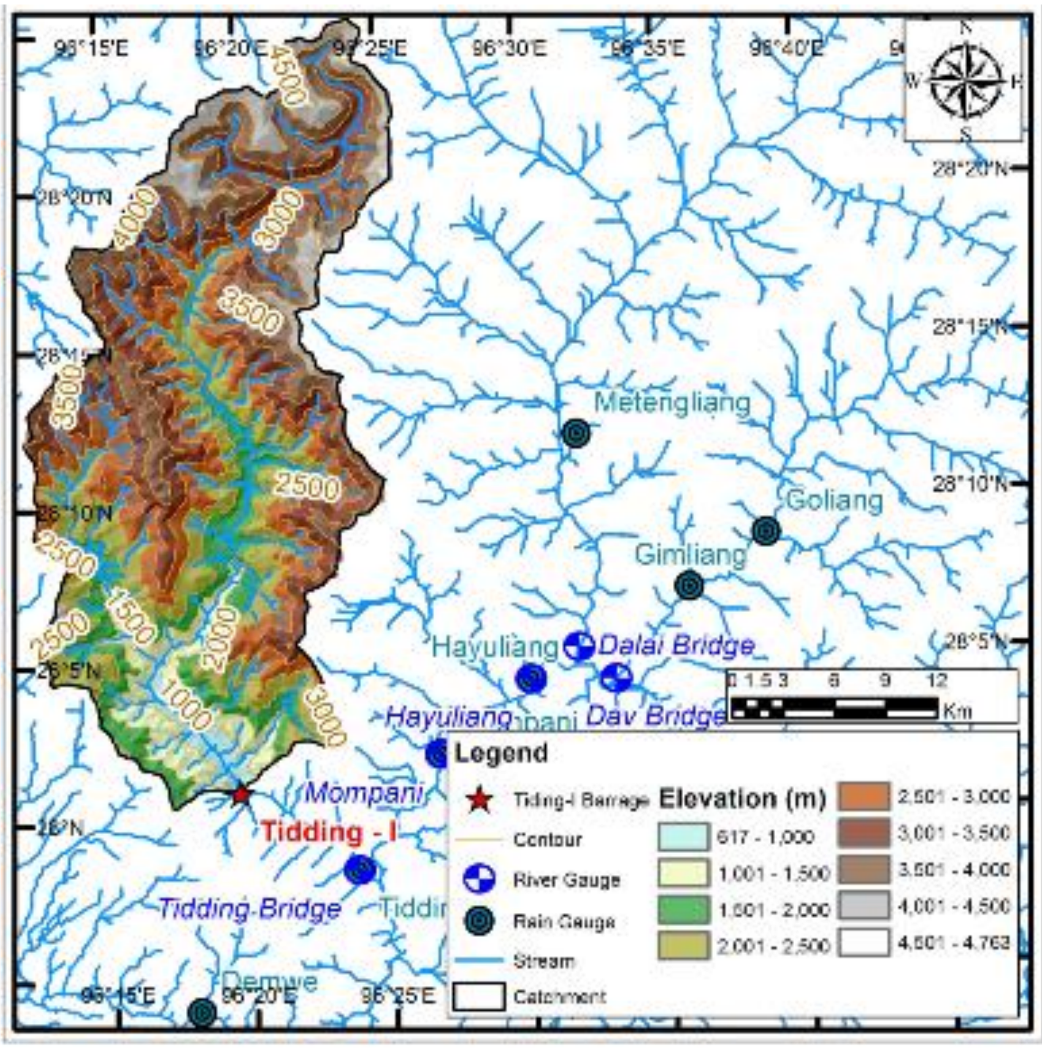


Figure-4.11: Catchment Area Map of Tidding-I HEP

The catchment is bean shaped, having a length of 45.78 km and widths of 2.4 km near the ridge, which increases to 21.48 km near the middle portion, andagain reduces to 10.11 km near the outlet.

4.13.3 Water availability

The water availability analysis for the project has been based on the 10-daily discharge series approved by the CWC for the Gimliang HEP. The catchment area up to the Tidding-I barrage site is 614.53 km². The same for Gimliang HEP is 371.46 km². For the purpose of assessment of power potential, 10-daily rainfed discharge series for the period 1985-86 to 2003-04 has been derived from the CWC approved discharge series for Gimliang HEP in the ratio of catchment areas, modified using multiplicative yield correction factor of 1.25 as suggested by CWC (Vide Memo. No. CWC U.O. No. 4/389/2013-Hyd (NE)/36162 dated 20th August, 2013, Appendix 8.1). The details are given in Table-4.28

.

Table-4.28: 10-daily discharge series for Tidding – I HEP(CA-614.23 sq.km)

Period		**1985-86**	**1986-87**	**1987-88**	**1988-89**	**1989-90**	**1990-91**	**1991-92**	**1992-93**	**1993-94**	**1994-95**	**1995-96**	**1996-97**	**1997-98**	**1998-99**	**1999-00**	**2000-01**	**2001-02**	**2002-03**	2003-04
May	**I**	64.35	22.81	46.22	64.75	65.31	73.72	86.81	62.06	80.82	45.6	97.52	101.95	39.29	89.81	77 51	145.05	58.75	36.29	40.39
	II	52.05	28.25	62.06	93.12	65.31	71.53	138.2	76.16	86.19	39.13	120.46	129.6	39.77	83.98	58.75	157.83	62.22	51.12	38.11
	III	87.85	31.25	67.35	143.72	98.48	84.99	88.47	65.31	76.97	62.7	140.08	117.54	49.05	142.94	124.24	173.58	92.48	52.44	44 56
June	**I**	158.28	30.05	91.44	113.28	102.07	128.73	81.58	67 25	97.59	97.59	119.57	117.91	122.26	120.91	77.4	165.85	122.57	45.18	55.81
	II	112.56	35.32	84.52	113.9	123.91	106.11	114.85	79.47	91.75	118.72	108.15	122.65	130.38	158.42	75.52	164.81	122.9	51 16	85.14
	III	116.98	5368	101.21	99.55	112.56	108.07	136.61	90.8	94.05	100.75	111.54	190.04	125.09	167.5	126.21	218.95	120.21	50.29	94.28
July	**i**	138.7	42.7	109.62	176.54	184.42	111.67	138.78	98.83	166.59	78.81	137.75	169.67	194.03	180.72	118.06	147.61	104.74	54.92	121.28
	II	130.98	40.1	90.7	104.89	127.2	140.21	143.27	87.62	129.25	72.03	97.4	232.81	207.5	153.19	145.48	139.48	109.15	74.24	71 24
	III	127.12	34.43	103.62	134.04	120.58	144.3	109.85	89.69	125.15	81.08	67.68	177.95	182.68	141.53	137.21	141.7	124.76	78.73	50.5
August	**I**	104.02	28.35	116 47	79.97	10243	101.33	105.28	78.09	108.98	66.96	50.33	167.52	191.1	130.65	119.22	170.77	105.67	54.51	36.23
	II	89.42	25.04	127.34	90.45	102.67	99.76	103.21	68.3	104.95	61.05	110.7	161.78	195.11	149.33	149.95	140.33	65.95	54.59	32.92
	III	86.75	25 91	115.35	216	88.57	82.18	91.32	65.95	96.59	61.05	70.21	143.27	166.2	144.59	164.94	128.92	70.91	37.97	35.05
Sep	**I**	39.17	25.37	107.26	126.17	100.87	74.38	81.25	48.62	79.04	60.45	61.85	132.64	166.28	206.01	160.84	123.02	65.72	33.56	35.92
	II	27.65	39.08	89.13	78.25	87.23	87.7	75.5	43.65	71.24	57.05	67.21-	113.49	171.89	110.97	147.75	122.24	46.65	31.35	34 20
	III	43.88	13.94	118.99	94.79	8061	73.52	70.37	36.64	72.65	50.58	100.17	107.57	184.73	89.69	102.14	91 73	42	63.36	28.6
Oct	**I**	42.35	21.16	73.95	140	91.53	87.43	60.01	27.77	71.76	45.35	45.43	119.03	91.47	67.73	81.13	54.66	53.87	50.62	29.99
	II	33.91	21.07	58.75	133.78	7569	59.7	62.68	36.21	58.36	39.13	40.08	98.79	60.88	74.43	96.88	40 47	40.7	32.12	28.33
	III	32.98	16.34	48.82	55.36	51.49	40.95	55.75	27.46	47 48	36.44	36.44	89.09	45.12	98.08	73.16	35.26	32.18	30.07	26.35
Nov	**I**	32.16	20.27	42.97	65.43	40.9	33.27	46.76	19 17	41.71	27.28	27.28	63.38	31.37	38 71	41.46	25.7	25.7	24.44	21 44
	II	28.14	20.1	30.83	54.24	34.45	28.93	39.25	16.79	38.32	25.54	25.54	54.55	29.63	30.44	31.54	24.75	24.22	22.79	20.58
	III	25.79	18.05	26.8	48.8	27.13	29.18	35.24	15.7	35.63	23.18	23.18	46.59	28.7	34.14	29.18	23.57	22.54	20.97	19.79
Dec	**I**	24.36	15.92	23.33	45.33	22.71	23.33	45.8	14.58	33.27	22.48	22.48	36.97	28.37	29.72	32.88	21.67	21.28	20.1	19 15
	II	22.54	15.05	21 44	38.46	20.41	17 18	34.68	13.32	31.54	22	22	34.14	27.98	25.54	30.11	20.74	20.35	19.4	18.45
	III	21.61	17.89	18.84	33.58	18.92	16.71	27.67	12.3	30.11	21.67	21.67	32.07	25.79	23.1	26.24	20.18	19.09	18.45	17.89
Jan	**I**	19.71	10.17	17.18	31.99	17.49	2025	23.72	12.45	15.22	18.59	19.79	30.34	24.03	21.67	24.36	19.79	18.2	17.66	17.49
	II	18 14	9.53	16.07	30.73	16.63	19.93	19.93	12.53	15.05	17.41	19.23	28.06	23.49	21.05	23.97	19	18.36	16.4	17 49
	III	17.27	9.31	15.67	29.41	18.14	20.49	18.36	11.44	16.01	16.23	20.02	26.72	22.62	20.25	24.28	18.92	18.84	17 10	17 49
Feb	**I**	18 14	9.22	1545	27.75	18.92	19.93	18.2	11.19	15.84	15.22	23.49	25.37	22.71	19.79	24.03	19.23	17.97	17.41	16 48
	II	17 66	9.53	16.79	27.11	18.92	20.33	18.2	14.74	15.28	16.79	24.59	27.34	23.33	19.62	23.72	19	18.45	17.58	16.23
	III	17.8	10.17	24.03	28.06	17.49	22.06	18.14	15.61	16.07	19	26.49	26.88	23.33	19.62	22.77	19.46	18.36	17.66	16.71
Mar	**I**	16.32	11.1	29.55	28.21	17.97	25.54	19.71	19.54	1648	19.79	28.06	29.32	27.03	21.51	25.93	19.79	19.23	17 18	18.05
	II	24.9	13.15	41.38	27.98	17.66	27.42	21.67	24.03	24.59	20.18	42.48	36.89	28.68	24.51	27.42	19.62	18.53	19.46	16 48
	III	22.93	15.36	40.28	34.76	26.95	30.81	34.2	26.88	54.7	22.71	53.83	35.47	37.28	24.28	31.37	31.37	20.89	18.84	27 98
Apr	**I**	27 32	54.66	41 17	31.49	34.08	47.73	46.61	47.73	29.51	24.15	51.91	30.46	33 93	31.49	51.74	34.33	21.49	21.71	25.89
	II	42.12	55.13	47.48	50.48	62.53	53.87	52.92	49.13	29.28	32.51	56.17	25.19	47.42	28.25	40.24	41.65	33.77	22.75	34.64
	III	24.46	50.33	46.61	67 44	72.01	40.64	34.25	60.65	32.67	45.35	69.09 '	25.33	50	53.95	54.18	46.61	32.43	23.45	39.91

It is seen that the annual minimum 10-daily average flow varies between 9.22 and 27.11 m^3/s whereas the maximum ranges from 55.13 to 232.81 m /s. The average of 10-daily flows is around 59.14m^3/s. it can be seen that the year 2002-03 has 90% dependability, while the year 1995-96 has 50% dependability. The 50% and 90% dependability is given in Table-4.29.

Table-4.29: Dependeble Energy Years for Tidding-I HEP (CA-614.53 sq.km)

Sl.No	Dependibility	Year	Annual Unrestricted Energy (MU)
1	90%	2002-03	453.57
2	50%	1995-95	791.79

4.13.4 Environmental Release

As per the recent approvals accorded by MOEF to similar hydropower projects, 20% of the average flow of four consecutive leanest months in a 90% dependable year should be maintained as environmental flow during the lean season (December to March). During the monsoon period (considered as June to September for this purpose, in tune with other projects in the country), 30% of average discharge computed on the basis of 90% dependable year has to be released. During the non-lean non-monsoon period (October – November and April – May) release of about 25% of the average discharge estimated on the basis of 90% dependable year is required. The year 2002-03 was identified as the 90% dependable year. The abstract of environmental release considered for the power potential study is given in Table 4.30.

Table-4.30: Environmental Release for Tidding-I HEP (CA-614.53 sq.km)

Sl.No	Period	Unit	Value
1	December to March	m^3/s	3.6
2	June to September	m^3/s	15.75
3	October - November, April - May	m^3/s	8.1

4.13.5 Design flood

The flood magnitudes at Tidding-I Barrage obtained through different approaches have been summarized under Table 4.31. Following CWC (2010), SPF may be considered to be equivalent to a 1000-year return period flood.

Table- 4.31: Flood magnitudes at Tidding-I Barrage by different Approaches

Method	Flood Discharge (m^3/s)
Dicken's method, 1000 Year Flood	4482
SPF following CWC (1991)	5223
Stochastic Approach: Wakeby Distribution, 1000 year flood	5688
Stochastic Approach: Gumbell Distribution, 1000 year flood	2318
Gumbell Distribution, 1000 Year Flood – 95% Upper confidence limit	3189

The design flood has been adopted as 5225 m³/s after rounding off, considering hydraulic head between upstream and downstream of the barrage to be 25 m. The magnitude of the design flood has been approved by the CWC, vide Memo. No. CWC U.O. No. 32/93/13-PA(S)/1618 dated 24.07.2013.

4.14 TIDDING-II HYDROELECTRIC PROJECT

4.14.1 Catchment Area

The Tidding-II barrage catchment is covered under Survey of India (SOI) topographic maps of 1:50,000 scale Numbered 91D/3, 91D/4, 91D/7 and 91D/8. The catchment area up to the proposed barrage site is 525.695 km2, delineated from ASTER GDEM. Only about 1.689 km2 (0.3%) of the catchment area lies above the permanent snowline, considered at an elevation of 4500 m above mean sea level (a.m.s.l.). Catchment area map has been furnished in Figure-4.12, which also shows the distribution of catchment area under different elevation zones.

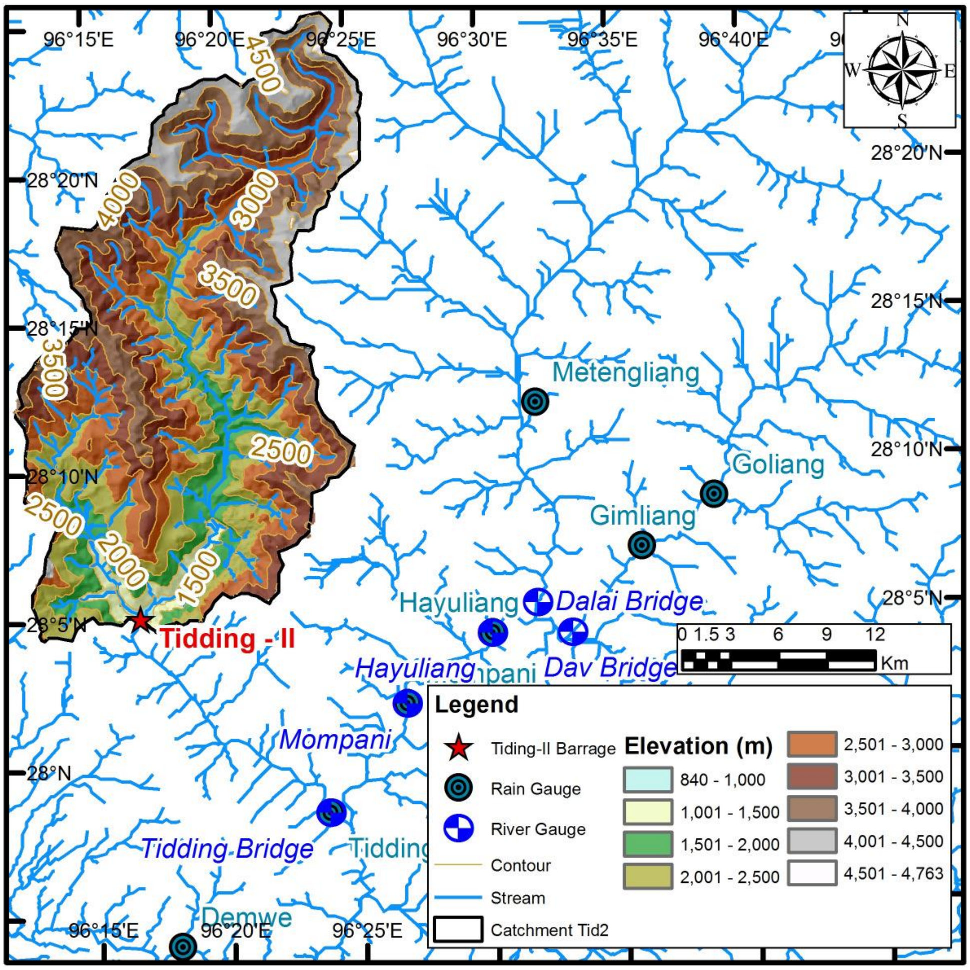


Figure-4.12: Catchment Area Map of Tidding-II HEP

The catchment is irregular wedge shaped, having a length of 39.35 km with widths of 2.4 km near the ridge, which increases to 21.48 km near the lower middle portion, and again reduces to 14.21 km near the outlet.

4.14.2 Water availability

The project authorities are observing the discharge data near Tidding bridge site (CA-685 sq.km) located about 9 km downstream of the proposed barrage site. The average annual yield of the observed data for the year 2009, 2010, 2011 and 2012 is about 8360 mm, which seems to be very high comparing the catchment representative average annual rainfall of the order of 4200 mm. There seems to be large inaccuracy in the measured data. Accordingly the same has not been considered for water availability computations. The water availability series for Tidding-II HE Project has been worked out on the basis of approved water availability series of Gimliang HE Project proposed on Dav river. The total catchment area at Gimliang HE Project is about 371.46 sq.km out of which snow fed catchment area is about 0.86 sq.km for permanent snow line at EL 4500 m. The average annual yield of 10-daily discharge series for Gimliang HE Project approved by Hydrology (NE) Directorate is about 2438 mm. The corresponding average annual yield for Tidding-II diversion site as assessed in this Directorate through yield model has been found as 2853 mm for catchment representative average annual rainfall of 3900 mm. The yield correction factor for Tidding-II in comparison to Gimliang is 1.17. Hence, the 10 daily discharge series for Tidding-II has been computed from Gimliang HEP approved 10 daily series using the following relationship:

10-daily water availability series for Tidding-II HE Project for the period 1985-86 to 2003-04 with average annual flow of 1500 MCM (2853 mm) is generally in order. The 10 dialy discharge series of Tidding-II HEP is given in Table-4.32

4.14.3 Design flood

The proposed barrage of Tidding-II HEP envisages storage height of 15 m. Hence, as per BIS criteria the design flood for the proposed barrage will be SPF. The design flood study has been carried out using hydro-meteorological approach. The 1-day SPS value as supplied by IMD has been taken as 352 mm. The clock hour correction has been considered as 15%. The unit hydrograph has been worked out as per FER-subzone-2(a). The loss rate of 2.4 mm/hr and base flow of 0.05 cumec/km2 have been adopted. The snowmelt contribution has been computed as per WMO formula. The SPF as per hydro-meteorological approach has been estimated as 4760 cumec.

Table-4.32: 10-daily discharge series for Tidding – II HEP(CA-525.70 sq.km)

Period		1985-86	1986-87	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1998-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
May	**I**	51.53	18.26	37.01	51.84	52.29	59.03	69.51	49.69	64.71	36.51	78.09	81.63	31.46	71.91	62.06	116.14	47.04	29.06	32.34
	II	41.68	22.62	49.69	74.56	52.29	57.27	110.66	60.98	69.01	31.33	96.45	103.77	31.84	67.24	47.04	126.37	49.82	40.93	30.52
	III	70 34	25.02	53.93	115.08	78.85	68.05	70.84	52.29	61.63	50.2	112.16	94.12	39.28	114.45	99.48	138.99	74.05	41.99	35.68
June	**I**	126.73	24.06	73.22	90.7	81.73	103.07	65.32	53.85	78.14	78.14	95.74	94.41	97.89	96.81	61.98	132.8	98.14	36.18	44.69
	II	90.13	28.28	67.67	91.2	99.22	84.96	91.96	63.63	73.47	95.06	86.6	98.21	104.4	126.85	60.47	131.97	98.4	40.96	68 17
	III	93.67	42.98	81.03	79.71	90.13	86.53	109.38	72.71	75.31	80.67	89.31	152.17	100.16	134.12	101.05	175.32	96.25	40.27	75.49
July	**I**	111.05	34 19	87.77	141.36	147.66	89.41	111.12	79.13	133.39	63.1	110.29	135.86	155.36	144.7	94.53	118.19	83.87	43.98	97.11
	II	104.88	32.11	72.62	83.98	101.85	112.26	114.71	70.16	103.49	57.67	77.99	186.41	166.14	122.66	116.49	111.68	87.39	59.44	57.04
	III	101.78	27.57	82.97	107.33	96.55	115.54	87.96	71.81	100.21	64.92	54.19	142.48	146.27	113.32	109.86	.113.46	99.89	63.04	40 43
August	**I**	83.29	22.7	93.25	64.03	82.01	81.13	84.3	62.52	87.26	53.61	40.3	134.14	153.01	104.61	95.46	136.74	84.61	43.65	29.01
	II	71.6	20.05	101.96	7242	82.21	79.88	82 64	54.69	84.03	48.88	88.63	129.53	156.22	119.57	120.06	112.36	52.8	43.71	26.36
	III	69.46	20.75	92.36	172.95	70.92	65.8	73.12	52.8	77.34	48.88	56.21	114.71	133.08	115.77	132.07	103.22	56.78	30.4	28.07
Sep	**I**	31 36	20.32	85.89	101.02	80.77	59.56	65.06	38.93	63.28	48.4	49.52	106.2	133.14	164.95	128.79	98.5	52.62	26.87	28 76
	II	22 14	31.29	71.36	62.66	69.84	70.22	60.45	34.95	57.04	45.68	53.81	90.87	137.63	88.85	118.31	97.87	37.35	25.1	27.39
	III	35.14	11 16	95.27	75.9	64.54	58.86	56.35	29.34	58.17	40.5	80.21	86.13	147.91	71.81	81.78	73.45	33.63	50.73	22 90
Oct	**I**	33.91	16.94	59.21	112.1	73.29	70.01	48.05	22.24	57.46	36.31	36.38	95.31	73.24	54.23	64.96	43.76	43.13	40.53	24.01
	II	27 16	16.87	47.04	107.11	60.6	47.8	50.19	28.99	46.73	31.33	32.09	79.1	48.75	59.59	77.57	32.4	32.59	25.71	22.68
	III	26.41	13.08	39.09	44.33	41.23	32.78	44.64	21.99	38.02	29 18	29.18	71.33	36.13	78.53	58.58	28.23	25.76	24.08	21.09
Nov	**I**	25.75	16.23	34.41	52.39	32.75	26.64	37.44	15.35	33.4	21.84	21.84	50.75	25.12	31	33.2	20.58	20.58	19.57	17 17
	II	22.54	16.09	24.69	4343	27.59	23.16	31.43	13.45	30.68	20.45	20.45	43.68	23.73	24.37	25.25	19.82	19.39	18.25	16.48
	III	20.65	14 46	21.46	39.08	21.72	23.36	28.21	12.57	28.53	18.56	18.56	37.31	22.98	27.34	23.36	18.88	18.05	16.79	15.85
Dec	**I**	19.51	12.75	18.68	36.3	18.18	18.68	36.68	11.67	26.64	18	18	29.61	22.72	23.79	26.33	17.35	17.04	16.09	15.33
	II	18.05	12.05	17.17	30.8	16.34	13.76	27.77	10.66	25.25	17.62	17.62	27.34	22.4	20.45	24.11	16.61	16.29	15.53	14.77
	III	17.3	14.32	15.08	26.89	15.15	13.38	22.15	9.85	24.11	17.35	17.35	25.68	20.65	18.5	21.01	16.16	15.28	14.77	14.32
Jan	**I**	15.78	8 15	13.76	25.62	14.01	16.21	18.99	9.97	12.19	14.89	15.85	24.29	19.24	17.35	19.51	15.85	14.57	14.14	14.01
	II	14.52	7.63	12.87	24.61	13.31	15.96	15.96	10.03	12.05	13.94	15.4	22.47	18.81	16.86	19.19	15.22	14.7	13.13	14.01
	III	13.83	7.45	12.55	23.55	14.52	16.41	14.7	9.16	12.82	13	16.03	21.39	18.11	16.21	19.44	15.15	15.08	13.69	14.01
Feb	**I**	14.52	7.38	12.37	22.22	15.15	15.96	14.57	8.96	12.68	12.19	18.81	20.32	18.18	15.85	19.24	15.4	14.39	13.94	13.2
	II	14.14	7.63	13.45	21.71	15.15	16.28	14.57	11.81	12.24	13.45	19.69	21.89	18.68	15.71	18.99	15.22	14.77	14.07	13
	III	14.26	8.15	19.24	22.47	14.01	17.67	14.52	12.5	12.87	15.22	21.21	21.53	18.68	15.71	18.23	15.58	14.7	14.14	13.38
Mar	**I**	13.06	8.89	23.66	22.59	14.39	20.45	15.78	15.65	13.2	15.85	22.47	23.48	21.64	17.22	20.76	15.85	15.4	13.76	14.46
	II	19.94	10.53	33.13	22.4	14.14	21.96	17.35	19.24	19.69	16.16	34.01	29.54	22.97	19.62	21.96	15.71	14.84	15.58	13.2
	III	18.36	12.3	32.25	27.83	21.58	24.67	27.39	21.53	43.8	18.18	43.1	28.4	29.85	19.44	25.12	25.12	16.72	15.08	22.4
Apr	**I**	21.87	43.76	32.97	25.22	27.29	38.22	37.32	38.22	23.63	19.34	41.56	24.39	27.17	25.22	41.43	27.49	17.2	17.39	20.73
	II	33.73	44.14	38.02	40.42	50.07	43.13	42.37	39.34	23.45	26.03	44.97	20.17	37.97	22.62	32.22	33.35	27.04	18.21	27.73
	III	19.59	40.3	37.32	54	57.65	32.54	27.42	48.56	26.16	36.31	55.32	20.28	40.04	43.2	43.38	37.32	25.96	18.78	31.96

It is seen that the annual minimum 10-daily average flow varies between 7.38 and 21.71 m^3/s whereas the maximum flow ranges from 44.14 to 186.41 m^3/s. The average of 10-daily flows is around 47.35 m^3/s. it can be seen that the year 2002-03 has 90% dependability, while the year 1995-96 has 50% dependability. The 50% and 90% dependability is given in Table-4.33

Table-4.33: Dependable Energy Years for Tidding-I HEP (CA-614.53 sq.km)

Sl.No	Dependibility	Year	Annual Unrestricted Energy (MU)
1	90%	2002-03	392.73
2	50%	1995-95	685.57

4.14.4 Environmental Release

As per the recent approvals accorded by MOEF to similar hydropower projects, 20% of the average flow of four consecutive leanest months in a 90% dependable year should be maintained as environmental flow during the lean season (December to March). During the monsoon period (considered as June to September for this purpose, in tune with other projects in the country), 30% of average discharge computed on the basis of 90% dependable year has to be released. During the non-lean non-monsoon period (October – November and April – May) release of about 25% of the average discharge estimated on the basis of 90% dependable year is required. The year 2002-03 was identified as the 90% dependable year. The abstract of environmental release considered for the power potential study is given in Table 4.34.

Table-4.34: Environmental Release for Tidding-II HEP

Sl.No	Period	Unit	Value
1	December to March	m^3/s	2.9
2	June to September	m^3/s	12.6
3	October - November, April - May	m^3/s	6.5

4.15 KAMLANG HYDROELECTRIC PROJECT

4.15.1 River Characteristics

Kamlang is a major left bank tributary of Lohit River, originating at an elevation of about 3618m, reaching an elevation of 408m at the barrage site after travelling a distance of about 46km. It flows westwards at it origin and then towards south west and again westwards till the barrage site. It is fed by its tributaries Thaosam Brai, Moto Brai, Chi Brai and Sina Brai from the right and Dab Brai, Tamal Brai, Lambad Brai, Loli Brai, Towal Brai and Chibrali Brai from the left. The river network is dendritic in nature, with an average basin slope of about 1:25.

4.15.2 Catchment Area

The catchment of Kamlang River upstream of proposed barrage site (27°44'41.68" North and 96°22'47.90" East) of Kamlang HEP is about 520sq. km. The catchment of the Kamlang is leaf-shaped, in-between fan and fern shape, having a length of 34km and a width of 15.2km and spread between Latitudes 28°4'49.11'' and 28°17'10.97'' North and Longitudes 96° 35'44.52'' and 96°53'7.98'' East. The entire catchment of Kamlang lies in the State of Arunachal Pradesh. The catchment map has been prepared using 1:50,000 from Survey of India (SOI) topographic maps (No. 92A/5, 92A/6, 92A/9 and 92A/10) having contour interval of 20m, which approximately matches with the area calculated using the Google Earth. The highest elevation in the catchment is 4028m**.** The catchment area Map of Kamlang river has been furnished in Figure -4.13.

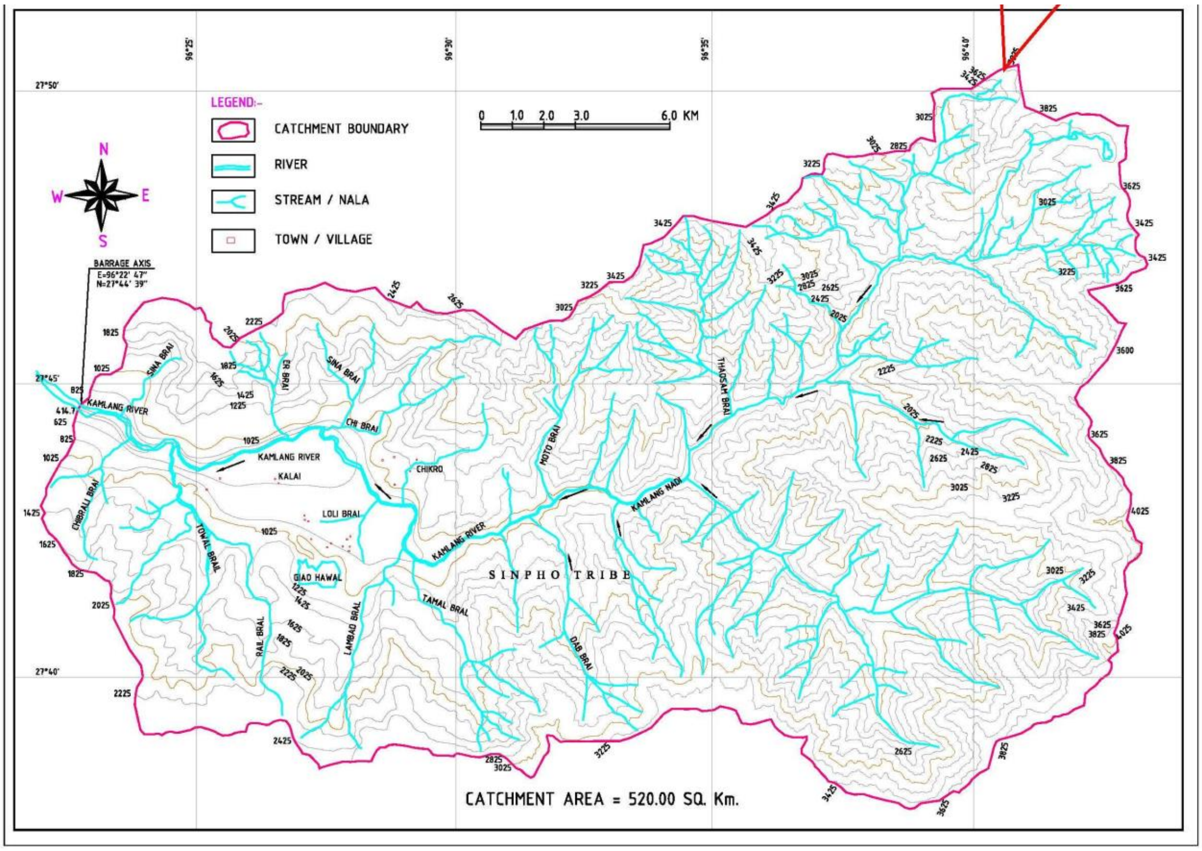


Figure -4.13: Catchment area of Kamlang river

4.15.3 Power Potential

Based on the flow duration curve and allowing 15% of lean period discharge as environmental flow, the incremental power potential and energy availability of Kamlang SHEP has been worked out. On the basis of study, a installed capacity of 24.9 MW (3 x 8.3 MW) adopted for the project appears to be in order. The energy generated in 75% dependable year at this installed capacity is about 133 GMh with load factor of 61%. In 50% dependable year the energy generated will be 167.52 Million kWh.

4.15.4 Dependable Flow Analysis

The annual flow volume estimates for the period 1985-86 to 2003-04 and 2008- 09 to 2011-12 has been utilized to arrive at the 75% and 50% dependable hydrologic year, based on derived and observed data using Weibull Plotting position formula. The summary is given in

Table-4.35.

Table-4.35: Summary of Dependable Year Flow Volumes

Dependability	Dependable Water Year (June-May)	Annual Flow Volume (mcm)	Dependable Water Year (June-May)	Annual Flow Volume (mcm)
	Based on Derived Data		Based on observed data	
90%	2002-03	695.57	-	-
75%	2001-02	1016.57	2008-09	2345.91
50%	1991-92	1273.42	2011-12	3003.94

4.15.5 Environment Release

As per recent recommendations of MOEF for river valley projects, 15% of the average flow of four consecutive leanest months should be maintained for environmental flow till scientific study from reputed institute for deciding the minimum flow to be released during the lean season is completed. Environmental flow though the barrage is to be maintained so that the stretch of river between the barrage and the tailrace tunnel outfall does not dry out. Based on observed series, November to February 2009- 10 was identified as the period having lowest average flow for four consecutive leanest months, with monthly average discharges computed as 29.37, 17.00, 12.08 and 10.52cumecs respectively, with an average discharge of 17.24 cumecs. The environmental release, computed as 15% of the average flow of four leanest months, is derived as 2.586 cumecs. The 10 daily discharge of Kamlang river at Kamlang Barrage site is given in Table-4.36.

Table-4.36: Ten Daily Discharge of Kamlang River at Barrage site based on Observed discharge at Wakro Bridge (2008-09 to 2011-12)

Period			2008-09	2009-10	2010-11	2011-12	2012-13
Jun	1	- 10	125	46	200	74	179
	11	- 20	95	47	144	60	130
	21	- 30	322	133	295	90	770
Jul	1	- 10	290	318	398	308	134
	11	- 20	165	122	279	106	154
	21	- 31	195	101	271	233	176
Aug	1	- 10	107	110	151	147	19
	11	- 20	135	223	96	202	18
	21	- 31	117	207	115	130	17
Sep	1	- 10	172	92	119	108	19
	11	- 20	86	57	110	113	158
	21	- 30	79	73	91	108	122
Oct	1	- 10	84	50	84	80	46
	11	- 20	43	44	103	62	55
	21	- 31	41	34	88	56	57
Nov	1	- 10	36	25	67	40	-
	11	- 20	28	39	58	40	-
	21	- 30	25	24	61	40	-
Dec	1	- 10	21	21	47	32	-
	11	- 20	18	16	44	35	-
	21	- 31	16	15	38	33	-
Jan	1	- 10	15	13	20	31	-
	11	- 20	13	12	22	31	-
	21	- 31	15	10	20	31	-
Feb	1	- 10	13	10	19	29	-
	11	- 20	12	11	35	32	-
	21	- 28	24	11	26	32	-

Period			2008-09	2009-10	2010-11	2011-12	2012-13
Mar	1	- 10	22	87	34	41	-
	11	- 20	23	26	44	37	-
	21	- 31	24	106	66	86	-
Apr	1	- 10	61	296	58	87	-
	11	- 20	45	402	55	131	-
	21	- 30	82	717	84	249	-
May	1	- 10	45	172	72	187	-
	11	- 20	43	517	49	176	-
	21	- 31	37	209	82	137	-

4.16 TEN DAILY DISCHRGE FOR 90% DEPENDABLE YEAR

The 10 daily discharges for 90% dependable year is given in Table-4.37 to 4.39

Table-4.37: Discharge for 90% dependable year for various Hydroelectric Projects

Month		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Anjaw HEP	Demwe Upper HEP	Demwe Lower HEP
June	I	695.12	710	1192.87	1224.88	696	1072	1126
	II	767.36	798	1233.91	1267	805	1578	1657
	III	756.05	784	1455.55	1494.59	788	1737	1824
July	I	1002.64	841	2138.15	2195.51	809	2142	2249
	II	1023.38	1124	1922.42	1973.99	1157	1277	1341
	III	781.37	1189	1645.75	1689.9	1238	918	964
August	I	819.29	861	1160.34	1191.46	877	745	783
	II	816.91	863	1129.17	1159.45	879	688	723
	III	616.19	619	1025.83	1053.24	579	726	762
September	I	553.61	539	752.96	773.15	484	727	764
	II	526.8	506	657.18	674,81	444	697	732
	III	913.31	975	636.76	653.84	1022	601	631
October	I	622.18	758	533.39	547.69	765	556	584
	II	399	487	471.73	484.38	431	527	553
	III	374.18	457	376.93	387.04	394	493	517
November	I	345.66	358	358.09	367.7	403	439	461
	II	316.13	353	307.26	315.5	375	418	438
	III	284.9	307	293.12	300.98	346	398	418
December	I	268.99	294	423.31	434.67	332	382	401
	II	256.2	283	388.49	398.91	320	365	383
	III	240.43	270	397.74	405.33	305	351	368
January	I	225.49	258	269.5	276.73	291	341	358
	II	203.35	239	278.58	286.06	271	340	357
	III	216.93	251	227.26	233.36	283	341	358
February	I	221.81	255	219.88	225.77	288	315	330
	II	224.6	257	226.01	232.06	290	310	325
	III	226.21	258	304.24	312.4	292	320	336
March	I	217.62	251	170.86	175.44	284	353	371
	II	257.71	285	200.78	206.16	321	314	330
	III	246.99	276	221.81	227.75	312	603	634
	I	419.78	322	474.29	487.01	360	600	630

Month		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Anjaw HEP	Demwe Upper HEP	Demwe Lower HEP
April	II	445.8	337	572.66	588.02	376	819	860
	III	449.27	347	612.98	629.42	388	951	998
May	I	570.08	550	715.77	734.96	506	780	820
	II	748.43	766	805.53	837.24	773	740	777
	III	764.87	786	820.5	842.51	797	852	895

Table-4.38: 10 daily discharges for 90 % dependable year for various HEPs

Months		Gimliang HEP	Raigam HEP	Tidding-I HEP	Tidding-II HEP
May	I	17.55	78.45	36.29	29.06
	II	24.72	110.23	51.12	40.93
	III	25.36	113.10	52.44	41.99
June	I	21.85	98.17	45.18	36.18
	II	24.74	111.02	51 16	40.96
	III	24.32	109.16	50.29	40.27
July	I	26.56	119.21	54.92	43.98
	II	35.9	160.63	74.24	59.44
	III	38.07	170.26	78.73	63.04
August	I	26.36	118.40	54.51	43.65
	II	26.4	118.57	54.59	43.71
	III	18.36	82.91	37.97	30.40
September	I	16.23	73.10	33.56	26.87
	II	15.16	68.36	31.35	25.10
	III	30.64	136.99	63.36	50.73
October	I	24.48	109.08	50.62	40.53
	II	15.53	69.35	32.12	25.71
	III	14.54	64.96	30.07	24.08
November	I	11.82	52.4	24.44	19.57
	II	11.02	48.85	22.79	18.25
	III	10.14	44.96	20.97	16.79
December	I	9.72	43.1	20.10	16.09
	II	9.38	41.58	19.40	15.53
	III	8.92	39.55	18.45	14.77
January	I	8.54	37.86	17.66	14.14
	II	7.93	35.16	16.40	13.13
	III	8.27	36.68	17 10	13.69
February	I	8.42	37.35	17.41	13.94
	II	8.5	37.69	17.58	14.07
	III	8.54	37.86	17.66	14.14
March	I	8.31	36.87	17 18	13.76
	II	9.41	41.78	19.46	15.58
	III	9.11	40.42	18.84	15.08
April	I	10.5	46.83	21.71	17.39
	II	11.00	49.03	22.75	18.21
	III	11.34	50.55	23.45	18.78

Table-4.39: 10 daily discharges for 75 % dependable year for Kamalang HEP

Months		Kamlang HEP
June	I	125
	II	95
	III	322
July	I	290
	II	165
	III	195
August	I	107
	II	135
	III	117
September	I	172
	II	86
	III	79
October	I	84
	II	43
	III	41
November	I	36
	II	28
	III	25
December	I	21
	II	18
	III	16
January	I	15
	II	13
	III	15
February	I	13
	II	12
	III	24
March	I	22
	II	23
	III	24
April	I	61
	II	45
	III	82
May	I	45
	II	43
	III	37

CHAPTER – 5
TERRESTRIAL ECOLOGY

CHAPTER-5
TERRESTRIAL ECOLOGY

5.1 INTRODUCTION

The state of Arunachal Pradesh lies within coordinates 26° 30' N and 29° 30' N latitudes and 91° 30' E and 97° 30' E longitudes. The state has a very wide altitudinal variation ranging from flood plains of Brahmaputra to more than 7600 m high mountain peaks. The elevational variation, associated variability in climatic and edaphic factors, phytogeographical position, and undulating topography of the state have led to formation of varied ecological diversity, with a rich gene pool of wild and domesticated plant species. The mountainous topography of the state presents an ideal condition for the development of hydro-electric projects. Based on the size and volume of water drained, there are five major river basins in the state, namely, Kameng River Basin, Subansiri River Basin, Siang River Basin, Dibang River Basin and Lohit River Basin. The above mentioned major rivers of the state either constitute or finally drain into the Brahmaputra River. Each of these rivers has very high potential of hydro-power generation. Besides, there are many tributaries and distributaries of these rivers which also offer suitable locations for the development of hydro-electric power projects. On the other hand, more than 80% of the total geographical area of Arunachal Pradesh is covered with forest (FSI 2003). Therefore, development of hydropower projects would obviously affect the forest area of the state. Considering the importance of power in country’s development, it is required to maintain a balance between the development of hydropower projects and forest conservation. As the first step of forest conservation, it is essential that the floristic survey of the proposed project sites be made in order to make an account of the plant diversity in the area and identify the species for conservation.

5.2 HISTORICAL ACCOUNT ON FLORISTIC SURVEYS IN ARUNACHAL PRADESH

A large number of European botanists and explorers visited the area in the early 19th century (Buchanan-Hamilton 1820, Roxburgh 1820-1824, Griffith 1847, Hooker 1854, 1872-1897, Hooker and Thompson 1855, Clarke 1889, Burkill 1924-1925, 1965, Kingdom Ward 1929, 1960). Lieutenant R. Wilcox and Captain Bedford visited the *Mishmi Hills* in Arunachal Pradesh during their survey of Assam and the neighboring countries for geographic discoveries in the North East Frontier (1825-1828). However, it was W. Griffith (1847) who made botanical explorations for the first time and the ‘*Flora of Mishimee Hills’* was based on his collections made during October-December, 1836. After that Thomas J. Booth made horticultural explorations during 1840-1850 from *Bisnath* (Assam) to the ‘*Daphla Hills*’ in the southeastern corner of Bhutan and described a few Rhododendrons from the area. However, Robinson

(1841) gave the first kind of floristic account of the region. Further, Hooker (1854 and 1906) presented a detailed account on the vegetation and flora of the region. In the 20th century, the floristic explorations gained momentum which resulted in publication of some important floristic accounts of the region such as *Botany of Abor Expedition* by I.H. Burkill (1924-25), *Botanical Expedition in the Mishmi Hills* by Kingdom Ward (1929-1931), *A Sketch of the Vegetation of Aka Hills* by N.L. Bor (1938), *Lohit Valley* by Kingdom Ward (1953) and, *The Flora of Aka Hills* by K.P. Biswas (1941) based on the collections of N.L. Bor (1931-1934). Lately, Kanjilal *et al*. (1934-1940) published the regional *Flora of Assam* in 5 volumes, containing the first hand account of the vegetation of North East.

For extensive floristic explorations in the northeast region, the Botanical Survey of India was reorganized and the Eastern Circle was established at Shillong in December, 1955. To enable further explorations in Arunachal Pradesh, a Field Station was established at Itanagar in July 1977. Since then, several floristic accounts on Arunachal Pradesh were published viz., Panigrahi and Naik (1961), Rao and Panigrahi (1961), Panigrahi (1965, 1966), Rao and Joseph (1965), Panigrahi and Joseph (1966), Sastry (1966), Panigrahi and Kar (1967), Joseph (1968, 1975, 1981), Rao and Ahuja (1969), Sahni (1969), Rao (1972), Rao and Deori (1980), Hajra (1970, 1973, 1976), Rao and Murti (1990), Rao (1994). *A contribution to the Flora of Namdapha, Arunachal Pradesh* (Chauhan *et al*. 1996), *Materials for the Flora of Arunachal Pradesh*, Vol. 1 (ed. Hajra *et al*. 1996), Orchidaceae of Arunachal Pradesh (Checklist) (Chowdhery and Pal 1997), and Orchid Flora of Arunachal Pradesh (Chowdhery 1998) are some of the contributions made towards the floristic accounts of Arunachal Pradesh. Haridasan (1997) and Haridasan *et al.* (1998) gave a brief account of the flora of Dibang valley and Lohit districts of Arunachal Pradesh.

5.3 FOREST TYPES IN ARUNACHAL PRADESH

Champion and Seth (1968), Rao and Panigrahi (1961), Sahni (1981), Rao and Hajra (1986) are some prominent workers who studied the forest and vegetation of Arunachal Pradesh. Rao (1972) categorized the vegetation of Arunachal Pradesh into the following types:

- Tropical
- Sub-tropical
- Temperate
- Sub-alpine
- Alpine based

Recently, Kaul and Haridasan (1987) classified the forest and identified 6 major types within 4 climatic categories and compared them with the classical types of Champion and Seth (1968). The forest types of Arunachal Pradesh can be classified into:

1. Tropical Forests
    i. Tropical evergreen forests
    ii. South Bank Tropical Wet Evergreen Dipterocarpus Forests
    iii. North Bank Tropical Evergreen Nahor-Jutuli Forests
    iv. Tropical Semi-Evergreen Forests
    v. Low Hills and Plains Semi-Evergreen Forests
    vi. Riverine Semi-Evergreen Forests
2. Sub-tropical Forests
3. Pine Forests
4. Temperate Forests
    i. Temperate broad leaved forests
    ii. Temperate conifer forests
5. Alpine Forests
6. Degraded Forests
    i. Bamboo forests
    ii. Grasslands

According to Champion and Seth (1968) classification the forest types of Arunachal Pradesh can be categorized as:

1. Assam valley tropical evergreen forests (IB/C1)
2. Upper Assam valley tropical evergreen forests (IB/C2)
3. Assam alluvial plains semi-evergreen forests (2B/C1a)
4. Sub Himalayan light alluvial semi-evergreen forests (2B/C1/S1)
5. East Himalayan moist deciduous forests (3C/C3B)
6. Eastern hollock forests (3/1S2)
7. East Himalayan subtropical forests (8B/C1)
8. Assam subtropical pine forests (9/C2)
9. East Himalayan wet temperate forests (11B/C1)
10. Lauraceae forests (11B/C1a)
11. Bak Oak forests (11B/C1b)
12. High level Oak forests (11B/C1c)
13. Naga hill temperate forests (11B/C2)
14. East Himalayan mixed coniferous forests (12/C3a)
15. Abies delavayi forests (12/C3b)
16. East Himalayan sub-alpine birch/fir forests (14/C2)
17. Alpine pastures (15/C3)
18. Dry alpine scrub (16/C1)
19. Dwarf juniper scrub (16/E1)

5.4 FLORISTIC DIVERSITY OF ARUNACHAL PRADESH

Arunachal Pradesh accounts for 2.5% of the total geographical area of the country and contains more than 23.5% of the flowering plants of India. 76.9% families of India are represented in Arunachal Pradesh. Chowdhery *et al*. (1996) enumerated 4,117 species of angiosperms belonging to 1295 genera and 192 families from the state against 17,500 species in 2984 genera and 247 families in India. Out of these 2,986 species belonging to 970 genera and 165 families are of dicots and 1,131 species under 325 genera belonging to 27 families are of monocots. There are about 41 monotypic families. Among the dicots, the monotypic herbaceous families, Balsaminaceae, Begoniaceae, are represented by 33 species of *Impatiens* and 19 species of *Begonia* respectively. While, the monotypic families representing the tree species like Aceraceae and Symplocaceae are represented by 15 species of *Acer* and 13 species of *Symplocos* respectively. The monotypic families of the monocots are Dioscoreaceae and Smilacaceae. They are represented by 25 species of *Dioscorea* and 19 species of *Smilax* respectively. Pteridophytes also form a significant feature of the vegetation in the state. Out of 1020 species of ferns occurring in India, 452 species are recorded from Arunachal Pradesh (Baishya 1999). The diversity of fern allies like *Selaginella* and *Lycopodium* are best represented in this region.

The family Orchidaceae is a highly evolved groups of plants with 1,229 species belonging to 184 genera in India (Singh and Chauhan 1999) out of which 545 species belonging to 122 genera are reported from Arunachal Pradesh (Chowdhery 1998), of which 20 species are endemic to the state (Hegde 1998). Among all the described species of orchids from Arunachal Pradesh, 17 species are saprophytes, 138 species are terrestrials and 383 species are epiphytes. Some of the dominant genera are *Bulbophyllum*, *Calanthe*, *Cymbidium*, *Dendrobium* and *Eria*.

Bamboos are also a dominant group of plants in the state. 23 genera and 120 species are so far known from India (Biswas 1998) of which 17 genera and 89 species are represented in the northeast India (Haridasan 2000). 26 species belonging to 9 genera of bamboo occur in Arunachal Pradesh. Some of the important genera are: *Bambusa* (4 species), *Dendrocalamus* (6 species), *Schizostachyum* (7 species) and *Chimonocalamus* (2 species).

Among Gymnosperms, out of 48 species belonging to 15 genera and 8 families native in India 24 species in 13 genera are found in Arunachal Pradesh. Some of the cultivated species of gymnosperms include *Agathis robusta*, *Araucaria columnaris*, *Cryptomeria japonica*, *Taxodium disticum* and *Thuja orientalis*. *Amentotaxus assamicus* is endemic to Arunachal Pradesh.

The state abounds in quite a large number of primitive flowering plants and many species of Annonaceae, Piperaceae and Lauraceae do not occur in other parts of India except Northeast region, Eastern Himalaya, Assam and Burma. Some of the primitive genera are *Magnolia*, *Alnus*, *Betula*, *Holboellia*, *Exbucklandia* etc.

The physiographic features along with its geological history have contributed to high endemism in this relatively young mountain system. The occurrence of endemics, determined by biogeographic provinces, unique ecosystems, and topographical and climatological interfaces, is suggestive of biogeography, center of speciation, and adaptive evolution of the biota of this region. Out of 17,500 described species of flowering plants, over 5000 species belonging to 140 genera and 47 families are endemic to India. It is estimated that *ca* 3,500 endemic species occur in northeast India. Chowdhery (1999) provides a list of 238 endemic taxa from Arunachal Pradesh.

5.5 FOREST TYPES IN LOHIT BASIN

Lohit basin is rich in plant diversity. The major forest types surveyed in the Lohit river basin including the Upstream area are:

- Tropical semi-evergreen forest
- Tropical secondary forest
- Plantation forests
- Montane sub-tropical wet hill forest
- East Himalayan sub-tropical pine forest
- East Himalayan wet lower temperate forest
- East Himalayan wet temperate forest
- East Himalayan coniferous forest.

5.5.1 Tropical semi-evergreen forests

The vertical stratification in these types of forests is clearly distinguishable into emergent, canopy and sub-canopy tree layers, shrub layer and ground flora. The tropical climatic conditions have favored growth of a multitude of plants making these forests resource rich. Patches of primary undisturbed evergreen forests, especially on the left bank of Lohit river are seen, which are dominated by tree species such as *Altingia excelsa, Canarium strictum, Duabanga grandiflora*, *Ficus* spp*., Terminalia myriocarpa*, *Pterospermum acerifolium, Meliosma simplicifolia,* etc. The shrub layer is rich and includes species like *Acacia pennata, Acacia pruinescen, Boehmeria longifolia, Boehmeria macrophylla, Calamas erectus, Calamus leptospadix, Clerodendron coolebrokianum, Debregessia longifolia* and *Desmodium laxiflorum.* The herbaceous layer consists of *Begonia* sp., *Cyanotis vaga*, *Lygodium flexuosum*, *Ophiopogon intermedius*, *Pilea* sp., *Symethea ciliata* etc. Some species found in the study area are important from conservation point of view such as *Lagerstroemia muniticarpa* which is globally an endangered category of species. Plants of economic importance such as timber, medicinal, edible fruits were common e.g., *Canarium strictum* is a very good incense yielding tree and *Pandanus* species is a fiber yielding tree species.

Such forests are seen all along the river valley and are found in the areas of Kalai stage-1, Kalai stage-2, Hutong stage-1, Hutong stage-2, Upper Demwe, Lower Demwe hydroelectric projects. These forests belong to the following categories of Champion and Seth classification (1968):

2B/C1a Assam alluvial Plains semi-evergreen forests

This is a closed high forest community with varying proportions of evergreen and deciduous trees in the top storey. The important species include *Terminalia myriocarpa, Ailanthus integrifolia, Canarium strictum, Castanopsis indica, Dillenia indica, Dysoxylum procerum, Garuga gamblei, Michelia champaca, Phoebe cooperiana, Pterospermum acerifolium* and *Syzygium cumini.* Second storey is represented by trees like *Albizia lucida, Cinnamomum pauciflorum, Dalbergia sissoo, Gynocardia odorata, Magnolia hodgsonii, Meliosma simplicifolia* etc. Understorey is represented by bamboos, canes, and many woody shrubs and climbers. Epiphytes are represented by a few ferns, orchids and lianas that grow on the large tree trunks. Shrubs in these forests are represented by *Boehmeria macrophylla, Calamus leptospadix, Dracaena angustifolia, Oxyspora paniculata, Maotia puya, Phlogacanthus thrysiflorus, Micromelum integerimum, Difflugossa colorata.* The forest floor, wherever disturbed, is covered with herbs and tall grasses like *Ageratum conyzoides, Bidens bipinnata, Eriophorum comosum, Commelina benghalensis, Imperata cylindrica, Pogonatherum paniceum, Saccharum longisetosus* and *S. spontaneum.*

2B/1S1 Sub-Himalayan light alluvial semi-evergreen forest

This is a mixed high forest community which occurs in lower elevation of Lohit basin, particularly along the river banks. The top canopy in these forests consists of many deciduous trees, while the second storey is dense mixed and consists of both evergreen and deciduous tree species. The top canopy comprises *Duabanga grandiflora, Garuga gamblei, Phoebe hainesiana, Artocarpus lokoocha, Spondias pinnata* and *Terminalia myriocarpa.* The second storey is represented by *Callicarpa arborea, Glochidion lanceolarium, Gynocardia odorata, Macaranga denticualata Mallotus roxburghii, Ficus elmerii, Endospermum chinensis,* etc. This type of forest is found in the submergence area of Demwe Lower hydroelectric project. The understorey of these forests is represented by bamboos, canes, palms and shrubs. Shrubby species include *Bambusa pallida, Boehmeria macrophylla, Calamus floribundus, Clerodendrum bracteatum, Costus speciosus, Boehmeria hamiltonii, Micromelum integerrimum, Oxyspora paniculata* and *Pinanga gracilis.* *Caryota urens,* a tall palm, makes a noticeable presence in this forest. Climbers are represented by species of *Pegia nitida, Cayratia pedata, Dioscorea pentaphylla, Entada purseatha, Pothosscandens, Raphidophora lancifolia, Stephania hernandifolia, Thunbergia grandiflora,* etc. Some common epiphytes present here are species of *Dendrobium, Pholidota, Eria, Asplenium, Hoya, Lepisorus* and *Microsorium.* The forest floors which are disturbed at many places show gaps and are covered with herbs and grasses like *Polygonum chinensis, Ageratum conyzoides, Alpinia alughas, Bidens bipinnata, Commelina benghalensis, Cyrtococcum accrescens, Digitaria ciliaris, Oplismenus compositus, Saccharum longisetosus, S. spontaneum* and *Thysanolaena maxima.*

5.5.2 Tropical secondary forests

These forests have lesser species diversity and are formed of secondary successional species. The density of plants is low and structure is less complex. The secondary forests have grown along the West bank of the river where primary forests have been cleared in the past for timber or shifting cultivation. The secondary forests are dominated by trees belonging to species *Macaranga denticulate* and *Callicarpa arborea.* The old grown secondary forest, particularly in certain patches along Lohit River gives the impression of an undisturbed primary forest. The herbaceous flora of these forests is mostly of weedy nature. These types of forests are seen along the West bank of the river in all the project sites.

According to Champion and Seth (1968) classification, the following forest type is also found under the secondary forest category.

2SI Secondary moist bamboo brakes

These scattered bamboo brakes occur in areas which are abandoned and cleared for agriculture. *Bambusa pallida, Dendrocalamus Hamiltoni* are the important species under this forest category.

5.5.3 Plantation forests

The plantations have been raised along the left bank of the Lohit river in Lower Demwe where primary forests have been cleared in the past for timber. The plantation is dominated by trees belonging to species *Bombax cieba*, *Emblica officinalis*, *Albizia chinensis* and *Kydia calycina*. Some tree species that grow here are *Bombax ceiba, Macaranga denticulata, Sterculia villosa, stereospermum colais, Spondias pinnata*, etc. and are found growing along the edges of degraded bamboo forests.

5.5.4 Montane Subtropical wet hill forests

This forest type occurs in Lohit basin around upper reaches of Demwe and Zero point. These forests generally occur on hilly terrain between 900-1200 m elevations and are dominated by evergreen species. These forests are undisturbed on the left bank of the river Lohit (opposite bank of the road). One can approach these forests after crossing the hanging bridges across the river. *Alnus nepalensis, Prunus cerasoides, Quercus lamellosa* and *Engelhardtia spicata* are dominant species in this forest.

According to Champion and Seth (1968) classification, the forest falls under 8B/ C I East Himalayan sub-tropical wet hill forests category. A number of deciduous trees also occur in the canopy. The top canopy is comprised of *Alnus nepalensis, Castanopsis hystrix, Cinnamomum glaucesens, Engelhardtia spicata, Phoebe attenuata, Prunus cersoides, Quercus lamellosa, Magnolia campbellil,* etc. The second storey is represented by some medium sized evergreen tree species such as *Brassaiopsis speciosa, Macropanax undulatus, Rhus chinensis, Saurauia roxburghii, Persea gambelii, Symplocos glomerata,* etc. The understorey consists of a number of shrubs and climbers and among shrubs found in these forests are *Boehmeria macrophylla, Chasalia curviflora, Debregeasia longifolia, Eurya acuminata, Medinilla erythrophylla, Oxyspora paniculata,* etc. There are numerous climbers and epiphytes and the species of *Mastersia, Cissus, Pegia, Bauhinia, Clematis, Dioscorea, Smilax, Entada,* etc. constitute important climbers and lianas. The ground flora at many places is disturbed and the canopy shows gaps. These gaps are represented by herbs and grasses viz., *Ageratum conyzoides, Aster mollisculus, Anaphalis busua, Bidens bipinnata, Cardamine hirsuta, Crassocephalum crepidioides, Impatiens* sp., *Persicaria capitata, P. barabata, Setaria glauca, Themeda arundinacea, Thysanolaena maxima, Viola pilosa,* etc.

5.5.5 East Himalayan sub-tropical pine forest

This forest type is not found in Champion and Seth (1968) classification. This forest is dominated by *Pinus merkusii* occurring at an elevational range of 1200 – 1400 m in Chigwinti Walong – Kaho area and before reaching Walong. Although not described by Champion and Seth (1968), it can be categorized as Sub-tropical pine forests.

5.5.6 East Himalayan wet lower temperate forest

This forest type is in continuity with montane subtropical wet hill forest occurring in the elevation range of 1200 -2500 m elevation. The dominant tree species in this forest are *Acer campbellii, Alnus nepalensis, Castanopsis tribuloides, Engelhardtia spicata* and *Quercus lamellose.* According to Champion and Seth (1968) classification, following forest type falls under this category.

11b/C1 East Himalayan Wet temperate forests

These forests are closed evergreen forests of trees of medium height and occur between 1700-2700m in the higher hills. The important trees of the canopy include *Acer campbellii, Alnus nepalensis, Betula alnoides, Exbucklandia populnea, Castanopsis tribuloides, Engelhardtia spicata* and *Quercus lamellosa.* The middle storey is represented by some moderate sized tree species such as *Eurya acuminata, Ilex dipyrena, Litsea* sp., *Lyonia ovalifolia, Prunus cerasoides* and *Mahonia pycnophylla*. These forests are found in upper reaches of Khairang and Chigunti areas. Shrubs are represented by the species of *Berberis, Mahonia, Rubus, Sinarundinaria falcata, Viburnum erubescens,* etc. There are only a few climbers, while epiphytes are represented by ferns and orchids. The ground flora is represented by species of *Anaphalis, Cardamine, Campanula, Circium, Fragaria, Plantago, Persicaria, Stellaria* and *Viola.*

5.5.7 East Himalayan coniferous forest

This forest is found on the drier ridges between 2500 m and 2700m elevations. Beyond Kibito, this forest type is encountered. They form the Upstream area of the basin. According to Champion and Seth (1968), this forest belongs to 12/C3 East Himalayan mixed coniferous forests category.

The forests of this zone are dense evergreen, with predominating Hemlocks and firs. Hemlock *(Tsuga dumosa*) makes appearance in the upper reaches as a dominant tree species, At the higher elevations Hemlock gives way to Silver fir (*Abies densa*). Apart from the conifers, some oak mixed deciduous broad-leaved species such as *Acer, Betula, Magnolia* and *Rhododendron* are also found in the forests. The undergrowth is represented by a number of evergreen shrubs such as *Berberis, Cotoneaster, Rhododendron, Salix, Thamnocalamus and Viburnum.* Most of the shrubs are laden with many epiphytic mosses and lichens.

5.6 VEGETATION PATTERN IN THE LOHIT BASIN

The vegetation particularly along East bank is relatively undisturbed. However, there are patches of forests which have been recently cleared for shifting cultivation even along this bank. The West bank of the river is relatively degraded. Orange orchards, human settlements and jhum fields are often seen along this accessible bank. In some of the areas which had long fallow period usually in little remote areas had trees like *Duabanga grandiflora*, *Macaranga denticulata* and bamboo species which essentially are pioneer species. Such tree species are good for fuel wood purpose. A few fodder trees such as *Ficus* spp. were seen along the roadside. Beside this, Bamboo species and *Musa* sp*.* were also found in these jhum fallows. The forest at the disturbed area shows stunted growth and showed three distinct strata viz., canopy layer of trees with 10m height, shrub layer and the ground layer. However, undisturbed primary forest of the area had distinct stratification. At places emergent trees of isolated trees followed by a thick canopy, subcanopy and undercanopy layers was observed.

5.7 PLANT DIVERSITY IN THE PROJECT SITES ON MAIN LOHIT RIVER

The vegetation and floristic survey in the Lohit basin was done for the project sites listed as below:

- Kalai stage-1 hydroelectric project
- Kalai stage-2 hydroelectric project
- Hutong stage-1 hydroelectric project
- Hutong stage-2 hydroelectric project
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project

The monitoring was done for two seasons, i.e., summer season (April 2009) and monsoon season (August 2009).

5.8 FIELD SURVEY

Field visit was undertaken to gather information on the representative floral diversity of each project area and for which 4 to 5 sampling locations were identified at each project site. Considering the difficult terrain, quadrat method was used for vegetation sampling. The phyto-sociological data was collected by laying the quadrats randomly of different sizes at each sampling site of the selected projects. The size of the quadrats laid were 10x10m for trees and shrubs and 1 x 1 m for herb component.

The sampling locations for terrestrial ecological survey for main lohit river are shown in Figure-5.1.

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 were measured at 1.5 m above the ground level.

Based on the quadrat data, frequency, density and cover (basal area) of each species were calculated. The importance value index (IVI) 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. IVI represent the contribution that a species makes to the community in respect of: (a) the number of plants within the quadrats (abundance), (b) its influence on the other species through its shading, competition or aggressiveness (dominance), and (c) its contribution to the community through its distribution (frequency). Thus, the index is purely a measure of the contribution of a species to that vegetation in which it is present, regardless of whether the ground is completely covered or very sparsely covered.

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 volume was estimated using the formula: $\pi r^2 h$, where r is the radius and h is the estimated height of the bole of the tree. The data on density and volume were presented in per ha basis.

To assess diversity of floral elements and numerical structure of the plant community in the study sites, different diversity indices were used. A diversity index is a mathematical measure of species diversity in a community. They provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account. Two species diversity indices viz., Shannon index of general diversity (H) and Evenness index (e) were computed using PAST software:

Shannon index. It is an index used to measure diversity in categorical data. In a basic sense, it is the information entropy of the distribution in a given area treating species as symbols and their relative population sizes as the probability. The diversity index takes into account the number of individuals as well as number of taxa. It varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. The advantage of this index is that it takes into account the number of species and the evenness of the species. The index is increased either by having additional unique species, or by having greater species evenness. Higher values of Shannon index indicate that a particular community has more information.

$$\overline{H} = -\Sigma \frac{ni}{N} ln \left(\frac{ni}{N} \right)$$

Buzas and Gibson's evenness index was calculated using the formula: e^H / S, where H is the Shannon's index and S represents the number of species. It indicates the relative abundance or proportion of individuals among the species.

During the vegetation survey, herbaria were prepared for the plants that had flowers and fruits. Conservation status of the recorded plant 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.

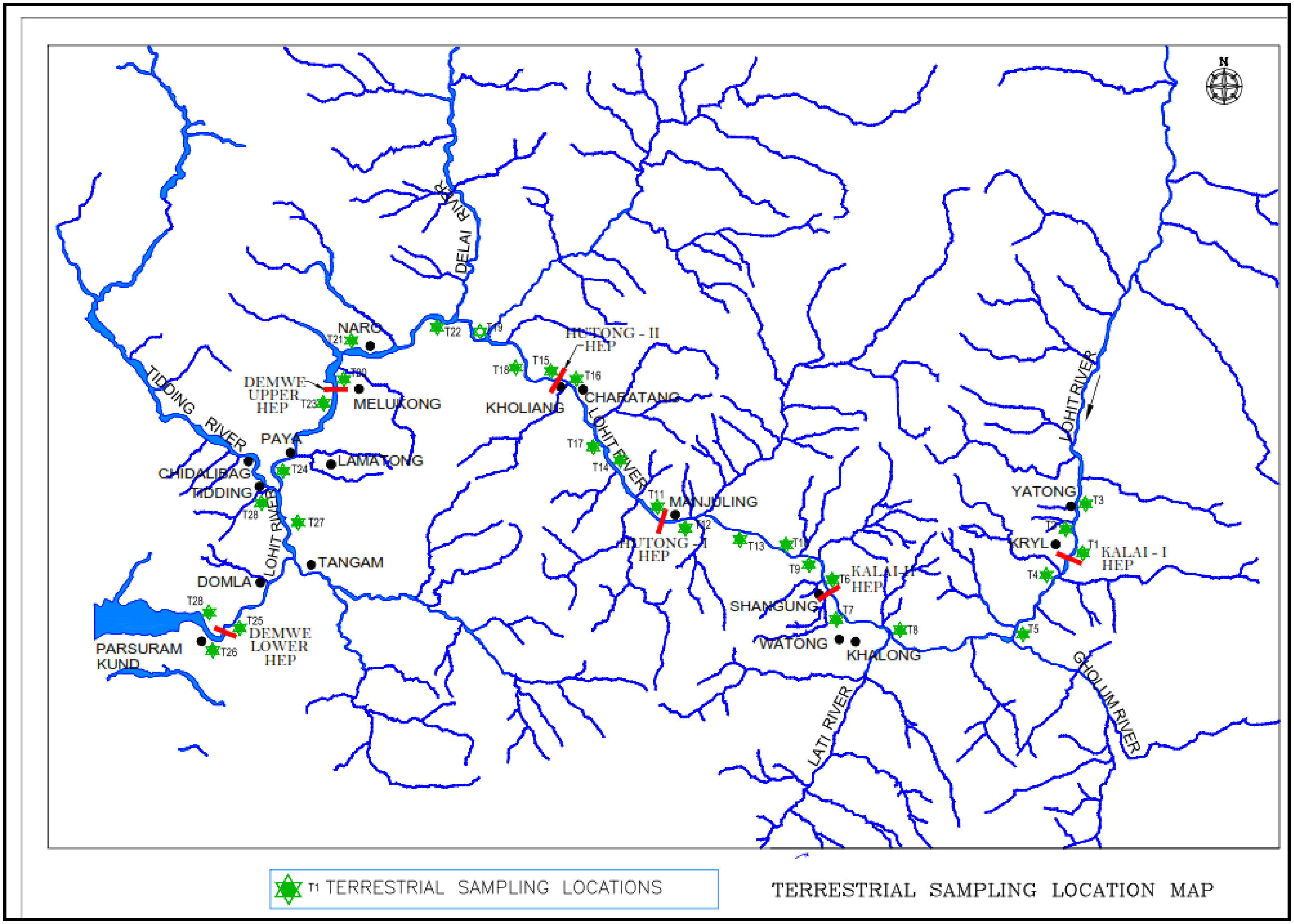


Figure-5.1: Terrestrial ecological survey Location for main lohit river

5.9 PLANT DIVERISTY AT VARIOUS SITES

5.9.1 Kalai hydroelectric project, Stage-1

The following sites were monitored as a part of the Terrestrial Ecological Survey:

- T1 - Dam site
- T2 - Submergence area
- T3 - Upstream area
- T4 - 1 km downstream of dam site
- T5 - 3 km downstream of Wallang village

The findings of the vegetation survey at various sampling sites are given in **Annexure-I.** The summary of the findings of vegetation survey are given in Table-5.1. The diversity indices of various floral species are given in Table-5.2.

Table-5.1: Density (ind./ha) of various floral species at various sampling sites covered in Kalai hydroelectric project, Stage-1

S.No.	Sampling Site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam site	570	1895	294520	361500
2.	Submergence area	550	2245	270000	354000
3.	Upstream area	290	1320	297500	380500
4.	1 km downstream of dam site	335	4100	238000	374525
5.	3 km downstream of Wallang village	320	2235	277500	393500

Note: Summer Season- April 2009, Monsoon season- August 2009

Table-5.2: Species Diversity Indices for Kalai hydroelectric project, Stage-1

Vegetation component	Diversity Indices Shannon's Diversity Index (H)	Evenness Index (e)
Dam site		
Trees	2.35	0.89
Shrubs	2.11	0.88
Herbs	2.18 (April), 2.71 (Aug)	0.75 (April), 0.90(Aug)
Submergence area		
Trees	1.75	0.76
Shrubs	2.00	0.87
Herbs	2.27 (April), 2.25 (Aug)	0.91 (April), 0.91 (Aug)
Upstream area		
Trees	0.17	0.25
Shrubs	1.85	0.83
Herbs	1.49 (April), 1.55 (Aug)	0.72 (April), 0.75 (Aug)
1 km downstream of dam site		
Trees	2.40	0.88
Shrubs	1.94	0.78
Herbs	2.45 (April), 2.65 (Aug)	0.90 (April), 0.92 (Aug)

Vegetation component	**Diversity Indices Shannon's Diversity Index (H)**	**Evenness Index (e)**
3 km downstream of Wallang village		
Trees	1.37	0.70
Shrubs	1.66	0.85
Herbs	1.58 (April), 1.55 (Aug)	0.76 (April), 0.75 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

The dam site is located near Quibang village. The submergence is confined to narrow strips along the river Lohit, on account of steep slopes on both the sides. Relatively less steep areas, which has greater human interferences on account of increased accessibility, disturbed secondary forests were observed. A few jhum cultivation plots and orange orchards were also seen along this bank. In the proposed damsite, 14 tree species were recorded. The average tree density at this site was 570 trees/ha. *Albizia* sp. with 180 individuals was the dominant tree species. There were 12 shrubs with a density of 1895 individuals/ha. *Boehmeria longifolia* and *Debregessia longifolia* dominated the shrub layer. The species richness as well as density of herb was higher during the monsoon season as compared to summer season. *Ageratum conyzoides* and *Saccharum spontaneum* were dominant species in the herbaceous layer. Species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2 in the forests studied. The evenness index value ranged from 0.75-0.90 for most of the components.

In the submergence area, 10 tree species were recorded in this forest. The average tree density at this site was 550 trees/ha. Eleven shrub and twelve herbs including climbers were recorded from this forest. *Artemisia nilagirica* and *Debregessia longifolia* were dominant shrub species, while *Imperata cylindrica* and *Ageratum conyzoides* were the dominant herbs. Shannon's diversity index for tree, shrub and herb was more than 1.75, while the evenness index was also high having values more than 0.76.

The upstream area is represented by Pine forest and only two species were recorded in this forest. The average tree density at this site was low (290 trees/ha). *Pinus merkusii* was the dominant tree species. Nine shrub and eight herbs including climbers were recorded from this forest. The herb density was higher during the monsoon season. *Artemisia* spp., among shrub and *Imperata cylindrica, Ageratum conyzoides* and *Nephrolepis cordifolia* among herb were the dominant species. Shannon's diversity index for the tree components was very less (0.17) while for shrubs and herbs it ranged from 1.49-1.85. Evenness values ranged from 0.25-0.83 for trees, shrub and herbs.

In 1 km downstream of dam site, 15 tree species were recorded. The dominant tree species in the site were *Ficus cunia* (90 individuals /ha) and *Saurauria nepalensis* (45 individuals /ha). The average tree density at this site was 335 trees/ha. *Artemisia nilagirica* and *Boehmeria longifolia* were dominant shrub species. *Imperata cylindrica* and *Ageratum conyzoides* were dominant herbs in both summer and monsoon seasons.

Seven tree species were recorded at the site located 3 km downstream of Wallang village. The dominant tree species in the site was *Pinus merkusii* (135 individuals/ha). The average tree density at this site was 320 trees/ha. *Artemisia nilagirica* was dominant shrub species, while *Imperata cylindrica* and *Ageratum conyzoides* dominated the herbaceous layer in both the summer and monsoon season.

The tree and shrubs did not show any difference in terms of composition and diversity while herbaceous component shows difference in the density of the species with season at all the sites.

5.9.2 Kalai hydroelectric project, Stage-2

The following sampling sites were monitored at various locations in the Kalai hydroelectric project, Stage-2:

- T6 - Dam site
- T7 - Submergence area
- T8 - Upstream area
- T9 - 1 km downstream of Hawai
- T10 - 3-5 km downstream

The findings of the vegetation survey at various sampling sites are given in **Annexure-II**. The summary of the findings of vegetation survey are given in Table-5.3. The diversity indices of various floral species are given in Table-5.4.

Table-5.3: Density of various floral species at various sampling sites covered in Kalai hydroelectric project, Stage-2

Unit (No./ha)

S.N.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam Site	515	1490	196500	351000
2.	Submergence area	610	3040	187000	284500
3.	Upstream area	550	1695	293000	320500
4.	1 km downstream of Hawai	575	2920	199000	259500
5.	3-5 km downstream	640	2325	185500	299000

Note: Summer Season- April 2009, Monsoon season- August 2009

Table-5.4: Species Diversity Indices for different vegetation components in Kalai hydroelectric project, Stage-2

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Dam site		
Trees	2.44	0.95
Shrubs	2.08	0.86
Herbs	2.83 (April), 3.08 (Aug)	0.86 (April), 0.93 (Aug)
Submergence Area		
Trees	2.42	0.94
Shrubs	2.16	0.80
Herbs	2.84 (April), 2.91 (Aug)	0.90 (April), 0.90(Aug)
Upstream site		
Trees	2.35	0.89
Shrubs	2.16	0.87
Herbs	2.18 (April), 2.71(Aug)	0.75 (April), 0.93(Aug)
1km downstream of Hawai		
Trees	2.21	0.89
Shrubs	1.94	0.81
Herbs	2.75 (April), 2.84 (Aug)	0.90(April), 0.91 (Aug)
3-5 km downstream		
Trees	2.33	0.94
Shrubs	2.25	0.83
Herbs	2.65(April), 2.91 (Aug)	0.89 (April), 0.90 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

In the proposed dam site, thirteen tree species were recorded. The average tree density at this site was 515 trees/ha. Eleven shrub and twenty seven herbs including climbers were recorded from this forest. *Pandanas odoratissima* and *Grewia* sp. dominated the tree layer while *Boehmeria longifolia* and *Debregessia longifolia* dominated the shrub layer and *Drymaria cordata, Nephrolepis cordifolia* and *Pilea umbrosa* were dominant in the herbaceous layers. Species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2.0 in the forests studied. The evenness index was also high having values and ranged from 0.86-0.95 for most of the components.

In the submergence area, thirteen tree species were recorded. The average tree density at this site was 610 trees/ha and the dominant species were *Saurauria nepalensis* and *Ficus cunia*. *Artemisia nilagirica* and *Urena lobata* dominated the shrub layer. *Spilanthes paniculata* and *Nephrolepis cordifolia* were dominant species in the herbaceous layer.

In the sampling site within the upstream area, fourteen tree species were recorded. The average tree density at this site was 550 trees/ha. Twelve shrubs and eighteen herbs including climbers were recorded from this forest. *Boehmeria longifolia* and *Debregessia longifolia* dominated the shrub layer. *Ageratum conyzoides* and *Nephrolepis cordifolia* were dominant species in the herbaceous layer. In general, species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2.16 in the forests studied. The evenness index was more than 0.75 for all the components.

In 1 km downstream of Hawai, 12 tree species were recorded and the average tree density at this site was 575 trees/ha. The dominant tree species were *Ficus cunia* and *Grewia* sp. *Artemisia nilagirica* and *Urena lobata* dominated the shrub layer. *Bidens pilosa* and *Ageratum conyzoides* were dominant species in the herbaceous layer.

In 3-5 km downstream, 12 tree species were recorded and the average tree density at this site was 640 trees/ha. The dominant tree species were *Ficus cunia* and *Brassiopsis glomerulata*. *Artemisia nilagirica* and *Boehmeria longifolia* dominated the shrub layer. *Drymaria cordata*, *Nephrolepis cordifolia* and *Ageratum conyzoides,* were dominant species in the herbaceous layer.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight change in the density of herbaceous component in all the sites.

5.9.3 Hutong hydroelectric project, Stage-1

The following sampling sites were covered as a part of the terrestrial ecological survey for Hytong hydroelectric project, stage-1:

- T11 - Dam site
- T12- Submergence area
- T13 - Upstream area
- T14 - 1 km downstream of dam site

The findings of the vegetation survey at various sampling sites are given in **Annexure-III.** The summary of the findings of vegetation survey are given in Table-5.5. The diversity indices of various floral species are given in Table-5.6.

Table-5.5: Density of various floral species at various sampling sites of Hutong hydroelectric project, Stage-1 **Unit (No./ha)**

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam site	500	1540	199500	382500
2.	Submergence area	610	2020	203000	360500
3.	Upstream area	530	1500	356000	360340
4.	1 km downstream of dam site	740	3460	202000	346000

Note: Summer Season- April 2009, Monsoon season- August 2009

Table-5.6: Species Diversity Indices for different vegetation components in Hutong hydroelectric project, Stage-1

Vegetation	Diversity Indices	
component	**Shannon's Diversity Index (H)**	**Evenness Index (e)**
Dam site		
Trees	1.88	0.91
Shrubs	1.97	0.86
Herbs	2.97 (April), 2.99 (Aug)	0.92 (April), 0.93 (Aug)
Submergence Area		
Trees	2.33	0.93
Shrubs	2.28	0.84
Herbs	2.77 (April), 2.76 (Aug)	0.92 (April), 0.86 (Aug)
Upstream Area		
Trees	2.44	0.95
Shrubs	2.08	0.87
Herbs	2.83 (April), 3.08 (Aug)	0.85 (April), 0.93 (Aug)
1 km downstream of dam site		
Trees	2.24	0.90
Shrubs	2.40	0.80
Herbs	2.84 (April), 2.96 (Aug)	0.93 (April), 0.93 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

In the dam site eight tree species were recorded. The average tree density at this site was 500 trees/ha. Eleven shrubs and twenty five herbs including climbers were recorded from this forest. *Ficus cunia* and *Alnus nepalensis* dominated the tree layer while *Boehmeria longifolia* and *Debregessia longifolia* dominated the shrubs and *Ageratum conyzoides* and *Drymaria cordata* dominated the herbaceous layer. In general, diversity of herbs was high in the proposed damsite. The Shannon's Index for all three components (tree, shrub and herb) ranged from 1.88-2.99 in the forests studied. Evenness value was higher for the tree component in the proposed damsite and the evenness index ranged from 0.86-0.93 for most of the components.

In the submergence site 12 tree species were recorded and the average tree density at this site was 610 trees/ha. *Brassiopsis glomerulata* and *Grewia* sp. dominated the tree layer while *Urena lobata and Oxospora paniculata* were dominant shrubs. *Nephrolepis cordifolia* and *Ageratum conyzoides* were the dominant herb species during summer season while *Drymaria cordata* dominated the herbaceous layer during monsoon season.

In the Upstream site 13 tree species were recorded. The average tree density at this site was 530 trees/ha. Eleven shrub and twenty seven herbs including climbers were recorded from this forest. *Pandanas odoratissima* and *Ficus cunia*. dominated the tree layer while *Boehmeria longifolia* dominated the shrub layer and *Drymaria cordata* and *Nephrolepis cordifolia* were dominant in the shrub and herbaceous layer. In general, species diversity was high and the

Shannon's Index for all three components (tree, shrub and herb) was more than 2.0 in the forests studied. The evenness index ranged from 0.85-0.95 for most of the components.

Twelve tree species were recorded in 1 km downstream of damsite. The average tree density at this site was 740 trees/ha. *Alnus nepalensis* and *Ficus cunia* dominated the tree layer with 150 individuals/ha each. *Artemisia nilagirica* and *Urena lobata* were the dominant shrubs. *Nephrolepis cordifolia* and *Ageratum conyzoides* were the dominant herbs during summer while *Drymaria cordata* dominant the herbaceous layer during rainy season. The tree and shrubs did not show any difference in terms of composition and diversity while difference in the density of herbaceous component was recorded at all the sites in the two study season.

5.9.4 Hutong hydroelectric project, Stage-2

The following sampling sites were covered as a part of the ecological survey for Hutong hydroelectric project, stage-2:

- T15 - Dam site
- T16 - Submergence area
- T17 - Upstream area
- T18 - 1 km downstream of dam site
- T19 - Confluence point of Lohit and Dau rivers

The findings of the vegetation survey at various sampling sites are given in **Annexure-IV**. The summary of the findings of vegetation survey are given in Table-5.7 The diversity indices of various floral species are given in Table-5.8

Table-5.7: Density of various floral species at various sampling sites of Hutong hydroelectric project, Stage-2

Unit (No./ha)

S. No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	**Monsoon**
1.	Dam site	645	4200	214500	365500
2.	Submergence area	615	1965	188500	298000
3.	Upstream area	465	985	209500	364500
4.	1 km downstream of dam site	615	3445	199500	359500
5.	Confluence point of Lohit and Dau rivers	435	3140	223000	366000

Table-5.8: Species Diversity Indices for different vegetation components in Hutong hydroelectric project, Stage-2

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	**Evenness Index (e)**
Dam site		
Trees	2.59	0.86
Shrubs	2.15	0.70

Vegetation component	**Diversity Indices**	
	Shannon's Diversity Index (H)	**Evenness Index (e)**
Herbs	2.88 (April), 2.95 (Aug)	0.87 (April), 0.91 (Aug)
Submergence area		
Trees	2.81	0.89
Shrubs	2.59	0.81
Herbs	2.88 (April), 2.97 (Aug)	0.89 (April), 0.90(Aug)
Upstream area		
Trees	1.88	0.90
Shrubs	1.97	0.82
Herbs	2.97 (April), 2.99 (Aug)	0.92 (April), 0.93 (Aug[
1 km downstream of dam site		
Trees	2.33	0.84
Shrubs	2.56	0.87
Herbs	2.86 (April),3.12 (Aug)	0.88 (April), 0.94 (Aug)
Confluence point of Lohit and Dau rivers		
Trees	2.59	0.89
Shrubs	2.46	0.82
Herbs	2.96 (April), 3.20 (Aug)	0.90 (April), 0.95 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

The dam site is located near Kombling village. The submergence starts from the dam site and continues beyond Dhanbari village. Sampling included disturbed and degraded forest on the right bank and primary undisturbed vegetation on the left bank of river Lohit (about 1000 m). Because of steep slopes on both the sides, most submergence area is confined to narrow strips along the river Lohit. The west bank of the river, is relatively less steep and is dominated by disturbed secondary forests. A few jhum cultivation plots and orange orchards were seen along this bank.

Twenty tree species were recorded in the proposed dam site. The average tree density at this site was 645 trees/ha. Twenty two shrub and twenty seven herbs including climbers were recorded from this forest. *Musa* sp. and *Ficus cunia* dominated the tree layer while *Artemisia nilagirica* and *Urena lobata* dominated the shrub layer. *Ageratum conyzoides* and *Bidens pilosa* were dominant in the herbaceous layer during summer while in monsoon season *Ageratum conyzoides* dominated the herb layer. In general, species diversity was high for trees and herbs. The Shannon's Index for all three components (tree, shrub and herb) ranged from 2.15-2.95 in the forests studied. The evenness index values ranged from 0.70-0.91 for most of the components.

In the submergence area, 23 tree species were recorded. The average tree density at this site was high 615 trees/ha due to dominance of *Dendrocalamus* sp. Twenty four shrub and twenty seven herbs including climbers were recorded from this forest. *Oxospora paniculata, Artemisia nilagirica* and *Acacia pruniscens* were dominant shrub species. *Ageratum conyzoides* and *Borreria articularis* dominated the herb layer during summer while *Ageratum conyzoides and Spilanthes paniculata* was the dominant herb during monsoon season. Diversity of tree and herbs was higher. Shannon's diversity index for tree, shrubs and herbs ranged from 2.59-2.97 while the evenness index was more than 0.81.

In the Upstream area, eight tree species were recorded. The average tree density at this site was 465 trees/ha. Eleven shrub and twenty five herbs including climbers were recorded from this area. *Alnus nepalensis* and *Brassiopsis glomerulata* dominated the tree layer while *Debregessia longifolia* and *Oxospora paniculata* in the shrub layer and *Pilea sp., Galinsoga parviflora and Commelina sp* in the herb layer were dominant species. The Shannon's Index for all three components (tree, shrub and herb) ranged from 1.88-2.99 in the forests studied. Evenness value was higher for the tree component and the evenness index ranged from 0.82-0.93 for most of the components.

Sixteen tree species were recorded in 1 km downstream of dam site with average tree density of 615 trees/ha. The dominant species in this site were *Musa* sp. and *Artemisia* spp, were dominant shrub species, while *Nephrolepis cordifolia* and *Ageratum conyzoides* were the dominant herbs.

In the confluence point of Lohit and Dau river, 18 tree species were recorded. The average tree density at this site was 435 trees/ha. The dominant tree species in this site were *Musa* sp. and *Ficus cunia. Artemisia nilagirica, Artemisia spp.* and *Urena lobota* were dominant shrub species, while *Nephrolepis cordifolia* and *Ageratum conyzoides* were the dominant herb.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a difference in the density of herbaceous component at all the site in different study season.

5.9.5 Anjaw Hydroelctric Project

Adequate sampling in entire basin was carried out wrt Terrestrial ecology, aquatic ecology and other aspects. The sites downstream of Hatong II, i.e., T 18 & T19 are also giving base line information for Anjaw HEP.

5.9.6 Demwe Upper hydroelectric project

The following, sampling sites were monitored as a part of the vegetation survey for Demwe Upper hydroelectric project:

- T20 - Dam site
- T21 - Submergence area

- T22 - Upstream area
- T23 - 1 km downstream of confluence of Tidding and Lohit rivers
- T24 - Confluence point of rivers Dalai and Lohit

The findings of the vegetation survey at various sampling sites are given in Annexure-V. The summary of the findings of vegetation survey are given in Table-5.9. The diversity indices of various floral species are given in Table-5.10

Table-5.9: Density of various floral species at various sampling sites In Demwe Upper hydroelectric project Unit (No./ha)

S.N.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam Site	420	1205	186000	324500
2.	Submergence area	695	1565	219000	325500
3.	Upstream area	630	1370	215000	312500
4.	1 km downstream of confluence of Tidding and Lohit river	640	1530	232500	313000
5.	Confluence point of rivers Dalai & Lohit	635	3115	230000	333500

Note: Summer Season- April 2009, Monsoon season- August 2009

Table-5.10: Species Diversity Indices for different vegetation components in Demwe Upper Hydroelectric project

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Dam Site		
Trees	3.13	0.93
Shrubs	2.72	0.83
Herbs	3.06 (April), 3.14 (Aug)	0.90 (April), 0.92(Aug)
Submergence area		
Trees	3.19	0.92
Shrubs	2.40	0.72
Herbs	2.76 (April), 2.81 (Aug)	0.79(April), 0.81 (Aug)
Upstream area		
Trees	3.34	0.92
Shrubs	2.51	0.74
Herbs	2.95 (April), 2.99 (Aug)	0.88(April), 0.89(Aug)
1 km downstream of Tidding and Lohit river confluence point		
Trees	2.21	0.81
Shrubs	2.52	0.76
Herbs	2.84 (April), 3.02 (Aug)	0.89 (April), 0.89 (Aug)
Confluence point of Dalai and Lohit		
Trees	2.73	0.88
Shrubs	2.57	0.78
Herbs	3.03 (April), 3.11(Aug)	0.93 (April), 0.91 (Aug)

Note: Summer Season- April 2009, Monsoon season- August 2009

Twenty nine tree species were recorded in the proposed dam site. The average tree density at this site was 420 trees/ha. Twenty six shrub and thirty herbs including climbers were recorded from this forest. *Duabanga grandiflora* was the dominant tree species with 40 individuals/ha. *Artemisia nilagirica, Piper sp.* and *Debregessia longifolia*, dominated the shrub layer. *Elatostemma* sp. and *Commelina sp.* were dominant in the herbaceous layer during summer whereas Commelina sp. and *Drymaria cordata* were the dominant herbs during rainy seasons. Species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2.72 in the forests studied. The evenness index ranged from 0.83- 0.93 for most of the components.

In the submergence area, thirty two tree species were recorded. The average tree density at this site was 695 trees/ha. Twenty seven shrub and thirty two herbs including climbers were recorded from this forest. *Albizia chinensis* followed by *Dendrocalamus hamiltonii were* the dominant and co-dominant tree species respectively. *Artemisia nilagirica* was the dominant shrub species while *Drymaria cordata* dominated the herbaceous layer. Shannon's diversity index for tree, shrub and herb was more than 2.40, while the evenness index ranged from 0.72-0.92 for the trees, shrubs and herbs.

In the Upstream area, 37 tree species were recorded. The average tree density at this site was 630 trees/ha. *Bamboo* sp., *Pterospermum acerifolium, Canarium strictum* and *Altingia excelsa* are the dominant tree species. A total of twenty nine shrubs as well as 29 herbs including climbers were recorded from this forest. *Piper* sp. among shrub and *Elatostemma* sp. and *Commelina* sp., among herb were the dominant species. Shannon's diversity index for all the three components (tree, shrub and herb) was more than 2.51, while the evenness index ranged from 0.74-0.92 for trees, shrubs and herbs.

Fifteen tree species were recorded in 1 km downstream of Tidding and Lohit river confluence point. The average tree density at this site was 640 trees/ha due to dominance of *Musa* sp. Other dominant tree species are *Ficus cunia* and *Brassiopsis glomerulata*. *Piper* sp and *Boehmeria longifolia*, among shrub and *Elatostemma* sp. *Nephrolepis cordifolia,* and *Drymaria cordata* among herb were the dominant species.

In the confluence point of Dalai and Lohit river 22 tree species were recorded. The average tree density at this site was 635 trees/ha. *Pandanas odoratissima* followed by *Macaranga denticulata*, were the dominant tree species. *Plectranthus striatus* and *Artemisia nilagirica* among shrub and, *Thysanolaena maxima*, and *Ageratum conyzoides* among herbs were the dominant species.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight difference in the diversity of herbaceous component at all the sites.

5.9.7 Demwe Lower hydroelectric project

The various sampling sites were covered as a part of the vegetation survey for Demwe Lower hydroelectric project sites are:

- T25 - Dam and Power House site
- T26 - Submergence area
- T27 - Upstream area
- T28 - Downstream (Near Colony) area

The findings of the vegetation survey at various sampling sites are given in **Annexure-VI**. The summary of the findings of vegetation survey are given in Table-5.11 The diversity indices of various floral species are given in Table-5.12

Table-5.11: Density of various floral species at various sampling sites of Demwe Lower hydroelectric project Unit (No./ha)

S. No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Dam and Power House site	450	4050	139500	289500
2.	Submergence area.	300	1900	128500	247500
3.	Upstream area	390	1720	131000	287500
4.	Downstream (Near Colony)area	395	3455	152000	163000

Table-5.12: Species Diversity Indices for different vegetation components in Demwe Lower hydroelectric project

Vegetation component	Shannon's Diversity Index (H)	Evenness Index (e)
Dam site and Power House site		
Trees	2.68	0.92
Shrubs	1.93	0.77
Herbs	2.76(April), 2.07 (Aug)	0.90 (April), 0.67 (Aug)
Submergence area		
Trees	2.82	0.98
Shrubs	2.19	0.99
Herbs	3.08 (April), 3.07 (Aug)	0.91 (April), 0.91 (Aug)
Upstream area		
Trees	2.75	0.95
Shrubs	1.81	0.73
Herbs	3.01 (April), 3.09 (Aug)	0.89(April), 0.90 (Aug)
Downstream (Near Colony) area		
Trees	1.42	0.88
Shrubs	1.38	0.60
Herbs	2.12(April), 2.10 (Aug)	0.82(April), 0.82 (Aug)

Sampling included vegetation on east and west bank of river Lohit. The Power House site is located about 200 m downstream from the dam site. Because of steep slopes, most submergence area is confined to narrow strips along the river Lohit. The submergence area is mostly characterized by rock outcrop devoid of any trees with isolated sites having some tree cover. The proposed colony area is on the left bank of river Lohit and is approximately 100 m away from the existing helipad near Parsuram kund.

In the Dam and Power House site eighteen species of trees represented by 450 individuals/ha were recorded. *Alangium chinensis* was the dominant tree species. Twelve species of shrubs and twenty two herbs including climbers were recorded from the site. *Boehmeria macrophylla* was found as the most dominant shrub species. *Bidens pilosa*, *Elatostemma* sp. and *Imperata cylindrica* were the dominant herb species. Shannon's diversity index was more than 1.93 and evenness index ranged from 0.67-0.92.

The submergence area had sixteen tree species. The tree density was 300 individuals /ha. *Macaranga denticulata* was the dominant tree species. Nine shrub and twenty nine herbs including climbers were recorded from this site. *Boehmeria spp.* was the dominant species in the shrub layer and *Elatostema platyphyllum* and *Pilea* sp. were found to be dominant herbs species during summer. Shannon's diversity index was more than 2 for all the components and the evenness value ranged from 0.91-0.99.

In the upstream area, there were eighteen tree species. The density was 390 trees /ha and dominated by *Ficus semicordata*. The associated species in the tree canopy were *Alangium chinensis*, *Brassiopsis glomerulata*, *Duabanga grandiflora*, *Kydia calycina*, *Chukrasia tabularis*, and *Pandanus nepalensis*. Twelve shrub and thirty herb species including climbers were recorded in this forest. *Boehmeria longifolia* was the dominant shrub and *Pilea* sp and *Elatostemma* sp. and were the dominant species among herb layer. Shannon's diversity Index was more than 1.81 for all three components (tree, shrub and herb) and evenness index was between 0.73 -0.95.

Five tree species were recorded in the Downstream (Near Colony) area with a density of 395 individuals /ha. *Sterculia villosa* was the dominant tree species. Ten shrub and thirteen herbs were recorded from the site. *Eupatorium odoratum* dominated the shrub layer while *Ageratum conyzoides* followed by *Imperata cylindica* were dominant in the herb layer. Species diversity was low for tree and shrub Shannon's Index was less than 2 for tree and shrub while that for herbs Shannon's Index was above 2. The evenness index ranged from 0.60-0.88 for trees, shrub and herbs.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight difference in the diversity of herbaceous component in all the sites.

5.10 FLORAL ASPECTS ON TRIBUTARIES OF LOHIT BASIN

5.10.1 Plant Diversity at Various Sites

Gimiliang HE project area

Gimiliang HE project is proposed on Dav river. Both river banks were occupied by dense mix semi-evergreen forest. At the lower reaches of left bank, tree species dominated by *Bischofia javanica, Terminalia myriocarpa, Ficus semicordata, Kydia calycina, Macaranga denticulata, Pterospermum acerifolium, Duabanga grandiflora, Engelhardtia spicata, Brassiopsis griffithii, Saurauia roxburghii* and *Gmelina arborea*. The lower storey is represented by small trees and shrubs like *Debregessia longifolia, Hydrangea robusta, Musa balbisiana, Boehmeria longifolia, Artemisia nilagirica, Bambusa tulda, Pandanas furcatus, Boehmeria macrophylla, Brassiopsis griffithii, Calamus erectus, Desmodium elegans, Eupatorium odoratum* etc. The right bank has a more or less same type of vegetation in the lower reaches. Climbers represents by *Thunbergia coccinea,Thladanthia cordifolia, Photos scandens, Rhaphidophora hongkongensis, Rubia sikkimensis* and *Thunbergia coccinea* etc. The epiphytic ferns are represented by species of *Colysis, Lepisorus, Pyrrosia, Vittaria,* etc. The herbaceous vegetation comprises of *Dichrocephala crepidioides, Ageratum conyzoides, Alpinia allughas, Senecio cappa, Bidens pilosa, Hedychium coccineum, Spilanthes paniculata, Thysanolaena latifolia, Lecanthus peduncularis, Polygonum capitatum,* and *Pilea umbrosa* etc.

Raigam HE project area

The Raigam project site is located near Teepani on Dalai river**.** Fairly dense sub-tropical broad-leaved hill forest can be observed in the lower reaches on both the banks of Dalai river. The forest is dominated by tall evergreen species, but some deciduous tree species also occur in the top canopy. *Altingia excelsa, Castanopsis indica, Dysoxylum procerum, Engelhardtia spicata, Kydia calycina, Duabanga grandiflora* and *Schima wallichii* form the top storey. Other prominent trees are *Ficus semicordata, Gynocardia odorata, Alangium chinensis, Oroxylum indicum* and *Saurauia roxburghii*.

The Understorey consists of dense thickets of bamboos, *Musa* and many shrubs. The common shrubs are *Oxyspora paniculata, Debregessia longifolia, Bambusa tulda, Boehmeria macrophylla, Pandanas furcatus, Urena lobata, Girardinia diversifolia, Leea asiatica* and

Rubus ellipticus. On *Engelhardtia* and *Castanopsis* there is abundance of orchids like *Bulbophyllum, Dendrobium, Eria* and *Liparis*. Climbers are abundant. Tree fern (*Alsophila spinulosa*) is often seen in shaded and damp areas. The ground vegetation consists of many herbs and grasses include *Spilanthes, paniculata Bidens pilosa, Polygonum capitatum, Ageratum conyzoides, Thysanolaena maxima, Alpinia allughas, Artemisia nilagirica, Hedychium coccineum, Siegesosbekia orientalis, Commelina benghalensis, Pilea umbrosa, Saccharum longisetosum* and *Setaria pumila* etc.

Tiddind-I & II HE project area

A fairly dense sub-tropical broad-leaved mix forest occurs around dam axis with many riverine semi-evergreen plant species. At the right bank of Tidding-I, the top storey of the forest is dominated by trees like *Macaranga denticulata, Altingia excelsa,Terminalia myriocarpa, Castanopsis indica, Cinnamomum* sp., *Lannea coromandelica, Kydia calycina,* and *Duabanga grandiflora*. Second storey is represented by *Musa balbisiana, Ficus roxburghii, Brassiopsis aculeata, Elaeocarpus varuna, Ficus semicordata, Rhus acuminata, Saurauia roxburghii,* etc. Understorey is represented by many tall spreading shrubs and small trees. *Pandanas furcatus, Clerodendrum colebrookianum, Boehmeria macrophylla, Calamus erectus, Chromolaena odoratum, Debregeasia longifolia, Boehmeria polystachya, Melastoma normale, Rubus ellipticus, Maesa chisia, Pinanga gracilis* and *Boehmeria longifolia*. Same vegetation patterns can be noticed at upstream area of Tidding-II. The trunks of some of the trees are often loaded with epiphytic ferns, vines and orchids. Climbers and epiphytes are abundant. *Rhaphidophora grandis, Cuscuta reflexa, Rhaphidophora hongkongensis, Piper pedicellatum, Rhaphidophora decursiva, Aristolochia* sp., *Stephania glandulifera* etc., are some of the important trailing species in the area. Herbaceous flora is dominated by some terrestrial pteridophytes and herbs viz., *Adiantum lunulatum, Artemisia nilagirica, Alocasia indica, Commelina benghalensis, Dichrocephala chrysanthemoides, Equisetum diffusum, Imperata cylindrica, Lecanthus peduncularis, Xanthium indicum, Pilea scripta, Blumea fistulosa, Pteris subquinata, Saccharum longisetosum* and *Thysanolaena latifolia*.

Kamlang HE project area

Kamlang Hydrelectric project area is characterized by tropical semi-evergreen forest in the lower reaches, while evergreen mix forest is found in the upper reaches. The lower reaches in this area are characterized by degraded riverine semi- evergreen forest. The prominent trees in this area are *Duabanga grandiflora, Engelhardtia spicata, Brassiopsis griffithii, Ficus semicordata, Celtis tetrandra, Macaranga denticulata, Pterospermum acerifolium, Saurauia roxburghii* and *Terminalia myriocarpa*. The river terraces are being stabilized by *Albizia* *chinensis, Oroxylum indicum* and *Bischofia javanica*. The lower storey is represented by small trees and shrubs like *Boehmeria longifolia, Bambusa tulda, Pandanas furcatus, Boehmeria macrophylla, Brassiopsis griffithii, Chromolaena odoratum, Debregeasia longifolia, Desmodium elegans, Rubus ellipticus* etc. Climbers represents by *Photos scandens, Rhaphidophora hongkongensis, Rubia sikkimensis* and *Thunbergia coccinea* etc. Epiphytes are mostly represented by many species of ferns and orchids like species of *Bulbophyllum, Cymbidium, Dendrobium, Colysis, Lepisorus* etc. The epiphytic ferns are represented by species of *Colysis, Lepisorus, Pyrrosia, Vittaria,* etc. The ground floor is occupied by many herbs and grasses like *Bidens pilosa, Ageratum conyzoides, Alpinia allughas, Artemisia nilagirica, Hedychium coccineum, Spilanthes paniculata, Commelina benghalensis, Equisetum diffusum, Polygonum capitatum, Pilea scripta, P. umbrosa, Saccharum longisetosum* and *Thysanolaena latifolia*.

5.10.2 Field Studies

The sampling sites for terrestrial ecological survey were given in Table-5.13 and depicetd in Figure-5.2.

Table-5.13: Description of sampling sites for Terrestrial Ecology

Study site	Sampling locations
Site-I	Gimiliang Dam Site Area
Site-II	Downstream Area of Gimiliang Dam
Site-III	Raigam Dam Site Area
Site-IV	Downstream Area of Raigam Dam
Site-V	Tidding-I Dam Site Area
Site-VI	Downstream Area of Tidding-I Dam
Site-VII	Tidding-II Dam Site Area
Site-VIII	Downstream Area of Tidding-II Dam
Site-IX	Kamlang Dam Site Area
Site-X	Downstream Area/Power House Site of Kamlang Dam

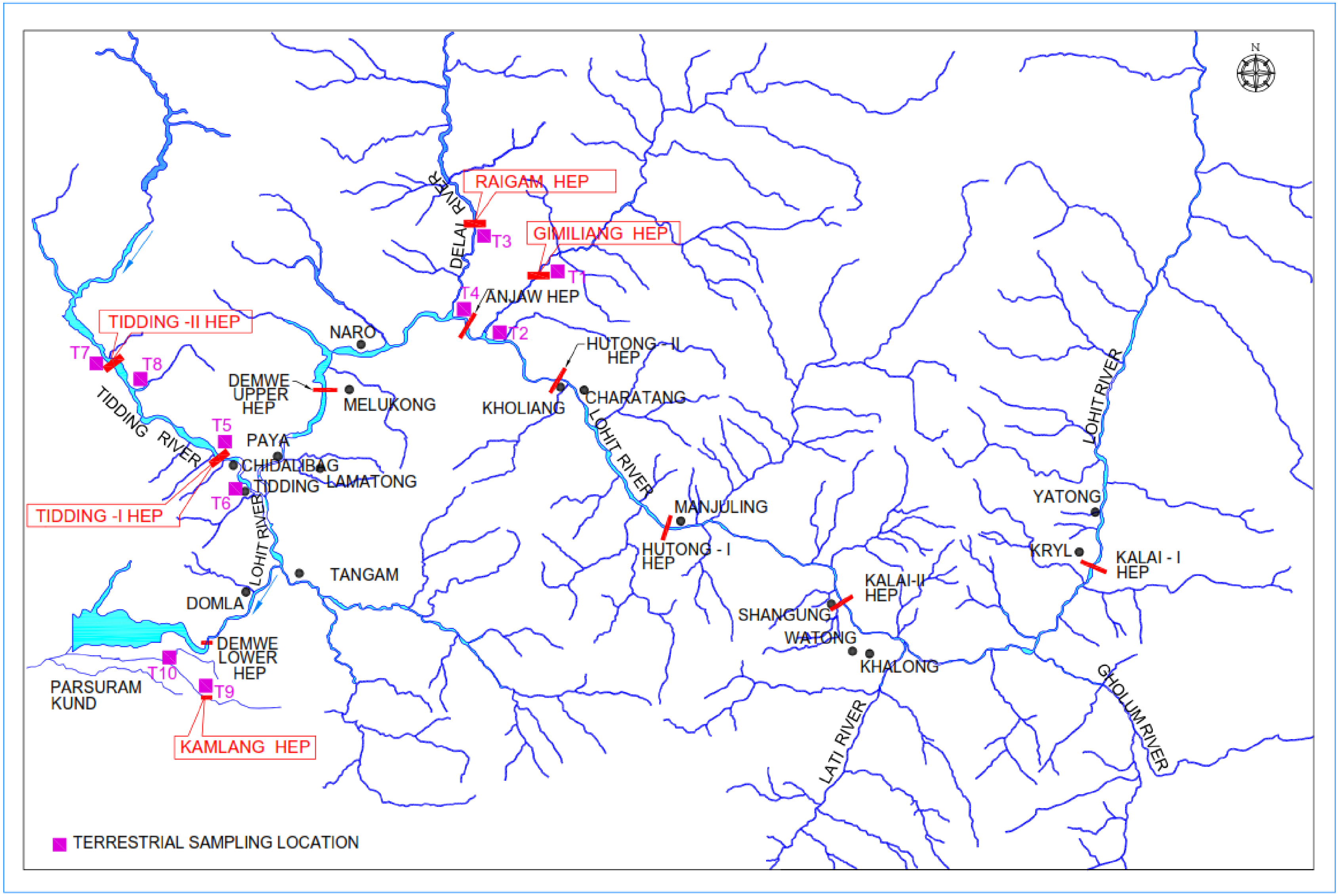


Figure-5.2: Terrestrial Sampling Location Map of projects on tributaries of Lohit Basin

5.10.3 Floristic Diversity

A total of 175 plant species were recorde during the floristic survey in the Study area. The details are given in Table-5.14. The number of plant species recorded in the study area is given in Table-5.15.

Table-5.14: Vegetation composition in the Study Area

S.N.	Life forms	No. of species	% of species
1	Trees	40	82.86
2	Shrubs	44	25.14
3	Herbs	47	26.86
4	Climbers	11	6.28
5	Grasses	19	10.86
6	Sedges	6	3.43
7	Orchids	7	4.0
8	Parasite	1	0.57
Total		**175**	**100**

Table-5.15: List of plant species recorded from the Study Area

Plant Species	Family	Habit
Abelmoschus moschat	Solanaceae	Shrub
Acacia pennata	Mimosaceae	Shrub
Acanthephippium striatum	Orchidaceae	Orchid
Aconogonum molle	Polygonaceae	Herb
Adiantum edgeworthii	Adiantaceae	Herb
Ageratum conyzoides	Asteraceae	Herb
Aglaia spectabilis	Meliaceae	Tree
Alangium chinensis	Alangiaceae	Tree
Albizia chinensis	Mimosaceae	Tree
Alnus nepalensis	Betulaceae	Tree
Alocasia indica	Araceae	Herb
Alpinia bracteata	Zinziberaceae	Herb
Amaranthus spinosus	Amaranthaceae	Herb
Amomum aromaticum	Zinziberaceae	Herb
Arisaema consanguineum	Araceae	Herb
Aristolochia sp.	Aristolochiaceae	Climber
Artemisia nilagirica	Asteraceae	Shrub
Arundo donax	Poaceae	Grass
Asplenium sp.	Aspleniaceae	Herb
Bambusa tulda	Poaceae	Grass
Bambusa pallida	Poaceae	Grass
Begonia sp.	Begoniaceae	Herb
Bidens pilosa	Asteraceae	Herb
Bischofia javanica	Bischofiaceae	Tree
Blumea fistulosa	Asteraceae	Herb
Boehmeria longifolia	Urticaseae	Shrub
Boehmeria macrophylla	Urticaseae	Shrub

Plant Species	**Family**	**Habit**
Boehmeria polystachya	Urticaceae	Shrub
Bombax cieba	Bombacaceae	Tree
Borreria articularis	Rubiaceae	Herb
Buddleja asiatica	Buddlejaceae	Shrub
Caesalpinia sp.	Caesapiniaceae	Shrub
Calamus erectus	Arecaceae	Shrub
Calamus latifolius	Arecaceae	Shrub
Calamus leptospadix	Arecaseae	Shrub
Calanthe sp.	Orchidaceae	Orchid
Callicarpa arborea	Verbenaceae	Tree
Cardamine hirsuta	Brassicaceae	Herb
Carex cruciata	Cyperaceae	Sedge
Castanopsis indica	Fagaceae	Tree
Celtis tetrandra	Ulmaceae	Tree
Chromolaena odoratum	Asteraceae	Shrub
Chrysopogon aciculatus	Poaceae	Grass
Chukrasia tabularis	Meliaceae	Tree
Cinnamomum sp.	Lauraceae	Tree
Clematis sp.	Ranunuculaceae	Climber
Clerodendrum colebrookianum	Verbenaceae	Shrub
Colocasia affinis	Araceae	Herb
Colocasia esculenta	Araceae	Herb
Colysis pedunculata	Polypodiaceae	Herb
Commelina benghalensis	Commelinaceae	Herb
Costos speciosus	Zinziberaceae	Herb
Crassocephalum crepidioides	Asteraceae	Herb
Curcuma caesia	Zinziberaceae	Herb
Cuscuta reflexa	Cuscutaceae	Parasite
Cyanotis vaga	Commelinaceae	Herb
Cymbidium ansifolium	Orchidaceae	Orchid
Cynodon dactylon	Poaceae	Grass
Cynoglossum lanceolatum	Boraginaceae	Herb
Cyperus laxus	Cyperaceae	Sedge
Cyperus pilolus	Cyperaceae	Sedge
Debregessia longifolia	Urticaceae	Shrub
Dendrobiub sp.	Orchidaceae	Orchid
Dendroblum aphylla	Orchidaceae	Orchid
Dendrocalamus hamiltonii	Poaceae	Grass
Dendrocalamus strictus	Poaceae	Grass
Desmodium elegans	Fabaceae	Shrub
Desmodium laxiflorum	Fabaceae	Shrub
Dichrocephala crepidioides	Asteraceae	Herb
Digitaria ciliaris	Poaceae	Grass
Digitaria longiflora	Poaceae	Grass
Drymaria sp.	Caryophyllaceae	Herb
Duabanga grandiflora	Lythraceae	Tree
Dysoxylum gobara	Meliaceae	Tree
Elusine indica	Poaceae	Grass

Plant Species	Family	Habit
Engelhardtia spicata	Juglandaceae	Tree
Equisetum diffusu	Equisetaceae	Herb
Eragrostis unioloides	Poaceae	Grass
Erythrina sp.	Fabaceae	Tree
Eupatorium odoratum	Asteraceae	Shrub
Ficus oligodon	Moraceae	Tree
Ficus roxburghii	Moraceae	Tree
Ficus semicordata	Moraceae	Tree
Fimbristylis sp.	Cyperaceae	Sedge
Galinsoga parviflora	Asteraceae	Herb
Garcinia pedunculata	Clusiaceae	Tree
Garuga floribunda	Burseraceae	Tree
Girardinia diversifolia	Urticaceae	Shrub
Gmelina arborea	Verbenaceae	Tree
Grewia disperma	Tiliaceae	Shrub
Hedychium coccineum	Zinziberaceae	Herb
Hydrangea robusta	Hydrangeaceae	Shrub
Ichnanthus vicinus	Poaceae	Grass
Impatiens sp.	Balsaminaceae	Herb
Imperata cylindrica	Poaceae	Grass
Indigofera sp.	Fabaceae	Shrub
Jasminium dispermum	Oleaceae	Shrub
Kydia calycina	Malvaceae	Tree
Lannea coromandelica	Anacardiaceae	Tree
Laportea crenulata	Urticaceae	Shrub
Lecanthus peduncularis	Urticaceae	Herb
Leea asiatica	Vitaceae	Shrub
Lepisorus nudus	Polypodiaceae	Herb
Lygodium flexuosum	Lygodiaceae	Herb
Macaranga denticulata	Euphorbiaceae	Tree
Macropanax disperma	Araliaceae	Tree
Maesa indica	Myrsinaceae	Shrub
Melastoma normale	Melastomataceae	Shrub
Mikania micrantha	Asteraceae	Climber
Mikania micrantha	Asteraceae	Herb
Musa balbisiana	Musaceae	Tree
Mussanda roxburghii	Rubiaceae	Shrub
Oplismenus sp.	Poaceae	Grass
Oroxylum indicum	Bignoniaceae	Tree
Osbeckia stellata	Melastomataceae	Shrub
Oxyspora paniculata	Melastomaceae	Shrub
Pandanas furcatus	Pandanaceae	Shrub
Paphiopedilum sp.	Orchidaceae	Orchid
Photos scandens	Araceae	Climber
Phylanthus emblica	Euphorbiaceae	Tree
Phyrnium pubinerve	Marantaceae	Herb
Pilea umbrosa	Urticaceae	Herb

Plant Species	**Family**	**Habit**
Pinanga gracilis	Arecaceae	Shrub
Polygonum barbata	Polygonaceae	Herb
Polygonum capitatum	Polygonaceae	Herb
Polypodioides wattii	Polypodiaceae	Herb
Prunus cerasoides	Rosaceae	Tree
Pteris sp.	Pteridaceae	Herb
Pteris stenophylla	Pteridaceae	Herb
Pterospermum acerifolium	Sterculiaceae	Tree
Pycerus flavidus	Cyperaceae	Sedge
Pyrrosia nuda	Polypodiaceae	Herb
Rhaphidophora decursiva	Araceae	Climber
Rhaphidophora grandis	Araceae	Climber
Rhaphidophora hongkongensis	Araceae	Climber
Rhus acuminata	Anacardiaceae	Tree
Rhus javanica	Anacardiaceae	Tree
Rhus punjabensis	Anacardiaceae	Tree
Ricinus communis	Euphorbiaceae	Tree
Rubia sikkimensis	Rubiaceae	Climber
Rubus ellipticus	Rosaceae	Shrub
Rubus foliolus	Rosaceae	Shrub
Rubus niveus	Rosaceae	Shrub
Saccahraum longisetosum	Poaceae	Grass
Saccharum spontaneum	Poaceae	Grass
Saurauria nepalensis	Actinidiaceae	Tree
Scleria terrestris	Cyperaceae	Sedge
Senecio cappa	Asteraceae	Herb
Setaria pumila	Poaceae	Grass
Sida rhombifolia	Malvaceae	Shrub
Siegesosbekia orientalis	Asteraceae	Herb
Solanum erianthum	Solanaceae	Shrub
Solanum torvum	Solanaceae	Shrub
Solanum viarum	Solanaceae	Herb
Spilanthes paniculata	Asteraceae	Herb
Spondias pinnata	Anacardiaceae	Tree
Sporobolus sp.	Poaceae	Grass
Stephania glandulifera	Menispermaceae	Climber
Stercularia villosa	Sterculiaceae	Tree
Terminalia myriocarpa	Combretaceae	Tree
Tetrastigma obovatum	Vitaceae	Shrub
Thladanthia cordifolia	Cucurbitacea	Climber
Thunbergia coccinea	Acanthaceae	Climber
Thysanolaena maxima	Poaceae	Grass
Toona ciliata	Meliaceae	Tree
Trema amboinensis	Ulmaceae	Shrub
Trema orientalis	Ulmaceae	Tree
Triumfetta bartramia	Tiliaceae	Shrub
Urena lobata	Malvaceae	Shrub
Urtica dioica	Urticaceae	Shrub

Plant Species	Family	Habit
Vanda coenulea	Orchidaceae	Orchid
Vitex peduncularis	Verbenaceae	Shrub
Vittaria sp.	Vittariaceae	Herb
Xanthium indicum	Asteraceae	Herb
Zanthoxylum acanthopodium	Rutaceae	Shrub

5.10.4 Community Characteristics at Various Sampling Sites

In order to understand the community structure, vegetation sampling was carried out at different locations in the project area.

Site-I, Gimiliang Dam Site Area

At this sampling site, a total of 16 tree species were recorded during field study. The average density of this group of species was recorded to be 480 trees/ha. The highest value of IVI (49.92) as well as density (80 trees/ ha) was recorded for *Macaranga denticulata* which was the most dominant species at the site followed by *Gmelina arborea* (IVI, 36.68) and *Duabanga grandiflora*(IVI,30.33). Frequency value ranged from 10% to 45%.

In shrub community layer, a total of 21 shrub species were recorded from this sampling site. The average density of this group of species was recorded to be 1150 individuals/ ha. The highest value of IVI (41.38) as well as density (235 individuals/ ha) was recorded for *Artemisia nilagirica* which was the dominant species at this site. *Urena lobata* (IVI, 36.21) and *Debregessia longifolia* (IVI,23.00) were the co-dominant species of this vegetation stand.

A total of 27 herbaceous species were recorded with an average density of 32.00 individuals /m^2. This sampling site represents maximum species richness as compared to other sampling sites. The highest value of IVI (29.71) as well as density (4.48 individuals/m^2) was recorded for *Ageratum conyzoides* which was found to be dominant species at this site. *Pilea umbrosa*(IVI, 27.02) and *Thysanolaena maxima* (IVI, 21.75) were the other associate species. The details are given in Table-5.16.

Table-5.16: Distribution analysis of Tree, Shrub and Herb community at site-I (Gimliang Dam Site)

Species Name	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Bischofia javanica	20	35	1.75	19.03
Terminalia myriocarpa	25	40	1.60	28.59
Engelhardtia spicata	20	30	1.50	19.24
Duabanga grandiflora	25	45	1.80	30.33
Kydia calycina	15	20	1.33	12.13
Ficus semicordata	10	25	2.50	10.53
Musa balbisiana	20	30	1.50	14.04
Rhus punjabensis	10	15	1.50	7.06

Species Name	Frequency %	Density	Abundance	IVI
Macaranga denticulata	45	80	1.78	49.92
Garuga floribunda	10	10	1.00	6.87
Chukrasia tabularis	25	35	1.40	24.14
Erythrina sp.	10	10	1.00	5.83
Pterospermum acerifolium	15	20	1.33	16.62
Gmelina arborea	35	60	1.71	36.68
Celtis tetrandra	15	15	1.00	11.99
Macropanax disperma	10	10	1.00	6.98
Total		**480**		**300**
Shrub Community (Density/ha)				
Boehmeria longifolia	35	60	1.71	22.03
Boehmeria macrophylla	30	75	2.50	19.87
Melastoma normale	20	40	2.00	9.19
Artemisia nilagirica	60	235	3.92	41.38
Indigofera sp.	30	45	1.50	16.34
Triumfetta bartramia	25	55	2.20	11.33
Urena lobata	55	210	3.82	36.21
Debregessia longifolia	30	65	2.17	23.00
Girardinia diversifolia	20	30	1.50	10.60
Urtica dioica	15	25	1.67	8.04
Pandanas furcatus	25	40	1.60	16.35
Rubus foliolus	15	20	1.33	10.47
Eupatorium odoratum	25	65	2.60	14.21
Solanum erianthum	15	20	1.33	7.03
Osbeckia stellata	10	15	1.50	4.53
Solanum torvum	15	30	2.00	9.33
Trema amboinensis	20	25	1.25	8.81
Hydrangea robusta	10	20	2.00	6.80
Calamus erectus	10	15	1.50	4.31
Desmodium laxiflorum	30	50	1.67	15.22
Acacia pennata	10	10	1.00	4.95
Total		**1150**		**300**
Herb Community (Density/m^2)				
Bidens pilosa	28	0.68	2.43	8.34
Galinsoga parviflora	24	0.64	2.67	7.84
Siegesosbekia orientalis	20	0.32	1.60	5.32
Spilanthes paniculata	36	1.68	4.67	14.61
Xanthium indicum	24	0.52	2.17	7.03
Polygonum capitatum	28	1.08	3.86	10.85
Oplismenus sp.	20	2.48	12.40	21.62
Thysanolaena maxima	36	2.96	8.22	21.75
Ageratum conyzoides	68	4.48	6.59	29.71
Setaria pumila	36	1.40	3.89	13.04
Crassocephalum crepidioides	20	0.24	1.20	4.72
Begonia sp.	12	0.20	1.67	3.84
Pilea umbrosa	32	3.80	11.88	27.02
Lygodium flexuosum	12	0.16	1.33	3.42
Sporobolus sp.	16	1.32	8.25	13.74

Species Name	Frequency %	Density	Abundance	IVI
Eragrostis unioloides	20	1.68	8.40	15.58
Alocasia indica	12	0.16	1.33	3.42
Dichrocephala crepidioides	16	0.24	1.50	4.40
Cynoglossum lanceolatum	24	0.72	3.00	8.39
Hedychium coccineum	8	0.12	1.50	2.86
Adiantum edgeworthii	20	1.12	5.60	11.36
Senecio cappa	28	0.72	2.57	8.59
Impatiens sp.	40	1.16	2.90	12.00
Cyanotis vaga	24	0.60	2.50	7.57
Polygonum barbata	40	1.60	4.00	14.35
Solanum viarum	12	0.20	1.67	3.84
Lecanthus peduncularis	32	1.72	5.38	14.78
Total		**32**		**300**

Site-II, Downstream Area of Gimiliang Dam

A total of 17 tree species were recorded at this siteduring field studies at the site. The average density of this group of species was recorded to be 575 individuals/ha. The highest value of (IVI 51.70) as well as density (90 individuals/ha) with 45% frequency, was recorded for p*terospermum acerifolium* which was the dominant species of the site followed by *Duabanga grandiflora (*IVI 36.02) and*Ficus semicordata (*IVI 33.37.27).

In shrub community layer, a total of 19 species were recorded at this sampling site. The average density of this group of species was recorded to be 1365 individuals/ha. In terms of importance value index (IVI, 47.75), *Boehmeria longifolia* was found to be dominant shrub species followed by *Debregessia longifolia* (IVI, 45.78) and *Pandanas furcatus* (IVI, 23.98). Frequency value ranged from 10% to 60%.

In herbaceous community layer, a total of 21 species were recorded at this site during field studies. The average density of this group of species was recorded to be 22.60 individuals/m^2. The highest value of IVI (33.42) as well as density (3.40 individuals/m^2) was recorded for *Ageratum conyzoides* which was found to be dominant species at this site followed by *Lecanthus peduncularis*(IVI, 26.78) and *Saccharum spontaneum* (IVI, 25.57). Frequency value ranged from 4% to 64%. The details are given in Table-5.17.

Table-5.17: Distribution Analysis of Tree, Shrub and Herb community at Site-II (Downstream of Gimiliang Site)

Name of species	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Terminalia myriocarpa	25	40	1.60	24.02
Engelhardtia spicata	20	30	1.50	17.50
Duabanga grandiflora	35	50	1.43	36.02
Ficus semicordata	50	75	1.50	33.37

Name of species	Frequency %	Density	Abundance	IVI
Musa balbisiana	25	30	1.20	12.43
Rhus punjabensis	15	20	1.33	8.14
Macaranga denticulata	30	45	1.50	24.82
Garuga floribunda	20	30	1.50	14.62
Pterospermum acerifolium	45	90	2.00	51.70
Gmelina arborea	20	35	1.75	15.88
Celtis tetrandra	15	25	1.67	13.49
Alangium chinensis	10	20	2.00	6.96
Oroxylum indicum	10	15	1.50	5.67
Saurauria nepalensis	20	20	1.00	10.09
Cinnamomum sp.	10	10	1.00	5.72
Albizia chinensis	20	25	1.25	10.79
Bischofia javanica	15	15	1.00	8.79
Total		**575**		**300**
Shrub Community (Density/ha)				
Solanum torvum	25	45	1.80	10.51
Pandanas furcatus	40	80	2.00	23.98
Desmodium elegans	45	90	2.00	18.36
Clerodendrum colebrookianum	30	40	1.33	12.40
Chromolaena odoratum	25	70	2.80	10.96
Pinanga gracilis	15	15	1.00	4.51
Tetrastigma obovatum	10	25	2.50	5.50
Sida rhombifolia	35	100	2.86	16.65
Calamus leptospadix	15	25	1.67	5.88
Artemisia nilagirica	50	110	2.20	18.96
Triumfetta bartramia	30	60	2.00	10.99
Boehmeria longifolia	60	210	3.50	47.75
Boehmeria macrophylla	40	70	1.75	17.78
Melastoma normale	35	60	1.71	12.51
Urena lobata	50	115	2.30	19.08
Debregessia longifolia	55	175	3.18	45.78
Rubus foliolus	20	30	1.50	6.54
Solanum erianthum	15	20	1.33	5.66
Osbeckia stellata	20	25	1.25	6.20
Total		**1365**		**300**
Herb Community (Density/m^2)				
Ageratum conyzoides	64	3.40	5.31	33.42
Begonia sp.	20	0.48	2.40	8.75
Pilea umbrosa	36	1.96	5.44	21.94
Alocasia indica	16	0.40	2.50	7.76
Cynoglossum lanceolatum	12	0.20	1.67	5.13
Senecio cappa	20	0.28	1.40	6.67
Impatiens sp.	24	0.96	4.00	13.53
Polygonum barbata	20	1.04	5.20	14.57
Solanum viarum	16	0.44	2.75	8.24
Lecanthus peduncularis	40	2.60	6.50	26.78
Digitaria ciliaris	16	1.80	11.25	24.40
Borreria articularis	12	0.24	2.00	5.71

Name of species	Frequency %	Density	Abundance	IVI
Saccharum spontaneum	24	2.24	9.33	25.57
Arisaema consanguineum	12	0.12	1.00	3.98
Alpinia bracteata	4	0.24	6.00	8.98
Amomum aromaticum	16	0.32	2.00	6.81
Cynodon dactylon	48	2.20	4.58	24.23
Bidens pilosa	40	0.68	1.70	12.56
Spilanthes paniculata	44	1.00	2.27	15.41
Xanthium indicum	12	0.16	1.33	4.56
Thysanolaena maxima	36	1.84	5.11	21.01
Total		**22.6**		**300**

Site-III, Raigam Dam Site Area

In tree community layer, a total of 17 tree species were recorded during field studies. The average density for this group of species was recorded to be 450 trees /ha. A perusal of the data on the ecological analysis reveals that the highest value of (IVI 43.48) was recorded for *Macaranga denticulata* which was the dominant species of the site followed by*Aglaia spectabilis*(IVI, 40.11)and *Duabanga grandiflora* (IVI, 28.90). Frequency value ranged from 10% to 45%.

In shrub community layer, a total of 21 shrub species were recorded from this sampling site. The average density of this group of species was recorded to be 1430 individuals/ha. In terms of IVI (33.16), *Debregessia longifolia* was the dominant species followed by *Artemisia nilagirica* (IVI, 32.97) and *Clerodendrum colebrookianum* (IVI,22.61). The maximum density and density (240 individuals/ha) was recorded for *Artemisia nilagirica.* Frequency value ranged from 10% to 60%.

A total of 24 herbaceous species were recorded with an average density of 37.84 individuals /m^2.*Ageratum conyzoides* with highest value of density (6.163.45 individuals/m^2) and IVI (35.08) was found to be dominant herb species at this sampling site followed by *Saccahraum longisetosum*(IVI, 29.60), *Imperata cylindrica* (IVI, 26.66) and *Thysanolaena maxima* (IVI,23.96). *Ageratum conyzoides* was the most frequent species with 72% frequency. The details are given in Table-5.18.

Table-5.18: Distribution analysis of Tree, Shrub and Herb community at Site-III (Raigam Dam Site)

Species Name	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Ficus semicordata	25	35	1.40	18.69
Musa balbisiana	10	15	1.50	6.92
Pterospermum acerifolium	15	25	1.67	18.00
Gmelina arborea	15	20	1.33	12.91
Rhus punjabensis	10	15	1.50	7.04

Species Name	**Frequency %**	**Density**	**Abundance**	**IVI**
Macaranga denticulata	45	65	1.44	43.48
Saurauria nepalensis	20	25	1.25	18.17
Stercularia villosa	15	20	1.33	11.84
Celtis tetrandra	15	20	1.33	13.87
Macropanax disperma	15	25	1.67	16.43
Aglaia spectabilis	40	55	1.38	40.11
Erythrina sp.	15	15	1.00	8.75
Engelhardtia spicata	20	30	1.50	25.65
Duabanga grandiflora	25	35	1.40	28.90
Albizia chinensis	10	15	1.50	9.33
Alangium chinensis	15	20	1.33	13.03
Oroxylum indicum	10	15	1.50	6.88
Total		**450**		**300**
Shrub Community (Density/ha)				
Chromolaena odoratum	40	65	1.63	15.35
Urena lobata	30	50	1.67	9.74
Debregessia longifolia	45	160	3.56	33.16
Girardinia diversifolia	30	70	2.33	11.94
Urtica dioica	20	30	1.50	7.34
Oxyspora paniculata	15	25	1.67	4.87
Leea asiatica	10	10	1.00	3.47
Pandanas furcatus	25	45	1.80	14.68
Bambusa pallida	30	65	2.17	14.51
Rubus foliolus	15	40	2.67	8.90
Melastoma normale	20	60	3.00	11.04
Clerodendrum colebrookianum	30	85	2.83	22.61
Bambusa tulda	20	75	3.75	11.80
Artemisia nilagirica	60	240	4.00	32.97
Desmodium elegans	20	45	2.25	9.64
Indigofera sp.	15	25	1.67	6.32
Maesa indica	30	55	1.83	15.90
Rubus ellipticus	20	45	2.25	13.44
Triumfetta bartramia	50	105	2.10	20.13
Boehmeria longifolia	40	65	1.63	16.15
Boehmeria macrophylla	45	70	1.56	16.05
Total		**1430**		**300**
Herb Community (Density/m^2)				
Spilanthes paniculata	28	1.04	3.71	10.33
Xanthium indicum	20	0.28	1.40	5.28
Polygonum capitatum	24	3.20	13.33	22.01
Borreria articularis	32	0.80	2.50	9.57
Elusine indica	20	1.04	5.20	9.93
Oplismenus sp.	16	2.48	15.50	20.18
Thysanolaena maxima	40	3.84	9.60	23.96
Ageratum conyzoides	72	6.16	8.56	35.08
Curcuma caesia	16	0.20	1.25	4.25
Chrysopogon aciculatus	20	2.44	12.20	18.50
Saccahraum longisetosum	28	4.80	17.14	29.60

Species Name	Frequency %	Density	Abundance	IVI
Vittaria sp.	8	0.08	1.00	2.33
Imperata cylindrica	24	4.04	16.83	26.66
Setaria pumila	28	1.80	6.43	14.22
Colocasia affinis	16	0.24	1.50	4.53
Crassocephalum crepidioides	12	0.16	1.33	3.49
Begonia sp.	16	0.40	2.50	5.65
Commelina benghalensis	20	0.48	2.40	6.51
Phyrnium pubinerve	12	0.24	2.00	4.17
Digitaria ciliaris	20	2.24	11.20	17.27
Bidens pilosa	28	0.64	2.29	8.28
Blumea fistulosa	16	0.28	1.75	4.81
Galinsoga parviflora	24	0.64	2.67	7.83
Siegesosbekia orientalis	20	0.32	1.60	5.53
Total		**37.84**		**300**

Site-IV, Downstream Area of Raigam Dam

At the site-IV, a total of 19 tree species were recorded during field study. The average density of this group of species was recorded to be 595 trees/ha. A perusal of the data on the ecological analysis reveals that the highest value of IVI (44.50) as well as density (75 trees/ha) was recorded for *Castanopsis indica* which was the dominant species of the site followed by *Castanopsis indica* (IVI,35.49) and *Duabanga grandiflora* (IVI, 32.52). *Spondias pinnata* was the least importance species at this community layer. Frequency value ranged from 10% to 40%.

In shrub community layer, a total of 18 shrub species were recorded at this sampling site. The average density of this group of species was recorded to be 1245 individuals/ha. The highest value of IVI (43.49) was recorded for *Pandanas furcatus* which was dominant species of the site. *Boehmeria longifolia* (IVI, 41.12) and *Maesa indica*(IVI, 35.20) were the co-dominant species of this community. Frequency value ranged from 10% to 60%.

In herbaceous layer, a total of 19 herbaceous species were recorded with an average density of 22.68 individuals /m^2. In terms of importance value index (IVI, 39.68) and density (4.08 individuals /m^2), *Ageratum conyzoides* was the dominant herbaceous species at this sampling site followed by *Thysanolaena maxima* (IVI,31.03 and *Saccahraum longisetosum* IVI (28.45). Frequency value ranged from 8% to 64%. The details are given in **Table-5.19.**

Table-5.19: Distribution analysis of Tree, Shrub and Herb community at Site-IV (Downstream of Raigam Dam)

SpeciesName	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Kydia calycina	10	15	1.50	7.56
Ficus semicordata	20	35	1.75	14.34
Musa balbisiana	15	20	1.33	8.39

SpeciesName	Frequency %	Density	Abundance	IVI
Rhus punjabensis	20	20	1.00	10.13
Macaranga denticulata	25	40	1.60	20.34
Saurauria nepalensis	30	50	1.67	27.18
Rhus acuminata	15	25	1.67	10.33
Garuga floribunda	25	40	1.60	24.05
Spondias pinnata	10	10	1.00	6.18
Castanopsis indica	30	75	2.50	44.50
Cinnamomum sp.	10	10	1.00	6.84
Chukrasia tabularis	10	20	2.00	11.31
Dysoxylum gobara	10	15	1.50	8.00
Alangium chinensis	15	15	1.00	8.44
Oroxylum indicum	15	20	1.33	8.63
Bischofia javanica	10	10	1.00	6.58
Terminalia myriocarpa	40	60	1.50	35.49
Engelhardtia spicata	10	15	1.50	9.20
Duabanga grandiflora	30	50	1.67	32.52
Total		**545**		**300**
Shrub Community (Density/ha)				
Girardinia diversifolia	40	115	2.88	25.62
Urtica dioica	25	50	2.00	10.53
Calamus latifolius	10	10	1.00	4.39
Pinanga gracilis	15	30	2.00	8.65
Oxyspora paniculata	25	50	2.00	10.75
Pandanas furcatus	55	130	2.36	43.49
Tetrastigma obovatum	15	25	1.67	6.11
Bambusa pallida	20	60	3.00	11.79
Artemisia nilagirica	50	80	1.60	18.51
Desmodium elegans	30	55	1.83	12.32
Indigofera sp.	15	20	1.33	5.92
Maesa indica	40	170	4.25	35.20
Rubus ellipticus	10	20	2.00	5.93
Triumfetta bartramia	20	30	1.50	7.31
Boehmeria longifolia	60	215	3.58	41.12
Boehmeria macrophylla	35	125	3.57	34.78
Melastoma normale	25	40	1.60	9.77
Clerodendrum colebrookianum	15	20	1.33	7.79
Total		**1245**		**300**
Herb Community (Density/m^2)				
Thysanolaena maxima	36	3.00	8.33	31.03
Ageratum conyzoides	64	4.08	6.38	39.68
Curcuma caesia	12	0.20	1.67	5.50
Chrysopogon aciculatus	28	2.08	7.43	24.14
Saccahraum longisetosum	24	2.48	10.33	28.45
Vittaria sp.	12	0.16	1.33	4.93
Imperata cylindrica	20	2.24	11.20	27.53
Setaria pumila	24	1.88	7.83	22.85
Colocasia affinis	16	0.32	2.00	7.31
Crassocephalum crepidioides	24	0.40	1.67	9.04

SpeciesName	Frequency %	Density	Abundance	IVI
Begonia sp.	20	0.72	3.60	11.85
Commelina benghalensis	24	0.84	3.50	13.15
Bidens pilosa	28	0.60	2.14	11.37
Blumea fistulosa	20	0.36	1.80	8.14
Galinsoga parviflora	24	0.52	2.17	10.16
Siegesosbekia orientalis	20	0.36	1.80	8.14
Spilanthes paniculata	24	1.00	4.17	14.64
Xanthium indicum	8	0.16	2.00	4.84
Polygonum capitatum	24	1.28	5.33	17.25
Total		**22.68**		**300**

Site-V, Tidding-I Dam Site Area

In tree community layer, a total of 19 tree species were recorded during field studies at the site. The average density of this group of species was recorded to be 620 trees/ha. A perusal of the data on the ecological analysis reveals that the highest value of (IVI, 664.014.56) as well as density (115 trees/ha) was recorded for *Duabanga grandiflora* which was the dominant species of the site followed by *Macaranga denticulata* (IVI,39.27) and*Terminalia myriocarpa* (IVI, 21.51). Frequency value ranged from 10% to 60%.

In shrub community layer, a total of 20 shrub species were recorded at this sampling site. The average density of this group of species was recorded to be 1439 individuals/ ha. The highest value of IVI (33.43 was recorded for *Boehmeria longifolia* which was dominant species at the site. *Artemisia nilagirica* (IVI, 28.27) and *Bambusa tulda* (IVI, 26.89) were the co-dominant species at this community. *Debregessia longifolia* found to be most frequent species with 60% frequency.

In herbaceous community layer, a total of 24 species were recorded with an average density of 37.60 individuals /m^2.*Saccahraum longisetosum* with highest value of density (6.16 individuals/m^2) and IVI (35.99) was found to be dominant species at this site followed by *Ageratum conyzoides* (IVI, 29.13) and *Digitaria ciliaris* (IVI, 28.54). Frequency value ranged from1 8% to 52%. The details are given in Table-5.20.

Table-5.20: Distribution analysis of tree, shrub and herb community at Site-V (Tidding-I Dam Site Area)

Name of species	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Macaranga denticulata	40	80	2.00	39.27
Musa balbisiana	30	45	1.50	15.90
Duabanga grandiflora	60	115	1.92	64.01
Ficus semicordata	20	40	2.00	13.92
Gmelina arborea	15	20	1.33	9.20
Alangium chinensis	20	25	1.25	11.10

Name of species	**Frequency %**	**Density**	**Abundance**	**IVI**
Oroxylum indicum	15	20	1.33	7.58
Saurauria nepalensis	10	15	1.50	5.47
Bischofia javanica	20	25	1.25	11.66
Kydia calycina	10	10	1.00	5.58
Chukrasia tabularis	15	20	1.33	10.62
Aglaia spectabilis	20	30	1.50	14.65
Spondias pinnata	20	25	1.25	9.89
Castanopsis indica	20	30	1.50	16.61
Stercularia villosa	15	20	1.33	10.41
Lannea coromandelica	20	25	1.25	11.23
Bombax cieba	10	15	1.50	6.75
Terminalia myriocarpa	30	35	1.17	21.51
Engelhardtia spicata	20	25	1.25	14.65
Total		**620**		**300**
Shrub Community (Density/ha)				
Debregessia longifolia	60	120	2.00	10.46
Solanum erianthum	20	25	1.25	8.74
Pandanas furcatus	25	50	2.00	17.56
Clerodendrum colebrookianum	40	55	1.38	16.72
Tetrastigma obovatum	10	20	2.00	4.91
Sida rhombifolia	30	80	2.67	13.02
Jasminium dispermum	20	30	1.50	8.15
Vitex peduncularis	25	75	3.00	13.15
Girardinia diversifolia	40	120	3.00	23.86
Urtica dioica	20	30	1.50	7.00
Eupatorium odoratum	35	90	2.57	15.66
Trema amboinensis	30	50	1.67	11.73
Grewia disperma	15	30	2.00	7.81
Rubus ellipticus	20	25	1.25	7.32
Bambusa tulda	30	145	4.83	26.89
Artemisia nilagirica	50	205	4.10	28.27
Boehmeria longifolia	45	165	3.67	33.43
Boehmeria macrophylla	40	120	3.00	21.04
Melastoma normale	30	40	1.33	9.05
Urena lobata	50	80	1.60	15.24
Total		**1439**		**300**
Herb Community (Density/m^2)				
Saccharum spontaneum	32	4.20	13.13	27.53
Arisaema consanguineum	20	0.24	1.20	4.94
Amomum aromaticum	20	0.28	1.40	5.22
Cynodon dactylon	36	3.40	9.44	22.95
Polygonum capitatum	28	1.68	6.00	14.15
Cyanotis vaga	20	0.48	2.40	6.60
Blumea fistulosa	24	0.40	1.67	6.42
Elusine indica	20	1.04	5.20	10.45
Chrysopogon aciculatus	24	2.60	10.83	20.02
Saccahraum longisetosum	40	6.16	15.40	35.99
Vittaria sp.	12	0.16	1.33	3.53

Name of species	Frequency %	Density	Abundance	IVI
Phyrnium pubinerve	12	0.20	1.67	3.92
Ichnanthus vicinus	16	0.24	1.50	4.54
Bidens pilosa	32	0.84	2.63	9.72
Spilanthes paniculata	28	1.40	5.00	12.56
Xanthium indicum	16	0.20	1.25	4.22
Thysanolaena maxima	40	2.16	5.40	16.89
Ageratum conyzoides	52	4.80	9.23	29.13
Cynoglossum lanceolatum	20	0.24	1.20	4.94
Impatiens sp.	24	0.72	3.00	8.40
Polygonum barbata	20	0.84	4.20	9.08
Solanum viarum	8	0.08	1.00	2.37
Digitaria ciliaris	40	4.60	11.50	28.54
Borreria articularis	24	0.64	2.67	7.90
Total		**37.6**		**300**

Site-VI, Downstream Area of Tidding-I Dam

At this site, a total of 15 tree species were recorded during field study. The average density of this group of species was recorded to be 695 trees/ha. A perusal of the data on the ecological analysis reveals that the highest value of IVI (51.98) was recorded for *Gmelina arborea* which was the dominant species at the site followed by *Kydia calycina* (IVI, 33.92) and*Aglaia spectabilis* (IVI, 33.55). *Aglaia spectabilis* was found to be least important species with least value of density and IVI as well.

A total 19 shrub species were recorded at this site during the field study. The average density of this group of species was recorded to be 1335 individuals /ha. The Importance values of shrub species shows that *Boehmeria longifolia* was the dominant species having highest value of IVI (35.96) and density (160 individuals/ha) with 60% frequency. Other associate species for this vegetation stand were *Clerodendrum colebrookianum, Pandanas furcatus* and *Rubus ellipticus.*

A total of 23 herbaceous species were recorded with a density of 38.96 individuals /m^2 at the site-VIII during the field study. The highest value of IVI (32.82) as well density (6.16 individuals/m^2) was recorded for *Ageratum conyzoides* which was the dominant species at this site followed by *Saccharum spontaneum* (IVI, 29.69) and *Saccahraum longisetosum* (IVI,24.60). Frequency value ranged from 12% to 60%. The details are given in Table-5.21.

Table-5.21: Distribution analysis of tree, shrub and herb community at Site-VI (Downstream of Tidding-I dam site)

Name of species	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Chukrasia tabularis	25	40	1.60	15.53
Aglaia spectabilis	45	110	2.44	33.55
Spondias pinnata	15	25	1.67	8.53

Name of species	**Frequency %**	**Density**	**Abundance**	**IVI**
Castanopsis indica	20	35	1.75	15.60
Stercularia villosa	25	40	1.60	22.95
Gmelina arborea	50	90	1.80	51.98
Alangium chinensis	30	50	1.67	16.44
Oroxylum indicum	15	20	1.33	6.91
Saurauria nepalensis	10	15	1.50	5.23
Bischofia javanica	20	25	1.25	12.19
Kydia calycina	40	75	1.88	33.92
Duabanga grandiflora	45	55	1.22	33.35
Ficus semicordata	30	40	1.33	14.79
Musa balbisiana	20	35	1.75	10.50
Macaranga denticulata	30	40	1.33	18.54
Total		**695**		**300**
Shrub Community (Density/ha)				
Pandanas furcatus	40	120	3.00	28.87
Clerodendrum colebrookianum	50	175	3.50	35.02
Tetrastigma obovatum	20	30	1.50	7.12
Sida rhombifolia	30	75	2.50	11.17
Jasminium dispermum	10	15	1.50	3.84
Vitex peduncularis	40	70	1.75	14.25
Girardinia diversifolia	30	100	3.33	17.33
Urtica dioica	25	40	1.60	8.83
Eupatorium odoratum	25	45	1.80	7.76
Trema amboinensis	30	50	1.67	11.44
Grewia disperma	20	40	2.00	10.79
Rubus ellipticus	165	25	0.15	24.02
Bambusa tulda	35	80	2.29	15.72
Artemisia nilagirica	40	75	1.88	12.97
Boehmeria longifolia	60	160	2.67	35.96
Boehmeria macrophylla	45	70	1.56	16.01
Melastoma normale	20	25	1.25	5.71
Urena lobata	40	75	1.88	12.47
Debregessia longifolia	45	65	1.44	20.72
Total		**1335**		**300**
Herb Community (Density/m^2)				
Saccahraum longisetosum	24	3.56	14.83	24.60
Begonia sp.	28	0.60	2.14	7.34
Pilea umbrosa	40	1.16	2.90	11.13
Senecio cappa	24	0.60	2.50	7.05
Lecanthus peduncularis	44	1.84	4.18	14.49
Galinsoga parviflora	40	0.92	2.30	10.03
Siegesosbekia orientalis	20	0.40	2.00	5.55
Oplismenus sp.	20	2.96	14.80	22.45
Setaria pumila	24	1.44	6.00	12.03
Sporobolus sp.	32	1.68	5.25	13.20
Eragrostis unioloides	24	1.04	4.33	9.66
Equisetum diffusu	16	0.24	1.50	4.15
Pteris stenophylla	12	0.20	1.67	3.60

Name of species	Frequency %	Density	Abundance	IVI
Mikania micrantha	20	0.28	1.40	4.76
Digitaria ciliaris	36	3.40	9.44	21.58
Borreria articularis	24	1.00	4.17	9.42
Saccharum spontaneum	32	4.92	15.38	29.69
Cynodon dactylon	44	2.60	5.91	17.84
Polygonum capitatum	24	1.44	6.00	12.03
Bidens pilosa	16	0.24	1.50	4.15
Spilanthes paniculata	36	0.96	2.67	9.85
Thysanolaena maxima	48	1.32	2.75	12.58
Ageratum conyzoides	60	6.16	10.27	32.82
Total		**38.96**		**300**

Site-VII, Tidding-II Dam Site Area

A total of 18 tree species were recorded during the field study. The average density of this group of species was recorded to be 585 trees/ha. A perusal of the data on the ecological analysis reveals that the highest value of (IVI, 53.64) as well as density (100 trees/ha) was recorded for *Macaranga denticulate.* It was the dominant species of the site followed by *Duabanga grandiflora (*IVI 50.25), *Saurauria nepalensis*(IVI, 27.08) *Terminalia myriocarpa*(IVI 19.99).Frequency value ranged from 10% to 60%.

A total of 18 species were recorded at this sampling site. The average density of this group of species was recorded to be 1285 individuals/ha. In terms of importance value index (IVI, 40.36) and density (175 individuals/ha), *Bambusa tulda* was found to be most dominant species at this site followed by *Debregessia longifolia* (IVI,32.71) and *Desmodium elegans*(IVI, 30.57). In herbaceous community, a total of 21 herbaceous species were recorded with an average density of34.04individuals/m^2. The highest value of IVI (34.64) was recorded for *Ageratum conyzoides*which was the dominant species at this site followed by *Chrysopogon aciculatus* (IVI, 27.02), *Saccahraum longisetosum* (IVI, 27.02) and *Cynodon dactylon* (IVI,23.85). The details are given in Table-5.22.

Table-5.22: Distribution analysis of tree, shrub and herb community at Site-VII (Tidding-II Dam Site)

Species Name	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Callicarpa arborea	25	25	1.00	14.52
Toona ciliata	15	20	1.33	11.95
Trema orientalis	15	15	1.00	7.01
Duabanga grandiflora	50	80	1.60	50.25
Ficus semicordata	25	35	1.40	14.31
Erythrina sp.	20	30	1.50	11.38
Macaranga denticulata	60	100	1.67	53.64

Species Name	Frequency %	Density	Abundance	IVI
Alangium chinensis	15	20	1.33	8.00
Saurauria nepalensis	40	55	1.38	27.08
Bischofia javanica	20	25	1.25	13.34
Kydia calycina	15	30	2.00	15.48
Chukrasia tabularis	10	20	2.00	9.49
Aglaia spectabilis	15	25	1.67	12.33
Stercularia villosa	10	25	2.50	11.40
Terminalia myriocarpa	20	35	1.75	19.99
Rhus punjabensis	10	15	1.50	5.55
Garuga floribunda	10	10	1.00	5.27
Cinnamomum sp.	10	20	2.00	9.02
Total		**585**		**300**
Shrub Community (Density/ha)				
Clerodendrum colebrookianum	30	55	1.83	15.43
Rubus ellipticus	25	50	2.00	11.38
Bambusa tulda	55	175	3.18	40.36
Triumfetta bartramia	40	105	2.63	19.07
Rubus foliolus	10	15	1.50	4.24
Solanum torvum	20	25	1.25	9.62
Desmodium elegans	60	150	2.50	30.57
Calamus erectus	10	25	2.50	4.97
Maesa indica	30	60	2.00	18.71
Oxyspora paniculata	40	65	1.63	15.20
Zanthoxylum acanthopodium	20	25	1.25	9.40
Artemisia nilagirica	40	105	2.63	18.65
Boehmeria longifolia	30	125	4.17	26.25
Boehmeria macrophylla	30	65	2.17	16.76
Melastoma normale	15	25	1.67	5.55
Urena lobata	25	55	2.20	10.31
Debregessia longifolia	40	130	3.25	32.71
Pandanas furcatus	20	30	1.50	10.81
Total		**1285**		**300**
Herb Community (Density/m^2)				
Borreria articularis	20	0.60	3.00	8.06
Saccharum spontaneum	24	2.60	10.83	21.94
Arisaema consanguineum	12	0.12	1.00	3.38
Cynodon dactylon	32	3.12	9.75	23.85
Polygonum capitatum	28	1.92	6.86	16.93
Blumea fistulosa	16	0.24	1.50	4.90
Elusine indica	24	1.04	4.33	11.29
Chrysopogon aciculatus	48	4.48	9.33	30.26
Saccahraum longisetosum	40	3.80	9.50	27.02
Begonia sp.	16	0.28	1.75	5.25
Pilea umbrosa	36	1.20	3.33	12.93
Siegesosbekia orientalis	24	0.60	2.50	8.29
Oplismenus sp.	24	1.68	7.00	15.66
Setaria pumila	20	0.80	4.00	9.58
Sporobolus sp.	20	0.84	4.20	9.88

Species Name	Frequency %	Density	Abundance	IVI
Bidens pilosa	36	1.44	4.00	14.25
Spilanthes paniculata	28	1.28	4.57	12.92
Thysanolaena maxima	32	1.80	5.63	16.13
Ageratum conyzoides	52	5.40	10.38	34.64
Cynoglossum lanceolatum	16	0.20	1.25	4.55
Impatiens sp.	24	0.60	2.50	8.29
Total		**34.04**		**300**

Site-VIII, Downstream Area of Tidding-II Dam

In tree community layer, a total of 16 tree species were recorded at this sampling siteduring the field study. The average density of this group of species was recorded to be 610 trees/ha. A perusal of the data on the ecological analysis reveals that the highest value of IVI (42.20) as well as density (110 trees/ha) was recorded for *Ficus semicordata* which was the dominant species of the site followed by *Chukrasia tabularis* (IVI, 39.50) and*Bischofia javanica* (IVI,27.64). Frequency value ranged from 10% to 50%.

In shrub community layer, a total of 17 shrub species were recorded from this sampling site. The average density of this group of species was recorded to be 1085 individuals/ ha. On the basis of importance value index, *Boehmeria longifolia* was found to be the most dominant species having maximum IVI (52.74).*Debregessia longifolia* (IVI, 42.88) and *Chromolaena odoratum* (IVI, 23.49) were the co-dominant species at this community.

A total of 22 herbaceous species were recorded with an average density of 32.12 individuals /m^2.*Imperata cylindrica* with highest value of density (7.40 individuals/m^2) and IVI (46.60) was the dominant herb species at this site followed by *Ageratum conyzoides* (IVI, 30.05) and *Bidens pilosa* (IVI,25.30). *Bidens pilosa* was the most frequent species with 64% frequency. The details are given in Table -5.23.

Table-5.23: Distribution analysis of tree, shrub and herb community at Site-VIII (Downstream of Tidding-II Dam Site)

Species Name	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Duabanga grandiflora	20	30	1.50	20.91
Ficus semicordata	50	110	2.20	42.20
Celtis tetrandra	15	20	1.33	10.39
Cinnamomum sp.	10	15	1.50	7.86
Erythrina sp.	10	10	1.00	4.68
Callicarpa arborea	20	25	1.25	13.83
Toona ciliata	20	30	1.50	16.75
Saurauria nepalensis	25	35	1.40	15.38
Bischofia javanica	40	70	1.75	27.64
Kydia calycina	30	40	1.33	19.99

Species Name	Frequency %	Density	Abundance	IVI
Chukrasia tabularis	45	85	1.89	39.50
Aglaia spectabilis	25	45	1.80	22.29
Stercularia villosa	20	25	1.25	14.60
Terminalia myriocarpa	30	35	1.17	23.26
Macaranga denticulata	15	20	1.33	14.83
Alangium chinensis	10	15	1.50	5.87
Total		**610**		**300**
Shrub Community (Density/ha)				
Maesa indica	35	55	1.57	15.47
Oxyspora paniculata	25	45	1.80	10.73
Zanthoxylum acanthopodium	15	25	1.67	7.58
Tetrastigma obovatum	20	20	1.00	7.13
Triumfetta bartramia	40	75	1.88	20.29
Solanum torvum	25	35	1.40	8.94
Desmodium elegans	30	55	1.83	11.36
Chromolaena odoratum	45	110	2.44	23.49
Indigofera sp.	15	15	1.00	5.05
Bambusa pallida	25	70	2.80	21.22
Artemisia nilagirica	30	60	2.00	12.37
Boehmeria longifolia	75	165	2.20	52.74
Boehmeria macrophylla	50	80	1.60	22.89
Melastoma normale	25	35	1.40	8.78
Urena lobata	45	70	1.56	15.62
Debregessia longifolia	60	130	2.17	42.88
Pandanas furcatus	30	40	1.33	13.46
Total		**1085**		**300**
Herb Community (Density/m^2)				
Imperata cylindrica	40	7.40	18.50	46.60
Setaria pumila	28	1.04	3.71	11.64
Colocasia affinis	20	0.40	2.00	6.67
Crassocephalum crepidioides	12	0.24	2.00	4.71
Begonia sp.	16	0.20	1.25	4.66
Commelina benghalensis	20	0.60	3.00	8.17
Phyrnium pubinerve	12	0.20	1.67	4.29
Digitaria ciliaris	20	2.60	13.00	23.16
Bidens pilosa	52	3.28	6.31	25.30
Blumea fistulosa	16	0.24	1.50	5.00
Galinsoga parviflora	32	0.96	3.00	11.50
Spilanthes paniculata	24	1.12	4.67	11.99
Xanthium indicum	16	0.36	2.25	6.03
Polygonum capitatum	28	0.64	2.29	9.14
Borreria articularis	20	0.48	2.40	7.27
Elusine indica	24	1.00	4.17	11.18
Oplismenus sp.	20	1.92	9.60	18.06
Thysanolaena maxima	36	2.12	5.89	18.38
Ageratum conyzoides	64	4.08	6.38	30.05
Curcuma caesia	12	0.16	1.33	3.87
Chrysopogon aciculatus	16	0.48	3.00	7.06

Species Name	Frequency %	Density	Abundance	IVI
Saccahraum longisetosum	16	2.60	16.25	25.27
Total		**32.12**		**300**

Site-IX, Kamlang Dam Site Area

In tree community layer, a total of 17 species were recorded during field studies at this site. The average density for this group of species was recorded to be 510 trees/ha. A perusal of the data on the ecological analysis reveals that, the highest value of IVI (60.39) as well as density (75 trees/ha) was recorded for *Duabanga grandiflora*. It wasfound to be dominant species at this site followed by *Pterospermum acerifolium* (IVI, 49.94) and *Terminalia myriocarpa* (IVI,27.45).

In shrub community layer, a total of 20 shrub species were recorded at this site. The average density of this group of species was recorded to be 1120 individuals/ha. The highest value of IVI (49.10) as well as density (210 individuals/ha) was recorded for *Boehmeria macrophylla* which was dominant species of the site. *Artemisia nilagirica* (IVI, 42.94) and *Debregessia longifolia* (IVI, 31.35) were the co-dominant species at this community. Frequency value ranged from 10% to 65%.

In herbaceous community layer, a total of 21 species were recorded with an average density of 37.76 individuals /m^2. The highest value of IVI (44.34) and density (8.20 individuals/m^2) with 60% frequency was recorded for *Ageratum conyzoides* which was found to be dominant species at this site followed by *Saccahraum longisetosum* (IVI, 42.26) and *Digitaria ciliaris* (IVI, 40.77). The least value of IVI (3.46) was recorded for *Hedychium coccineum.*The details are given in Table-5.24

Table-5.24: Distribution analysis of tree, shrub and herb community at Site-IX

Species Name	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Duabanga grandiflora	40	75	1.88	60.39
Kydia calycina	20	30	1.50	17.33
Toona ciliata	15	20	1.33	12.96
Albizia chinensis	20	25	1.25	13.02
Ficus roxburghii	10	15	1.50	6.44
Ficus semicordata	30	40	1.33	19.75
Musa balbisiana	20	25	1.25	11.38
Pterospermum acerifolium	50	90	1.80	49.94
Stercularia villosa	15	25	1.67	14.35
Celtis tetrandra	10	10	1.00	8.11
Gmelina arborea	15	20	1.33	12.62
Oroxylum indicum	10	15	1.50	6.27
Bischofia javanica	20	25	1.25	12.23
Garuga floribunda	10	15	1.50	7.14
Terminalia myriocarpa	30	50	1.67	27.45
Erythrina sp.	10	10	1.00	5.26

Species Name	Frequency %	Density	Abundance	IVI
Engelhardtia spicata	20	20	1.00	15.35
Total		**510**		**300**
Shrub Community (Density/ha)				
Artemisia nilagirica	60	180	3.00	42.94
Chromolaena odoratum	30	105	3.50	20.39
Eupatorium odoratum	20	75	3.75	13.84
Buddleja asiatica	15	30	2.00	12.59
Caesalpinia sp.	10	15	1.50	4.95
Desmodium elegans	25	50	2.00	11.01
Indigofera spp	20	25	1.25	7.56
Hydrangea robusta	10	10	1.00	3.79
Sida rhombifolia	10	20	2.00	4.40
Urena lobata	40	50	1.25	13.74
Maesa indica	30	60	2.00	18.38
Rubus ellipticus	15	25	1.67	6.73
Solanum erianthum	15	30	2.00	11.45
Triumfetta bartramia	20	35	1.75	8.38
Boehmeria polystachya	15	30	2.00	7.91
Debregessia longifolia	45	70	1.56	31.35
Girardinia diversifolia	20	30	1.50	9.14
Urtica dioica	15	30	2.00	7.91
Boehmeria longifolia	25	40	1.60	14.44
Boehmeria macrophylla	65	210	3.23	49.10
Total	**505**			**300**
Herb Community (Density/m^2)				
Chrysopogon aciculatus	28	5.28	18.86	34.51
Digitaria ciliaris	24	6.04	25.17	40.77
Saccahraum longisetosum	36	7.24	20.11	42.26
Bidens pilosa	40	0.84	2.10	11.71
Blumea fistulosa	32	0.48	1.50	8.72
Dichrocephala crepidioides	20	0.44	2.20	6.83
Galinsoga parviflora	48	1.28	2.67	14.89
Siegesosbekia orientalis	12	0.20	1.67	4.20
Spilanthes paniculata	24	1.52	6.33	13.77
Xanthium indicum	16	0.24	1.50	4.96
Cynoglossum lanceolatum	12	0.16	1.33	3.83
Polygonum capitatum	24	1.00	4.17	10.66
Borreria articularis	16	0.52	3.25	7.10
Pilea umbrosa	24	1.40	5.83	13.05
Hedychium coccineum	12	0.12	1.00	3.46
Adiantum edgeworthii	28	1.68	6.00	14.71
Pteris sp.	16	0.36	2.25	5.87
Pteris stenophylla	12	0.16	1.33	3.83
Ageratum conyzoides	60	8.20	13.67	44.34
Crassocephalum crepidioides	16	0.32	2.00	5.57
Mikania micrantha	12	0.28	2.33	4.95
Total		**37.76**		**300**

Site-X, Downstream Area/Power House Site of Kamlang Dam

At this site, a total of 18 tree species were recorded during the field study. The total density of this group of species was recorded to be 570 trees/ha. A perusal of the data on the ecological analysis reveals that, the highest value of IVI (57.93) as well as density (90 individuals/ha) was recorded for *Duabanga grandiflora* which was the dominant species of the site followed by *Macaranga denticulata* (IVI, 46.99), *Ficus semicordata* (IVI, 24.43) and *Albizia chinensis* (IVI,20.60). Frequency value ranged from 10% to 55%

A total 16 shrub species were recorded at this site during field study. The total density of this group of species was recorded to be 1080 individuals/ha. On the basis of IVI (47.88) and density (160 individuals/ha), *Clerodendrum colebrookianum* was found as the dominant shrub species at this site. Other associate species were *Boehmeria longifolia,Bambusa tulda*and *Desmodium elegans*. Frequency value ranged from 15% to 55%.

In herbaceous community layer, a total of 19 species were recorded with an average density of 33.32 individuals /m^2 at the site-II. In terms of density (5.00 individuals/m^2) and IVI (34.50), *Thysanolaena maximum* was found to be dominant herb species followed by *Ageratum conyzoides* (IVI, 31.49) and *Oplismenus* sp. (IVI, 29.56). *Ageratum conyzoides* was the most frequent species with 56% frequency.The details are given in Table-5.25.

Table-5.25: Distribution analysis of tree, shrub and herb community at Site-X

Species Name	Frequency %	Density	Abundance	IVI
Tree Community (Density/ha)				
Duabanga grandiflora	55	90	1.64	57.93
Kydia calycina	20	30	1.50	14.05
Toona ciliata	15	20	1.33	12.77
Albizia chinensis	30	50	1.67	20.60
Ficus roxburghii	10	20	2.00	6.97
Ficus semicordata	40	60	1.50	24.43
Musa balbisiana	30	40	1.33	15.58
Pterospermum acerifolium	25	30	1.20	18.18
Gmelina arborea	20	25	1.25	11.34
Lannea coromandelica	15	20	1.33	10.79
Bombax cieba	10	15	1.50	8.89
Macaranga denticulata	45	70	1.56	46.99
Phylanthus emblica	10	10	1.00	4.62
Ricinus communis	10	10	1.00	4.57
Alangium chinensis	15	20	1.33	8.26
Rhus acuminata	10	20	2.00	6.86
Bischofia javanica	20	25	1.25	14.86
Terminalia myriocarpa	10	15	1.50	12.30
Total		**570**		**300**
Shrub Community (Density/ha)				
Desmodium elegans	30	100	3.33	24.89

Species Name	**Frequency %**	**Density**	**Abundance**	**IVI**
Indigofera sp.	25	50	2.00	13.81
Sida rhombifolia	20	25	1.25	7.22
Maesa indica	15	35	2.33	10.19
Rubus ellipticus	20	45	2.25	13.26
Solanum erianthum	15	25	1.67	6.79
Triumfetta bartramia	35	75	2.14	16.14
Boehmeria polystachya	15	35	2.33	9.92
Boehmeria longifolia	40	130	3.25	41.62
Boehmeria macrophylla	45	75	1.67	23.35
Melastoma normale	50	80	1.60	21.29
Osbeckia stellata	15	20	1.33	6.06
Clerodendrum colebrookianum	55	160	2.91	47.88
Bambusa tulda	25	125	5.00	29.46
Artemisia nilagirica	55	70	1.27	19.72
Eupatorium odoratum	20	30	1.50	8.40
Total		**1080**		**300**
Herb Community (Density/m^2)				
Spilanthes paniculata	32	1.84	5.75	17.15
Xanthium indicum	20	0.32	1.60	6.36
Polygonum capitatum	28	1.40	5.00	14.34
Borreria articularis	24	0.48	2.00	8.00
Pilea umbrosa	40	3.92	9.80	28.74
Lygodium flexuosum	44	1.36	3.09	15.56
Pteris sp.	16	0.24	1.50	5.25
Sporobolus sp.	20	2.24	11.20	21.10
Elusine indica	32	1.68	5.25	16.20
Eragrostis unioloides	24	2.00	8.33	18.48
Oplismenus sp.	28	3.80	13.57	29.56
Thysanolaena maxima	40	5.00	12.50	34.50
Alocasia indica	12	0.20	1.67	4.50
Ageratum conyzoides	56	4.40	7.86	31.49
Costos speciosus	12	0.16	1.33	4.07
Curcuma caesia	8	0.12	1.50	3.32
Digitaria ciliaris	28	3.00	10.71	24.49
Bidens pilosa	36	0.96	2.67	12.40
Blumea fistulosa	12	0.20	1.67	4.50
Total		**33.32**		**300**

5.10.5 Diversity Indices

Shannon Weinner index (H′) is an index used to measure diversity in categorical data. Value of Shannon Weinner index (H′) more than 2 is indicative higher species diversity while its value around 1 or less than 1 indicates low diversity. Diversity index (H') increases in value as the number of species increases. Thus, higher the value of (H′) the greater is the species diversity in the community. In the present study, species diversity (H') ranged from 2.52 to 2.72 for tree, 2.09to 2.91 for shrub strata and 2.69 to 3.10 for herbaceous layer in all sampling sites. The maximum index for any community clearly indicates that the species richness and favorable condition for plant growth plays an important role in increasing species diversity.

Dominance diversity (Cd) is another diversity index which always ranges from 0 - 1, indicates species dominance within community gives greater weight to common species. In addition, the value of dominance closer to 1 indicates areas dominated by single or few species. The value of dominance had followed an opposite trend of diversity. In the present study, site-IX, Kamlang dam site (tree layer) found to have maximum concentration dominance (0.101) with least diversity (2.52) whereas, site-I, Gmliang dam site (herb layer) found to have lowest dominance (0.052) with highest species diversity (3.10). Dominance is also used for the estimation of heterogeneity of various sites.

The distribution of individuals among the species, referred to as evenness, which compares the similarity of the population size of each of the species present. As species richness and evenness increase, so diversity increases. In the present study Pielou’s evenness (J) ranged between 0.90 to 0.95 for tree species, 0.91 to 0.97 for shrub species and 88 to 95 for herbaceous species in all sampling sites.Diversity indices calculated for all the sites separately for trees, shrubs and herbs are given in Tables-5.26 to 5.28 respectively.

Table-5.26: Diversity indices of tree species occurring in various sampling sites

Study sites	Sampling locations	Shannon-wiener Diversity Index (H′)	Concentration of dominance (Cd)	Evenness (J)
Site-I	Gimiliang Dam Site Area	2.58	0.089	0.93
Site-II	Downstream Area (d/s) of Gimiliang dam	2.62	0.087	0.94
Site-III	Raigam Dam Site Area	2.66	0.080	0.94
Site-IV	Downstream Area (d/s) of Raigam dam	2.72	0.079	0.93
Site-V	Tidding-I Dam Site Area	2.68	0.091	0.91
Site-VI	Downstream Area (d/s) of Tidding-I dam	2.56	0.092	0.93
Site-VII	Tidding-II Dam Site Area	2.64	0.091	0.91
Site-VIII	Downstream Area (d/s) of Tidding-II dam	2.62	0.081	0.95
Site-IX	Kamlang Dam Site Area	2.52	0.101	0.90
Site-X	Downstream Area (d/s) /Power House site of Kamlang dam	2.63	0.093	0.91

Table-5.27: Diversity indices of shrub species occurring in various sampling sites

Study sites	Sampling locations	Shannon-Wiener Diversity Index (H′)	Concentration of dominance (Cd)	Evenness (J)
Site-I	Gimiliang Dam Site Area	2.85	0.069	0.94
Site-II	Downstream Area (d/s) of Gimiliang dam	2.71	0.082	0.92
Site-III	Raigam Dam Site Area	2.91	0.061	0.97
Site-IV	Downstream Area (d/s) of Raigam dam	2.63	0.088	0.91
Site-V	Tidding-I Dam Site Area	2.87	0.063	0.96
Site-VI	Downstream Area (d/s) of Tidding-I dam	2.79	0.069	0.95
Site-VII	Tidding-II Dam Site Area	2.72	0.074	0.92
Site-VIII	Downstream Area (d/s) of Tidding-II dam	2.73	0.087	0.93
Site-IX	Kamlang Dam Site Area	2.73	0.082	0.91
Site-X	Downstream Area (d/s) /Power House site of Kamlang dam	2.09	0.088	0.93

Table-5.28: Diversity indices of herb species occurring in various sampling sites

Study sites	Sampling locations	Shannon-wiener Diversity Index (H′)	Concentration of dominance (Cd)	Evenness (J)
Site-I	Gimiliang Dam Site Area	3.10	0.052	0.95
Site-II	Downstream Area (d/s) of Gimiliang dam	2.86	0.065	0.94
Site-III	Raigam Dam Site Area	2.93	0.064	0.92
Site-IV	Downstream Area (d/s) of Raigam dam	2.75	0.073	0.94
Site-V	Tidding-I Dam Site Area	2.91	0.066	0.92
Site-VI	Downstream Area (d/s) of Tidding-I dam	2.96	0.059	0.94
Site-VII	Tidding-II Dam Site Area	2.87	0.064	0.94
Site-VIII	Downstream Area (d/s) of Tidding-II dam	2.84	0.062	0.92
Site-IX	Kamlang Dam Site Area	2.69	0.089	0.88
Site-X	Downstream Area (d/s) /Power House site of Kamlang dam	2.74	0.073	0.93

5.11 ECONOMICALLY IMPORTANT PLANTS

5.11.1 Projects on Main Lohit River

The forests of Arunachal Pradesh are endowed with many useful plant species viz., timber yielding species, medicinal plants, bamboos, rattans, wild ornamental plants, etc. The state can be termed as a repository of medicinal plants (Haridasan et at. 1996). The indigenous people in the state live in close association with the forests and have accumulated a vast treasure of knowledge related to utilization of plants. This knowledge of medicinal plants is becoming a potential source of information for the pharmaceutical industries. The list of economically important plant species observed at various sampling sites in the area of various hydroelectric projects is given in Table-5.29.

Table-5.29: List of Economically important plant species observed at various sampling sites on main Lohit river

S. N.	Species	Uses
A.	**Kalai Hydroelectric Project, Stage-1**	
1	*Ficus cunia*	Fodder
2	*Macaranga denticulata*	Fuel
3	*Nephrolepis cordifolia*	Medicinal
4	*Alnus nepalensis*	Fuel
5	*Rubus* spp.	Edible
6	*Thysanolaena maxima*	Broom industry, fodder
7	*Saurauria nepalensis*	Fodder
B.	**Kalai Hydroelectric Project, Stage-2**	
1	*Ficus cunia*	Fodder
2	*Macaranga denticulata*	Fuel
3	*Nephrolepis cordifolia*	Medicinal
4	*Pandanus odoratissima*	Fibre
5	*Rubus* spp.	Edible
6	*Thysanolaena maxima*	Broom industry, fodder
7	*Saurauria nepalensis*	Fodder
C.	**Hutong Hydroelectric Project, Stage-1**	
1	*Ficus cunia*	Fodder fuel
2	*Macaranga denticulata*	
3	*Nephrolepis cordifolia*	Medicinal
4	*Rubus* spp.	Edible
5	*Thysanolaena maxima*	Broom industry, fodder
D.	**Hutong Hydroelectric Project Stage-2**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Ficus cunia*	Fodder
3	*Macaranga denticulata*	Fuel
4	*Nephrolepis cordifolia*	Medicinal
5	*Rubus* spp.	Edible
6	*Terminalia myriocarpa*	Timber
7	*Thysanolaena maxima*	Broom industry, fodder
8	*Saurauria nepalensis*	Fodder
9	*Spondias axillaries*	Fruits edible
E.	**Demwe Upper Hydroelectric Project**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Ficus cunia*	Fodder
3	*Ficus roxburqhii*	Fodder, fruits edible
4	*Macaranga sp.*	Fuel
5	*Nephrolepis cordifolia*	Medicinal
6	*Pandanus odoratissima*	Fibre
7	*Rubus* spp.	Edible
8	*Terminalia myriocarpa*	Timber
9	*Thysanolaena maxima*	Broom industry, fodder
10	*Saurauria nepalensis*	Fodder

S. N.	Species	Uses
11	*Sapium baccatum*	Timber
12	*Spondias axillaries*	Fruits edible
F.	**Demwe Lower Hydroelectric Project**	
1.	*Syzygium cumini*	Medicinal, leaves edible
2.	*Ficus roxburghii*	Fodder, fruits edible
3.	*Macaranga spp.*	Fuel
4.	*Nephrolepis cordifolia*	Medicinal
5.	*Kydia calycina*	Fuel, timber
6.	*Rubus sp.*	Edible
7.	*Terminalia myriocarpa*	Timber, fuel
8.	*Dalbergia sissoo*	Timber
9.	*Spondias pinnata*	Fruits edible, medicinal
10.	*Emblica officinalis*	Fruits edible, medicinal

In Kalai Hydroelectric Project, Stage-1, seven economically important plant species were recorded. They were namely, *Ficus cunia*, *Macaranga denticuiata*, *Nephrolepis cordifolia*, *Alnus nepalensis*, *Rubus* spp., *Thysanolaena maxima* and *Saurauria nepalensis*.

At Kalai Hydroelectric Project, Stage-2, various plants of economic importance such as timber, medicinal, edible fruits were commonly observed. *Pandanus odoratissima* is a fiber yielding tree species & *Nephrolepis cordifolia has medicinal values*. These are seen commonly here and there at the project sites.

Five economically important plants were recorded from Hutong Hydroelectric Project, Stage-1 viz., *Ficus cunia*, *Macaranga denticuiata*, *Nephrolepis cordifolia*, *Rubus* spp. and *Thysanolaena maxima.*

About 9 economically important plant species were recorded from the study area in Hutong Hydroelectric Project, Stage-2. These include *Clerodendron colebrookianum*, *Ficus cunia*, *Macaranga denticulata*, *Nephrolepis cordifolia*, *Rubus* spp., *Terminalia myriocarpa*, *Thysanolaena maxima*, *Saurauria nepalensis* and *Spondias pinnata*.

About 12 economically important plant species we re recorded from the study area in Demwe Upper Hydroelectric Project. These species include *Clerodendron colebrookianum, Ficus cunia, Ficus roxburghii, Macaranga* sp., *Nephrolepis cordifolia, Pandanus odoratissima, Rubus spp., Terminalia myriocarpa, Thysanolaena maxima, Saurauria nepalensis, Sapium baccatum and Spondias axillaries.*

Ten economically important plant species were recorded from the study area in Demwe Lower Hydroelectric Project. Plant of economical importance such as timber (*Terminalia myriocarpa*, *Dalbergia sissoo,),* medicinal *(Nephrolepis cordifolia, Spondias pinnata*), edible fruits (*Ficus roxburhghii, Rubus* sp.*)* and *Macaranga* spp. known for fuel wood value were commonly seen here and there at the project site.

5.11.2 Pojects on Tributaries of Lohit River

Medicinal Plants

The list of some medicinally important plant species found in the project area given in Table-5.30.

Table-5.30: List of medicinal plans found in the study area

Plant Species	Parts used	Uses
Rhaphidophora decursiva	Leaves, flower	Malarial fever, backache, stomach disorder, aphrodisiac
Ageratum conyzoides	Whole plant	Eye treatment to stop bleeding in Cutsandwoundstocheckbleedingandearlyhealing
Bidens pilosa	Leaves, roots	Jaundice,stomach disorder, aphrodisiac
Begonia sp.	Entire plant	Stomach,Vomiting,Diarrhoea
Borreria articularis	Leaves	Cold,cough,fever
Costos speciosus	Rhizomes	Strong anthelmentic
Curcuma caesia	Rhizomes	Cold,cough,fever
Alocasiamacrorrhiza	Seeds, rhizomes	Treatment of insectbite
Cuscuta reflexa	Whole plant	Antidote
Artemisia nilagirica	Flower & leaves	Stomachdisorder
Sida rhombifolia	Roots & leaves	Antidoteinsnakebite
Zanthoxylum acanthopodium	Seeds & leaves	Toothache,stomachdisorder,Cold,cough
Gynocardiaodorata	Barks	Teeth extraction, fruit used as poison for killing insects,wormsandfishes
Oroxylum indicum	Seeds & barks	BlooddysenteryandDiarrhoea
Spilanthespaniculata	Leaves	Tooth-ache, cough
Solanum torvum	Leaves & fruit	Stomachpain
Macaranga denticulata	Stem barks	Fracture
Phylanthus emblica	Fruits	Bloodpurifier,abdominalpain,gastric,and improved in digestion
Dendrocalamusstrictus	Young shoot	Injuries,woundor cut
Engelhardtia spicata	Stem barks	Fracture
Cinnamomum sp.	Leaves, roots & barks	Liverandurinarytroubles

Food Plants

The people of Arunachal Pradesh collect a large number of wild edible plants in the form of tubers, rhizomes, shoots, flowers, fruits, berries, seeds, etc. as the natural supplement for their diet. These wild edible species are very rich in carbohydrates, starch, protein, sugar and oil. Among the wild edible plants consumed are the leaves and young twigs of *Aconogonum molle, Amaranthus spinosus, Cardamine hirsuta, Chenopodium album, Fagopyrum esculentum, Girardinia diversifolia* and *Urtica urdance*. The various edible vegetables collected from the forests are bamboo shoot (*Dendrocalamus hamiltonii*), wild banana (*Musa balbasiana*) flowers. Other wild species consumed as vegetables are *Zanthoxyllum rhetsa*, *Clerodendrum colebrookianum*, *Alpinia allughas, Alocasia indica, Piper pedicellatum* and *Colocasia esculenta*. Young shoots of *Bambusa tulda* and *Dendrocalamus hamiltonii* are used as food ingredients. Flower buds of *Bauhinia purpurea* and *Oroxylum indicum* are used as vegetables. Fruits of *Garcinia pedunculata, Phylanthus emblica, Rubus ellipticus, Ficus semicordata*, *Prunus cerasoides, Musa* sp., are eaten raw or cooked as vegetables. Paddy (*Oryza sativa*), maize (*Zea mays*), millets (*Pennisetum typhoides*), potato (*Solanum tuberosum*), ginger (*Zingiber officinale*) are main crops of this region.

Timber and Fuelwood Trees

Forest is the most important source of timber in the study area. Most important timber yielding species of the area are *Terminalia myriocarpa, Duabanga grandiflora, Bischofia javanica, Castanopsi indica, Canarium strictum,Toona ciliata, Gynocardia odorata, Pterospermum acerifolium* , and *Tetrameles nudiflora* etc. *Phoebe cooperiana, Alnus nepalensis* and *Altingia excelsa* are the other timber yielding species which are also made use of. *Macaranga denticulata*) and *Callicarpa arborea* are commonly used for making poles for house constructions. Species like *Callicarpa arborea, Macaranga denticulate* are highly preferred for use as fire wood. These are very light woods, easily combustible, leave less smoke while burning and dry easily. In addition to these, many inferior wood species are also made use of for fuel wood purposes. In addition to these trees, some bamboos like *Bambusa tulda* and *Dendrocalamus hamiltonii* are commonly used for house construction. It also comes in very handy as stilts, struts, purlins and rafters in the same along with the woody species.

Fodder Plants

The human population of the area depends essentially on naturally growing trees, shrubs, herbs and grasses for the fodder requirements of their cattle and livestock. Major fodder species used by the local community are *Ficus roxburghii, Debregeasia longifolia,* *Gynocardia odorata, Ficus semicordata, Alangium chinensis, Thysanolaena maxima, Digitaria ciliaris, Arundo donax* and wild banana or *Musa* sp. (*kulung*), the former for being palatable, easy to digest and for its milk enhancing properties and the latter for its easy availability and palatability. In addition bamboo foliage also acts as a supplementary fodder in this region.

5.12 FLORA UNDER THREATENED CATEGORY

The lower elevations of the study area are presently degraded due to high human pressure, large scale lopping and removal of fodder and timber species, grazing, construction of road, etc. Nayar and Sastry (1987-1990) have reported 35 species of rare and endangered plant species from Arunachal Pradesh. Of these threatened species *Acer oblongum* var. *microcarpum, Begonia burkillii, Calanthe manii, Dioscorea deltoidea, Paphiopedilum wardii* and *Phoenix rupicola* have been reported from low hills in the altitudinal range of 300-1200 m. The details are given in table-5.31. There is a possibility that some of these species may be present in the project areas though the present surveys were not able to record these in the field. During the course of survey, only one species i.e., *Lagerstroemia muniticarpa* classified as endangered plant species as per IUCN Red list.

Table-5.31: Rare, vulnerable and endangered plants reported from secondary literature in the Study Area

S. No.	Species	Family	Altitude (m)	Habit	Status
1.	*Acer oblongum* var. *microcarpum*	Acerceae	500-1200	Tree	Endangered
2.	*Begonia burkillii*	Begoniaceae	300-1000	Herb	Rare
3.	*Calanthe manii*	Orchidaceae	Up to 1000	Herb	Rare
4.	*Dioscorea deltoidea*	Dioscoreaceae	300-3000	Climber	Endangered
5.	*Paphiopedilum wardii*	Orchidaceae	Up to 1000	Herb	Rare
6.	*Phoenix rupicola*	Arecaceae	Up to 450	tree	Rare

Source: CEIA Study, Demwe Lower Hydroelectric Project

5.13 PARASITIC FLORA

As per the review of secondary data, few parasitic plant species are reported. These plant species belong to the families Cuscutaceae and Loranthaceae. *Cuscuta reflexa* (Cuscutaceaae) was found growing on wide range of hosts in the area namely, *Debregeasia longifolia* and *Rhus chinensis*. *Scurrula elata* was found growing as parasite on *Ficus* spp. in the area.

5.14 EPIPHYTES

As per the review of secondary data, epiphytes belonging mainly to family Orchidaceae and Moraceae are reported. There is also rich growth of epiphytic ferns. A number of orchids belonging to the genera *Bulbophyllum*, *Coelogyne*, *Cymbidium*, *Dendrobium*, etc., were observed hanging on the trees. The epiphytic ferns found in the area include species of *Lepisorus*, Polypodioides, *Pyrrosia*, *Vittaria*, etc. A large number of non-vascular epiphytes such as lichens and a variety of mosses also covered considerable pace on the bark of the trees in the area.

5.15 LOWER PLANT DIVERSITY (CRYPTOGAMS)

Cryptogamic flora of Arunachal Pradesh is very rich with a diverse species composition. However, studies on this component of the flora are largely lacking. As many as 54 species of algae belonging to 23 genera have been reported from the area (refer Table-5.32). The lichen flora of Arunachal Pradesh is also rich in species composition with nearly 331 species of lichens belonging to 72 genera and 41 families recorded from the state. Pteridophytes are important constituents of the floristics of Arunachal Pradesh. The Botanical Survey of India has recorded about 452 species of fern and fern allies from Arunachal Pradesh Himalaya.

Table-5.32: Some of the common pteridophytes of the Study Area (based on available literature)

S.No.	Species	Family	Habit	Altitude (m)
1.	*Equisetum diffusum*	Equisetaceae	herb	Up to 3000
2.	*Selaginella indica*	Selaginellaceae	herb	700-2800
3.	*Marsilea minuta*	Marsileaceae	herb	Up to 1200
4.	*Alsophila spinulosa*	Cyatheaceae	herb	Up 300-1500
7.	*Adiantum capillus-*	*veneris* Adiantaceae	herb	Up to 1600
8	*Vittaria flexuosa*	Vittariaceae Epiphytic	herb	300-4000
9.	*Pteris vittata*	Pteridaceae	herb	Up to 1500
10.	*Pyrrosia adnascens*	Polypodiaceae	epi. Fern	800-1200
11.	*P. nuda*	Polypodiaceae	epi. Fern	Up to1600
12.	*Colysis pedunculata*	Polypodiaceae	epi. Fern	Up to 1200

Source: CEIA Report, Lower Demwe Hydroelectric Project

5.16 LOWER PLANT DIVERSITY

Cryptogrammic flora (Pteridophytes) of Arunachal Pradesh is very rich with a diverse species composition. The Botanical Survey of India has recorded about 452 species of fern and fern allies from Arunachal Pradesh Himalaya. Based upon the data compiled from secondary information as well as primary surveys 37 species of Pteridophytes in Lohit basin have been recorded. A detailed list of the Pteridophytes reported in the study area is given inTable-5.33.

Table-5.33:List of Pterido phytes reported from Study Area

Family	Name of Species
Adiantaceae	*Adiantum capillus-veneris*
Adiantaceae	*Adiantum edgeworthii*
Adiantaceae	*Adiantum lunulatum*
Cyatheaceae	*Alsophila spinulosa*

Family	Name of Species
Vittariaceae	*Antrophyum plantagineum*
Polypodiaceae	*Arthromeris wallichiana*
Aspleniaceae	*Asplenium nidus*
Aspleniaceae	*Asplenium sp.*
Woodsiaceae	*Athyrium angustum*
Pteridaceae	*Cheilanthes tenuifolia*
Polypodiaceae	*Colysis latiloba*
Polipodiaceae	*Colysis pedunculata*
Cyatheaceae	*Cyathea spinulosa*
Thelypteridaceae	*Cyclosorus appendiculatus*
Dryopteridaceae	*Diplazium caudatum*
Dipteridaceae	*Dipteris wallichii*
Equisetaceae	*Equisetum diffuse*
Equisetaceae	*Equisetum diffusum*
Lycopodiaceae	*Huperzia squarrosa*
Polypodiaceae	*Lepisorus kashyapii*
Polipodiaceae	*Lepisorus nudus*
Lygodiaceae	*Lygodium flexuosum*
Adiantaceae	*Onychinum siliculosum*
Polypodiaceae	*Polypodioides microrhizoma*
Polipodiaceae	*Polypodioides wattii*
Dryopteridaceae	*Polystichum aleuticum*
Pteridaceae	*Pteris aspericaulis ssp. Subindivisa*
Pteridaceae	*Pteris nervosa*
Pteridaceae	*Pteris scabristipes*
Pteridaceae	*Pteris stenophylla*
Pteridaceae	*Pteris wallichiana*
Polypodiaceae	*Pyrrosia lanceolata*
Polypodiaceae	*Pyrrosia lingua*
Polipodiaceae	*Pyrrosia nuda*
Selaginellaceae	*Selaginella wallichii*
Vittariaceae	*Vittaria elongate*
Vittariaceae	*Vittaria merrillii*

5.17 RARE AND ENDANGERED SPECIES

Shifting cultivation, over exploitation of medicinal and other useful economic plants, various developmental activities are some of the major threats to the flora of Arunachal Pradesh. As a result of the impact of these biotic and abiotic factors, a number of species have become rare, vulnerable, threatened or endangered (Hajra *et* al., 1996). Some of the plant species of the state which fall under these categories include *Alniphyllum fortune, Ardisia rhynchophylla, Boehmeria tirapensis, Bulbophyllum depressum, B. virens Cymbidium hookerianum, Buddleja yunnanensis, Dioscorea laurifolia, Diplomeris hirsute, Eria discolor, Ilex venulosa, Leptodermis scabrida, Sapria himalayana, Saurauia griffithii* etc. However none of these species were recorded from the study area during field studies.

CHAPTER – 6
FAUNAL ASPECTS

CHAPTER – 6
FAUNAL ASPECTS

6.1 INTRODUCTION

The state of Arunachal Pradesh is widely covered with dense forest, it supports a vast and diverse group of fauna. The state is home to seven species of primates, Assamese macaque, pig-tailed macaque, hoolock gibbon, capped langur, rhesus macaque, slow loris and stump-tailed macaque. The state harbours a rich variety of wildlife which includes 4 major types of cats such as snow leopard, leopard, tiger and clouded leopard and three goat antelopes Serow, Goral and Takin. High altitude animals include Musk Deer, Bharal, Himalayan Black Bear, Red Panda and other animals like Elephants, Gaur, Wild Buffalo Civets, Rodents, Squirrels, Porcupine and Rats, Mongoose, Linsang, Shrew and Bat species are also commonly found. The state animal is Mithun (*Bos frontalis*) existing both in wild as well as in semi-domesticated form. This animal has religious significance and close relation with socio-cultural life of the people.

The state faunal wealth also comprises of around more than 500 birds species, including White-winged Duck, Sclater's Monal, Bengal Florican, Temminck tragopan, Rufous-necked Hornbill, Yellow-rumped Honeyguide, Spotted Wren Babbler, Broad-billed Flycatcher, Rufous-breasted Bush Robin, Long-billed Thrush and the Black-necked Crane, etc. The great Indian Hornbill is the state bird of Arunachal Pradesh. Apart from birds, there are numerous species of butterflies, moths, beetles in Arunachal Pradesh. Arunachal Pradesh is equally rich in reptiles and amphibians as well.

6.2 FAUNAL AFFINITIES

The fauna of eastern Himalaya is mainly governed by the species of southern China, Indo-China and Indo-Malaya regions and indigenous variety. Species, viz. *Elaphus maximus*, *Babalus bubalis*, *Bos gaurus*, hornbill species, Pittas species, Cobras etc. inhabit the monsoon forest below 1000 m, and have close affinity with that of the Indo-Malayan region. The northern part of Eastern Himalaya is close to palaearctic region in the faunal composition. It includes animal species - *Uncia uncia, Ursus arctos, Canis iupus* and many species of alpine ungulates. The faunal and other biotic resources are having influences of Kamlang Wildlife Sanctuary and Namdapha National Park on the Left bank of Lohit Valley and Mehao Wildlife Sanctuary and its influence from Dibang Valley towards right bank of Lohit Valley situated in the Mishmi hills.

Kamlang river originates from Glow lake situated in the Kamlang Wildlife Sanctuary. River Kamlang joins river Lohit downstream of Parsuram kund in the plains. On southern side, the sanctuary is bounded by the Lohit and Changlang district and in north the Anjaw district. Therefore, major fauna and wildlife present in the Lohit river basin is influenced by the wildlife sanctuaries located within or adjacent to the Study Area.

6.3 METHODOLOGY

As a part of the ground survey, each project area was divided in two zones, i.e. project site to upstream zone; and project influenced zone of downstream area till the confluence point of these streams/tributaries with Lohit river. The study was done as per line transect methodology. The methodology followed and lists of animals recorded during this study period are described in the following paragraphs.

Ground surveys was carried out by trekking the impact zone for identification of faunal species inhabiting the area along the riverbanks, adjoining forest on the slopes, nallahs, hill top and agricultural fields. Apart from direct sightings and primary data generated through transects and trails, secondary data from published literatures, Forest Department and other sources like siting of animals by the locals in the study area was also collected. The sighting of wild animals and other faunal groups were carried out during study period though being tough terrain and hill peaks remain covered in snow most of the period, the possible accounts are taxed in this section. The general methodology followed is described as below:

- For sampling butterflies the standard 'Pollard Walk' methodology was used by recording all the species that were encountered while trekking along the foot trails between these two sites, daily. Photographs of specimens of species were taken in the field for identification purpose. Sampling was done for 1 hour in a stretch on each transect (n=4).
- For sampling birds 'point sampling' along the fixed transects (foot trails) was carried out to record all the species of birds observed with the help of binoculars; field guides and photography for 1 hour on each transect(n=4).
- For sampling mammals, 'direct count on open width (20 m) transect' was used on the same transects (n=4) for 1 hour in each transect. Besides, information on recent sightings/records of mammals by the villagers and locals was also collected form these areas.
- 'Reptiles' mainly lizards were sampled by 'direct count on open width transects' (n = 4) for 1 hour in each transect.

The wild animals were identified by direct observation during field survey and signs of their pellets, scats, pugmarks and claw marks were also considered. A binocular (10X50X)was used for bird watching and the important features were noted. The identification ofavian fauna was made on the basis of available literature (Ali 1962, Gasten 1978 andGrimmett *et al* 2000). Interviews with the villagers and local people were also made togenerate information about wild animals and avian fauna. The secondary data andreported list of wild life were also consulted. On the basis of on-site observations as wellas secondary data, a check list of wild animals was prepared. The ecological status of the faunal species was categorized following IUCN criteria and Schedules of Indian Wildlife Protection Act (IWPA) 1972.

6.4 FAUNAL ASPECTS FOR STUDY AREA

6.4.1 Mammals

A total of 52 mammalian species were reported from the study area. The family Felidae had longest, representation followed by Bovidae and Sciuridae. Each of the families like Hotobatidae, Loridae, Mustelidae, Suidae, Moschidae, Hystricidae, Soricidae, Tupaiidae and Spalacidae were represented by a single species. Members of families like Ursidae, Canidae, Mustelidae and Felidae are carnivorus in nature. Most of these species are reported in Kamlang river and adjoining areas due to presence of Kamlang Wildlife Sanctuary as per the information retrieved from the locals and secondary data. These species are found in the forest area and towards snow covered hill peaks.However, few species of Ursidae and Canidae were also reported in vicinity to the agricultural fields at the fringes of forests, close to human habitations where they come in search of food.

Some of the common mammals found in the area are Himalayan brown bear (*Ursus arctos*), Himalayan black bear (*Selenarctos thibetanus*), Fox (*Vulpes montana*), and Goral (*Naemorhedus goral*) etc. which are generally observed at higher altitudes of Mishmi hills. Other wildlife observed in the area are Leopards, Jungle Cat, Common Langur, Takin etc. The list of mammal species reported in the Study Area and their conservation status is given in Table-6.1.

The description with respect to species / genera and orders is given in the subsequent paragraphs.

Primates

Order Primates is represented by 5 species belonging to 3 families. Hoolock Gibbon and Slow Loris inhabit tropical dense forests, upto an elevation of 800 m above mean sea level. Hoolock Gibbon is frequently reported from the surroundings of the human settlements on the fringe of influence zone near Kamlang Wildlife Sanctuary. Both the species have been included in the Schedule I as per Indian Wildlife Protection Act. Hoolock Gibbon is also categorized as 'Endangered' species (ZSI, 1994). Common langur, Assamese Macaque and Rhesus Macaque inhabit open forest and settlement areas. They are distributed up to an elevation of 2000 m above mean sea level. These species are not sighted in the study area of Dalai, Dav and Tidding rivers.

Carnivora

Carnivora is the largest order reported in the Lohit river basin and Mishmi hills. Most of the species of cat and dog families (Common Leopard, Clouded Leopard, Leopard Cat, Jungle Cat, Fishing Cat, Jackal, Wild Dog) are widely distributed upto an elevation of 1500 m above mean sea level. All civet species are found in the dense forest and are rarely sighted. Mongoose dwells in open areas; and is observed up to 800 m elevation. Common Leopard, Fishing Cat and Leopard Cat are the most hunted animals. Tribes use their skin and jaws for ornaments.

Himalayan Black Bear is reported to be found in forests upto an elevation of 1000 m above mean sea level. Locally, Common Leopard, Clouded Leopard, Leopard Cat, Fishing Cat and Black Bear have been included in 'threatened' category, in which Clouded Leopard is 'endangered' and remaining are 'vulnerable' (ZSI. 1994).

Proboscidae

Proboscidae is represented by Asian Elephant, which inhabits foothill stretch (up to 300m efevation) of Lohit river. It is restricted in areas near Kamlang river. A herd of 3-5 individuals is sighted commonly by the villagers in the forest near Wakro (more than 10 km from the project area. Asian Elephant is classified as Schedule I species under Indian Wildlife Protection Act, 1972.

Artiodactyla

8 species belonging to families Bovidae, Cervidae, Moschidae and Suidae were reported in the Study Area. Mithun, Goral, Barking Deer, Serow, Hog Deer and Wild Boar inhabit the project areas and its surrounding. Mithun a semi-domesticated cattle is commonly observed in the region. Wild buffalo is restricted in the lower reaches of Kamlang sanctuary while Goral, Barking Deer, Serow, Hog Deer and Wild Boar are distributed up to 1000 m elevation. Takin and Musk deer are found at higher altitudes of the Study Area; Takin inhabits the elevation range between 2100-3000 m whereas Musk Deer is found above 3000 m elevation range. ZSI (1994) criterion includes Musk Deer and Wild Boar under the 'endangered' category and Serow as Vulnerable'. Except Mithun all species have been scheduled. Only Takin is considered as endemic species of Eastern Himalaya. Most of these species except Mithun are not reported in the project area of hydroelectric projects proposed on Tiding, Dalai and Dav rivers.

Lagomorpha

Lagomorpha is represented by a single species i.e., Indian hare. It inhabits scrubs, forest and distributed in the stretch from foothills to 1200 m. It is a game animal, hunted by tribes for its skin. It is categorized under Schedule IV category, as per Indian Wildlife Protection Act, 1972.

Pholidota

Chinese Pangolin and Indian Pangolin have been reported from the lower reaches in the project area. Both species belong to family Manidae. They are distributed up to an elevation of 300 m above mean sea level. Indian Chinese Pangolin has been placed under Schedule I of Indian Wildlife Protection Act, 1972.

Rodentia

Rodentia is represented by rats, porcupine, squirrels and shrews in the Study Area. Rats are widely distributed and are very common around the project sites and Upstream areas. Indian

Porcupine is distributed up to 1000 m elevation and inhabits open areas. Squirrels (*Tamiops macclelland, Petaurista magnific, Petauhsta petaurist, Hylopetes alboniger* etc.) and Shrew (*Tupaia belangeri* and *Soriculus leucops*) inhabit dense forests. They are very common around the project sites. None of the rodent species is globally and locally threatened. Most, of them have been placed under Schedule V as per Indian /Wildlife Protection Act, 1972.

Chiroptera

All bat species are restricted to the lower reaches. They are nocturnal and invade citrus orchards in the region. They have been placed under the Schedule V as per Indian /Wildlife Protection Act, 1972.

The list of commomly observed mammal species in the Study Area alongwith their conservation status is given in Table-6.1.

Table-6.1: Mammalian speies reported from the study area and their conservation status

S. No.	Family / Common Name	*Scientific Name*	IUCN Status	WPA (1972)
	Hylobatidae			
1	Hoolock gibbon	*Bunopithecus hoolock*	EN	I
	Loridae			
2	Slow loris	*Nycticebus coucang*	EN	I
	Cercopithecidae			
3	Hanuman Langur	*Semnopithecus entellus*	LC	II
4	Rhesus Macaque-monkey	*Macaca mulatta*	LC	II
5	Assamese macaque	*Macaca assamensis*	LC	II
	Bovidae			
6	Mithun	*Bos frontalis*	LC	III
7	Ghoral	*Naemorhedus goral*	NT	III
8	Takin	*Budorcas taxicolor*		I
9	Mainland Serow	*Nemorhaedus sumatraensis*	VU	
	Family: Cervidae			
10	Hog deer	*Axis porcinus*	LC	III
11	Barking deer or kakar*	*Muntjac muntjac*	LC	III
	Family : Moschidae			
12	Himalayan musk deer	*Moschus chrysogaster*	EN	I
	Felidae			
13	Common leopard	*Panthera pardus*	EN	I
14	Clouded leopard	*Neofelis nebulosi*	EN	I
15	Leopard cat	*Prionailurus bengalensis*	EN	I
16	Fishing cat	*Prionailurus viverrinus*	LC	I
17	Jungle cat	*Felis chaus*	LC	II
18	Golden cat	*Catopuma temmincki*	LC	I
	Canidae			
19	Gidar / jackal	*Canis auresus*	LC	II
20	Bharia / Wolf*	*Canis lupus*	LC	I

S. No.	Family / Common Name	*Scientific Name*	IUCN Status	WPA (1972)
21	Indian fox	*Vulpus bengalensis*	LC	III
22	Wild dog*	*Cuon alpinus*	LC	II
	Ursidae			
23	Himalayan Black Bear	*Salenarctos thibetanous*	VU	II
24	Himalayan Brown Bear	*Ursus arctos*	VU	II
25	Bhalu* sloth bear	*Melursus ursinus*	VU	II
	Sciuridae			
26	Himalayan Stripped Squirrel	*Tamiops macclellandi*	LC	V
27	Hodgson's flying Squirrel	*Petaurista magnificus*	LC	V
28	Particolored Flying Squirrel	*Hylopetes alboniger*	LC	V
29	Red Giant flying squirrel	*Petaurista petaurista*	LC	V
30	Particolored flying squirrel	*Hylopetes alboniger*	LC	V
31	Orange bellied Him. squirrel	*Dremomys lokriah*	LC	V
32	Hoary bellied Him. squirrel	*Callosciurus pygerythrus*	LC	V
	Vespertilionidae			
33	Coromandel Pipistrelle or Indian Pipistrelle	*Pipistrellus coromandra*	LC	V
34	Indian Pygmy Bat	*Pipistrellus tenuis*	LC	V
35	Nepalese whiskered bat	*Myotis muricola*	LC	V
	Family: Viverridae			
36	Large Indian Civet	*Viverra zibetha*	-	
37	Common palm civet	*Paradoxurus Hermaphroditus*	-	
38	Small Indian Civet	*Viverricula indica*	-	
	Family Manidae			
39	Silu, Indian Pangolin	*Manis crassicaudata*	NT	I
40	Chinese pangolin	*Manis pentadactyla*	-	I
	Suidae			
41	Wild Bore	*Sus scrofa*	LC	III
	Muridae			
42	Large Bandicoot rat	*Bandicota indica*	LC	V
43	Indian house rat	*Rattus rattus-refescena*	LC	V
44	White bellied rat	*Niviventer niviventer*	LC	V
	Family: Tupalidae			
45	Northern tree shrew	*Tupaia belangeri*	LC	V
	Family: Soricidae			
46	Indian long tailed	*Soriculus leucops*	LC	V

S. No.	Family / Common Name	*Scientific Name*	IUCN Status	WPA (1972)
	shrew			
	Herpestidae			
47	Common Mongoose	*Herpestes edwardsii*	LC	IV
	Family: Spalacidae			
48	Bay bamboo rat	*Cannomys badius*	LC	V
	Leporidae			
49	Indian Hare	*Lepus nigricollis*	LC	IV
	Hystricidae			
50	Indian Porcupine*	*Hystrix indica*	LC	IV
	Family: Mustelidae			
51	Eurasian otter	*Lutra lutra*	--	IV
	Family: Elephantidae			
52	Asian elephant	*Elephas maximus*	VU	I

** Information from the locals, Secondary data from literature & of forest & wildlife division*
** EN-Endangered, LC-Least Concern ; nt – Near Threatened*

6.4.2 Avi-Fauna

The Study Area has a good representation of avian diversity harbouring about 126 species of birds as per the present survey. The commonly observed avi-fauna within the study area includes eagles, pheasants, hoopoe, barbets, woodpeckers, hornbills, pigeons, doves, tits, flycatchers, bulbuls, thrushes, laughing thrushes, shrikes, redstarts, drongo, crow, wagtails, forktails, minivets, sunbirds, swallow, tree pies, etc.

Order Pelecaniformes is represented by family Phalacrocoridae with a species - Large Cormorant. It inhabits open areas near river zones up to 1000 m elevation. Large Cormorant is widespread resident in the distribution It is abundant in the lower reaches of Lohit valley.

Order Gruiformes comprises of 2 species (White-breasted water hen and Moorhen), belong to family Rallidae. White-breasted water hen is very common in the foothills and Kamlang Wildlife Sanctuary. Both species are widespread resident and have been placed under the Schedule IV as per Indian Wildlife Protection Act, 1972.

Family Phasianidae represents the order Galliformes in the study area. It comprises of Mishmi Monal Pheasant, Red Jungle Fowl, Kaleej Pheasant and Grey Peacock Pheasant. Mishmi Monal Pheasant inhabits the elevation zone between 2000 – 3500 m in the Lohit valley, whereas Grey Peacock Pheasant descends up to 1000 m. Latter was sighted during the field survey near the Tidding area. Kaleej pheasant ascends up to 1000 m, while Red jungle fowl is restricted to the foothills. All species are hunted for their flesh and feathers. Mishmi monal and Grey peacock pheasant have been categorized as under Schedule I species as per Indian Wildlife Protection Act, 1972.

All species of this group belong to the family Accipitridae. They are distributed up to 2000 m. in the study area. Hawk eagle and Mountain Hawk eagle are widespread residents while Crested Serpent Eagle and Black Eagle are sparse resident in terms of their distribution habit. All species are placed under the Schedule I as per Indian Wildlife Protection Act, 1972.

Order Piciformes includes families Picidae and Megalaimidae, represented by Grey woodpecker and Great hill barbet, respectively. Both species are widespread resident. They inhabit dense forests and were very common around the project areas like proposed colony and power house areas.

Upupiformes is represented by Common Hoopoe (Upidae). It dwells near settlements and open areas. It is distributed up to 2000 m elevation in the Study Area. It was sighted near the Parasuram Kund in the study area. Common hoopoe is widespread resident and winter visitor.

Bucerotiformes comprises of Assam Wreathed Hornbill, Rufous necked Hornbill and Great Indian Pied Hornbill in the area. Former two species are 'vulnerable' while later is 'endangered'. They inhabit dense forests of the tropical eco-zone. All species have been categorized under the Schedule I of Indian Wildlife Protection Act (1972). Hornbills are the most vulnerable group in the Arunachal Pradesh including Lohit valley. They are hunted intensively for their beaks and feathers.

Columbiformes include members of the family Columbidae. Rock Pigeon, Spotted Dove, Oriental Turtle Dove and Emerald Dove dwell in open areas, agricultural fields and settlement areas. They are widespread resident and widely distributed. Except Emerald Dove all are common around the project and catchment areas. They are also hunted for their flesh. Other species of pigeons inhabit dense and open forests; they are sparse resident. All species of pigeons and doves are categorized under the Schedule IV as per Indian Wildlife Protection Act, 1972.

Cuculiformes group is comprised of Cuckoos, Koel and Coucals belonging to the families Cuculidae and Centropotidae. The Common Koel and Greater Coucal is widespread resident while remaining species are sparse resident. These are categorized as Schedule IV species as per Indian Wildlife Protection Act, 1972.

Passeriformes is the largest Order and accounts for major share of bird species. It comprises of 14 families. Muscicapidae is largest family, followed by the Carvidae. Most of the species are widely distributed. House Sparrow, Russet Sparrow, Jungle Crow, Indian Myna, White Wagtail, Blue Whistling Thrush, White-Capped Redstart, Plumbeous Redstart, Grey Hooded Warbler, Red-Vented Bulbul and Rufous Backed Shrike were most common species is observed of Passeriformes in the StuydAreas. Except crow, all species belong to Schedule IV of Indian Wildlife Protection Act (1972).

The list of avi-faunal species reported from the Study Area alongwith their Habitat and conservation status as per Indian Wildlife Protection Act (1972) is given in Table-6.2.

Table-6.2 List of avi-faunal recorded from the Study Area

S. No.	Family/Common Name	Scientific Name	Habit	IWPA status	GH EP	RH EP	T-I HEP	T-II HEP	KH EP
	Phalacrocoridae								
1	Large cormorant	*Phalacrocorax corbo sirensis*	R	IV	-	-	-	+	+
	Rallidae								
2	White-breasted water hen	*Amaurornis phoenicurus*	R	IV	-	-	-	-	+
3	Moorhen	*Gallinula chloropus*	R	IV	-	-	-	-	+
	Jacanidae								
4	Bronze winged jacana	*Metopidius indicus*	R	IV	-	-	-	-	+
	Phasianidae								
5	Mishmi monal pheasant	*Lophophorus sclateri*	R	I	-	-	-	-	+
6	Kaleej pheasant	*Lophura leucomelana*	R	-	-	-	-	-	+
7	Grey peacock pheasant	*Polyplectron bicalcaratum*	R	I	-	-	-	-	+
8	Redjungle fowl	*Gallus gallus*	R	-	-	-	-	-	+
	Accipitridae								
9	Changeable hawk Eagle	*Nisaetus cirrhatus*	R	I	-	-	-	+	+
10	Black eagle	*Ictinaetus malayensis*	R	I	-	-	-	+	+
11	Crested serpent eagle	*Spilornis cheela*	R	I	-	-	-	-	+
	Oriental Honey Buzzard	*Pernis ptilorhynchus*							
	Red-wattled Lapwing	*Vanellus indicus*							
	Picidae								
12	Grey-headed woodpecker	*Picus canus*	R	IV	+	+	+	+	+
13	Lesser Yellow nape	*P. chloronophus*			-	-	+	+	+
14	Bay woodpecker	*Blythipicus pyrrohtis*				-	-	-	+
	Megalaimidae	*Woodpecker*							
15	Great hill barbet	*Megalaima virens*	R	IV	+	+	+	+	+
16	Blue- throated barbet	*M.asiatica*			-	-	-	+	+
17	Fulvous Breasted	*Picoides macei*			-	-	-	+	+
	Upupidae								
18	Common hoopoe	*Upupa epops*	RW	IV	+	+	+	+	+
	Bucerotidae								
19	Assam Wreathed hornbill	*Rhyticeros undulates*	R	I	-	-	+	+	+
20	Great Indian pied hornbill	*Buceros bicornis*	R	I	-	-		+	+
21	Rufous necked hornbill	*Aceros nipalensis*	R	I	-	-	-	-	+
	Columbidae								
22	Rock pigeon	*Columba livia*	R	IV	+	+	+	+	+
23	Ashy wood pigeon	*C. pulchricollis*	R	IV	+	+	+	+	+
24	Speckled wood pigeon	*C. hodgsonii*	R	IV	-	-	-	-	+
25	Pintail green pigeon	*Treron apicauda*	R	IV	-	-	-	-	+
26	Green imperial pigeon	*Ducula aenea*	R	IV	-	-	-	-	+
27	Mountain imperial pigeon	*D. badia*			-	-	+	+	+
28	Spotted dove	*Streptopelia chinensis*	R	IV	-	-	+	+	+
29	Emerald dove	*Chalcophaps indica*	R	IV	-	-	+	+	+
30	Oriental Turtle Dove	*Streptopelia orientalis*						+	+
	Cuculidae								
31	Common hawk cuckoo	*Hierococcyx varius*	R	IV	+	+	+	+	+
32	Pied crested cuckoo	*Clamator jacobinus*	Rs	IV	-	-		+	+
33	Common koel	*Eudynamys scolopacea*	R	IV	-	-	-	+	+
34	Plaintive cuckoo	*Cacomantis merulimus*			-	-	-	-	+
	Centropodidae								

S. No.	Family/Common Name	Scientific Name	Habit	IWPA status	GH EP	RH EP	T-I HEP	T-II HEP	KH EP
35	Lesser coucal	*Centropus bengalensis*	R	IV	-	-	+	+	+
36	Greater coucal	*C. sinensis*	R	IV	-	-	+	+	+
	Aegithalidae								
37	Green backed tit	*Parus monticolus*	R	IV			+	+	+
38	Brown crested tit	*P. dichrous*	R	IV			+	+	+
39	Grey tit	*P. major*	R	IV	+	+	+	+	+
	Sittidae								
40	Wall creeper	*Tichodroma muraria*	rw	IV	-	-	-	-	+
41	Nectariniidae								+
42	Mrs. Gould’s sunbird	*Aethopyga gouldiae*	R	IV	-	-	+	+	+
43	Purple sunbird	*Nectarinia asiatica*	R	IV	-	-	+	+	+
	Sturniidae								
44	Common myna	*Acridotheres tristis*	R	IV	+	+	+	+	+
45	Hill myna	*Gracula religiosa*	R	IV	+	+	+	+	+
46	Jungle myna	*A.fuscus*			+	+	+	+	+
	Hirundinidae								
47	Wiretailed swallow	*Hirundo smithii*	R	IV					+
	Cicclidae								
48	Brown dipper	*Cinclus pallasii*	R	IV	-	-	-	+	+
	Pycnonotidae								
49	Red vented bulbul	*Pycnonotus cafer*	R	IV	-	-	-	+	+
50	Striated green bulbul	*P. striatus*	R	IV	+	+	+	+	+
51	Mountain bulbul	*Hypsipetes mcclellandii*	R	IV	+	+	+	+	+
52	Black bulbul	*H. leucocephalus*	R	IV	+	+	+	+	+
53	Red-whiskered bulbul	*Pycnonotus jocosus*	R	IV	-	-	+	+	+
54	White-throat bulbul	*Cringer flaveolus*			-	-	-	+	+
	Laniidae								
55	Rufous backed shrike	*Lanius schach*	R	IV					
56	Grey backed shrike	*L. tephronotus*	RW	IV	-	-	+	+	+
	Muscicapidae								
57	Blue whistling thrush	*Myophonus caeruleus*	R	IV				+	+
58	Grey winged black bird	*Turdus boulboul*	R	IV				+	+
59	Slaty backed forktail	*Enicurus schistaceus*	R	IV			+	+	
60	Little forktail	*E. scouleri*	R	IV			+	+	
61	White-capped Redstart	*Chaimarrornis leucocephalus*	R	IV	+	+	+	+	+
62	Plumbeous redstart	*Rhyacornis fuliginosus*	R	IV	+	+	+	+	+
63	Paradise flycatcher	*Terpsiphone paradise*	LC	IV	+	+	+	+	+
64	Bat winged flycatcher	*Hemipus picatus*	LC	IV	+	+	+	+	+
65	Rufous breasted bush robin	*Tarsiger hyperythrus*	LC	IV	+	+	+	-	-
66	Orange flanked bush robin	*Tarsiger cyanurus*	LC	IV	+	+	+	-	-
67	Stonechat	*Saxicola torquotta*	LC	IV	-	-	-	-	+
68	Daurian Redstart	*Phoenicurus frontalis*	LC	IV	+	+	+	+	-
69	Plumbeous Water Redstart	*Rhyacornis fuliginosus*	LC	IV	+	+	+	+	-
70	Riverchat /White cap Redstart	*Chaimorrornis leucocephalus*	LC	IV	+	+	+	+	+
71	Say-backed Forktail	*Enicurrus schistaceus*	LC	IV	+	+	+	+	+
72	Spotted Forktail	*Enicurrus maculatus*	LC	IV	+	+	-	-	-
73	Rufous-gorgeted flycatcher	*Ficedula strophiata*	LC	IV	+	+	-	-	-
74	Snowy-browed flycatcher	*F. hyperythra*	LC	IV	+	+	-	-	-
75	Grey headed flycatcher	*Culicicapa ceylonensis*	LC	IV	--	-	-	-	+

S. No.	Family/Common Name	Scientific Name	Habit	IWPA status	GH EP	RH EP	T-I HEP	T-II HEP	KH EP
	Coraciidae								
76	Indian roller	*Coracias benghalensis*	R	IV	-	-	-	+	+
	Carvidae								
77	Bronzed drongo	*Dicrurus aeneus*	R	IV	+	+	+	+	+
78	Black drongo	*Dicrurus macrocercus*	R	IV	-	-	-	-	+
79	Large billed crow	*Corvus macrorhynchos*	R	V	-	+	+	+	+
80	House crow	*Corvus splendens*	R	-	-	-	-	-	+
81	Himalayan treepie	*Dendrocitta formosae*	R	IV					
82	Maroon oriole	*Oriolus traillii*	R	IV	-	-	--	+	+
83	Black hooded oriole	*O. xanthornus*	R	IV	-	-	-	-	+
84	Common Green Magpie	*Cissa chinensis*			-	+	+	+	+
	Campephagidae								
85	Long tailed minivet	*Pericrocotus ethologus*					+	+	+
86	Scarlet minivet	*Pericrocotus flammeus*	R	IV	-	-	-	+	+
87	Rosy minivet	*Pericrocotus roseus*			-	-	-	-	+
	Sylviidae								
88	Striated laughing thrush	*Garrulax striatus*	R	IV	-	-	+	+	+
89	Grey hooded warbler	*Seicercus poliogenys*	R	IV	+	+	+	+	+
90	White-spectacled warbler	*Seicercus affinis*	R	IV	+	+	+	+	+
91	Ashy throated warbler	*Phylloscopus maculipennis*	rw	IV	+	+	+	+	+
92	Striated warbler	*Megalurus palustris*	R	IV	-	-	-	-	+
93	Large-billed leaf warbler	*Phylloscopus magnirostris*	rw	IV					
94	Brownish-flanked bushwarbler	*Cettia fortepis*	rw	IV	-	-	+	+	+
95	White-crested laughing Thrush	*Garrulax lleucolophus*			-	-	+	+	+
96	Greater Necklaced laughing Thrush	*Garrulax pectoralis*	R	IV	-	-	-	-	+
97	Blue Whisteling Thrush	*Garrulax sp*			+	+	+	+	+
	Passeridae								
98	Russet sparrow	*Passer rutilans*	R	IV	-	-	-	+	+
99	Tree sparrow	*P. montanus*	R	IV	-	-	-	+	+
100	White wagtail	*Motacilla alba*	W	IV	-	-	+	+	+
101	House sparrow	*Passer domesticus*			+	+	+	+	+
	Fringillidae								
102	Crested bunting	*Melophus lathami*	R	IV	-	-	-	-	+
	Ardeidae								
103	Indian Pond Heron	*Ardeola grayii*	R	V	-	-	-	-	+
104	Cattle Egret	*Bubulcus ibis*	R	V	-	-	-	-	+
	Accipitridae								
105	Long-billed vulture	*Gypus indicus*	R	V	-	-	+	+	+
	Phasianidae								
106	Common Hill Partridge	*Arborophila torqueola*	R	V	-	-	-	-	+
	Chestnut-breasted Partridge	*Arborophila mandellii*			+	+	+	+	-
	Strigidae								
107	Mountain Scops Owl	*Otus spilocephalus*	R	V	+	+	+	+	+
108	Tawny Owl / Brown Owl	*S.aluco / Strix aluco*	R	V	-	-	+	+	+
	Caprimulgidae								
109	Grey Nightjar	*Caprimulgus jakota*	R	V	+	+	+	+	+
	Apodidae								
110	Himalayan Swiftlet	*Aerodramus brevirostris*	R	V	+	+	+	+	+

S. No.	Family/Common Name	Scientific Name	Habit	IWPA status	GH EP	RH EP	T-I HEP	T-II HEP	KH EP
111	House swift	*Apus nipalensis*	R	V	-	-	-	+	+
	Halcyonidae								
112	Pied kingfisher	*Ceryle rudis*	R	V	-	-	+	+	+
113	Ruddy kingfisher	*Halcyon coromanda*	R	V	-	-	+	+	+
	Alaudidae								
114	Rufous winged bushlark	*Mirafra assamica*	LC	V	-	-	-	-	+
	Hirundinidae								
115	Nepal house Martin	*Delichon nepalensis*	LC	V	+	+	+	+	+
	Chloropseidae								
116	**Orange bellied leafbird**	*Chloropsis hardwickii*	LC	V	-	-	-	+	+
	Leiothrichidae								
117	Beautiful sibia	*Heterophasia pulchella*	LC	V	+	+	+	+	+
	Timaliidae	*Old world babblers*							
118	White bellied Yuhina	*Yuhina zantholeuca*	LC	V	-	-	-	-	+
119	Coral-bit scimitar babler	*Pomatorhinus ferruginosus*	LC	V	+	+	+	+	+
120	Golden babbler	*Stachyridopsis chrysaea*	LC	V	-	-	+	+	+
121	Grey headed parrot bill	*Paradoxomis gularis*	LC	V	-	-	-	+	+
	Turdidae								
122	Oriental Magpie robin	*Copsychus saularis*	LC	V	-	-	-	+	+
	Cisticolidae								
123	Grey breasted prinia	*Prinia hodgsonii*	LC	V				+	+
123	Rufescent prinia	*P. rufescens*	LC	V				+	+
	Cittidae								
124	Grey bellied Tesia	*Tesia cyanivnter*	LC	V			+	+	+
	Rhipiduridae								
125	White-throated Fantail	*Rhipidera albicollis*	LC	V	+	+	+	+	+
	Motacillidae								
126	White Wagtail	*Motacilla alba*	LC	V	+	+	+	+	+
R- Common Resident; LC-Least Concern ; P G-Project Gimliang, R-Raigam, T-Tidinng, K-Kamlang project areas									

6.4.3 Herpetofauna

A total of 34 species belonging to herpetofauna category have been reported from the Study Area. More than eight species of Amphibia, which comprises of toads and frogs are reported. *Rana* spp. and *Bufo meianostictus* are commonly observed in the Study Area. None of the frog and toad species in the Study Area is 'threatened' and endemic to Arunachal Pradesh.

Reptifian fauna comprised of 24 species belonging to 8 families. Sun Skink, Forest Skink, Khasi Lizard, House Lizard, Common Krait, Indian Monitor, Pit Viper, Rat Snake are most commonly observed within the Study Area. Python and Indian monitor Lizard have been categorized as 'endangered' species (ZSI, 1994). Former two species have also been placed under the Schedule I while Indian monitor lizard, Russell's Viper, Rat Snake. Cobra and King Cobra are categorized as Schedule-II species.

Most of these species are confined in the Kamlang Wildlife Sanctuary area as well as along Kamlang river and other water bodies located in the sanctuary area. However, few species of amphibains and lizard family were also observed in the vicinity of confluence of rivers Tiding and Lohit. The diversity of amphibians and reptiles are quite low in upstream area from Hayuliang onwards i.e. Dalai river and Dav river basin, being situated in the cold climate zone.

The list of herpetofauna species reported in the Study Area alongwith their Conservation Status is given in Table-6.3.

Table-6.3: List of Herpetofauna species recored from the Study Area

S.No.	Family/Common Name	Scientific Name	IUCN Status	Status as per IWPA 1972
	AMPHIBIA			
	Bufonidae			
1	Common toad	*Bufo melanostictus*	-	-
2	Himalayan toad	*Bufo himalayana*	-	-
	Pelobatidae			
3	Burmese Spadefoot toad	*Megophrys parva*	-	-
	Ranidae		-	-
4	Meghalaya stream frog	*Amolops afghanus*	-	-
5	Daniel's Oriental Stream frog	*Rana danieli*	-	-
6	Yembung Sucker Frog	*Rana gerbillus*	-	-
7	Taipei frog	*Rana taipehensis*	-	-
8	Silver-lined paddy frog	*Rana erythraea*	-	-
	Rhacophoridae			
9	Pied theloderma	*Philautus annandalii*	-	-
10	Twin-spotted Flying Frog	*Rhacophorus bipunctatus*	-	-
	REPTILES			
	Scincidae			
11	Sikkim sunskink	*Scinella sikimmensis*	-	-
12	Large Forest-skink	*Sphenomorphus indicum*	-	-
13	Writhing skinks	*Lygosoma sp*	-	-
	Gekkoniade			
14	Khasi lizard	*Cyrtodactylus khasiensis*	-	-
15	Brook's House Gecko	*Hemidactylus brookii*	-	-
16	House geckos	*H. frenatus*	-	-
	Laceridae			
17	Asian grass lizard	*Takydromus sexlineatus*	-	-
	Varanidae			
18	Indian monitor lizard	*Varanus bengalensis*	EN	II
	Elapidae			
19	Common krait	*Bungarus niger*	-	-
20	Banded krait	*B. fasciatus*	-	-
21	Cobra	*Naja kaouthia*	-	II
22	King cobra	*Ophiophagus hannah*	-	II
	Viperidae			
23	Bamboo pit viper	*Trimeresurus spp*	-	-
24	Russell’s viper	*Vipera russelli*	-	II
25	Brown-spotted pitviper	*Protobothrops mucrosquamatus*	-	-
26	Jerdon’s pitviper	*Protobothrops jerdoni*	-	-

S.No.	Family/Common Name	Scientific Name	IUCN Status	Status as per IWPA 1972
27	Mountain pitviper	*Ovophis monticola*	-	-
	Boidae			
28	Python	*Python molurus bivettatus*		EN
	Colubridae			
29	Green keelback	Macropisthodon plumbicolor	-	-
30	Common worm snake	*Typlina branmina*	-	-
31	Common wolf snake	*Lycodon aulicus*	-	-
32	Striped racer	*Elaphe taeniura*	-	-
33	Rat snake	*Ptyas mucosus*	-	II
34	Green rat snake	*Elaphe prasina*	-	-

Note: EN - endangered

6.4.4 Butterflies

Based on the data collected from primary as well as secondary sources, presence of 36 species which belonging to six families i.e. Pieridae (5), Nymphalidae (16), Lycaenidae (5), Papilionidae (9) and one species from family Hesperiidae has been reported from the Study Area.

The list of butterfly species reported in the study area is given in Table-6.4. Mostly, species occurring in the selected study locations are commonly observed. None of the species are recorded as Globally Endangered or Threatened as per IUCN status and Conservation Schedule of Indian Wildlife Protection Act, 1972.

Table-6.4: List of butterflies found in the study area w.r.t. to tributaries of lohit basin

S.No.	Common name	Scientific name	Family
1	Pale wanderer	*Pareronia avatar avatar*	Pieridae
2	Yellow orange tip	*Ixias pyrene familiaris*	Pieridae
3	Indian cabbage white	*Pieris canidia indica*	Pieridae
4	Common Grass Yellow	*Eurema hecabe hecabe*	Pieridae
5	Small Grass Yellow	*Eurema brigitta rubella*	Pieridae
6	Great Eggfly	*Hypolimnas bolina*	Nymphalidae
7	Yellow owl	*Neorina hilda*	Nymphalidae
8	Nigger	*Orsotrioena medus medus*	Nymphalidae
9	Himalayan fivering	*Ypthima sacra sacra*	Nymphalidae
10	Common fourring	*Y. hubenri hubenri*	Nymphalidae
11	Large yeoman	*Cirrochroa aoris aoris*	Nymphalidae
12	Indian fritillary	*Argyreus hyperbius hyperbius*	Nymphalidae
13	Veriegated Sailer	*Neptis antelope*	Nymphalidae
14	Small Yellow Sailor	*N. miah miah*	Nymphalidae
15	Orange staff sergeant	*Parathyma cama*	Nymphalidae
16	Blackvein sergeant	*P. ranga ranga*	Nymphalidae
17	Stripped blue crow	*Euploea mulciber*	Nymphalidae
18	Common Leopard	*Phalanta phalantha phalanth*	Nymphalidae
19	Dull Forester	*Lethe gulnihal*	Nymphalidae
20	Cruiiser	*Vindula erota erot*	Nymphalidae
21	Dark Archduke	*Lexias dirtea khasiana*	Nymphalidae
22	Longbanded silverline	*Spindasis lohita himalayanus*	Lycaenidae
23	Metallic cerulean	*Jamides alecto eurysaces*	Lycaenidae

S.No.	Common name	Scientific name	Family
24	Punchinello	*Zemeros flegyas indicus*	Lycaenidae
25	Eastern Grass Jewel	*Freyeria putli*	Lycaenidae
26	Golden Sapphire	*Heliophorus brahma majo*	Lycaenidae
27	Blue Peacock	*Priceps Arcturus*	Papilionidae
28	The red breasted	*P. aclmentor*	Papilionidae
29	Common mormon	*Papilio polytes Romulus*	Papilionidae
30	Common Peacoc	*Papilio polyctor Ganesa*	Papilionidae
31	Common Windmill	*B.polyeuctes polyeuctes*	Papilionidae
32	Tawny Mime	*Papilio agestor agestor*	Papilionidae
33	Paris Peacock	*Papilio paris paris*	Papilionidae
34	Common Jay	*Graphium doson axion*	Papilionidae
35	Common Bluebottle	*Graphium sarpedon sarpedon*	Papilionidae
36	Common Dart	*Potanthus zatilla*	Hesperiidae

CHAPTER-7
AQUATIC ECOLOGY

CHAPTER-7
AQUATIC ECOLOGY

7.1 GENERAL

Implementation of any developmental project requires sustainable management of the land and water resources. In order to ensure sustainable management of resources, an inventory of the existing resource base and its production and consumption pattern must be studied. As a part of the basin study detailed aquatic ecological sampling study was conducted. The sampling was conducted once every month for a period of six months from April 2009 to September 2009.

The objectives of the study were to:

- Assess biotic resources with special reference to zooplankton, phytoplankton, benthos, macrophytes, invertebrates and fishes.
- Estimate population densities and diversities of phytoplankton, zooplankton, benthos, macrophytes, invertebrates and fish.
- Estimate primary productivity of river at the study sites.
- Assess loss of habitat and conservation needs for fish species in the project area.
- Characterize river ecosystem for trophic status based on the existing status of riverine ecology.
- Document and identify migratory route of migratory fishes, spawning and breeding grounds of different fish species.

7.2 AQUATIC ECOLOGY FOR PROJECTS ON MAIN LOHIT RIVER

7.2.1 Sampling Sites

The study area lies within the state of Arunachal Pradesh and in each proposed project, following five sites were sampled, as listed below:

Kalai hydroelectric Project, Stage-1

- 5000 m upstream of dam site (S1)
- 3000 m upstream of dam site (S2)
- Dam site (S3)
- 3000 m downstream of dam site (S4)
- 5000 m downstream of dam site (S5)

Kalai hydroelectric Project, Stage-2

- 5000 m upstream of dam site (S6)
- 3000 m upstream of dam site (S7)
- Dam site (S8)
- 3000 m downstream of dam site (S9)
- 5000 m downstream of dam site (S10)

Hutong hydroelectric Project, Stage-1

- 5000 m upstream of dam site (S11)
- 3000 m upstream of dam site (S12)
- Dam site (S13)
- 3000 m downstream of dam site (S14)
- 5000 m downstream of dam site (S15)

Hutong hydroelectric Project, Stage-2

- 5000 m upstream of dam site (S16)
- 3000 m upstream of dam site (S17)
- Dam site (S18)
- 3000 m downstream of dam site (S19)
- 5000 m downstream of dam site (S20)

Anjaw Hydroelectric Project

Adequate sampling in entire basin was carried out wrt Terrestrial ecology, aquatic ecology and other aspects. The sites downstream of Hatong II like S19 and S20 are also giving base line information for Anjaw HEP.

Demwe Upper hydroelectric Project

- 5000 m upstream of dam site (S21)
- 3000 m upstream of dam site (S22)
- Dam site (S23)
- 3000 m downstream of dam site (S24)
- 5000 m downstream of dam site (S25)

Demwe Lower hydroelectric Project

- 5000 m upstream of dam site (S26)
- 3000 m upstream of dam site (S27)
- Dam site (S28)
- 3000 m downstream of dam site (S29)
- 5000 m downstream of dam site (S30)

The location of various sampling locations is shown in Figure-7.1.

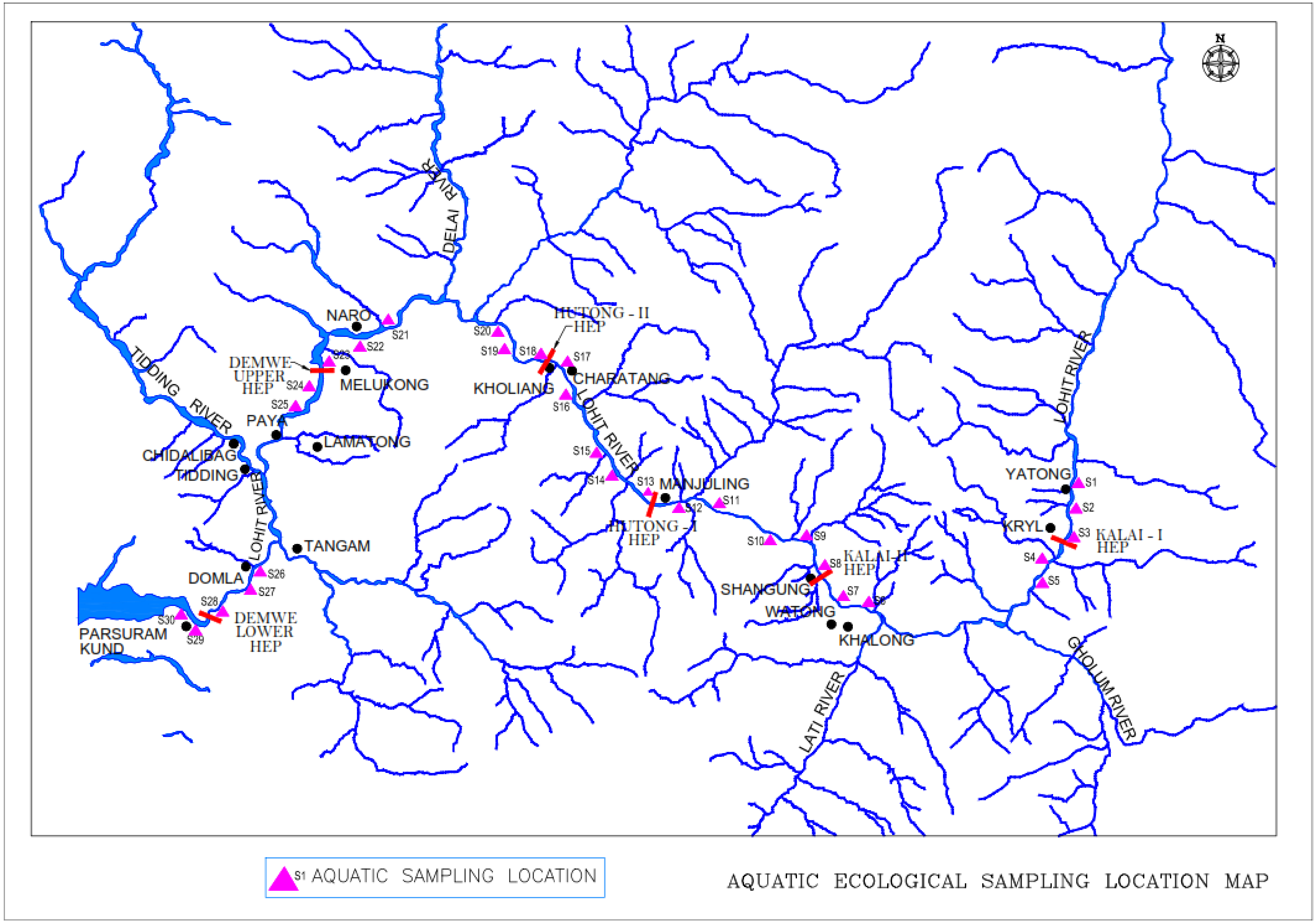


Figure-7.1: Aquatic Ecological Location Map

7.2.2 Phytoplanktons

Phytoplanktons are the autotrophic component of the plankton community and play an important role in the primary production process in the stream ecosystems. They serve as a base of the aquatic food web, providing essential ecological function for all aquatic life. In terms of numbers, the important groups of phytoplankton comprise of diatoms, dinoflagellates, cyanobacteria, and other groups of unicellular algae. The construction of hydroelectric stations in the mountain rivers/streams will have profound impact on the planktonic communities as the planktonic organisms pass through a regulated stream with cascades of reservoirs. The species composition of two conditions viz. lake conditions and river conditions will be different. Hence, prior to dam construction it is necessary to know the composition, density and diversity of phytoplankton. Density and diversity of phytoplankton in the river water was studied for a period of six months viz., April, May, June, July, August and September 2009 by collecting samples from various sampling locations.

Phytoplankton species, their population density at various sampling sites for different projects is given in **Annexure-VII**. The summary of phytoplankton density observed at various sampling stations during the sampling period is given in Table-7.1.

Table-7.1: Phytoplankton density at various sampling stations (No. of individuals/l)

Project	Month					
	April 2009	May 2009	June 2009	July 2009	August 2009	September 2009
Kalai HEP Stage 1	2-16	3-10	2-6	5-8	2-10	2-6
Kalai HEP Stage 2	5-28	2-3	2-15	5-17	3-9	4-9
Hutong HEP Stage 1	2-15	1-7	1-13	4-14	2-7	3-6
Hutong HEP Stage 2	2-17	2-6	1-15	5-18	2-5	4-11
Demwe Upper HEP	5-18	2-19	2-17	2-15	3-16	1-11
Demwe Lower HEP	2-11	1-16	1-4	5-12	4-12	3-5

- Phytoplankton density ranged from 2-16 at various sampling stations monitored for Kalai HEP stage 1.
- Phytoplankton density ranged from 2-28 at various sampling sites monitored for Kalai HEP Stage 2.
- Phytoplankton density ranged from 1-15 at various sampling sites monitored for Hutong HEP Stage 1.
- Phytoplankton density ranged from 1-18 at various sampling sites monitored for Hutong HEP Stage 2.
- Phytoplankton density ranged from 1-19 at various sampling sites monitored for Demwe Upper hydroelectric project.
- Phytoplankton density ranged from 1-16 at various stations monitored for Demwe Lower hydroelectric project.

The density of phytoplanktons was recorded higher in Kalai stage-2 as compared to other projects **(Annexure-VII).** Analysis of variance showed that total density of phytoplankton differed significantly between different projects but did not differ between different sites in each project. The phytoplankton species in the Lohit basin belonged to three classes i.e. Bacillariophyceae, Chlorophyceae and Cyanophyceae. Some of the dominant phytoplanktons found in the Lohit river basin were *Actinastrum*, *Chlorella*, *Microcystis*, *Cymbella* and *Neidium*.

The diversity of phytoplanktons at various sampling locations during the study period is given in Tables-7.2 to 7.7.

Table-7.2: Diversity of phytoplanktons at various sampling locations in April 2009

Diversity indices	**Kalai HEP,Stage-1**					**Kalai HEP,Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	3	6	3	2	2	6	3	3	3
No. of individuals	16	7	12	5	2	8	28	21	5	21
Shannon's diversity	0.69	0.80	1.47	0.95	0.69	0.38	1.54	0.67	0.95	0.83
Simpson's index	0.50	0.45	0.69	0.56	0.50	0.22	0.76	0.38	0.56	0.53
Equitability	1.00	0.72	0.82	0.87	1.00	0.54	0.86	0.61	0.87	0.76
	Hutong HEP,Stage-1					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	5	4	3	2	2	3	5	1	3
No. of individuals	4	15	15	13	2	5	16	17	2	3
Shannon's diversity	0.00	1.17	0.72	0.54	0.69	0.50	0.46	1.12	0.00	1.10
Simpson's index	0.00	0.59	0.35	0.27	0.50	0.32	0.23	0.55	0.00	0.67
Equitability	0.00	0.73	0.52	0.49	1.00	0.72	0.42	0.70	0.00	1.00
	Demwe Upper HEP					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	2	7	4	8	3	2	4	2	6
No. of individuals	5	5	12	14	18	3	2	4	2	11
Shannon's diversity	0.67	0.67	1.79	1.06	1.98	1.10	0.69	1.39	0.69	1.64
Simpson's index	0.48	0.48	0.81	0.58	0.85	0.67	0.50	0.75	0.50	0.78
Equitability	0.97	0.97	0.92	0.76	0.95	1.00	1.00	1.00	1.00	0.92

Table-7.3: Diversity of phytoplanktons at various sampling locations in May 2009

Diversity indices	**Kalai HEP,Stage-1**					**Kalai HEP,Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	4	2	3	3	2	3	2	2	2
No. of individuals	6	9	3	10	3	3	3	2	2	2
Shannon's diversity	0.45	1.00	0.64	0.64	1.10	0.64	1.10	0.69	0.69	0.69
Simpson's index	0.28	0.52	0.44	0.34	0.67	0.44	0.67	0.50	0.50	0.50
Equitability	0.65	0.72	0.92	0.58	1.00	0.92	1.00	1.00	1.00	1.00
	Hutong HEP,Stage-1					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	2	1	3	1	2	1	3	3	2	2
No. of individuals	7	2	3	1	2	2	5	4	6	2
Shannon's diversity	0.68	0.00	1.10	0.00	0.69	0.00	0.95	1.04	0.45	0.69
Simpson's index	0.49	0.00	0.67	0.00	0.50	0.00	0.56	0.63	0.28	0.50
Equitability	0.99	0.00	1.00	0.00	1.00	0.00	0.87	0.95	0.65	1.00

	Demwe Upper HEP					Demwe Lower HEP				
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Taxa	9	2	5	11	3	1	8	1	4	9
No. of individuals	14	2	8	19	4	1	16	1	4	15
Shannon's diversity	2	0.69	1.39	2.30	1.04	0.00	1.86	0.00	1.39	1.8
Simpson's index	0.88	0.50	0.69	0.89	0.63	0.00	0.81	0.00	0.75	0.87
Equitability	0.92	1.00	0.86	0.95	0.95	0.00	0.89	0.00	1.00	0.81

Table-7.4: Diversity of phytoplanktons at various sampling locations in June 2009

Diversity indices	**Kalai HEP,Stage-1**					**Kalai HEP,Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	2	5	1	2	2	4	3	1	3
No. of individuals	4	6	6	2	2	8	13	13	2	15
Shannon's diversity	0.69	0.45	1.26	0	0.69	0.37	1.19	0.53	0	0.62
Simpson's index	0.5	0.27	0.80	0	0.50	0.21	0.97	0.27	0	0.33
Equitability	1	0.65	0.78	0	1.00	0.5	0.86	0.48	0	0.57
Diversity indices	**Hutong HEP,Stage-1**					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	3	2	3	2	1	2	4	0	2
No. of individuals	1	12	13	13	2	1	12	15	0	2
Shannon's diversity	0.00	0.72	0.27	0.53	0.69	0	0.28	0.85	0.00	0.69
Simpson's index	0.00	0.40	0.14	0.43	0.50	0	0.15	0.43	0.00	0.50
Equitability	0.00	0.65	0.39	0.61	1.00	0	0.85	0.61	0.00	1.00
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	1	2	2	3	7	1	2	2	2	3
No. of individuals	2	4	3	4	17	1	2	4	2	4
Shannon's diversity	0	0.69	1.63	1.03	1.67	0	0.69	0.56	0.69	1.03
Simpson's index	0	0.5	0.44	0.62	0.76	0	0.50	0.37	0.50	0.62
Equitability	0	1	0.91	0.94	0.86	0	1.00	0.81	1.00	0.94

Table-7.5: Diversity of phytoplanktons at various sampling locations in July 2009

Diversity indices	**Kalai HEP,Stage-1**					**Kalai HEP,Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	1	2	6	2	1	1	4	2	3	2
No. of individuals/l	8	7	6	5	5	7	17	17	5	9
Shannon's diversity	0.00	0.68	1.79	0.67	0.00	0.00	1.05	0.22	0.95	0.35
Simpson's index	0.00	0.49	0.83	0.48	0.00	0.00	0.60	0.11	0.56	0.20
Equitability	0.00	0.99	1.00	0.97	0.00	0.00	0.76	0.32	0.87	0.50
Diversity indices	**Hutong HEP,Stage-1**					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	3	3	1	1	3	5	1	3	2
No. of individuals	4	11	14	11	6	9	18	11	7	5
Shannon's diversity	0.00	0.60	0.51	0.00	0.00	1.06	0.84	0.00	0.96	0.67
Simpson's index	0.00	0.31	0.26	0.00	0.00	0.64	0.38	0.00	0.57	0.48
Equitability	0.00	0.55	0.46	0.00	0.00	0.97	0.52	0.00	0.87	0.97
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
No. of Taxa	4	1	9	2	7	2	2	3	3	3
No. of individuals	8	2	13	5	15	6	5	11	10	12
Shannon's diversity	1.21	0.00	2.14	0.50	1.86	0.64	0.67	0.99	1.03	1.01

Simpson's index	0.66	0.00	0.88	0.32	0.65	0.44	0.48	0.60	0.62	0.61
Equitability	0.88	0.00	0.97	0.72	0.89	0.92	0.97	0.91	0.94	0.92

Table-7.6: Diversity of phytoplanktons at various sampling locations in August 2009

Diversity indices	**Kalai HEP,Stage-1**					**Kalai HEP,Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	1	3	1	2	2	1	2	1	2	2
No. of individuals	2	10	2	5	4	3	5	6	9	5
Shannon's diversity	0.00	1.09	0.00	0.67	0.69	0.00	0.67	0.00	0.35	0.67
Simpson's index	0.00	0.66	0.00	0.48	0.50	0.00	0.48	0.00	0.20	0.48
Equitability	0.00	0.99	0.00	0.97	1.00	0.00	0.97	0.00	0.50	0.97
Diversity indices	**Hutong HEP,Stage-1**					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	1	2	1	1	1	2	1	1	1
No. of individuals	4	2	7	3	2	2	4	2	5	2
Shannon's diversity	0.00	0.00	0.60	0.00	0.00	0.00	0.56	0.00	0.00	0.00
Simpson's index	0.00	0.00	0.41	0.00	0.00	0.00	0.38	0.00	0.00	0.00
Equitability	0.00	0.00	0.86	0.00	0.00	0.00	0.81	0.00	0.00	0.00
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	6	2	3	6	3	1	5	1	3	5
No. of individuals	16	6	3	14	4	5	9	6	4	12
Shannon's diversity	1.75	0.45	1.10	1.63	1.04	0.00	1.47	0.00	1.04	1.42
Simpson's index	0.82	0.28	0.67	0.78	0.63	0.00	0.74	0.00	0.63	0.72
Equitability	0.98	0.65	1.00	0.91	0.95	0.00	0.91	0.00	0.95	0.88

Table-7.7: Diversity of phytoplanktons at various sampling locations in September 2009

Diversity indices	**Kalai HEP,Stage-1**					**Kalai HEP,Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	2	1	1	2	2	2	2	3	3
No. of individuals	4	6	2	2	5	6	4	4	9	7
Shannon's diversity	0.56	0.45	0.00	0.00	0.67	0.64	0.69	0.56	0.94	0.96
Simpson's index	0.38	0.28	0.00	0.00	0.48	0.44	0.50	0.38	0.57	0.57
Equitability	0.81	0.65	0.00	0.00	0.97	0.92	1.00	0.81	0.85	0.87
Diversity indices	**Hutong HEP,Stage-1**					**Hutong HEP,Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	1	2	2	2	1	3	2	2	1
No. of individuals	5	6	4	6	3	6	11	7	8	4
Shannon's diversity	0.00	0.00	0.56	0.45	0.64	0.00	0.99	0.41	0.66	0.00
Simpson's index	0.00	0.00	0.38	0.28	0.44	0.00	0.60	0.24	0.47	0.00
Equitability	0.00	0.00	0.81	0.65	0.92	0.00	0.91	0.59	0.95	0.00
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	3	3	1	2	1	2	2	2	2
No. of individuals	11	8	6	1	3	4	4	3	5	3
Shannon's diversity	0.69	0.90	1.01	0.00	0.64	0.00	0.56	0.64	0.50	0.64
Simpson's index	0.50	0.53	0.61	0.00	0.44	0.00	0.38	0.44	0.32	0.44
Equitability	0.99	0.82	0.92	0.00	0.92	0.00	0.81	0.92	0.72	0.92

- Number of individuals was observed to be higher at sampling locations in the vicinity of Kalai stage-2 hydroelectric project, as compared to the other projects.

7.2.3 Zooplanktons

Zooplanktons are the heterotrophic component of the plankton community, and is a broad categorization spanning a range of organism sizes that includes both small protozoans and large metazoans. Through their consumption and processing of phytoplankton (and other food sources), zooplankton play an important role in aquatic food webs, both as a resource for consumers on higher trophic levels (including fish), and as a conduit for packaging the organic material in the biological pump. Since they are typically of small size, zooplanktons can respond relatively rapidly to increases in phytoplankton abundance, for instance, during the spring bloom. The construction of hydroelectric stations in the mountain rivers/streams will have profound impact on the planktonic communities as the planktonic organisms pass through a regulated stream with cascades of reservoirs. The species composition of two conditions viz. lake conditions and river conditions will be different. Hence, prior to dam construction it is necessary to know the composition, density and diversity of zooplankton. Density and diversity of zooplanktons in the river water was studied for a period of six months viz., April, May, June, July, August and September 2009 by collecting the samples from five sites of each project i.e. 5000 m upstream of dam site, 3000 m upstream of dam site, Dam site, 3000 m downstream of dam site, 5000 m downstream of dam site.

Zooplankton species, their population density and diversity in the different project sites are summarized in **Annexure VIII**. The density and diversity of zooplankton species was highest at all the sites in April and it showed decreasing trend in the months of May, June, July, August and September. This decreasing trend could be due to changes in physico-chemical properties of water across temporal scale. Analysis of variance showed that the total density of zooplankton differed significantly between different projects ($p<0.05$) but did not differ significantly between different sites in each project. Zooplankton community in Lohit river basin was dominated by members of Rotifera and Cladocera. The dominant genera were *Difflugia*, *Colurella*, *Testudinella*, *Philodina*, *Keratella*, and *Polyarthra*, although their dominance varied across sites and seasons in the Lohit river basin.

The summary of zooplankton density observed at various sampling locations during the study period is given in Table-7.8.

Table-7.8: Zooplankton Density at various sampling stations (No. of individuals/lit)

Project	**Month**					
	April 2009	**May 2009**	**June 2009**	**July 2009**	**August 2009**	**September 2009**
Kalai HEP Stage 1	15-26	9-20	5-14	7-10	7-9	2-4
Kalai HEP Stage 2	3-22	3-22	3-11	3-12	2-11	1-8
Hutong HEP Stage 1	2-12	5-10	2-10	5-7	5-8	1-8
Hutong HEP Stage 2	1-25	9-16	6-15	1-13	5-12	4-9
Demwe Upper HEP	2-21	2-21	7-11	1-15	2-16	2-7
Demwe Lower HEP	2-25	4-22	4-16	4-21	4-12	4-8

- Zooplankton density (No of individual/lit) ranged from 2-26 at various stations monitored for Kalai hydroelectric project stage 1.
- Zooplankton density (No of individual/lit) ranged from 1-22 at various stations monitored for Kalai hydroelectric project stage 2.
- Zooplankton density (No of individual/lit) ranged from 1-12 at various stations monitored for Hutong hydroelectric project stage 1.
- Zooplankton density (No of individual/lit) ranged from 1-25 at various stations monitored for Hutong hydroelectric project stage 2.
- Zooplankton density (No of individual/lit) ranged from 1-21 at various stations monitored for Demwe Upper hydroelectric project.
- Zooplankton density (No of individual/lit) ranged from 2-25 at various stations monitored for Demwe Lower hydroelectric project.

The zooplankton density was observed to be higher in the month of April and May 2009 as compared to results for other months.

The diversity of zooplanktons at various sampling locations during the study period is given in Tables-7.9 to 7.14.

Table-7.9: Diversity of zooplanktons in the month of April 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	6	5	6	8	7	3	2	1	7	7
No. of individuals	22	24	26	26	15	7	3	3	22	21
Shannon's diversity	1.45	1.51	1.73	1.78	1.68	0.96	0.64	0.00	1.68	1.59
Simpson's index	0.72	0.76	0.81	0.79	0.76	0.57	0.44	0.00	0.78	0.73
Equitability	0.81	0.94	0.96	0.85	0.86	0.87	0.92	0.00	0.87	0.82
Diversity indices	**Hutong HEP, stage-1**					**Hutong HEP stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	3	1	1	3	10	1	6	2	4
No. of individuals	3	12	5	2	11	19	1	25	2	10
Shannon's diversity	0.00	0.96	0.00	0.00	0.93	2.10	0.00	1.37	0.69	1.17
Simpson's index	0.00	0.57	0.00	0.00	0.58	0.85	0.00	0.68	0.50	0.64
Equitability	0.00	0.87	0.00	0.00	0.85	0.91	0.00	0.76	1.00	0.84
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	3	2	5	2	5	6	4	1	4	5
No. of individuals	4	7	10	2	21	25	14	2	6	10
Shannon's diversity	1.04	0.60	1.42	0.69	1.56	1.37	1.24	0.00	1.33	1.36
Simpson's index	0.63	0.41	0.72	0.50	0.78	0.68	0.68	0.00	0.72	0.68
Equitability	0.95	0.86	0.88	1.00	0.97	0.76	0.89	0.00	0.96	0.84

Table-7.10: Diversity of zooplanktons in the month of May 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	4	4	4	5	5	3	2	1	6	6
No. of individuals	9	17	20	12	13	7	3	3	22	12
Shannon's diversity	1.22	1.28	1.35	1.31	1.38	0.96	0.64	0.00	1.55	1.58
Simpson's index	0.67	0.70	0.74	0.67	0.70	0.57	0.44	0.00	0.75	0.75
Equitability	0.88	0.93	0.98	0.82	0.86	0.87	0.92	0.00	0.86	0.88
Diversity indices	**Hutong HEP, stage-1**					**Hutong -2, stage-1**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	2	2	1	2	2	7	3	4	2	3
No. of individuals	9	10	5	5	6	16	9	13	11	9
Shannon's diversity	0.69	0.61	0.00	0.67	0.45	1.69	0.94	1.16	0.69	0.94
Simpson's index	0.49	0.42	0.00	0.48	0.28	0.77	0.57	0.63	0.50	0.57
Equitability	0.99	0.88	0.00	0.97	0.65	0.87	0.85	0.83	0.99	0.85
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	3	1	4	2	5	4	3	4	3	3
No. of individuals/l	4	2	9	2	21	22	8	10	4	8
Shannon's diversity	1.04	0.00	1.22	0.69	1.56	1.28	0.97	0.94	1.04	0.90
Simpson's index	0.63	0.00	0.67	0.50	0.78	0.70	0.59	0.48	0.63	0.53
Equitability	0.95	0.00	0.88	1.00	0.97	0.92	0.89	0.68	0.95	0.82

Table-7.11: Diversity of zooplanktons in the month of June 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	2	2	2	2	2	2	3	4	4
No. of individuals/l	14	7	9	9	5	3	8	9	11	10
Shannon's diversity	0.26	0.60	0.64	0.64	0.67	0.64	0.66	1.00	1.37	1.22
Simpson's index	0.13	0.41	0.44	0.44	0.48	0.44	0.47	0.59	0.74	0.66
Equitability	0.37	0.86	0.92	0.92	0.97	0.92	0.95	0.91	0.99	0.88
Diversity indices	**Hutong HEP, stage-1**					**Hutong -2, stage-1**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	3	4	3	1	2	2	3	3	3	3
No. of individuals/l	9	8	10	2	6	8	9	15	6	10
Shannon's diversity	0.85	1.21	0.80	0.00	0.45	0.66	0.85	0.99	1.01	0.94
Simpson's index	0.49	0.66	0.46	0.00	0.28	0.47	0.49	0.60	0.61	0.58
Equitability	0.77	0.88	0.73	0.00	0.65	0.95	0.77	0.90	0.92	0.86
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	3	4	4	3	3	2	3	2	3
No. of individuals	7	7	11	10	11	16	9	15	4	10
Shannon's diversity	0.60	0.80	1.30	1.22	1.04	0.97	0.69	0.99	0.69	0.90
Simpson's index	0.41	0.45	0.71	0.66	0.63	0.59	0.49	0.60	0.50	0.54
Equitability	0.86	0.72	0.93	0.88	0.94	0.89	0.99	0.90	1.00	0.82

Table-7.12: Diversity of zooplanktons in the month of July 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	4	4	4	4	5	3	2	1	6	6
No. of individuals	7	8	9	10	10	7	3	3	12	12
Shannon's diversity	1.35	1.21	1.31	1.28	1.51	0.96	0.64	0.00	1.63	1.58

Diversity indices	Kalai HEP, Stage-1					Kalai HEP, stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Simpson's index	0.73	0.66	0.72	0.70	0.76	0.57	0.44	0.00	0.78	0.75
Equitability	0.98	0.88	0.95	0.92	0.94	0.87	0.92	0.00	0.91	0.88
Diversity indices	Hutong HEP, stage-1					Hutong HEP, stage-2				
	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Taxa	2	1	1	2	2	4	2	4	1	2
No. of individuals	6	7	5	5	6	10	4	13	1	2
Shannon's diversity	0.64	0.00	0.00	0.67	0.45	1.17	0.56	1.20	0.00	0.69
Simpson's index	0.44	0.00	0.00	0.48	0.28	0.64	0.38	0.64	0.00	0.50
Equitability	0.92	0.00	0.00	0.97	0.65	0.84	0.81	0.86	0.00	1.00
Diversity indices	Demwe Upper HEP					Demwe Lower HEP				
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Taxa	2	1	4	1	4	4	3	4	3	3
No. of individuals	3	2	9	1	15	21	8	10	4	8
Shannon's diversity	0.64	0.00	1.22	0.00	1.34	1.29	0.97	0.94	1.04	0.90
Simpson's index	0.44	0.00	0.67	0.00	0.73	0.71	0.59	0.48	0.63	0.53
Equitability	0.92	0.00	0.88	0.00	0.97	0.93	0.89	0.68	0.95	0.82

Table-7.13: Diversity of zooplanktons in the month of August 2009

Diversity indices	Kalai HEP, Stage-1					Kalai HEP, stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Taxa	4	4	4	5	4	3	1	1	5	5
No. of individuals	7	9	7	9	8	7	2	3	11	11
Shannon's diversity	1.15	1.37	1.28	1.47	1.32	0.96	0.00	0.00	1.55	1.41
Simpson's index	0.61	0.74	0.69	0.74	0.72	0.57	0.00	0.00	0.78	0.71
Equitability	0.83	0.99	0.92	0.91	0.95	0.87	0.00	0.00	0.96	0.88
Diversity indices	Hutong HEP, stage-1					Hutong HEP, stage-2				
	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Taxa	2	3	1	3	1	5	2	2	1	2
No. of individuals	8	6	5	7	5	12	6	10	5	8
Shannon's diversity	0.66	1.01	0.00	0.96	0.00	1.47	0.45	0.61	0.00	0.66
Simpson's index	0.47	0.61	0.00	0.57	0.00	0.75	0.28	0.42	0.00	0.47
Equitability	0.95	0.92	0.00	0.87	0.00	0.92	0.65	0.88	0.00	0.95
Diversity indices	Demwe Upper HEP					Demwe Lower HEP				
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Taxa	2	2	3	2	5	4	3	4	3	3
No. of individuals	3	6	8	2	16	12	8	10	4	8
Shannon's diversity	0.64	0.64	0.97	0.69	1.54	1.31	0.97	0.94	1.04	0.90
Simpson's index	0.44	0.44	0.59	0.50	0.77	0.71	0.59	0.48	0.63	0.53
Equitability	0.92	0.92	0.89	1.00	0.96	0.94	0.89	0.68	0.95	0.82

Table-7.14: Diversity of zooplanktons in the month of September 2009

Diversity indices	Kalai HEP, Stage-1					Kalai HEP, stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Taxa	2	1	2	2	1	1	1	2	2	3
No. of individuals	3	2	3	4	3	1	3	7	5	8
Shannon's diversity	0.64	0.00	0.64	0.56	0.00	0.00	0.00	0.60	0.67	0.90
Simpson's index	0.44	0.00	0.44	0.38	0.00	0.00	0.00	0.41	0.48	0.53
Equitability	0.92	0.00	0.92	0.81	0.00	0.00	0.00	0.86	0.97	0.82

Diversity indices	Hutong HEP, stage-1					Hutong HEP stage-2				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	1	2	2	2	1	2	2	2	2	2
No. of individuals	1	5	8	3	2	8	7	9	4	6
Shannon's diversity	0.00	0.50	0.38	0.64	0.00	0.66	0.41	0.53	0.56	0.45
Simpson's index	0.00	0.32	0.22	0.44	0.00	0.47	0.24	0.35	0.38	0.28
Equitability	0.00	0.72	0.54	0.92	0.00	0.95	0.59	0.76	0.81	0.65
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	3	2	2	2	2	1	1	1	3	2
No. of individuals	6	2	5	6	7	8	5	7	7	4
Shannon's diversity	1.01	0.69	0.50	0.45	0.60	0.00	0.00	0.00	0.96	0.56
Simpson's index	0.61	0.50	0.32	0.28	0.41	0.00	0.00	0.00	0.57	0.38
Equitability	0.92	1.00	0.72	0.65	0.86	0.00	0.00	0.00	0.87	0.81

Highest number of taxa (8) were observed at sampling stations located 3 km downstream of Kalai hydroelectric project stage 1. Highest number of individuals (26) were observed at Kalai hydroelectric project stage 1.

7.2.4 Periphytons

Periphyton is a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems. It serves as an important food source for invertebrates, tadpoles, and some fish. It can also absorb contaminants; removing them from the water column and limiting their movement through the environment. The periphyton is also an important indicator of water quality; responses of this community to pollutants can be measured at a variety of scales representing physiological to community-level changes. Construction of concrete structures on flowing waters alter the flow and temperature regimes, hydraulics, the availability and stability of substrata, channel morphology, the riparian vegetation, and as a result, the community structure of aquatic communities. The change in flow regimes may have impact on the periphytic community in the stream ecosystem. Hence, prior to construction of such large hydroelectric projects, a preliminary assessment of the composition, density and diversity of periphytic algal community is needed. The periphytic algal components were sampled in the project sites for 6 months viz. April, May, June, July, August and September 2009. During July-September, periphyton density could not be determined, as due to high volume of water and turbidity periphyton population was not found in the river. Samples of periphytic algae were collected by scraping 1 cm^2 area of the substratum on which they were growing. The scraped algae were then put in a small container and brought to the laboratory for identification. Density of the periphytic algae was expressed in terms of cm^2.

The Periphyton density observed at various sampling sites in different project sites are summarized in **Annexure IX**. Periphyton communities were prominent in the months of April, May and June in the shallow, rocky and gravelly bottoms in all the project sites of Lohit river basin. However, their population became inconspicuous in the months of July, August and September due to increase in water level in the river. The common periphyton genera found in the project sites were *Nitzchia*, *Hormidium*, *Spirogyra*, *Chlorella*, *Gloeocapsa* and *Cymbella*. Overall, 9 taxa of periphytic algae were recorded from all the sites in the Lohit river basin. Analysis of variance showed that the total density of periphytic algae did not differ significantly between different projects as well as between different sites in each project.

The summary of periphyton density observed at various sampling sites is given in Table-7.15.

Table-7.15: Density (No. of individuals/cm^2) of periphyton at various sampling sites

Project	**Month**		
	April 2009	**May 2009**	**June 2009**
Kalai HEP Stage 1	70-100	40-100	30-90
Kalai HEP Stage 2	30-110	40-80	30-60
Hutong HEP Stage 1	80-110	70-110	40-90
Hutong HEP Stage 2	70-120	50-120	30-80
Demwe Upper HEP	50-150	70-120	30-70
Demwe Lower HEP	30-160	60-140	30-90

- Density of periphytons ranged from 30-100 /cm^2 at various sampling sites monitored for Kalai hydroelectric project stage 1
- Density of periphytons ranged from 30-110 /cm^2 at various sampling sites monitored for Kalai hydroelectric project stage 2
- Density of periphytons ranged from 40-110 /cm^2 at various sampling sites monitored for Hutong hydroelectric project stage 1
- Density of periphytons ranged from 30-120 /cm^2 at various sampling sites monitored for Hutong hydroelectric project stage 2
- Density of periphytons ranged from 30-150 /cm^2 at various sampling sites monitored for Demwe Upper hydroelectric project
- Density of periphytons ranged from 30-160 /cm^2 at various sampling sites monitored for Demwe Lower hydroelectric project

The diversity of periphytons at various sampling locations during the study period is given in Tables-7.16 to 7.18.

Table-7.16: Diversity of periphytons in the month of April 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
No. of Taxa	2	2	2	3	4	3	2	1	4	4
No. of individuals	70	90	90	80	100	70	30	30	110	90
Shannon's diversity	0.60	0.53	0.64	0.74	1.16	0.96	0.64	0.00	1.12	1.15

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Simpson's index	0.41	0.35	0.44	0.41	0.64	0.57	0.44	0.00	0.61	0.62
Equitability	0.86	0.76	0.92	0.67	0.84	0.87	0.92	0.00	0.81	0.83
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
No. of Taxa	5	4	3	5	4	5	5	3	3	5
No. of individuals	110	110	90	80	100	110	100	110	120	70
Shannon's diversity	1.41	1.03	1.00	1.49	1.22	1.46	1.51	0.32	0.92	1.41
Simpson's index	0.71	0.55	0.59	0.75	0.66	0..97	0.76	0.15	0.57	0.74
Equitability	0.88	0.75	0.91	0.93	0.88	0.91	0.94	0.30	0.84	0.92
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
No. of Taxa	5	3	5	4	4	3	3	4	2	3
No. of individuals	120	130	150	50	150	160	80	100	30	80
Shannon's diversity	1.52	1.07	1.49	1.33	1.34	1.09	0.97	0.94	0.64	0.90
Simpson's index	0.76	0.65	0.76	0.72	0.73	0.66	0.59	0.48	0.44	0.53
Equitability	0.94	0.98	0.93	0.96	0.97	0.99	0.89	0.68	0.92	0.82

Table-7.17: Diversity of periphytons in the month of May 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	4	3	3	3	3	3	3	4	4	3
No. of individuals	90	40	60	100	100	60	40	80	70	60
Shannon's diversity	1.15	1.04	1.01	0.95	1.03	1.01	1.04	1.32	1.28	1.01
Simpson's index	0.62	0.63	0.61	0.56	0.62	0.61	0.63	0.72	0.69	0.61
Equitability	0.83	0.95	0.92	0.87	0.94	0.92	0.95	0.95	0.92	0.92
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Taxa	3	3	2	3	3	2	3	3	4	3
No. of individuals	110	80	80	80	70	50	120	110	90	90
Shannon's diversity	0.92	0.90	0.66	0.90	1.00	0.67	0.92	0.86	1.15	0.85
Simpson's index	0.56	0.53	0.47	0.53	0.61	0.48	0.57	0.51	0.62	0.49
Equitability	0.83	0.82	0.95	0.82	0.91	0.97	0.84	0.78	0.83	0.77
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	3	4	4	4	4	4	4	4	4	4
No. of individuals	90	70	80	100	120	140	70	100	60	100
Shannon's diversity	0.94	1.35	1.21	1.22	1.24	1.10	1.15	0.94	1.24	1.22
Simpson's index	0.57	0.73	0.66	0.66	0.68	0.62	0.61	0.48	0.67	0.66
Equitability	0.85	0.98	0.88	0.88	0.89	0.79	0.83	0.68	0.90	0.88

Table-7.18: Diversity of periphytons in the month of June 2009

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	2	1	2	2	1	2	2	1	2
No. of individuals	70	80	30	90	60	30	30	60	30	50
Shannon's diversity	0.60	0.56	0.00	0.64	0.69	0.00	0.64	0.64	0.00	0.67
Simpson's index	0.41	0.38	0.00	0.44	0.50	0.00	0.44	0.44	0.00	0.48
Equitability	0.86	0.81	0.00	0.92	1.00	0.00	0.92	0.92	0.00	0.97
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**

Diversity indices	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Taxa	2	3	1	2	3	3	3	1	3	1
No. of individuals	80	40	50	90	40	80	60	70	70	30
Shannon's diversity	0.66	1.04	0.00	0.64	1.04	1.08	1.01	0.00	0.96	0.00
Simpson's index	0.47	0.63	0.00	0.44	0.63	0.66	0.61	0.00	0.57	0.00
Equitability	0.95	0.95	0.00	0.92	0.95	0.99	0.92	0.00	0.87	0.00
Diversity indices	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Taxa	2	1	1	1	2	3	1	3	3	2
No. of individuals	50	50	40	30	70	40	30	50	90	50
Shannon's diversity	0.67	0.00	0.00	0.00	0.60	1.04	0.00	1.06	0.93	0.67
Simpson's index	0.48	0.00	0.00	0.00	0.41	0.63	0.00	0.64	0.56	0.48
Equitability	0.97	0.00	0.00	0.00	0.86	0.95	0.00	0.96	0.85	0.97

7.2.5 Benthic Invertebrates

Benthic invertebrates are organisms that live on the bottom of a water body (or in the sediment) and have no backbone. Their size spans 6-7 orders of magnitude and they range from microscopic (*e.g.* microinvertebrates, <10 microns) to a few tens of centimetres or more in length (*e.g.* macroinvertebrates, >50 cm). Benthic invertebrates live either on the surface of bed forms (*e.g.* rock, coral or sediment - epibenthos) or within sedimentary deposits (infauna), and comprise several types of feeding groups *e.g*. deposit-feeders, filter-feeders, grazers and predators. The abundance, diversity, biomass and species composition of benthic invertebrates can be used as indicators of changing environmental conditions. Construction of dams may impact the benthic invertebrates by alteration of the physical characteristics of the river which includes sub-stratum, current velocity, food availability, water temperature, dissolved oxygen level and water chemistry. Prior to commissioning of power projects on a river, an enumeration of the benthic invertebrates in the proposed sites is necessary. Therefore, in the present study, an enumeration of benthic invertebrates was done in order to know their composition, density and diversity in different reaches of the river.

The population density of various invertebrate species is summarized in **Annexure-X.** Lohit river basin showed a high diversity of benthic invertebrates with overall 30 of invertebrates belonging to 8 orders recorded from all the project sites. Members of Ephemeroptera, Trichoptera, Plecoptera and Diptera dominated the invertebrate group in the project sites. Other orders included Coleoptera, Hemiptera, Megaloptera and Odonata. The families of macroinvertebrates included *Baetidae, Chironomidae, Cordulegastridae, Corixidae, Corydalidae, Dytiscidae, Ecdyonuridae, Elmidae, Ephemerellidae, Glossosomatidae, Gomphidae, Gyrinidae, Heptageniidae, Hydropsychidae, Leptoceridae, Leptophlebiidae, Mesovelidae, Molannidae, Nemouridae, Peltoperlidae, Perlidae, Perlodideae, Philopotamidae, Polycentropidae, Psychomyiidae, Rhagionidae, Simulidae, Tabanidae,* *Taeniopterygidae* and *Tipulidae* and their abundance varied across different months as well as at different sites. Analysis of variance showed that the total density of invertebrates differ significantly between the projects ($p<0.05$) but did not significantly differ between different sites in each project. The diversity and abundance of macroinvertebrates was higher in the months of April and May, while it decreased in the rainy months of July, August and September. The density and abundance of macroinvertebrates in the later months decreased due to increased water flow regime which washed off the macroinvertebrates and their habitats.

The summary of density of benthic invertebrates at various sampling sites is given in Table-7.19.

Table-7.19: Density of Benthic invertebrates at various sampling sites (No. of individuals/cm^2)

Project	**Month**					
	April 2009	**May 2009**	**June 2009**	**July 2009**	**August 2009**	**September 2009**
Kalai HEP Stage 1	15-28	12-30	5-12	7-12	2-8	2-5
Kalai HEP Stage 2	13-20	12-26	6-16	8-12	2-6	2-5
Hutong HEP Stage 1	7-13	7-11	4-17	3-9	4-6	4-11
Hutong HEP Stage 2	8-22	4-8	3-11	7-12	3-7	3-11
Demwe Upper HEP	6-17	5-8	3-5	8-11	5-10	1-7
Demwe Lower HEP	8-24	3-9	1-7	5-13	2-7	1-9

- The density of benthic invertebrates ranged from 2-30 at various sampling sites of Kalai hydroelectric project stage 1.
- The density of benthic invertebrates ranged from 2-26 at various sampling sites of Kalai hydroelectric project stage 2.
- The density of benthic invertebrates ranged from 3-17 at various sampling sites of Hutong hydroelectric project stage 1.
- The density of benthic invertebrates ranged from 3-22 at various sampling sites of Hutong hydroelectric project stage 2.
- The density of benthic invertebrates ranged from 1-17 at various sampling sites of Demwe Upper hydroelectric project.
- The density of benthic invertebrates ranged from 1-24 at various sampling sites of Demwe Lower hydroelectric project.

In general, the density of benthic invertebrates was higher in the months of April and May as compared to the other months.

The diversity of benthic invertebrates at various sampling locations during the study period is given in Tables-7.20 to 7.25.

Table-7.20: Diversity of benthic invertebrates in the month of April 2009

Diversity indices	Kalai HEP, Satge-1					Kalai HEP, Stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Number of Taxa	6	5	6	8	7	8	7	7	8	7
No. of individuals	28	24	26	27	15	20	16	17	19	13
Shannon's diversity	1.36	1.51	1.73	1.75	1.68	1.88	1.84	1.82	1.89	1.73
Simpson's index	0.69	0.76	0.81	0.78	0.76	0.82	0.83	0.82	0.82	0.78
Equitability	0.76	0.94	0.96	0.84	0.86	0.90	0.95	0.94	0.91	0.89
Diversity indices	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Number of Taxa	5	5	3	4	4	10	4	6	5	5
No. of individuals	9	13	7	8	12	22	10	15	8	11
Shannon's diversity	1.52	1.30	0.80	1.32	1.14	1.97	1.19	1.62	1.49	1.37
Simpson's index	0.77	0.65	0.45	0.72	0.64	0.81	0.66	0.77	0.75	0.69
Equitability	0.95	0.81	0.72	0.95	0.83	0.86	0.86	0.90	0.93	0.85
Diversity indices	Upper Demwe					Lower Demwe				
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Number of Taxa	4	3	6	5	5	7	4	6	5	5
No. of individuals	6	9	11	7	17	24	14	12	8	10
Shannon's diversity	1.33	1.00	1.59	1.55	1.54	1.87	1.24	1.35	1.56	1.36
Simpson's index	0.72	0.59	0.76	0.78	0.78	0.84	0.68	0.63	0.78	0.68
Equitability	0.96	0.91	0.89	0.96	0.96	0.96	0.89	0.75	0.97	0.84

Table-7.21: Diversity of benthic invertebrates in the month of May 2009

Diversity indices	Kalai HEP, Satge-1					Kalai HEP, Stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Number of Taxa	6	3	3	4	3	6	4	3	6	3
No. of individuals	30	14	20	12	24	22	15	14	26	12
Shannon's diversity	1.56	0.83	0.83	1.08	0.65	1.61	1.24	1.06	1.56	0.72
Simpson's index	0.58	0.87	0.87	0.58	0.35	0.77	0.68	0.64	0.76	0.40
Equitability	0.87	0.76	0.76	0.78	0.59	0.90	0.89	0.97	0.87	0.66
Diversity indices	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Number of Taxa	3	3	4	3	5	3	2	5	5	5
No. of individuals	11	8	9	10	7	5	4	8	7	8
Shannon's diversity	0.93	1.04	1.31	0.90	1.55	1.05	0.56	1.39	1.55	1.49
Simpson's index	0.58	0.63	0.72	0.54	0.78	0.64	0.38	0.69	0.78	0.75
Equitability	0.85	0.95	0.95	0.82	0.96	0.96	0.81	0.86	0.96	0.93
Diversity indices	Upper Demwe					Lower Demwe				
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Number of Taxa	4	3	5	3	3	4	4	4	2	3
No. of individuals	8	5	8	6	7	7	9	8	3	5

Shannon's diversity	1.12	1.05	1.49	0.87	1.08	1.28	1.15	1.26	0.64	0.95
Simpson's index	0.66	0.64	0.75	0.50	0.65	0.69	0.62	0.69	0.44	0.56
Equitability	0.88	0.96	0.93	0.79	0.98	0.92	0.83	0.91	0.92	0.86

Table-7.22: Diversity of benthic invertebrates in the month of June 2009

Diversity indices	**Kalai HEP, Satge-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Number of Taxa	5	4	5	4	5	4	2	4	4	4
No. of individuals	12	8	10	5	9	12	7	16	8	6
Shannon's diversity	1.23	1.21	1.56	1.33	1.52	0.98	1.00	1.16	1.07	1.24
Simpson's index	0.61	0.66	0.78	0.72	0.77	0.51	0.41	0.62	0.56	0.67
Equitability	0.77	0.88	0.97	0.96	0.95	0.71	0.86	0.83	0.77	0.90
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Number of Taxa	3	4	5	4	3	5	2	4	2	5
No. of individuals	4	9	17	5	7	7	3	11	5	8
Shannon's diversity	1.04	1.21	1.52	1.33	1.00	1.55	0.64	1.24	0.67	1.49
Simpson's index	0.63	0.67	0.76	0.72	0.61	0.78	0.44	0.68	0.48	0.75
Equitability	0.95	0.88	0.94	0.96	0.91	0.96	0.92	0.89	0.97	0.93
Diversity indices	**Upper Demwe**					**Lower Demwe**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Number of Taxa	3	3	4	3	2	3	4	1	1	2
No. of individuals	5	4	5	3	4	7	6	5	1	2
Shannon's diversity	0.95	1.04	1.33	1.10	0.56	0.96	1.24	0.00	0.00	0.69
Simpson's index	0.56	0.63	0.72	0.67	0.38	0.57	0.67	0.00	0.00	0.50
Equitability	0.68	0.95	0.98	1.00	0.81	0.87	0.90	0.00	0.00	1.00

Table-7.23:Diversity of benthic invertebrates in the month of July 2009

Diversity indices	**Kalai HEP, Satge-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Number of Taxa	4	5	5	5	5	4	4	6	6	8
No. of individuals	8	9	12	11	7	12	11	8	10	10
Shannon's diversity	1.07	1.52	1.47	1.29	1.48	1.31	1.37	1.73	1.61	1.03
Simpson's index	0.56	0.77	0.75	0.64	0.73	0.71	0.74	0.81	0.76	0.86
Equitability	0.77	0.95	0.92	0.80	0.92	0.94	0.99	0.97	0.90	0.97
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Number of Taxa	4	5	3	3	4	6	4	6	6	4
No. of individuals	6	8	5	3	9	7	12	12	8	10
Shannon's diversity	1.24	1.49	0.95	1.10	1.15	1.75	1.31	1.54	1.67	1.17

Simpson's index	0.67	0.75	0.56	0.67	0.62	0.82	0.71	0.74	0.78	0.64
Equitability	0.90	0.93	0.86	1.00	0.83	0.98	0.94	0.86	0.93	0.84
Diversity indices	**Upper Demwe**					**Lower Demwe**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Number of Taxa	4	3	3	5	2	6	5	3	4	3
No. of individuals	11	9	11	9	8	13	10	9	7	5
Shannon's diversity	1.16	1.00	0.99	1.52	0.56	1.63	1.23	0.68	1.28	1.05
Simpson's index	0.64	0.53	0.60	0.77	0.38	0.78	0.60	0.37	0.69	0.64
Equitability	0.84	0.91	0.91	0.95	0.81	0.91	0.76	0.62	0.92	0.96

Table-7.24: Diversity of benthic invertebrates in the month of August 2009

Diversity indices	**Kalai HEP, Satge-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Number of Taxa	2	2	3	4	1	2	2	3	4	3
No. of individuals	6	3	6	8	2	6	2	5	5	6
Shannon's diversity	0.64	0.64	1.10	1.26	0.00	0.64	0.69	0.95	1.33	1.01
Simpson's index	0.44	0.44	0.61	0.69	0.00	0.46	0.50	0.56	0.72	0.61
Equitability	0.92	0.92	0.92	0.91	0.00	0.92	1.00	0.86	0.96	0.92
Diversity indices	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Number of Taxa	2	4	4	1	1	5	2	2	2	3
No. of individuals	4	4	6	6	4	7	3	5	7	3
Shannon's diversity	0.56	1.39	1.33	0.00	0.00	1.48	0.64	0.67	0.68	1.10
Simpson's index	0.38	0.75	0.72	0.00	0.00	0.73	0.44	0.48	0.49	0.67
Equitability	0.81	1.00	0.96	0.00	0.00	0.92	0.92	0.97	0.99	1.00
Diversity indices	**Upper Demwe**					**Lower Demwe**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Number of Taxa	4	4	5	5	3	2	2	2	3	3
No. of individuals	7	10	6	5	5	4	2	4	7	4
Shannon's diversity	1.28	1.28	1.56	1.61	0.95	0.69	0.69	0.69	0.96	1.04
Simpson's index	0.69	0.70	0.78	0.80	0.56	0.50	0.50	0.50	0.57	0.63
Equitability	0.92	0.92	0.97	1.00	0.86	1.00	1.00	1.00	0.87	0.95

Table-7.25: Diversity of benthic invertebrates in the month of September 2009

Diversity indices	**Kalai HEP, Satge-1**					**Kalai HEP, Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Number of Taxa	1	2	3	3	1	2	4	2	4	2
No. of individuals	3	3	5	3	2	2	4	5	5	4
Shannon's diversity	0.00	0.64	1.05	1.10	0.00	0.69	1.39	0.67	1.33	0.69
Simpson's index	0.00	0.44	0.64	0.67	0.00	0.50	0.25	0.48	0.72	0.50
Equitability	0.00	0.92	0.96	1.00	0.00	1.00	1.00	0.97	0.96	1.00

Diversity indices	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Number of Taxa	5	4	3	3	4	3	1	2	3	2
No. of individuals	5	6	11	4	8	8	4	11	7	3
Shannon's diversity	1.61	1.33	1.00	1.04	1.21	1.08	0.00	0.47	1.00	0.64
Simpson's index	0.80	0.72	0.60	0.65	0.66	0.66	0.00	0.30	0.61	0.44
Equitability	1.00	0.96	0.91	0.95	0.88	0.99	0.00	0.68	0.91	0.92
Diversity indices	Upper Demwe					Lower Demwe				
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Number of Taxa	1	2	5	5	4	4	2	5	1	3
No. of individuals	1	4	6	7	7	9	6	8	1	9
Shannon's diversity	0.00	0.69	1.56	1.55	1.28	1.15	0.64	1.49	0.00	1.00
Simpson's index	0.00	0.50	0.78	0.78	0.69	0.62	0.44	0.75	0.00	0.59
Equitability	0.00	1.00	0.97	0.96	0.92	0.83	0.92	0.93	0.00	0.91

7.2.6 Primary Productivity

Phytoplanktons are autotrophic, prokaryotic or eukaryotic algae that live near the water surface where there is sufficient light to support photosynthesis. Among the more important groups are the diatoms, cyanobacteria, dinoflagellates and coccolithophores. Phytoplankton accounts for half of all photosynthetic activity on Earth and contribute significantly to primary production process in aquatic ecosystems. Phytoplankton primary productivity is defined as the rate of organic matter production by the growth of planktonic plants.

The details of primary productivity for the months of April, May, June, July, August and September 2009 at different project sites are summarized in **Annexure XI**. Gross primary production (GPP) and net primary production (NPP) show an increase in the months of April May and June, and then decreases in the months of July, August and September at all the sites. The summary of primary productivity observed at various sampling sites is given in Table-7.26.

Table-7.26: Primary productivity at various sampling sites

Project		Month					
		April 2009	May 2009	June 2009	July 2009	August 2009	September 2009
Kalai HEP Stage 1	Gross Primary	18.7-37.5	31.2-93.7	46.9-93.8	17.5-18.1	17.8-19.7	17.5-19.7
	Net Primary	12.5-37.5	15.6-46.8	15.6-46.9	11.5-13.5	11.2-14.8	11.5-14.8
Kalai HEP Stage 2	Gross Primary	28.1-37.5	46.8-78.1	46.9-93.7	17.5-18.1	16.8-18.5	17.5-18.8
	Net Primary	25.0-37.5	31.2-62.5	15.6-48.9	12.0-25.0	11.2-12.8	11.5-12.5
Hutong HEP Stage 1	Gross Primary	18.7-28.1	46.8-62.5	31.2-62.5	18.1-18.7	16.5-16.8	16.7-18.1
	Net Primary	12.5-25.0	15.6-31.2	15.5-54.7	12.0-12.5	10.2-12.4	11.5-12.5
Hutong HEP Stage 2	Gross Primary	28.1-37.5	31.2-78.1	46.9-78.1	17.5-18.1	17.1-18.1	16.5-18.7
	Net Primary	12.5-37.5	15.6-46.8	15.6-54.7	11.5-13.5	10.8-13.2	11.2-12.8
Demwe Upper HEP	Gross Primary	18.8-56.3	31.2-62.5	46.9-62.5	16.3-18.8	16.2-17.2	16.3-18.8
	Net Primary	12.5-50.0	15.6-31.2	15.6-31.3	12.0-14.0	11.2-12.6	11.0-13.6
Demwe Lower HEP	Gross Primary	18.7-37.5	46.8-78.1	46.9-93.7	17.5-18.7	16.5-17.1	17.1-18.5
	Net Primary	12.5-25.0	15.6-31.3	15.6-62.5	12.5-25.0	11.2-12.6	10.8-12.5

7.2.7 Trophic Status in Lohit Basin

Trophic status is a useful means of classifying water bodies and describing aquatic processes in terms of the productivity of the system. The trophic status of a water body can be determined by estimating the quantities of nitrogen and phosphorous concentration. The estimation of these two nutrients in an aquatic body is necessary as they tend to be the limiting resources and an increase in these nutrients increases the algal productivity. Algal biomass and productivity is yet another indicator of the trophic status of a water body in which lower values correspond to oligotrophic state. Vollenweider (1974) used GPP as a criteria for classifying water bodies on trophic nature as, oligotrophic (0.065 - 0.3 g $Cm^{-2}d^{-1}$), mesotrophic (0.25 – 1.0 g $Cm^{-2}d^{-1}$) and eutrophic (1.0 – 8.0 g $Cm^{-2}d^{-1}$).

In the present study, the water bodies in different project sites had low concentrations of nitrate and total phosphorous (<0.015 mg l^{-1}). Overall, phytoplankton population is also low and the community is mainly dominated by Bacillariophyceae (diatoms), although some sites had dominance of Chlorophyceae and Cyanophyceae. Periphytic algal communities can be seen in some shallow areas of the project sites, but their diversity and density is low and their distribution is restricted to some pockets only. Overall, zooplankton population is dominated by Rotiferans and Cladocerans which mostly feed on fish waste, dead bacteria, algae and small particles of food suspended in water generated from falling leaf litter from the riparian forest areas. The benthic invertebrate communities are dominated by Ephemeroptera and Plecoptera which are abundant in undisturbed habitats mainly feeding on detritus. They can be classified as grazers, scrapers and filter feeders. Some invertebrates are carnivorous feeding on larvae of other species. The GPP values for all the project sites lies within the range of 0.065 - 0.3 g $Cm^{-2}d^{-1}$ as suggested by Vollenweider (1974). Hence, based on all the above the trophic status of the project areas may be classified as oligotrophic.

7.3 AQUATIC ECOLOGY-PROJECT ON TRIBUTARIES OF LOHIT RIVER

The details of sampling sites pertaining to Aquatic Ecology are given in Table-7.27 and depicted in Figure-7.2.

Table-7.27: Details of study sites selected w.r.t. to various HEP projects on the river Lohit

Sampling sites	Location	Description of Study Area (Habitat Structure & River Morphology)	Coordinates
Gimiliang	**HEP - Dav river**		
Site I	Gimiliang / Dav village : Suspension bridge	Narrow Valley with Mixed dense forest. Dav river with high gradiend and rocky substratum and rapis and cascade predominates with >4% gradient slope (**Plate**)	28°07.067'N & 096°35.938'E ; 739 ± 4m
Site II	D/s zone- Dav river bridge & confluence zone with Lohit	U/s confluence narrow gorge and near confluence wide spread valley. Rapids, Riffle and pools dominant (Slope between 2-4%)	28°04.258'N & 096°33.129'E ; 554 ± 3m

Sampling sites	Location	Description of Study Area (Habitat Structure & River Morphology)	Coordinates
Raigam HEP - Dalai River			
Site III	Area Adjoining Teapani, Gamin, Raigam /Roilongbasti	High gradient Dalai river with rapids habitat and banks stable & rocky, with thick riparian cover of dense mixed forest in narrow valley (High / gradient slope river course >4%)	28°10.299'N & 096°31.312'E ; 760+3m
Site IV	D/s area-Dalai Bridge / Dalai basti near Hayuliang	At Dalai bridge river flow through wide valley and low gradient slope. Habitat like run, pools predominates and near Lohit confluence zone large growth of Sacharam and other grasses (2-4% slope)	28°05.314'N & 096°31.837'E ; 544+3m
Tidding – II HEP : Tiding River			
Site V	U/s Tiding basti	Tiding flows through Tiding thrust and stable river morphlogy with 'v' shape valley & stable habitat structure as rapids and cascade pools. Some places following bed rock with boulder cobble deposits and lesser amount of sand. Gradient range between 2-4%.	405±5m; 27°58.384'N & 096°23.758'E
Site VI	D/s zone of Tiding bridge near confluence of Lohit	Tiding flows through open & wide valley near Tiding basti where Sacharam and other greass predominate in the flood prone areas near confluence zone of Tiding & Lohit river. River gradient is comapratively low (2-4%) with riffle dominat followed by rapids and substratum with gravels, cobbles and pebbles dominat with sand.	27°58.380'N &096°23.752' E ; 390±3m
Tidding – I HEP : Tiding River			-
Site VII	Dam site area u/s of Chidalibagbasti	'V' shape with valley with mixed dense forest stable river banks covering of riparian vegetation cover along hill slopes. Rapids and cascade followed by fewever riffle and pools and rocky substratum and high bed slope. High gradient river (>4%)	27°59.387'N & 096°23.762'E ; 465±4m
Site VIII	D/s Influence area	V shale valley with mixed dense forest cover and stable morphology with high river bed slopes. Rapid formation frequently observed with 2-4% gradient.	27°59.387'N &096°23.762' E ; 420±4m
Kamlang HEP : Kamlang River			
Site IX	U/s Kamlang bridge- KWS	Kamlang flows throughh V shape valley, and has stable geomorphology and dense miex forest. River gradient varies from 2-4 % with heterogenous habitat structure –cascade, rapids, riffles and pools with bedrock substratum deposits of large bouders impregnated in sand along banks atlandsurface slopes covered by riparian vegetation above the bankful land surface area.	27°45.352'N &096°21.503' E ; 396±5m
Site X	D/s area and confluence with Lohit	Kamlang d/s zone enters in wide open valley and further enters in Plains near cnfluence with Lohit river and has thick forest cover with mixed flora. River gradient falls below 2% with gravels, cobbles & sands deposits – alluvial morphology,with riffle pool habitat structures.	27°45.350'N &096°21.501' E ; 385±3m

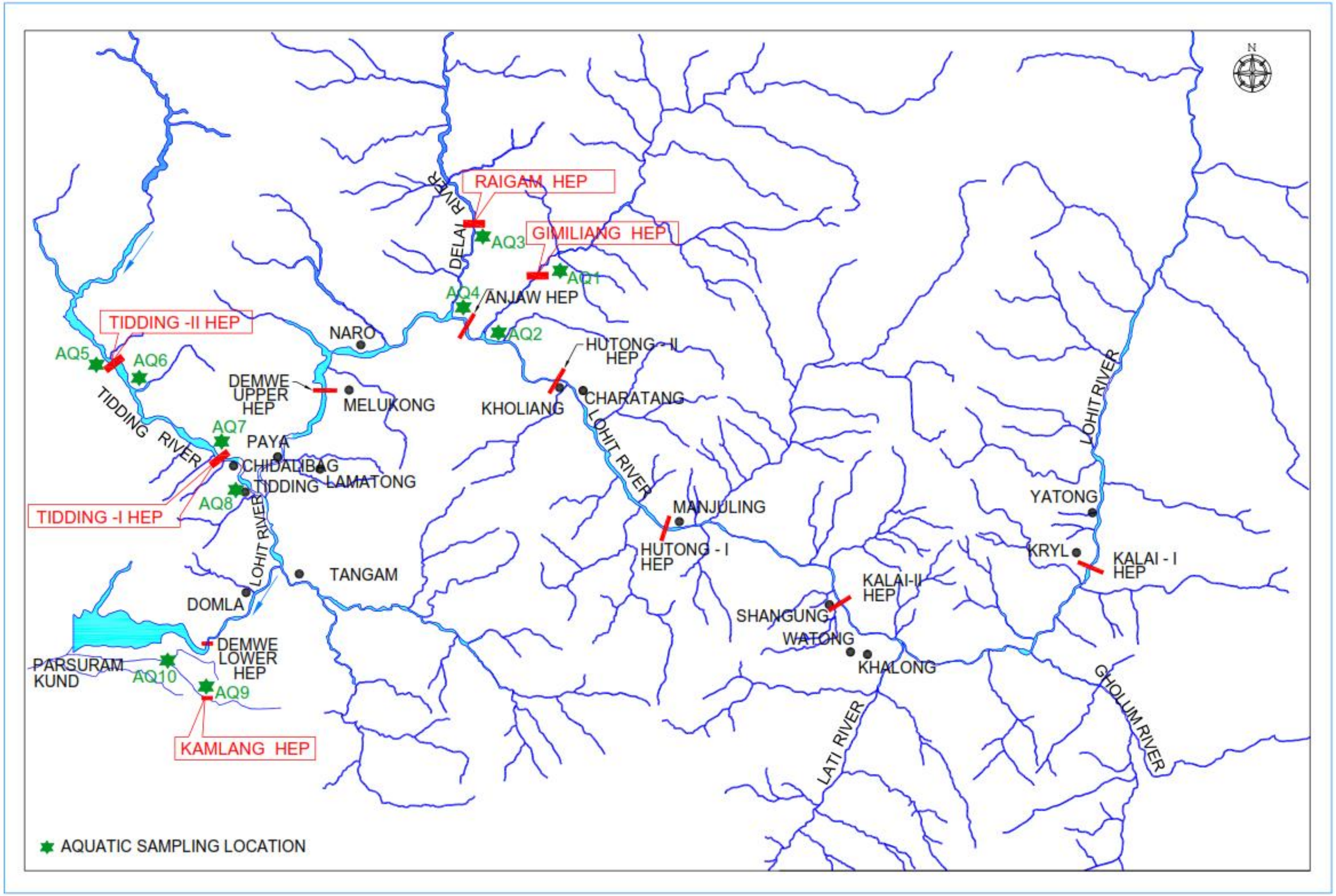


Figure-7.2: Aquatic Ecological Sampling Location Map

	
Dav river near Gimliang or Dav Basti, Project Area	Dav river near suspension bridge, Dav Basti
	
Dav river D/s veiw from Suspension bridge	Dav river u/s confluence of Lohit
	
Dav river habitat at d/s area near confluence	Dav river confluences with Lohit at its Right bank

Plate 1 :Dav River, Morphology and Habitat structure in the Study area of Gimliang HEP

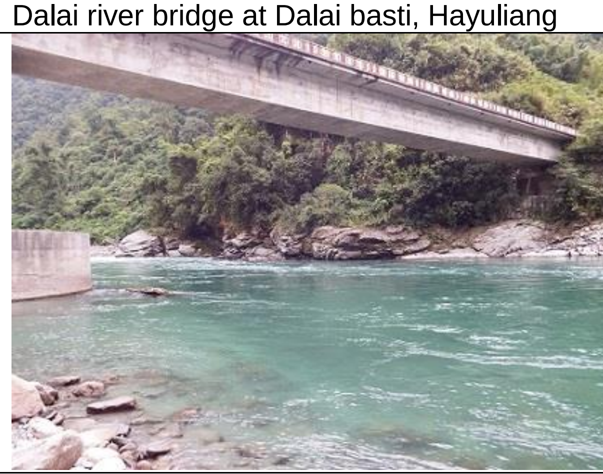
Dalai river at Raigam HEP

Dalai river near Raigam/Teapanibasti vicinity

Rapid Habitat at project vicinity-Torrent flow

Dalai river bridge at Dalai basti, Hayuliang

Dalai river confluence with Lohit river, Hayuliang



Pool habitat under Dalai river bridge d/s area

Plate 2 : Dalai/Delei River, Morphology and Habitat structure in the Study area of Riagam HEP

	
Tiding River upstream zone-Changlambasti	Tiding near Tiding bati
	
Tiding near confluence site with Lohit	D/s Tiding- Alluvial deposits with sand at banks
	
Riffle and Rapids Habitat with gravelled bed	Tiding Basti along the bank of Tiding river

Plate 3: Tiding River Morphology and Habitat structure in the Study area of Tiding HEP I& II

	
Kamlang river u/s area (Near KWS)	Kamlang river d/s zone entering plains
	
Rapid Habitat Formation u/s reaches	Riffle Habitat d/s zone
	
Kamlang joins with Lohit in plains –fan strs.	Kamlang confluence and dense mixed forests

Plate 4: Kamlang River Morphology and Habitat structure in the Study area of Kamlang HEP

7.3.1 Phytoplanktons

Phytoplanktons are the autotrophic component of the plankton community and play an important role in the primary production process in the stream ecosystems. They serve as a base of the aquatic food web, providing essential ecological function for all aquatic life. In terms of numbers, the important groups of phytoplankton comprise of diatoms, dinoflagellates, cyanobacteria, and other groups of unicellular algae. The construction of hydroelectric power stations in the mountain rivers/streams will have profound impact on the planktonic communities as the planktonic organisms pass through a regulated stream with cascades of reservoirs. The species composition of two conditions viz. lake conditions and river conditions will be different. Hence, prior to dam construction it is necessary to know the composition, density and diversity of phytoplankton.

Micro flora of Lohit river and its tributaries comprises of species belonging to families Chlorophyceae (Green algae), Cynophyceae (Blue green algae) and Bacillarionphyceae (Brown algae)**.** Chlorophyceae included *Rhizoclonium* sp. *Spirotaenia* sp. and *Ulothrix* sp., Spirogyra sp, *Zygnema* sp and Cladophora as filamentous algae forming sheets on the river bed.

Cladophora sp was found attached in the rapid waters also on small boulders and pools formed along banks of high gradient strerams. Other green algae observed include *Chlorella, Scenedesmu*s sp and Closterium.

The flagellates were represented by *Chlymadomonas* and *Euglena* sp. Blue green algae was represented by *Anabaena* sp*, Oscillatoria*sp, *Microcystis*sp*, Phormidium*sp and *Aphanothece*sp. After green algae*, diatoms* (Bacillariophyceae) are the dominant group.

The decreasing trend of occurrence of algal communities in the tributaries from foot hills to typical hill streams as Dalai and Dav rivers and upstream zone of Tiding can be attributed to change in habitat structure, river morphology and climatic conditions as change in temperature and other physical and chemical characteristics of the river. The same trend has also been observed for zooplanktons, periphytons, benthic communities and fish diversity which has been described in the subsequent sections.

At most of the sampling sites *Achnanthes* sp*, Cocconeis placentula, Fragilaria* spp, *Gomphonema* spp*, Cymbella* and *Neidium,* were the most common species in the upstream zone of Kamlang, Tiding, Dalai and Dav rivers. However, there was not much variations observed in the Dalai, Dav and Tidding river zones except at the confluence with Lohit river and Kamlang river which has altogether different geomorphology near and u/s confluence zone of KamlangLohit river.

Genera like *Synedra* spp, *Hannaea* spp*, Naviculas* spp, *Gomphonema* spp*, Tabellaria* spp*, Surirella* spp and *Achnanthes Haukiana* were recorded in the planktonic community while *Gomphonema* sp. and *Eunotia* sp. was specific to periphytons / benthic community of upper Lohit basin. Macroflora/ Macrophytes: Among macrophytes potamogeton sp. is found in abundance followed by occurrence of other species like Nitella and Chara spp. were observed in the cold waters of upstream Lohit basin tributaries.

The list of phytoplankton species reported at various sampling sites in the study area is given in Table-7.28.

Table-7.28: Phytoplankton Species observed at various sampling sites in the Study Area

Taxon	**S I**	**S II**	**S III**	**S IV**	**S V**	**S VI**	**S VII**	**S VIII**	**S IX**	**S X**
Blue Green Algae										
Anabaena sp.	-	-	-	-	-	-	-	+	+	++
Oscillatoria sp.	++	+	++	+	+	+	+	++	+	+
*Microcystis*sp.	-	-	-	-	-	-	+	+	+	+
*Rivularia*sp	++	+	+	+	+	+	+	-	+	-
*Synechocystis*sp	+	+	+	+	+	++	+	+	+	+
Schizothrix sp.	++	+	++	+	-	++	+	++	+	+
Lyngbyabirgei	-	-	-	-	-	-	-	-	-	+
Green Algae										
Zygnemasp	+++	+	+++	+	+	+	+	+	+	+
Spirogyra spp.	+++	-	++	+	+	+	-	+	+	+
Oedogonium sp.	+	-	+	+	+	+	-	+	+	+
Ulothrixxsp	+	-	+	+	+	+	-	+	+	-
Cladophora	+++	+	-	+	-	+	+	+	+	-
Melosirasp	+	+	+	+	+	+	+	+	+	-
Cylindrithecasp	+	+	++	+	-	+	+	+	+	+
Scenedesmussp	+	+	++	-	-	+	+	+	-	-
Chlorella sp	++	++	++	+	++	++	++	+	+	+
Chlamydomonassp	++	+	+	+	+	++	+	+	+	+
Cryptomonassp	++	+	+	+	+	++	+	+	+	-
Rhodomonas sp.	+	+	+	+	+	+	+	+	+	-
Euglena sp	++	++	+	+	+	++	++	++	+	-
Trichelomonassp	+	+	+	+	+	+	+	+	-	-
Protococcus sp.	++	++	++	+	+	++	++	++	+	+
Spirotaeniasp	++	+	++	+	-	++	+	++	+	-
Batrachospermumsp	+	-	+	-	-	+	-	+	+	-
Closteriopsissp	-	+	-	+	-	-	+	+	-	+
Closteriumsp	-	+	-	+	-	-	+	-	-	+
Diatoms									+	
Tabellaria sp.	++	-	+++	+	+	+	+	+	+	-
Cocconeis sp.	+	+	++	+	+	+	+	+	+	-
Synechoccus sp.	+	+	+	+	+	+	+	+	+	+
Diatoma spp.	+	+	+	+	+	+	+	+	+	+
Fragilaria sp.	+	+	+	+	+	+	+	+	+	++
Synedra spp.	+	+	+	+	-	++	+	+	+	+
Hannaea spp.	+	+	+	+	+	+	+	+	+	+
Achnanthes spp.	+	+	+	+	+	+	+	+	+	+
Eunotia sp.	++	-	-	-	+	+	+	-	+	+
Stauroneis sp.	+	+	+	+	+	+	+	+	+	+

Taxon	**S I**	**S II**	**S III**	**S IV**	**S V**	**S VI**	**S VII**	**S VIII**	**S IX**	**S X**
Nitzschiasp	+	+	+	+	+	+	+	+	+	+
Navicula spp.	+	+	+	+	+	+	+	+	+	+
Cymbella spp.	+	+	+	+	+	+	+	+	+	-
Gomphoneissp	+	+	+	+	+	+	+	+	+	-
Gomphonema spp.	+	+	+	+	+	+	+	+	+	-
Pinnularia sp.	+	+	+	+	+	+	+	+	+	-
Surirella sp.	+	-	++	+	+	+	+	++	+	-
Frustuliasp	-	+	-	+	-	-	+	-	+	-
Mastogloiasp	-	+	-	+	-	-	+	-	-	-
Neidiumaffinis	-	-	-	+	-	-	+	-	+	-
Actinastrumsp	+	-	+	-	-	+	+	+	+	+
Penium simplex	-	-	+	-	-	-	-	-	-	-
Macrophytes										
Potamogetonsp	-	-	+	-	-	-	+	+	+	-
Nitellasp	-	-	+	-	+	+	+	-	+	-
Charasp	+	-	+	+	+	+	+	-	+	-

7.3.2 Periphytons

Periphyton is a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems. It serves as an important food source for invertebrates, tadpoles, and some fish. It can also absorb contaminants; removing them from the water column and limiting their movement through the environment. The periphyton is also an important indicator of water quality; responses of this community to pollutants can be measured at a variety of scales representing physiological to community-level changes. Construction of concrete structures on flowing waters alter the flow and temperature regimes, hydraulics, the availability and stability of substrata, channel morphology, riparian vegetation, and as a result, the community structure of aquatic communities. The change in flow regimes will have significant impact on the periphytic community in the stream ecosystem. Hence, prior to construction of such ubiquitous structures a preliminary assessment of the composition, density and diversity of periphytic algal community is needed. Samples of periphytic algae were collected by scraping 1 cm^2 area of the substratum on which they were growing. The scraped algae were then put in a small container and brought to the laboratory for identification. Density of the periphytic algae was expressed in terms of cm^2.

Periphyton communities were prominent in the shallow, rocky and gravelly bottoms in all the project sites proposed on tributaries ofLohit river basin. However, their population became inconspicuous due to increase in water level in the river during monsoons. The common periphyton genera found in the project sites were *Nitzchia*, *Hormidium*, *Spirogyra*, *Chlorella*, and

Cymbella. Overall, 15 taxa of periphytic algae were recorded from all the sites in the Lohit river basin**.** Analysis of variance showed that the total density of periphytic algae did not differ significantly between different projects as well as between different sites in each project.

The presence of periphytonj communities in the Study Area is given in Table-7.29.

Table-7.29: Periphyton communites at various sampling sites in the Study Area

Genus	S I	S II	S III	S IV	S V	S VI	S VII	S VIII	S IX	S X
Nitzchiabacata	+	+	-	+	+	+	+	+	+	+
Cymbellacistula	+	+	+	+	+	+	+	+	+	+
Hormidium sp.	+	-	+	+	+	+	+	+	+	+
Fragilaria sp.	+	+	+	+	+	+	+	+	+	+
Cosmerium sp.	-	+	-	+	-	-	-	+	+	+
Spirotaena sp.	+	-	-	+	-	-	+	+	+	+
Spirogyra varians	+	+	+	+	+	+	+	+	+	+
Chlorella vulgaris	-	+	+	+	+	+	+	+	+	+
Gloeocapsa sp.	-	-	-	+	-	-	-	+	-	+
Nostoc sp.	-	-	-	-	-	-	-	+	-	+
Anabaena sp.	-	-	-	-	-	-	-	+	+	+
Zygnema sp	+	-	+	-	+	-	+	-	+	-
Cladophora sp	+	-	+	+	+	+	+	-	+	-
Gomphoneis sp	+	+	+	+	+	+	+	+	+	+
Gomphonema sp	+	+	+	+	+	+	+	-	+	-

7.3.3 Zooplanktons

Zooplanktons are the heterotrophic component of the plankton community, and is a broad categorization spanning a range of organism sizes that includes both small protozoans and large metazoans, rotifer and crustacean (copepods and cladoceran). Among protozoans Arcella, Peridinium, Actinophrys, Paramecium and ceratium genera are observed in upstream zone, whereas these have shown rare occurrence in the downstream area. Rotifers are represented by Keratella, Brachionus, Epiphanes, Philodina, and Asplanchna sp. Copepods consists of moina, bosmina, and daphnia species whereas cladocerans are represented by Cyclopes and diaptomus only. The dominant genera were *Difflugia*, *Colurella*, *Testudinella*, *Philodina*, *Keratella*, and *Polyarthra*, although their dominance varied across different sites with respect to proposed power projects on different tributaries of the Lohit river basin. Since, they are typically of small size, zooplankton can respond relatively rapidly to increase in phytoplankton abundance, for instance, during the spring bloom and plays an important water quality indicator and constitutue trophic level for fishes. However, in the torrent streams zooplanktons are poorly representing group among planktonic communiities due towash away effect of fast water current and other factors where habitat like scour pools in high gradient zone and rapids in lower slope zone playing limiting factor.

The list of commonly observed zooplankton species at various sampling sites in the Study Area is given in Table-7.30.

Table-7.30: Occurrence of Zooplankton

Zooplanktons	S I	S II	S III	S IV	S V	S VI	S VII	S VIII	S IX	S X
Protozoan										
Peridiniumsp	+	+	+	+	+	+	++	+	+	+
Actinophrys sp.	+	+	+	+	+	+	-	+	+	+
Arcellasp	+	+	+	+	+	++	++	+	+	+
Ceratium sp.	+	+	+	+	+	+	+	++	+	+
Difflugiasp	+	+	+	+	+	+	+	+	+	+
Polyarthrasp	+	+	+	+	+	+	+	+	+	+
Rotifers										
Brachionus	++	+	++	+	+	++	+	++	+	+
Keratellasp	++	++	++	+	+	++	++	++	+	+
Epiphanes	++	-	+	-	-	++	-	+	-	-
Asplanchna sp.	+	+	+	++	+	+	+	+	++	+
Philodenasp	+	-	-	-	-	+	-	-	-	-
Cladoceran										
Bosminasp	+	-	-	-	-	++	-	-	-	-
Daphnia sp	+	-	+	-	-	++	-	++	-	-
Monostylasp	+	+	+	+	+	+	+	+	+	+
Bosminopsissp	+	+	+	+	+	+	+	+	+	+
Testudinellasp	-	+	-	+	-	-	+	-	+	-
Copepods										
Cyclops sp.	+	-	+	-	-	-	-	+	+	+
Diaptomussp	+	-	+	-	-	-	-	+	+	+

7.3.4 Benthic Invertebrates

The population density of various invertebrate species is summarized in Table-7.31. A high diversity of benthic invertebrates with overall 28 taxa of invertebrates belonging to 8 orders were recorded from various sampling sites in the Study Area. Members of Ephemeroptera, Trichoptera, Plecoptera and Diptera dominated the invertebrate group in the project sites. The families of macro-invertebrates included *Baetidae, Chironomidae, Dytiscidae, Elmidae, Ephemerellidae, Heptageniidae, Hydropsychidae, Leptoceridae, Perlidae, Simulidae,* and *Tipulidae* and their abundance varied across longitudinal section of the corresponding hill streams or tributaries of Lohit river basin both upstream and downstream zone.

Ephemeropterans were observed as the dominant group, followed by Placopteran and Dipterans. Species of genera *Stenonema, Epeorus, Baetis, Ephemera, Rithrogena, Rhycophila, Leptocella* and *Siphonomus* are observed in abundance. Maximum occurrence of chironomids and simulids was observed in high sedimentation zone, which has habitat structures, i.e. pools and riffles of slow flow zone and wide and open valley type. These areas also have shown algal blooms and mats of filamentous algae where bottom consists of sand and mud with lesser amount of cobbles, pebbles and gravels and few scattered boulders. The distribution and occurrence is directly related to the habitat structure of river where cascades, rapids and scour pools are present and river has >4% gradient with rocky bottom and banks.

Table-7.31: Macro-invertebrates composition in the study area

Taxon	S I	S II	S III	S IV	S V	S VI	S VII	S VIII	S IX	S X
Heptageniidae										
Epeorussp	+	+	+	+	+	+	+	-	-	-
Heptagenia sp.	+	+	+	+	+	+	+	-	-	-
Baetidae										
Baetis sp.	+	+	+	+	+	+	+	+	+	+
Centroptilumsp	+	+	+	+	+	+	+	-	-	-
Sipholonurussp	++	+	+	+	+	+	+	-	-	-
Cloeonsp	+	+	+	+	+	+	+	+	+	-
Ephemerellidae										
Ephemera sp.	+	+	+	+	+	+	+	+	+	+
Rithrogena sp.	++	-	+	-	+	+	+	-	+	+
Stenonema sp.	+++	-	+	-	+	+	+	-	+	-
Ameletussp	+	+	+	+	+	+	+	-	+	-
Perlidae										
Perlasp	+	+	+	+	+	+	+	+	+	+
Choloroperla sp.	+	-	+	-	+	+	+	-	+	-
Capniasp	+	+	+	+	+	+	+	+	+	+
Rhabdiopteryx sp.	+	-	+	-	+	+	+	+	+	-
Hydropsychidae										
Hydropsyche sp.	+	+	+	+	+	+	+	+	+	-
Rhyacophila sp.	+	+	+	+	+	+	+	+	+	-
Leptoceridae										
Leptocellasp	+	+	+	+	+	+	+	-	+	-
Hydroptilidae										
Ochrotrichiasp	+	-	+	-	+	+	-	-	-	-
Psephanidae										
Psephanussp	+	-	+	-	+	+	-	-	-	-
Chironomidae										
Chironemoussp	-	+	-	+	-	-	-	+	-	+
Tendipes sp.	+	-	+	-	+	+	+	-	-	-
Simulidae										
Simulids (Simulumsp)	+	+	+	+	+	+	-	-	-	-
Blepharoceridae										
Bibiocephallesp	+	-	+	-	+	+	+	-	-	-
Dytiscidae/Elmidae										
Narpussp/	+	+	+	+	+	+	+	+	+	-
Dytiscus sp.	+	-	+	-	+	-	-	+	+	-

Taxon	S I	S II	S III	S IV	S V	S VI	S VII	S VIII	S IX	S X
Amphizoidae (trout beetel)										
Amphizoa sp.	+	+	+	+	+	+	+	-	+	-
Anechurinae (scuds)										
Anechurabipunctata	+	+	+	+	+	+	+	-	-	-
Acrania(crustacea)										
Hydracarinasp	+	+	+	+	+	+	+	-	-	-

7.4 FISHERIES ON RIVER LOHIT

Ichthyofaunal diversity of Lohit river comprises of 62 species of 16 families with Cyprinidae forming the largest family represented by 25 species. Each of the families Channidae, Heteropneustidae, Notopteridae, Nandidae, Claridae, Anabantidae, Belonidae, Psilorhynchidae and Anguillidae is represented by a single species. Table-7.32 depicts the composition and conservation status of fish in Lohit river based on available literature.

Table-7.32: Fish composition and their status in Lohit river

Family	Species	Status
Cyprinidae	*Aspidoparia jaya*	VU
Cyprinidae	*A. morar*	LRnt
Cyprinidae	*Barilius barna*	LRnt
Cyprinidae	*Barilius bendelisis*	LRnt
Cyprinidae	*B. tileo*	LRnt
Cyprinidae	*Chagunius chagunio*	
Cyprinidae	*Crossocheilus latius latius*	LRnt
Cyprinidae	*Garra gotyla gotyla*	VU
Cyprinidae	*G. gotyla lissorhynchus*	VU
Cyprinidae	*G. macllelandi*	
Cyprinidae	*Labeo dero*	VU
Cyprinidae	*Labeo dyocheilus*	VU
Cyprinidae	*L. pangusia*	LRnt
Cyprinidae	*L.gonius*	LRnt
Cyprinidae	*Acrossocheilus hexagonolepis*	
Cyprinidae	*Puntius ticto*	LRnt
Cyprinidae	*Raiamas bola*	
Cyprinidae	*Schizopyge stolizckae*	LRnt
Cyprinidae	*Schizothoraichthys esocinus*	LRnt
Cyprinidae	*S. Progastus*	LRnt
Cyprinidae	*Schizothorax richardsonii*	VU
Cyprinidae	*Tor putitora*	EN
Cyprinidae	*T. tor*	EN
Cyprinidae	*T.mosal*	EN
Cyprinidae	*Rasbora elanga*	
Sisoridae	*Hara hara*	
Sisoridae	*Hara jerdoni*	
Sisoridae	*Bagarius bagarius*	VU

Family	**Species**	**Status**
Sisoridae	*Euchiloglanis hodgarti*	EN
Sisoridae	*Euchiloglanis kamengensis*	VU
Sisoridae	*Exostoma labiatum*	
Sisoridae	*Glyptothorax coheni*	
Sisoridae	*Glyptothorax conirostris*	
Sisoridae	*Glyptothorax pectinopterus*	LRnt
Sisoridae	*Pseudocheneis sulcatus*	VU
Sisoridae	*Sisor rhabdophorus*	EN
Cobitidae	*Somileptes gongota*	LRnt
Cobitidae	*Botia dario*	
Cobitidae	*Botia rostrata*	
Cobitidae	*Noemacheilus botia*	LRnt
Cobitidae	*Noemacheilus rupecola repecola*	LRnt
Cobitidae	*Noemacheilus sikimaiensis*	EN
Amblycipitidae	*Amblyceps apangi*	
Amblycipitidae	*Amblyceps arunachalensis*	
Amblycipitidae	*Amblyceps mangois*	LRnt
Anabantidae	*Anabus testudineus*	
Anguillidae	*Anguilla bengalensis*	EN
Bagridae	*Olyra longicaudata*	
Bagridae	*Aorichthys singhala (often found)*	DD
Siluridae	*Rita rita*	LRnt
Siluridae	*Silurus afgana*	
Siluridae	*Wallago attu (often found)*	
Claridae	*Clarias batrachus (often found)*	VU
Balitoridae	*Aborichthys elongatus*	
Balitoridae	*Aborichthys kempi*	
Balitoridae	*Balitora bruceii*	LRnt
Channidae	*Channa* sp. *(rarely found)*	
Heteropneustidae	*Heteropneoustis fossilis (often found)*	VU
Nandidae	*Badis badis*	DD
Notopteridae	*Notopterus notopterus*	LRnt
Psilorhynchidae	*Psilorhynchus balitora*	
Belonidae	*Xenontodon cancilai*	LRnt

Source: CEIA Report, Lower Demwe Hydroelectric Project
Note: (VU) vulnerable, LRnt-Low Risk- near threatened; EN-Endangered.

Out of 62 species of fishes reported in Lohit river based on available literature, 41 have been assessed for their conservation status (CAMP-BCPP, 1997). A total of 7 species are ‘endangered’ (EN) while 11 are ‘vulnerable’ (VU). The ‘VU’ species which are fished abundantly in Lohit river are *Schizothorax richardsonii*, *Labeo dero*, *Garra gotyla gotyla* and *G. lissorhynchus* whereas, *Tor putitora, T. tor*, *T. mosal* are ‘EN’ species, which accounts as the main capture fishery. Two species like *Aorichthys seenghala* and *Badis badis* have been categorized under the threatened category of ‘Data Deficient’ (DD); the remaining species are declared as ‘Low Risk- near threatened’ (LRnt).

7.4.1 Assessment of Fish Diversity in River Lohit

The assessment of fish diversity in Lohit basin was done in the months of April, May, June, July, August and September 2009. Random sampling in selected areas of the projects in the river basin was carried out using a cast net at morning (6:00 — 8:00) hours. The sampling was done at various sampling sites outlined in section 6.2. The sampled fishes were identified using the taxonomic keys (Nath & Dey 2000, Bagra *et al*. 2009, and Viswanath NBFGR).

The fish fauna at the sampling sites belonged to 2 families i.e. Cyprinidae and Siluridae. The fishes encountered in Kalai I and Kalai II project areas were *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis*. In Hutong I and Hutong II hydroelectric project areas, *Schizothorax richardsonii*, *Tor putitora* and *Acrossocheilus hexagonolepis* were encountered. The fish species found in area of Upper Demwe hydroelectric were *Schizothorax richardsonii*, *Tor putitora* and *Acrossocheilus hexagonolepis*. In Lower Demwe HEP the fish composition comprised of *Schizothorax richardsonii*, *Tor putitora*, *Labeo pangusia*, *Tor tor*, *Chagunius chagunio*, *Garra gotyla*, *Acrossocheilus hexagonolepis* and *Rita rita*. The details are given in Tables-7.33to 7.38.

Table-7.33: Fish composition at various sampling sites of Kalai HEP, Stage-1

Family	Species	S1	S2	S3	S4	S5
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

Table-7.34: Fish composition at various sampling sites of Kalai HEP, Stage-2

Family	Species	S6	S7	S8	S9	S10
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

Table-7.35: Fish composition at various sampling sites of Hutong HEP, Stage-1

Family	Species	S11	S12	S13	S14	S15
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	
Cyprinidae	*Tor putitora*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

Table-7.36: Fish composition at various sampling sites of Hutong HEP, Stage-2

Family	Species	S16	S17	S18	S19	S20
Cyprinidae	*Schizothorax richardsonii*	×	×		×	×
Cyprinidae	*Tor putitora*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

Table-7.37: Fish composition at various sampling sites of Demwe Upper HEP

Family	Species	S21	S22	S23	S24	S25
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×
Cyprinidae	*Tor putitora*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×

Table-7.38: Fish composition at various sampling sites of Demwe Lower HEP

Family	Species	S26	S27	S28	S29	S30
Cyprinidae	*Schizothorax richardsonii*	×	×	×	×	×
Cyprinidae	*Tor putitora*	×	×	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×	×	×
Cyprinidae	*Tor tor*	×	×	×	×	×
Cyprinidae	*Chagunius chagunio*	×	×	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×	×	×
Cyprinidae	*Acrossocheilus hexagonolepis*	×	×	×	×	×
Siluridae	*Rita rita*	×	×	×	×	×

Adequate sampling in entire basin was carried out wrt Terrestrial ecology, aquatic ecology and other aspects. The sites downstream of Hatong II like S19 and S20 are also giving base line information for Anjaw HEP.

Fish species such as *Tor tor* and *Tor putitora* are migratory in nature. The construction of dam under various proposed project would affect the upward and downward migration of fish and may disturb the fish habitat. In course of impoundment, the resident species (both migratory and non-migratory) would get trapped as a result of damming. The natural recruitments may be affected due to closure of migratory routes from the flood plains to the hill streams. Due to different construction activities of dam most of the substratum in the river bed will be altered, and some of these sites can be potential breed/spawning sites to some of the non-migrating resident fishes. The spawning ground of most of the fishes is characterized by a gravelly substrate with a slower water flow rate. The removal of boulder, gravel, sand and earth may have adverse impact on the spawning of these species.

The migratory route of the fishes as such would be affected to some extent, but then the entire river course is regularly drained by numerous inlets in forms of small rivers, seasonal nallahs, channels, rivulets and like water sources where these fishes can get refuge during course of their migration to carry out their annual spawning/breeding activity. In a nutshell, total fish community will not be wiped out or totally disturbed because of dams, However there will be some ecological changes in the river course. For which conservation and mitigation measures has been proposed under Chapter 11 i.e. Environment Management Plan (EMP).

Breeding grounds for fishes

Tor spp. are long distance migrants, while other species such as *Schizothorax*, *Acrossocheilus*, *Labeo*, *Chagunius*, and *Garra* spp. migrate mid to short distances. The spawning period for long distance migrants is from September to October, while for other species the migration period is mainly from June to August. All the fishes in the present study need a gravelly substrate for spawning.

It is noted that, a study was carried out by fisheries expert for the evaluation of fish habitats and breeding grounds in the project area of Demwe Lower Hydro Electric Project as part of environmental impact assessment study of the project. The study concluded that, owing to the straight reach (without any meanders), moderate to steep gradient of the river course, high flow velocity of water, absence of stagnant/ calm water pools, human interference etc the project area of Demwe Lower HEP does not represent the ideal conditions for fish breeding grounds.

7.4.2 Fisheries on Projects on Tributaries of River Lohit

The fisheries survey at various locations of tributaries of Lohit river basin was undertaken in the month of September 2015.The studies on fish fauna were carried out at various locations listed in Table-7.27. The secondary data was also consulted from the available literature on Lohit river basin to support the primary data. Common fishing methods were used to land fishes e.g. used hooks and caste nets by the locals to land fishes (**Plate 5).**

Majority of the Himalayan rivers are known for cold water fisheries and studies showed that Lohitriver tributaries was no different. The poor diversity is due to sub-temperate type climate and habitat structures in upper reaches situated beyond Hayuliangdue to high gradient in the project vicinity. Except one fish species – Snow trout, no other fish species are observed in Dalai and Dav rivers that may be due to local migration at the end of monsoon period **(Plate 5).**

Along with snow trout (*Schizothoirax richardsonii),* other species viewed from local interaction in the upper reaches tributaries of Lohit basin study area are *Garrana ganensis*, *Puntiusticto, Mystus bleekeri, Chandaranga* and *Glossogo biusgiuris*.

Ichthyofaunal diversity of various tributaries of Lohit river comprises of 27 species of 5 families with Cyprinidae forming the largest family represented by 17 species. The fish species along with their conservation status in the Study Area is given in Table-7.39.

Table-7.39: Fish composition and their status in the study area

Species	**Family**	**Conservation Status**	**GHEP**	**RHEP**	**T-I HEP**	**T-II HEP**	**PK**
Cyprinidae	*Chagunius chagunio*		-	-	-	+	+
Cyprinidae	*Crossocheilus latiuslatius*	LRnt	-	-	-	+	+
Cyprinidae	*Garragotyla gotyla*	VU	+	+	+	+	+
Cyprinidae	*Labeo dero*	VU	-	-	-	+	+
Cyprinidae	*Labeo dyocheilus*	VU	-	-	-	+	+
Cyprinidae	*Acrossocheilushexagonolepis*		+	+	+	+	+
Cyprinidae	*Aspidoparia. Morar*	LRnt	-	-	-	+	+
Cyprinidae	*Bariliusbarna*	LRnt	-	-	-	-	+
Cyprinidae	*Bariliusbendelisis*	LRnt	-	-	-	+	+
Cyprinidae	*B. tileo*	LRnt	-	-	-	-	+
Cyprinidae	*Puntius ticto*	LRnt	-	-	-	-	+
Cyprinidae	*Schizothoraichthys esocinus*	LRnt	+	+	+	+	+
Cyprinidae	*S. Progastus*	LRnt	+	+	+	+	+
Cyprinidae	*Schizothorax richardsonii*	VU	+	+	+	+	+
Cyprinidae	*Tor putitora*	EN	-	-	-	+	+
Cyprinidae	*T. tor*	EN	-	-	-	+	+
Cyprinidae	*Rasbora elanga*	-	-	-	-	-	+
Sisoridae	*Bagarius bagarius*	VU	-	-	-	+	+
Sisoridae	*Euchiloglanis kamengensis*	VU	-	-	-	-	+
Sisoridae	*Glyptothorax coheni*	-	-	-	+	+	+
Sisoridae	*Glyptothorax pectinopterus*	LRnt	-	-	+	+	+
Sisoridae	*Pseudocheneis sulcatus*	VU	+	+	+	-	-
Cobitidae	*Botia dario*	-	-	-	-	+	+
Cobitidae	*Botia rostrata*	-	-	-	-	+	+
Cobitidae	*Noemacheilus botia*	LRnt	-	-	-	-	+
Cobitidae	*Noemacheilus repecola*	LRnt	-	-	-	-	+
Balitoridae	*Aborichthys elongatus*		-	-	-	-	+
Belonidae	*Xenontodoncancilai*	LRnt	-	-	-	-	+

Note: (VU) vulnerable,LRnt-Low Risk- near threatened; EN-Endangered.

- GHEP - Gmiliang HEP
- RHEP - Raigam HEP
- T-I HEP- Tidding –I HEP
- T-II HEP - Tidding-II HEP
- KHEP - Kamlang HEP

Out of 27 species of fish species reported in the Study Area based on available literature, 22 have been assessed for their conservation status (CAMP-BCPP, 1997). A total of 2 species are 'endangered' (EN) while 7 are 'vulnerable' (VU) and remaining are of as 'Low Risk- near threatened' (LRnt). The 'VU' species which are captured abundantly in tributaries of Lohit river are *Schizothorax richardsonii*, *Labeo dero*, *Garragotylagotyla* whereas, *Tor putitora and T. tor* are 'Endangered' species, which are the main capture fishery.

Out of these 27 fishes maximum diversity was found in the Kamlang river, which also provides the accessible route to different migratory fishes as viewed from the river morphology, habitat structure and its confluence with Lohit in the plains afterward d/s Parsuramkund of Wakro areas. Fish diversity decreases from Kamlang to Tiding river and minimum diversity was observed in upper reaches of Dar and Dalai rivers.

The fishe species encountered in Dav and Dalai rivers were *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis*. However, downstream zone of Lohit basin near Hayuliang area, presence of *Tor putitora* and *Acrossocheilus hexagonolepis*was also reported. The fish species found in area near confluence of Tidding with Lohit are *Schizothorax richardsonii*, *Tor putitora* and *Acrossocheilus hexagonolepis*. In Kamlang river the fish composition comprised of *Schizothorax richardsonii*, *Tor putitora*, *Labeo* sp, *Tor tor*, *Chagunius chagunio*, *Garra gotyla*, *Acrossocheilus hexagonolepis* and *Glyptothorax* sp.

Some of these sites can be potential breed/spawning sites to some of the non-migrating resident fishes. The spawning ground of most of the fishes is characterized by a gravelly substrate with a slower water flow rate. The removal of boulder, gravel, sand and earth will have a negative impact on the spawning of these species.

7.4.3 Migration Characteristics

The migration characteristics of various fish species observed from the literature cited in the study area is given in Table-7.40

Table-7.40: Migration distance, spawning season & spawning substrate of some of the fish species

Family	Species	Migration distance	Spawning season	Spawning substrate
Cyprinidae	*Schizothorax richardsonii*	Short to Mid	Aug-Sep	Gravelly substrate
Cyprinidae	*Neolissochilus hexagonolepis*	Short to Mid	May-July	Gravelly substrate
Cyprinidae	*Labeosp*	Short to Mid	May -July	Gravelly substrate
Cyprinidae	*Chagunius chagunio*	Short to Mid	May-June	Gravelly substrate
Cyprinidae	*Tor putitora*	Long	Sep -Oct	Gravelly

Family	**Species**	**Migration distance**	**Spawning season**	**Spawning substrate**
				substrate
Cyprinidae	*Tor tor*	Long	Sep -Oct	Gravelly substrate
Cyprinidae	*Garra gotyla*	Short to Mid	May - Jul	Gravelly substrate
Cobitidae	*Botia dario*	Short	Jun - Aug	Gravelly substrate
Sisoridae	*Glyptothorax* sp.	Short	May- Jul	Gravelly substrate

Tor spp. are long distance migrants, while other species such as *Schizothorax*, *Neolissocheilus*, *Labeo* sp, *Chagunius*, and *Garra* spp. migrate mid to short distances. Species like *Botia* sp, *Amblyceps*, *Glyptothorax*, and *Psuedechnius* sp. migrate to short distances. The spawning period for long distance migrants is from September to October, while for other species the migration period is mainly from June to August. All the fishes in the present study need a gravelly substrate for spawning.

Angling rod used as fishing gear in the area

Local fisherman with fish catch

Snow trout- Schizothorax sp in cold waters of Delei river

Plate 5: Local fisherman using angling rod for fishing in Dalai /Delei river near confluence with Lohit river, Hayuliang

CHAPTER-8
PROTECTED AREA

CHAPTER-8
PROTECTED AREA

8.1 INTRODUCTION

The Kamlang Wildlife Sanctuary (KWLS) has approximately 783 sq km area and it falls in the south-eastern part of Lohit district. The geographical location of the Sanctuary is $20^04'$-$28^000'$ N latitudes and $96^020'$-$96^055'$ E longitudes. Lang and Lati rivers form the boundary of the Sanctuary in the north & west respectively with Tawe river on the east and in the south the district boundaries of Lohit and Changlang district surround the Sanctuary. In the south, the KWLS is continuous to the Namdapha National Park.

The Kamlang Wildlife Sanctuary (KWLS) was declared as Wildlife Sanctuary in 1989. The name Kamlang is given to the Sanctuary on the name of river Kamlang which flows through the Sanctuary area and meets Lohit river downstream of Parsuram Kund. The Sanctuary has approximately 783 sq km area and it falls in the south-eastern part of Lohit district. Lang and Lati rivers form the boundary of the Sanctuary in the north & west respectively with Tawe river on the east and in the south the district boundaries of Lohit and Changlang district surround the Sanctuary. In the south, the KWLS is continuous to the Namdapha National Park.

The nearest project in the vicinity of KWLS on main lohit river is Demwe Lower HEP and dam site of which is located about 10 km from the boundary of KWLS on Lang River. The nearest boundary of KWLS with respect to the Dam site of Demwe Lower HEP is located about 11.8 km away (along the river) at the confluence of Lang and Tawai river at EL 425 m (tributaries of River Lohit) on the left bank of the Lohit river. There is no existing direct road approach & footpath on Left Bank of Lohit River from the project area to the nearest boundary of KWLS, and further no roads have been proposed on Left bank of River Lohit by the project developer. Also, due to steep mountain range of more than 6000 feet separates the project area from KWLS making the Sanctuary inaccessible from the project site. Further, most of the construction activities are proposed in the vicinity of the Dam site which is located around 11.8 km along the river from the nearest boundary of the Kamlang Wildlife Sanctuary on Lang River. Project reservoir would be the nearest project component to the KWLS only during Operation Phase, which has to be maintained as Protected Area. In the eastern, western and northern boundaries of KWLS is surrounded by natural barriers mostly in the form the of rivers/deep gorges of width varying 30-100 m & high ridges and in southern side the boundary of Kamlang Wildlife Sanctuary coincides with Namdapha National Park. Considering the location of the KWLS no adverse impacts are foreseen on the KWLS due the Demwe Lower HE Project during construction as well as in operation phase. The Kamlang Wildlife Sanctuary is located about 1 km from Kamlang hydroelectric project site.

The location of Kamlang Wildlife Sanctuary is depicted in Figure-8.1.

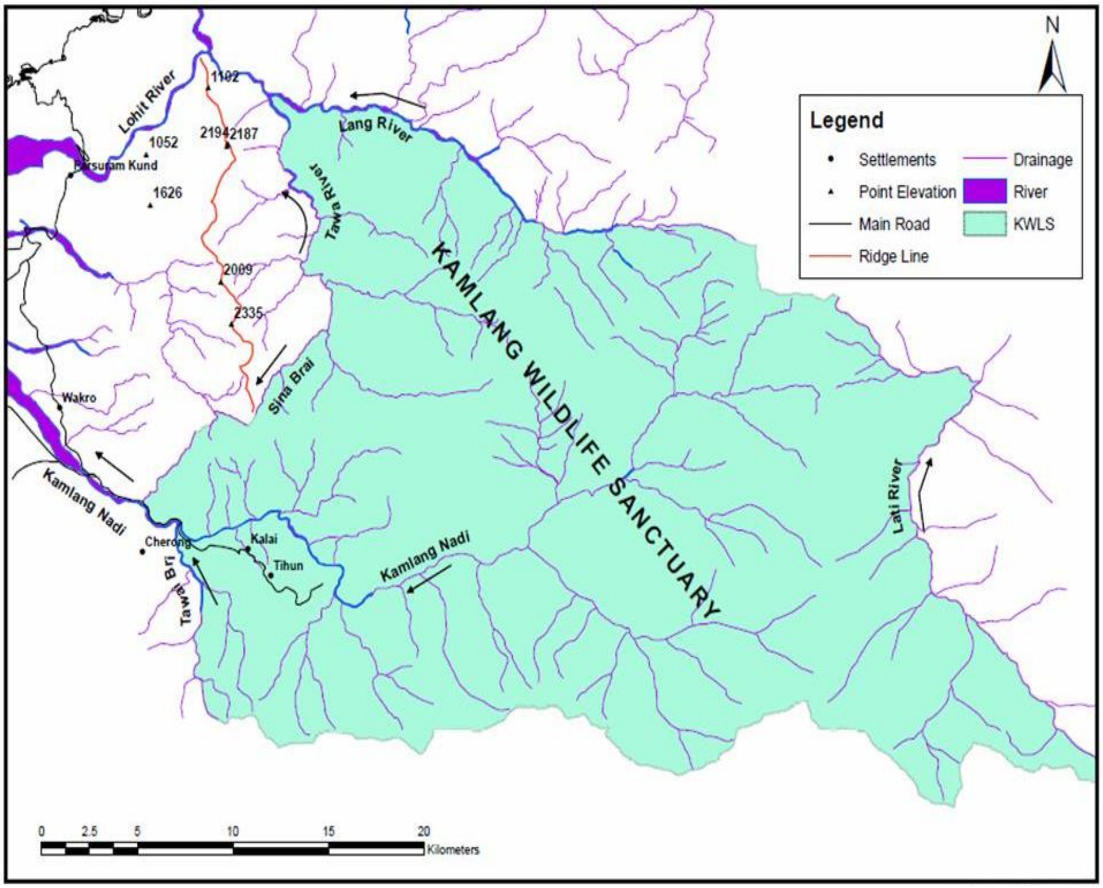


Figure-8.1: Location of Kamlang Wildlife Sanctuary

8.2 FOREST TYPES AND VEGETATION COVER

The heterogeneous forests found in the tract can be broadly classified into following types as per Champion and Seth (1986).

- 2B/C1a Semi-Evergreen Alluvial Plains,
- 2B/1S1 Sub-Himalayan light semi-evergreen forests,
- 3/IS2, *Terminalia-Duabanga*
- Miscellaneous forests.

The above referred forest types are described in the following sub-sections.

8.2.1 Semi-evergreen Forest in the Alluvial Plains

This is an evergreen dense forest with deciduous tree species in the plains. Some commonly evergreen tall tree species of the first storey are *Aglaia spectabilis, Bischofia javaica, Castanopsis indica, Canarium bengalense, Duabanga grandiflora, Dillenia indica, Dysoxylum* *procerum, Kayea assamica, Magnolia hodgsonii, Messua ferrea, Pterospermum acerifolium, shorea assamica and Terminalia bellerica.* Most common small trees and shrubs found within this type are *Abroma angusta, Bauhinia purpurea, Boehmeria macrophylla, Buddleja asiatica, Clerodendrum bracteatum, Mussaenda roxburghii, Phlogacanthus sp., Sambucus hookeri and Solanum torvum*.

8.2.2 Semi-evergreen Forests in the sub-Himalayan Region

This is a mixed forest which occurs on the ridges. The top canopy consists of many deciduous trees. *Ailathus integrifolia, Alibizia odoratissima, Bischofia javanica, Craetaeva unilocularis, Duabanga grandiflora, Garuga gamblei, Phoebe hainesiana, Sloanea sterculacea, Spondias pinnata, terminalia muriocarpa*, etc. form the first storey. Second storey is represented by *Callicarpa arborea, Calophyllum polyanthum, Gynocardia odorata, Mallotus roxburghii, Oroxylum indicum*, etc. Under storey is represented by bamboos, canes, palms and shrubs like *Bambusa pallida, Boehmeria macrophylla, Calamus floribundus, Clerondendrum griffithianum, Costus speciosus, Elatostema platyphyllum, Oxyspora paniculata and Pinanga gracilis*.

8.2.3 Terminalia – Duabanga Forest

There are patches of evergreen tree type forests species like *Termanalia* and *Duabanga* in the Wildlife Sanctuary. Second storey is represented by *Albizia lucida, Bischofia javanica, dillenia indica, Dysoxylum binectriferum, Endospermum chinense, Magnolia hodsonii, Michelia oblonga and Syzgium cumini*. Third storey is represented by some canes, shrubs and twiners. *Bambusa tulda, Calamus tenuis, Clerodendrum bracteatum, Dendrocalamus hamiltonii, Entada phaseolodes, Ficus spp., Strobilanthes coloratus,* etc are some of the important plant species make the forest dense.

8.2.4 Mixed Open Forests

This type of forest is more or less open and occurs in scattered patches of varying sizes. Some of the important trees found in this forest are *Aglaia spectabilis, Albizia lebbeck, A. lucida, Bischofia javanica, Bombax ceiba, Castanopsis indica, Duabanga grandiflora, dysoxylum procerum, Kydia calycina, Sterculia villosa* and *Terminalia myriocarpa.* The undergrowth is dense mixed consists of many spreading shrubs and tall weeds.

8.3 FAUNA

The list of commonly observed Mammals, Avi-fauna & Herpetofauna in Kamlang Wildlife Sanctuary is given in Tables-8.1 to 8.3.

Table 8.1: List of mammal species reported in Kamlang Wildlife Sanctuary

S.No.	Scientific Name	Common Name/Local Name
	ARTIODACTYLA	
1	*Bos gaurus*	Gaur
2	*Bubalus bubalis*	Wild buffalo
3	*Budorcas taxicolor*	Mishmi takin
4	*Capricomis sumatraensis*	Serow
5	*Nemorhaedus goral*	Goral
6	*Sus scrofa*	Indian wild boar
7	*Cervus unicolor*	Sambar
8	*Axis procinus*	Hog Deer
9	*Muntiacus muntjak*	Muntjak or Barking deer
10	*Moschus moschiferus*	Musk deer
	PROBOSCIDEA	
1	*Elephas maximus*	Asiatic elephant
	CARNIVORA	
1	*Panthera tigris tigris*	Tiger
2	*P. pardus*	Leopard
3	*P. uncia*	Snow leopard
4	*Neofelis nebulosa*	Clouded leopard
5	*Felis marmorata*	Marbled cat
6	*F. temminckii*	Golden cat
7	*F. viverrina*	Fishing Cat
8	*F. bengalensis*	Leopard cat
9	*F .chaus*	jungle cat
10	*Cuon alpinus*	Indian wild dog or Dhole
11	*Canis aureus*	Jackel
12	*Vulpes bengalensis*	Indian fox
13	*Selenarctors thibetanus*	Himalayan black bear
14	*Melursus ursinus*	Sloth bear
15	*Ailurus fulgens*	Red panda or Car bear
16	*Vivericula indica*	small indian civet
17	*Viverra zibetha*	Large indian civet
18	*Paguma larvata*	Himalayan palm civet
19	*Arctictis binturong*	Binturonga or Bear cat
20	*Lutra lutra*	common otter
21	*Aonyxcinerea nimal*	Clawless otter
22	*Martes flavigula*	Yellow throated marten
23	*Herpestes urva*	Crabeating mongoose
	PRIMATES	
1	*Hylobates hoolock*	Hoolock
2	*Macaca assamensis*	Assamese macaque
3	*Macaca mulatta*	Rhesus macaque
4	*Macaca arctoides*	stump tailed macaque
5	*Semnopithecus entellus*	Common langur
6	*Nycticebus coucang*	slow loris
	INSECTIVORA	
1	*Soccalus griffittii*	Common shrew

S.No.	Scientific Name	Common Name/Local Name
	CHIROPTERA	
1	*Rousettus leschenaulti*	Fulvous bat or leschenault's rdousette
2	*Cynopterus angulatus*	Eastern fruit bat
3	*Megaerops ecaudatus*	Tailless Fruit bat
4	*Macroglossus minumus*	Long tongued fruit bat
5	*Rhinolophus luctus*	Horseshoe bat
	RODENTIA	
1	*Ratufa bicolour gigantea*	Malayan giant squirrel
2	*Petaurista petaurista*	Common giant flying squirrel
3	*Biswamopterus biswasi*	Namdapha flying squirrel
4	*Callosciurus erytharaeus*	Pallas squirrel
5	*Callosciiurus pygerythrus*	Hoary bellied Himalayan squirrel
6	*Tamiop macclellandi*	Himalayan giant squirrel
7	*Dremomys rufigensis indian*	Red-cheered squirrel
8	*Procupine (Hystrix indica)*	
9	*Mus booduga*	Indian field mouse
10	*Rattus rattus*	Common house rat
	PHILODOTA	
1	*Manis crassicaudata*	Indian pangolin
2	*Manus pentadactyla*	Chinese pangoli

Table-8.2: List of avi-fauna reported in Kamlang Wildlife Sanctuary

S.No.	Scientific Name	Common Name/Local Name
	PELECANIFORMES	
1	*Phalacrocorax carbosirensis*	Large cormorant
	FALCONIFORMES	
1	*Falco peregrinus*	Sharin
2	*(F.severus*	Indian severus or oriental hobby
3	*Ictinaetus malayensis*	Black eagle
4	*Icthyophaga nana*	Lesser fishing eagle
5	*Spizaetus nipalensis*	Feathertoed or mountain hawkeagel
6	*Spilornis cheela*	Crested serpent eagle
	GALLIFORMES	
1	*Gallus gallus*	Red junglefowl
2	*Lopohura leucomelana*	Kalij pheasant
3	*Polyplectron bicalacaratum*	Grey peacock-pheasant
	COLUMBIFORMES	
1	*Chalcophaps indica*	Emerald dove
2	*Ducula sensex*	Imperial pigeon
3	*D.badia*	Maroonbacked or mountain imperial pigeon
4	*Streptopelia chinesis*	Spotted dove
5	*Treron apicauda*	Pintailed green pigeon
		Great Indian Hornbill
		Oriental Pied Hornbill (AVES)
		Large Rocket tailed Drongo
		Bronzed drongo

S.No.	Scientific Name	Common Name/Local Name
	STRIGIFORMES	
1	*Phodilus badius*	Bay Owl
2	*Glaucidium cuculoides*	Asian barred owlet
	PICIFORMES	
1	*Chrysocolaptes lucidus*	Greater goldenback woodpecker
2	*Dinopium benghalense*	Black-rumped goldenback
3	*Megalaima virens*	Great barbet
4	*M.asiatica*	Blue-throated barbet
5	*Celeus brachurus*	Rufous woodpecker
6	*Picumnus innominatus*	Speckled piculet
7	*Picus canus*	Grey headed woodpecker
8	*P.chlorolophus*	Small chlorolophus (or lesser yellow nape
9	*Picoides mecod rufous*	Fulvous-breasted pied woodpecker
10	*Sasia ochraeea*	White-browed Piculet
	CARPRIMULGIFORMES	
1	*Trachostomus hodgson*	Hodgson's fromgmouth
	PASSERIFORMES	
1	*Acridotdheres tristis*	Indian myna
2	*A.fuscus lora (Aegithina tiphia)*	Jungle myna
3	*Aethopyga saturata*	Black-throated sunbird
4	*Alcippe nipalensis*	Quaker babbler or Nepal fulvertta
5	*Anthus hodgsoni*	Indian tree pipit
6	*Artamus fuscus*	Greater racketail or ashy wood swallow
7	*Arachnothera longirostra*	Little spiderhunter
8	*A.magna*	Streaked spiderhunter
9	*Brachypteryx leucophrys*	Lesser shortwing
10	*B.cryfical*	Namdapha shortwing
11	*Chloropsis hardwickii*	Orange-bellied leafbird
12	*Corvus macrorhynchos*	Jungle or large-billed crow
13	*Copsychus saularis*	Magpie robin
14	*Criniger flaveolus*	White-tdhroatee bulbul
15	*Dendrocitta frontalis*	Blackbrown or collared treepie
16	*Dicrurus aeneus*	Bronzed drongo
17	*D.paradiseus*	Large rackettailed drongo
18	*Deaecum Cruentatum*	Scarletbacked flowerpecker
19	*Enicurus schistaceus*	Slaty-backed forktail
20	*Garrulax pectoralis*	
21	*G.leucolophus*	Whitecrested laughingthrus
22	*G.Chinensis*	Ogle's laughrush
23	*G.delesserti*	
24	*G.ruficollis*	Rufous-necked laughingthrush
25	*G.subunicolor*	Plain coloured or scaly laughingthrush
26	*G.proeniceus*	Crimson-winged laughingthrush
27	*Gampso rhynchus rufulus*	White-headed shrike lbabbler
28	*Gracula religiosa*	Hill myna
29	*Hypsipetes favalal*	Ashy bulbul
30	*H.madagascariensis*	Black bulbul

S.No.	Scientific Name	Common Name/Local Name
31	*Irena puella*	Fairy bluebird
32	*Lanius tepjphronotus*	Greey-backs shrike
33	*Leiothrix argentauris*	Silvereared mesia
34	*Melanochlora sultanea*	Sultantit
35	*Niltava grandis*	large nitava
36	*N.sundara*	Rufousbellied niltava
37	*Megalurus palustris*	Striated marsh warbler
38	*Myopnonus caeruleus*	Blue whistling thrush
39	*Nepothera brevicaudata*	Streaked wren-babbler
40	*Orthotoremus atrogularis*	Goldenheaded or mountain tailorbird
41	*Oriolus xanthornus*	Black-headed oriole
42	*Parus major*	Great tit
43	*Passer montanus*	Tree sparrow
44	*Pericrocotus flammeus*	Scarlet minivet
45	*Phoenicurrus auroreus*	Daurian reastrat
46	*Phylloscopus cantator*	Yellow-throated leaf warbler
47	*Pnoepyga pusilla*	wren-babbler
48	*Pomatorhinus ferruginosus namdapha*	Corabilled scimitat babbler
49	*Pycnonotos melanicterus*	Black creasted yellow bulbul
50	*P.cafer*	Red-wented bulbul
51	*Mirafra assamica*	Rufous-winged bushlark
52	*Rhipidura albocollis*	White-Throated fantail flycatcher
53	*Macronous gularis*	Yellowbreasted babbler or striped titbabbler
54	*Sturnus malabricus*	Chestnut myna or chestnut-tailestrarling
55	*S.contra*	pied myna
56	*S.nigriceps*	Red-headed 0r Grey throated babbler
57	*Tesia olivea*	Slary-bellied ground warbler
58	*Tephrodonis gularis*	Large wood strike
59	*Turdoides striatus*	Jungle babbler

Table-8.3: List of herpetofauna reported in the Kamlang Wildlife Sanctuary

S.No.	Scientific Name	Common Name/Local Name
	SNAKES (POISONOUS)	
1	*Ophiophagus hannah*	King cobra
2	*Naja naja naja*	Common cobra
3	*Naja naja kaothia*	Monocellate or Bengal cobra
4	*Trimeresurus moticola*	Blotched pit viper
5	*T.popeorum*	Green pit viper
6	*Bangarus niger*	Black Krait
7	*B.candidus*	Common Krait
8	*Bangarus fasciatus*	Banded Krait
	SNAKES (NON-POISONOUS)	
1	*Python molurus bivittatus*	Indian python or Ajgar
2	*P.reticularies*	Malayan or Reticulate or royal python
3	*Typhlops diardi diardi*	Diard's blind snake or worm snake
4	*Elaphe porphyraces porphyraces*	Blackbanded trinket snake
5	*E.prasina lapha*	Green tree racer or trinket snake

S.No.	Scientific Name	Common Name/Local Name
6	*Oligodon cinereus*	White-barred kukri snake
7	*Lycodon jara*	yellow-spectacled wolf snake
8	*Xenochrophis piscator*	Checkered keelback
9	*Amphiesma stolata*	Striped keelback
10	*Trichischium monticola*	Assam oriental worm snake
11	*Rhabdophis himalayana*	Himalayan keelback
12	*Elaphe absoleta*	Rat Snake

The commonly observed mammal species include mammalian species, viz. Serow, Goral, Indian Wild Boar, Barking deer, Clouded leopard, Common leopard, Fishing cat, Jungle cat, Leopard cat, Jackal, Assamese Macaque, Common langur etc.

The common species of snakes observed in Kamlang Wildlife Sanctuary include King cobra, Cobra, Blotched pit viper, Black krait, Indian python, etc.

CHAPTER-9
PREDICTION OF IMPACTS

CHAPTER-9

PREDICTION OF IMAPCTS

9.1 INTRODUCTION

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). For intangible impacts qualitative assessment has been done.

9.2 LENGTH OF RIVER WITH NORMAL FLOW

The biggest impact on hydrologic regime is on account of change in the free flowing condition of the river. With the construction of the proposed hydroelectric projects, the free flowing river shall be available on an intermittent basis only for a length of 10 km in a stretch of 109 km. The details are given in Table-9.1.

Table-9.1: Details of length of free flow of river in the study area

S. No.	Stretch	Distance Km
1	Free flowing stretch from International boundary to submergence of Kalai Stage 1	32
2	Submergence of Kalai Stage 1 HEP	17
3	Free flowing stretch between Kalai stage 1 and Kalai stage 2 HEP	1
4	Submergence of Kalai stage 2 HEP	20
5	Free flowing stretch between Kalai stage 2 and Hutong stage 1 HEP	2
6	Submergence of Hutong stage 1 HEP	3
7	Intervening stretch between Hutong stage 1 and submergence of Hutong stage 2 HEP over which HRT is proposed	4.5
8	Submergence of Hutong stage 2 HEP	12.5
9	Free flowing stretch between Hutong stage 2 and Anjaw Project	1.8
10	Submergence of Anjaw project	4.8
11	Free flowing stretch betweenAnjaw HEP and Demwe Upper HEP	3.8
12	Submergence of Demwe Upper HEP	17
13	Free flowing stretch between Demwe Upper and Demwe Lower HEP	1.8
14	Submergence of Demwe Lower HEP	23
	Total	**144.2**

The river which in the present stage (pre-project scenario) is flowing freely over a stretch of 144.2 km, will get converted into a series of reservoir and free flowing length of the river will be in order of 42.4 km i.e. about 30 % of river stretch. The conversion of free flowing river into reservoirs is likely to have an adverse impact on riverine ecology.

The linear extent of the proposed six hydroelectric projects including reservoir submergence is located over a stretch of 109 km. The details are shown in Figure-9.1.

On tributaries Dav, Dalai and Kamlang are hydroelectric project each is proposed. The distance of confluence of Power House Tail Race Disposal Sites for projects on Dav, Dalai and Kamlong are 4.5 km, 4.0 km and 15.0 km respectively.

On river Tidding, two hydroelectric projects are proposed the distance between confluence are Power House or TRT disposal site of Tidding-II HEP is 2.2 km. The distance between FRL of Tidding-II HEP and TWL of Tidding-I HEP is about 8 km. The details of cascade development of hydroelectric projects on tributaries of Lohit Basin are depicted in Figure-9.2.

The river which in the present stage (pre-project scenario) is flowing freely over a stretch of 109 km, will get converted into a series of reservoir and free flowing stretch of river. Six reservoirs with a total length of about 99 km will be formed. Likewise, free flowing length of the river will be only 9 km spread over five stretches. The conversion of free flowing river into reservoirs will have an adverse impact on riverine ecology.

Normally, under such circumstances, adverse impacts on water quality as well, increases the residence time in the reservoir. As a result, there could be adverse impacts on water quality. In the study area, the pollution loading is virtually negligible, on account of low population density, low cropping intensity with minimal use of agro-chemicals and absence of industrialization in the area. Thus, the pollution loading is low, and as a result no major impacts on reservoir water quality is anticipated.

9.3 MODIFICATION IN HYDROLOGIC REGIME

Out of`7 hydroelectric projects on main river Lohit under review as a part of the present study, 6 hydroelectric projects (except for Hutong hydroelectric project stage-1) have a dam toe power house. All the five hydroelectric projects on tributaries of Lohit Basin have head Race tunnel as water diversion arrangement. The proposed hydroelectric project would require filling up reservoir upto its live storage capacity, which would then be used for peaking power. The discharge for 90% dependable year for hydroelectric projects on main river Lohit and projects on tributaries of Lohit river are given in Tables-9.2 and 9.3 respectively. The number of hours of peaking operation for various hydroelectric projects on river Lohit and its tributaries is given in Tables-9.4 to 9.15.

Table-9.2: 90% Dependable Year for HEPS on main river Lohit (unit: cumec)

Month		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Anjaw HEP	Demwe Lower HEP
June	I	2123.64	1184.76	1192.87	1224.88	1072	696	1126
	II	1909.37	1225.83	1233.91	1267	1578	805	1657
	III	1634.58	1445.66	1455.55	1494.59	1737	788	1824
July	I	1152.46	2123.64	2138.15	2195.51	2142	809	2249
	II	1121.49	1909.37	1922.42	1973.99	1277	1157	1341
	III	1018.76	1634.58	1645.75	1689.9	918	1238	964
August	I	747.84	1152.46	1160.34	1191.46	745	877	783
	II	652.71	1121.49	1129.17	1159.45	688	879	723
	III	632.43	1018.76	1025.83	1053.24	726	579	762
September	I	529.76	747.84	752.96	773.15	727	484	764
	II	468.63	652.71	657.18	674,81	697	444	732
	III	374.37	632.43	636.76	653.84	601	1022	631
October	I	355.66	529.76	533.39	547.69	556	765	584
	II	305.17	468.63	471.73	484.38	527	431	553
	III	291.13	374.37	376.93	387.04	493	394	517
November	I	420.44	355.66	358.09	367.7	439	403	461
	II	385.85	305.17	307.26	315.5	418	375	438
	III	392.06	291.13	293.12	300.98	398	346	418
December	I	267.68	420.44	423.31	434.67	382	332	401
	II	276.7	385.85	388.49	398.91	365	320	383
	III	225.72	392.06	397.74	405.33	351	305	368
January	I	218.38	267.68	269.5	276.73	341	291	358
	II	224.47	276.7	278.58	286.06	340	271	357
	III	302.18	225.72	227.26	233.36	341	283	358
February	I	169.7	218.38	219.88	225.77	315	288	330
	II	199.42	224.47	226.01	232.06	310	290	325
	III	220.3	302.18	304.24	312.4	320	292	336
March	I	471.07	169.7	170.86	175.44	353	284	371
	II	568.77	199.42	200.78	206.16	314	321	330
	III	608.81	220.3	221.81	227.75	603	312	634
April	I	710.9	471.07	474.29	487.01	600	360	630
	II	800.15	568.77	572.66	588.02	819	376	860
	III	814.92	608.81	612.98	629.42	951	388	998
May	I	1184.76	710.9	715.77	734.96	780	506	820
	II	1225.83	800.15	805.53	837.24	740	773	777
	III	1445.66	814.92	820.5	842.51	852	797	895

Table-9.3: Discharge for 90% dependable year for various Hydro-electric Projects on tributaries of river Lohit (unit : cumec)

Month		Gmiliang HEP	Raigam HEP	Tidding-I HEP	Tidding-II HEP	Kamalang HEP
May	I	17.55	78.45	36.29	29.06	125
	II	24.72	110.23	51.12	40.93	95
	III	25.36	113.10	52.44	41.99	322
June	I	21.85	98.17	45.18	36.18	290
	II	24.74	111.02	51 16	40.96	165
	III	24.32	109.16	50.29	40.27	195
July	I	26.56	119.21	54.92	43.98	107
	II	35.9	160.63	74.24	59.44	135
	III	38.07	170.26	78.73	63.04	117
August	I	26.36	118.40	54.51	43.65	172
	II	26.4	118.57	54.59	43.71	86
	III	18.36	82.91	37.97	30.40	79
Septembei	I	16.23	73.10	33.56	26.87	84
	II	15.16	68.36	31.35	25.10	43
	III	30.64	136.99	63.36	50.73	41
October	I	24.48	109.08	50.62	40.53	36
	II	15.53	69.35	32.12	25.71	28
	III	14.54	64.96	30.07	24.08	25
November	I	11.82	52.4	24.44	19.57	21
	II	11.02	48.85	22.79	18.25	18
	III	10.14	44.96	20.97	16.79	16
December	I	9.72	43.1	20.10	16.09	15
	II	9.38	41.58	19.40	15.53	13
	III	8.92	39.55	18.45	14.77	15
January	I	8.54	37.86	17.66	14.14	13
	II	7.93	35.16	16.40	13.13	12
	III	8.27	36.68	17 10	13.69	24
February	I	8.42	37.35	17.41	13.94	22
	II	8.5	37.69	17.58	14.07	23
	III	8.54	37.86	17.66	14.14	24
March	I	8.31	36.87	17 18	13.76	61
	II	9.41	41.78	19.46	15.58	45
	III	9.11	40.42	18.84	15.08	82
April	I	10.5	46.83	21.71	17.39	45
	II	11.00	49.03	22.75	18.21	43
	III	11.34	50.55	23.45	18.78	37

Note: Discharge data for Kamlang HEP is for 75% Dependable Year

Table-9.4: Number of hours of peaking available in 90% dependable year for Kalai HEP, stage-1

Month		Discharge in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	I	2123.64	1033	23.29
	II	1909.37	1033	23.78
	III	1634.58	1033	18.15
July	I	1152.46	1033	19.03
	II	1121.49	1033	18.98
	III	1018.76	1033	14.32
August	I	747.84	1033	12.86
	II	652.71	1033	12.24
	III	632.43	1033	21.22
September	I	529.76	1033	14.46
	II	468.63	1033	9.27
	III	374.37	1033	8.69
October	I	355.66	1033	8.03
	II	305.17	1033	7.34
	III	291.13	1033	6.62
November	I	420.44	1033	6.25
	II	385.85	1033	5.95
	III	392.06	1033	5.59
December	I	267.68	1033	5.24
	II	276.7	1033	4.72
	III	225.72	1033	5.04
January	I	218.38	1033	5.15
	II	224.47	1033	5.22
	III	302.18	1033	5.26
February	I	169.7	1033	5.06
	II	199.42	1033	5.99
	III	220.3	1033	5.74
March	I	471.07	1033	9.75
	II	568.77	1033	10.36
	III	608.81	1033	10.44
April	I	710.9	1033	13.24
	II	800.15	1033	17.39
	III	814.92	1033	17.77
May	I	1184.76	1033	16.15
	II	1225.83	1033	17.83
	III	1445.66	1033	17.57

Table-9.5: Number of hours of peaking available in 90% dependable year for Kalai HEP, stage-2

Month		Discharge in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	I	1184.76	1112.27	24.0
	II	1225.83	1112.27	24.0
	III	1445.66	1112.27	24.0
July	I	2123.64	1112.27	24.0
	II	1909.37	1112.27	24.0
	III	1634.58	1112.27	24.0
August	I	1152.46	1112.27	24.0
	II	1121.49	1112.27	24.0
	III	1018.76	1112.27	22.0
September	I	747.84	1112.27	16.1
	II	652.71	1112.27	14.1
	III	632.43	1112.27	13.6
October	I	529.76	1112.27	11.4
	II	468.63	1112.27	10.1
	III	374.37	1112.27	8.1
November	I	355.66	1112.27	7.7
	II	305.17	1112.27	6.6
	III	291.13	1112.27	6.3
December	I	420.44	1112.27	9.1
	II	385.85	1112.27	8.3
	III	392.06	1112.27	8.5
January	I	267.68	1112.27	5.8
	II	276.7	1112.27	6.0
	III	225.72	1112.27	4.9
February	I	218.38	1112.27	4.7
	II	224.47	1112.27	4.8
	III	302.18	1112.27	6.5
March	I	169.7	1112.27	3.7
	II	199.42	1112.27	4.3
	III	220.3	1112.27	4.8
April	I	471.07	1112.27	10.2
	II	568.77	1112.27	12.3
	III	608.81	1112.27	13.1
May	I	710.9	1112.27	15.3
	II	800.15	1112.27	17.3
	III	814.92	1112.27	17.6

Table--9.6: Number of hours of peaking available in 90% dependable year for Hutong HEP, stage-1

Month		Discharge in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	I	1192.87	1423.02	20.1
	II	1233.91	1423.02	20.8
	III	1455.55	1423.02	24.0
July	I	2138.15	1423.02	24.0
	II	1922.42	1423.02	24.0
	III	1645.75	1423.02	24.0
August	I	1160.34	1423.02	19.6
	II	1129.17	1423.02	19.0
	III	1025.83	1423.02	17.3
September	I	752.96	1423.02	12.7
	II	657.18	1423.02	11.1
	III	636.76	1423.02	10.7
October	I	533.39	1423.02	9.0
	II	471.73	1423.02	8.0
	III	376.93	1423.02	6.4
November	I	358.09	1423.02	6.0
	II	307.26	1423.02	5.2
	III	293.12	1423.02	4.9
December	I	423.31	1423.02	7.1
	II	388.49	1423.02	6.6
	III	397.74	1423.02	6.7
January	I	269.5	1423.02	4.5
	II	278.58	1423.02	4.7
	III	227.26	1423.02	3.8
February	I	219.88	1423.02	3.7
	II	226.01	1423.02	3.8
	III	304.24	1423.02	5.1
March	I	170.86	1423.02	2.9
	II	200.78	1423.02	3.4
	III	221.81	1423.02	3.7
April	I	474.29	1423.02	8.0
	II	572.66	1423.02	9.7
	III	612.98	1423.02	10.3
May	I	715.77	1423.02	12.1
	II	805.53	1423.02	13.6
	III	820.5	1423.02	13.8

Table-9.7: Number of hours of peaking available in 90% dependable year for Hutong HEP, stage-2

Month		Discharge in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	I	1224.88	1423.02	20.7
	II	1267	1423.02	21.4
	III	1494.59	1423.02	24.0
July	I	2195.51	1423.02	24.0
	II	1973.99	1423.02	24.0
	III	1689.9	1423.02	24.0
August	I	1191.46	1423.02	20.1
	II	1159.45	1423.02	19.6
	III	1053.24	1423.02	17.8
September	I	773.15	1423.02	13.0
	II	674.81	1423.02	11.4
	III	653.84	1423.02	11.0
October	I	547.69	1423.02	9.2
	II	484.38	1423.02	8.2
	III	387.04	1423.02	6.5
November	I	367.7	1423.02	6.2
	II	315.5	1423.02	5.3
	III	300.98	1423.02	5.1
December	I	434.67	1423.02	7.3
	II	398.91	1423.02	6.7
	III	405.33	1423.02	6.8
January	I	276.73	1423.02	4.7
	II	286.06	1423.02	4.8
	III	233.36	1423.02	3.9
February	I	225.77	1423.02	3.8
	II	232.06	1423.02	3.9
	III	312.4	1423.02	5.3
March	I	175.44	1423.02	3.0
	II	206.16	1423.02	3.5
	III	227.75	1423.02	3.8
April	I	487.01	1423.02	8.2
	II	588.02	1423.02	9.9
	III	629.42	1423.02	10.6
May	I	734.96	1423.02	12.4
	II	837.24	1423.02	14.1
	III	842.51	1423.02	14.2

Table-9.8: Number of hours of peaking available in 90% dependable year for Anjaw HEP

.Month		Discharge in 90% Dependable year (cumec)	Discharge (cumec)	Time available for peaking power (hrs.)
June	I	696	1141.15	14.6
	II	805	1141.15	16.9
	III	788	1141.15	16.6
July	I	809	1141.15	17.0
	II	1157	1141.15	24.3
	III	1238	1141.15	26.0
August	I	877	1141.15	18.4
	II	879	1141.15	18.5
	III	579	1141.15	12.2
September	I	484	1141.15	10.2
	II	444	1141.15	9.3
	III	1022	1141.15	21.5
October	I	765	1141.15	16.1
	II	431	1141.15	9.1
	III	394	1141.15	8.3
November	I	403	1141.15	8.5
	II	375	1141.15	7.9
	III	346	1141.15	7.3
December	I	332	1141.15	7.0
	II	320	1141.15	6.7
	III	305	1141.15	6.4
January	I	291	1141.15	6.1
	II	271	1141.15	5.7
	III	283	1141.15	6.0
February	I	288	1141.15	6.1
	II	290	1141.15	6.1
	III	292	1141.15	6.1
March	I	284	1141.15	6.0
	II	321	1141.15	6.8
	III	312	1141.15	6.6
April	I	360	1141.15	7.6
	II	376	1141.15	7.9
	III	388	1141.15	8.2
May	I	506	1141.15	10.6
	II	773	1141.15	16.3
	III	797	1141.15	16.8

Table-9.9: Number of hours of peaking available in 90% dependable year for Demwe Upper HEP

Month		Discharge in 90% Dependable year (cumec)	Rated discharge (cumec)	Time available for peaking power (hrs.)
June	I	1072	1513	17.0
	II	1578	1513	24.0
	III	1737	1513	24.0
July	I	2142	1513	24.0
	II	1277	1513	20.3
	III	918	1513	14.6
August	I	745	1513	11.8
	II	688	1513	10.9
	III	726	1513	11.5
September	I	727	1513	11.5
	II	697	1513	11.1
	III	601	1513	9.5
October	I	556	1513	8.8
	II	527	1513	8.4
	III	493	1513	7.8
November	I	439	1513	7.0
	II	418	1513	6.6
	III	398	1513	6.3
December	I	382	1513	6.1
	II	365	1513	5.8
	III	351	1513	5.6
January	I	341	1513	5.4
	II	340	1513	5.4
	III	341	1513	5.4
February	I	315	1513	5.0
	II	310	1513	4.9
	III	320	1513	5.1
March	I	353	1513	5.6
	II	314	1513	5.0
	III	603	1513	9.6
April	I	600	1513	9.5
	II	819	1513	13.0
	III	951	1513	15.1
May	I	780	1513	12.4
	II	740	1513	11.7
	III	852	1513	13.5

Table-9.10: Number of hours of peaking available in 90% dependable year for Demwe Lower HEP

.Month		Discharge in 90% Dependable year (cumec)	Discharge (cumec)	Time available for peaking power (hrs.)
June	I	1126	2085	13.0
	II	1657	2085	19.1
	III	1824	2085	21.0
July	I	2249	2085	24.0
	II	1341	2085	15.4
	III	964	2085	11.1
August	I	783	2085	9.0
	II	723	2085	8.3
	III	762	2085	8.8
September	I	764	2085	8.8
	II	732	2085	8.4
	III	631	2085	7.3
October	I	584	1729	8.1
	II	553	1729	7.7
	III	517	1729	7.2
November	I	461	1729	6.4
	II	438	1729	6.1
	III	418	1729	5.8
December	I	401	1729	5.6
	II	383	1729	5.3
	III	368	1729	5.1
January	I	358	1729	5.0
	II	357	1729	5.0
	III	358	1729	5.0
February	I	330	1729	4.6
	II	325	1729	4.5
	III	336	1729	4.7
March	I	371	1729	5.2
	II	330	1729	4.6
	III	634	1729	8.8
April	I	630	1729	8.7
	II	860	1729	11.9
	III	998	1729	13.9
May	I	820	1729	11.4
	II	777	1729	10.8
	III	895	1729	12.4

Note: As directed by CEA, Demwe Lower HEP will operate on MDDL during monsoon season (June to September) and for other season the project will operate at FRL i.e. during monsoon season project will operate at rated discharge of 2085 cumec whereas for other season it will operate at design discharge of 1729 cumec

Table-9.11: Number of hours of peaking available in 90% dependable year for Gmiliang HEP

Month		Discharge in 90% Dependable year (cumec)	Rated discharged (cumec)	Time available for peaking power (hrs.)
June	I	21.85	28.17	18.62
	II	24.74	28.17	21.08
	III	24.32	28.17	20.72
July	I	26.56	28.17	22.63
	II	35.9	28.17	24.00
	III	38.07	28.17	24.00
August	I	26.36	28.17	22.46
	II	26.4	28.17	22.49
	III	18.36	28.17	15.64
September	I	16.23	28.17	13.83
	II	15.16	28.17	12.92
	III	30.64	28.17	26.10
October	I	24.48	28.17	20.86
	II	15.53	28.17	13.23
	III	14.54	28.17	12.39
November	I	11.82	28.17	10.07
	II	11.02	28.17	9.39
	III	10.14	28.17	8.64
December	I	9.72	28.17	8.28
	II	9.38	28.17	7.99
	III	8.92	28.17	7.60
January	I	8.54	28.17	7.28
	II	7.93	28.17	6.76
	III	8.27	28.17	7.05
February	I	8.42	28.17	7.17
	II	8.5	28.17	7.24
	III	8.54	28.17	7.28
March	I	8.31	28.17	7.08
	II	9.41	28.17	8.02
	III	9.11	28.17	7.76
April	I	10.5	28.17	8.95
	II	11.00	28.17	9.37
	III	11.34	28.17	9.66
May	I	17.55	28.17	14.95
	II	24.72	28.17	21.06
	III	25.36	28.17	21.61

Table-9.12: Number of hours of peaking available in 90% dependable year for Raigam HEP

Month		Discharge in 90% Dependable year (cumec)	Rated discharged (cumec)	Time available for peaking power (hrs.)
June	I	98.17	123.43	19.1
	II	111.02	123.43	21.6
	III	109.16	123.43	21.2
July	I	119.21	123.43	23.2
	II	160.63	123.43	24.0
	III	170.26	123.43	24.0
August	I	118.40	123.43	23.0
	II	118.57	123.43	23.1
	III	82.91	123.43	16.1
September	I	73.10	123.43	14.2
	II	68.36	123.43	13.3
	III	136.99	123.43	24.0
October	I	109.08	123.43	21.2
	II	69.35	123.43	13.5
	III	64.96	123.43	12.6
November	I	52.4	123.43	10.2
	II	48.85	123.43	9.5
	III	44.96	123.43	8.7
December	I	43.1	123.43	8.4
	II	41.58	123.43	8.1
	III	39.55	123.43	7.7
January	I	37.86	123.43	7.4
	II	35.16	123.43	6.8
	III	36.68	123.43	7.1
February	I	37.35	123.43	7.3
	II	37.69	123.43	7.3
	III	37.86	123.43	7.4
March	I	36.87	123.43	7.2
	II	41.78	123.43	8.1
	III	40.42	123.43	7.9
April	I	10.5	123.43	2.0
	II	11.00	123.43	2.1
	III	11.34	123.43	2.2
May	I	78.45	123.43	15.3
	II	110.23	123.43	21.4
	III	113.10	123.43	22.0

Table-9.13: Number of hours of peaking available in 90% dependable year for Tidding-I HEP

Month		Discharge in 90% Dependable year (cumec)	Rated discharged (cumec)	Time available for peaking power (hrs.)
June	I	45.18	55.90	19.40
	II	51 16	55.90	21.96
	III	50.29	55.90	21.59
July	I	54.92	55.90	23.58
	II	74.24	55.90	24.00
	III	78.73	55.90	24.00
August	I	54.51	55.90	23.40
	II	54.59	55.90	23.44
	III	37.97	55.90	16.30
September	I	33.56	55.90	14.41
	II	31.35	55.90	13.46
	III	63.36	55.90	24.00
October	I	50.62	55.90	21.73
	II	32.12	55.90	13.79
	III	30.07	55.90	12.91
November	I	24.44	55.90	10.49
	II	22.79	55.90	9.78
	III	20.97	55.90	9.00
December	I	20.10	55.90	8.63
	II	19.40	55.90	8.33
	III	18.45	55.90	7.92
January	I	17.66	55.90	7.58
	II	16.40	55.90	7.04
	III	17 10	55.90	7.34
February	I	17.41	55.90	7.47
	II	17.58	55.90	7.55
	III	17.66	55.90	7.58
March	I	17 18	55.90	7.38
	II	19.46	55.90	8.35
	III	18.84	55.90	8.09
April	I	21.71	55.90	9.32
	II	22.75	55.90	9.77
	III	23.45	55.90	10.07
May	I	36.29	55.90	15.58
	II	51.12	55.90	21.95
	III	52.44	55.90	22.51

Table-9.14: Number of hours of peaking available in 90% dependable year for Tidding-II HEP

Month		Discharge in 90% Dependable year (cumec)	Rated discharged (cumec)	Time available for peaking power (hrs.)
June	I	36.18	46.16	18.81
	II	40.96	46.16	21.30
	III	40.27	46.16	20.94
July	I	43.98	46.16	22.87
	II	59.44	46.16	24.00
	III	63.04	46.16	24.00
August	I	43.65	46.16	22.69
	II	43.71	46.16	22.73
	III	30.40	46.16	15.81
September	I	26.87	46.16	13.97
	II	25.10	46.16	13.05
	III	50.73	46.16	24.00
October	I	40.53	46.16	21.07
	II	25.71	46.16	13.37
	III	24.08	46.16	12.52
November	I	19.57	46.16	10.18
	II	18.25	46.16	9.49
	III	16.79	46.16	8.73
December	I	16.09	46.16	8.37
	II	15.53	46.16	8.07
	III	14.77	46.16	7.68
January	I	14.14	46.16	7.35
	II	13.13	46.16	6.83
	III	13.69	46.16	7.12
February	I	13.94	46.16	7.25
	II	14.07	46.16	7.32
	III	14.14	46.16	7.35
March	I	13.76	46.16	7.15
	II	15.58	46.16	8.10
	III	15.08	46.16	7.84
April	I	17.39	46.16	9.04
	II	18.21	46.16	9.47
	III	18.78	46.16	9.76
May	I	29.06	46.16	15.11
	II	40.93	46.16	21.28
	III	41.99	46.16	21.83

Table-9.15: Number of hours of peaking available in 75% dependable year for Kamlang HEP

Month		Discharge in 90% Dependable year (cumec)	Rated discharged (cumec)	Time available for peaking power (hrs.)
June	I	290	85.06	24.00
	II	165	85.06	24.00
	III	195	85.06	24.00
July	I	107	85.06	24.00
	II	135	85.06	24.00
	III	117	85.06	24.00
August	I	172	85.06	24.00
	II	86	85.06	24.00
	III	79	85.06	22.29
September	I	84	85.06	23.70
	II	43	85.06	12.13
	III	41	85.06	11.57
October	I	36	85.06	10.16
	II	28	85.06	7.90
	III	25	85.06	7.05
November	I	21	85.06	5.93
	II	18	85.06	5.08
	III	16	85.06	4.51
December	I	15	85.06	4.23
	II	13	85.06	3.67
	III	15	85.06	4.23
January	I	13	85.06	3.67
	II	12	85.06	3.39
	III	24	85.06	6.77
February	I	22	85.06	6.21
	II	23	85.06	6.49
	III	24	85.06	6.77
March	I	61	85.06	17.21
	II	45	85.06	12.70
	III	82	85.06	23.14
April	I	45	85.06	12.70
	II	43	85.06	12.13
	III	37	85.06	10.44
May	I	125	85.06	24.00
	II	95	85.06	24.00
	III	322	85.06	24.00

Kalai hydroelectric Project Stage-1

It can be seen from Table-9.4 that number of hours for which peaking power will be available, in 90% dependable year shall range from 12.2 to 23.8 hours in the monsoon season from May to September. In the months of October and April, peaking will be available for a period of 8.7 to 14.5 hours and 9.8 to 10.4 hours respectively.

In lean season, from November to March peaking will be available for a period of 4.7 to 8.0 hours in 90% dependable year. It can be observed that in lean season, river water will be stored for a period of 16 to 19 hours. As a result, downstream stretch of river from the dam site will be remain dry for a period of 16 to 19 hours, which will be followed by a continuous flow equal to rated discharge of 1033 cumec for a period of 5 to 8 hours.

Kalai hydroelectric Project Stage-2

In Kalai hydroelectric project stage-2, peaking power will be available for a period of 13.6 hours to 24 hours for 90% dependable year in monsoon season. In the months of October and April, peaking power is available for a period of 8.1 to 13.1 hours. In lean season, peaking power is available for a period of 3.7 to 9.1 hours in 90% dependable year. Thus, in lean season river water will be stored for a period of 15 to 20 hours. As a result, downstream stretch of river from the dam site will remain dry for a period of 15 to 20 hours. This will be followed by a continuous flow of 1112.27 cumec (rated discharge) for a period of 4 to 9 hours. The details are given in Table-9.5.

Hutong Hydroelectric Project Stage-1

As per the details given in Table-9.6, peaking power will be available for a period of 10.7 to 24 hours for 90% dependable year in monsoon season. In lean season, peaking power will be available for a period of 2.9 to 7.1 hours. Thus, in lean season, river water will be stored in the reservoir for a period of 17 to 21 hours. As a result, river will remain dry for the corresponding period downstream of dam site. This will be followed by a continuous discharge of 1423 cumec (rated discharge) for a period of 3 to 7 hours.

Hutong Hydroelectric Project Stage-2

The details of number of hours of availability of peaking power available in 90% dependable year in monsoon season for Hutong Hydroelectric Project, stage-2 shall range from 11 to 24 hours. In lean season, the number of hours for which peaking power will be available shall range from 3 to 7.3 hours. Thus, river water will be stored for a period of 17 to 21 hours, resulting in drying of river Lohit downstream of dam site. This will be following by a continuous discharge of 1423 cumec for a period of 3 to7 hours. The details are given in Table-9.7.

Anjaw Hydroelectric Project

The number of hours of availability of peaking power for Demwe Upper hydroelectric project in 90% dependable year is expected to be 14.6 to 21.5 hours in monsoon season. On the other hand, peaking power will be available for 5.7 to 6.8 hours in lean season. Thus, river flow will be used to fill up the reservoir in lean season for 17 to 18 hours. Thus, river will remain dry for this period in lean season. This will be followed by a continuous discharge of 1141.15 cumec of about 6 to 7 hours. The details are given in Table-9.8.

Demwe Upper Hydroelectric Project

The number of hours of availability of peaking power for Demwe Upper hydroelectric project in 90% dependable year is expected to be 9.5 to 24 hours in monsoon season. On the other hand, peaking power will be available for 4.9 to 9.6 hours in lean season. Thus, river flow will be used to fill up the reservoir in lean season for 14 to 19 hours. Thus, river will remain dry for this period in lean season. This will be followed by a continuous discharge of 1513 cumec of about 5 to 10 hours. The details are given in Table-9.9.

Demwe Lower Hydroelectric Project

The details of number of hours of availability of peaking power for Demwe Lower hydroelectric project are given in Table-9.10. The number of peaking power availability in monsoon and lean season shall be 7.3 to 24 hours and 4.5 to 13.9 hours respectively. As a result in lean season the river will remain dry for a period of 10 to 19 hours followed by 5 to 14 hours of design discharge (1729 cumec).

Gmiliang Hydroelectric Project

The details of number of hours of availability of peaking power for Gimiliang hydroelectric project are given in Table-9.11. The number of peaking power availability in monsoon and lean season shall be 14.95 to 24 hours and 6.76 to 8.02 hours respectively. As a result in lean season the river will remain dry for a period of 7 to 8 hours followed by 17 to 18 hours of design discharge (28.17 cumec).

Raigam Hydroelectric Project

The details of number of hours of availability of peaking power for Raigam hydroelectric project are given in Table-9.12. The number of peaking power availability in monsoon and lean season shall be 13.3 to 24 hours and 2.0 to 8.1 hours respectively. As a result in lean season the river will remain dry for a period of 2.0 to 8 hours followed by 22 to 16 hours of design discharge (123.43 cumec).

Tidding-I Hydroelectric Project

The details of number of hours of availability of peaking power for Tidding-I hydroelectric project are given in Table-9.13. The number of peaking power availability in monsoon and lean season shall be 13.46 to 24 hours and 7.04 to 8.63 hours respectively. As a result in lean season, river will remain dry for a period of 7 to 9 hours followed by 15 to 17 hours of design discharge (55.90 cumec).

Tiding-II Hydroelectric Project

The details of number of hours of availability of peaking power for Tidding-II Lower hydroelectric project are given in Table-9.14. The number of peaking power availability in monsoon and lean season shall be 13.05 to 24 hours and 6.83 to 8.37 hours respectively. As a result in lean season the river will remain dry for a period of 7 to 8 hours followed by 16 to 17 hours of design discharge (46.16 cumec).

Kamlang Hydroelectric Project

The details of number of hours of availability of peaking power for Kamlang hydroelectric project are given in Table-9.15. The number of peaking power availability in monsoon and lean season shall be 11.57 to 24 hours and 3.39 to 6.77 hours respectively. As a result in lean season the river will remain dry for a period of 3 to 7 hours followed by 17 to 21 hours of design discharge (1729 cumec).

9.4 IMPACTS DUE TO PEAKING POWER OPERATIONS ON DIBRU SAI KHOWA NATIONAL PARK

As a part of Environmental Clearance of Dibang Multi-purpose project, impacts on Dibru Saikhowa National Park due to combine peaking power operations of Dibang, Siang Lower and Demwe Lower hydroelectric projects was studied.

The Dibru-Saikhowa National Park is situated on the Left Bank of the river Brahmaputra in the extreme east of Assam and falls between the following geographical coordinates: Latitudes: 27° 30' – 27° 45'N, Longitudes: 95°10' – 95° 45'E. Brahmaputra River is mainly formed by confluence of three rivers namely Siang River, Dibang River and Lohit River. Series of hydropower projects are proposed on these three tributaries of Brahmaputra River upstream of confluence point out of which the three large projects located closest to it are, Demwe Lower HEP (1750 MW) on Lohit River, Dibang Multipurpose HEP (3000 MW) on Dibang River and Lower Siang HEP (2700 MW) on Siang River.

During the lean season months, i.e. from November to February, when the river discharges have considerably reduced, these projects operate at their installed capacities during peaking hours of the day (which may vary from duration of 3 hours to 6.5 hours depending upon the water availability). This essentially means that these projects will release only environmental flows during the non-peaking hours (non-peaking hours could varies from 17.5 to 21 hours every day) and in turn conserve the river discharges in its reservoir so as to supply peaking power by generating at their installed capacities during the remaining 3 hours to 6.5 hours in a day. It is thus apprehended by many that during peaking hours of the day, water flow below the downstream of each of these dams will vary on a daily basis and this will cause artificial floods during those 3 hours when these plants are in the peaking mode.

A model study was conducted by DHI to assess the impacts on seasonal flows to peaking power operations. The study has been done using MIKE 11 model.

The purpose of this model study is to simulate this situation and based on available data for these 3 projects simulate the hydraulic conditions to quantify the flows and stage during the lean months. The effect on the hydraulic conditions is to be studied particularly at one site on the Brahamputra river near the Dibru-Saikhowa National park which is a place of importance from the point of view of natural habitat of many species. Dibru-Saikhowa is actually a riverine island having rich bio-diversity. The details of the study are given in Annexure-XII. The key findings of the study are given in following sections.

9.4.1 River channel alignments and cross-sections

Before the year 1998, the flow scenario of Lohit, Dibang and Siang was different as compared to present day. Before year 1998, Lohit River used to meet with Dibang River and then the combined flow of Lohit and Dibang River used to meet with Siang River before Dibru Saikhowa National Park. But from the year 1998 to 2003, the transition of flow path has occurred in Lohit River and as consequence to this the flow path of Lohit has changed. From the year 2003 Dibang river directly meets with Siang River on the northern boundary and before DibruSaikhowa National Park while Lohit River flows along the Southern boundary of DibruSaikhowa National Park and then after passing along the southern boundary of DibruSaikhowa National Park, flow of Lohit River meets with the combined flow of Siang and Dibang River i.e. Brahmaputra River. The two scenarios i.e. Flow scenario before 1998 and after 2003 are given in Figures-9.1 and 9.2 respectively.

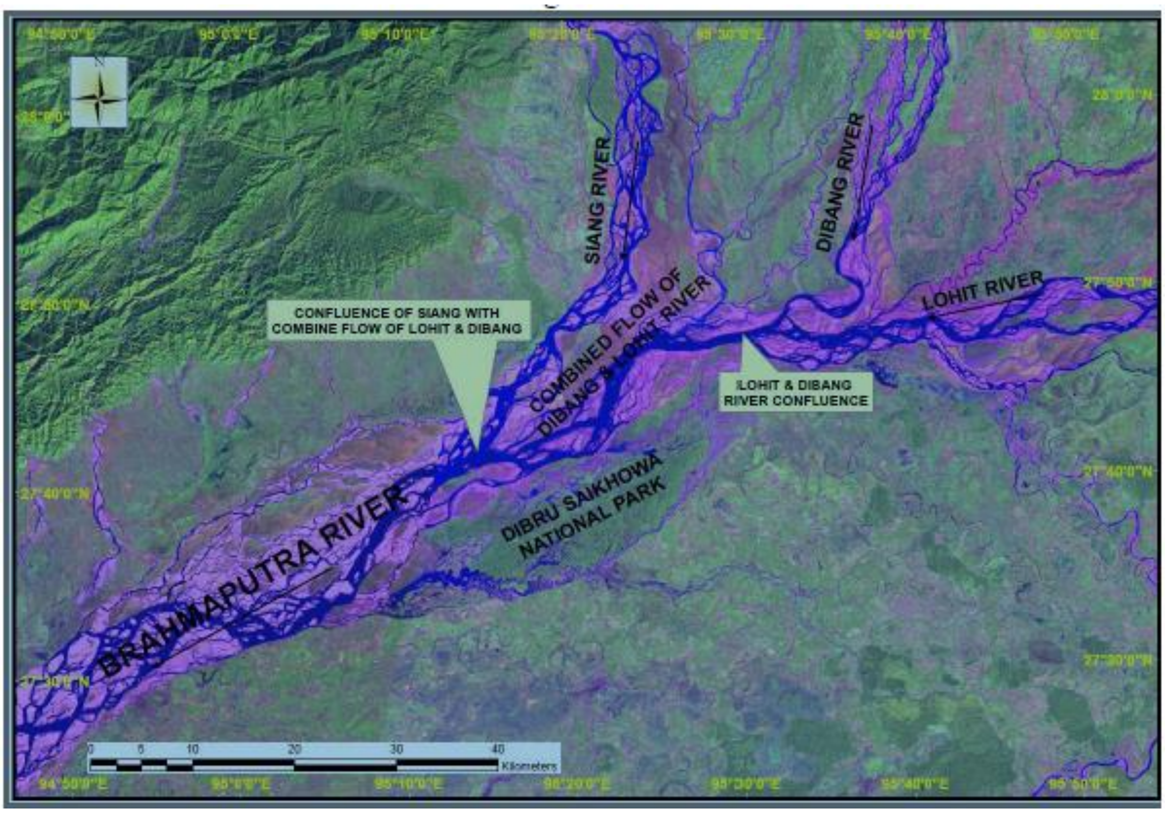


Figure -9.1: Flow scenario on Brahmaputra River before 1998

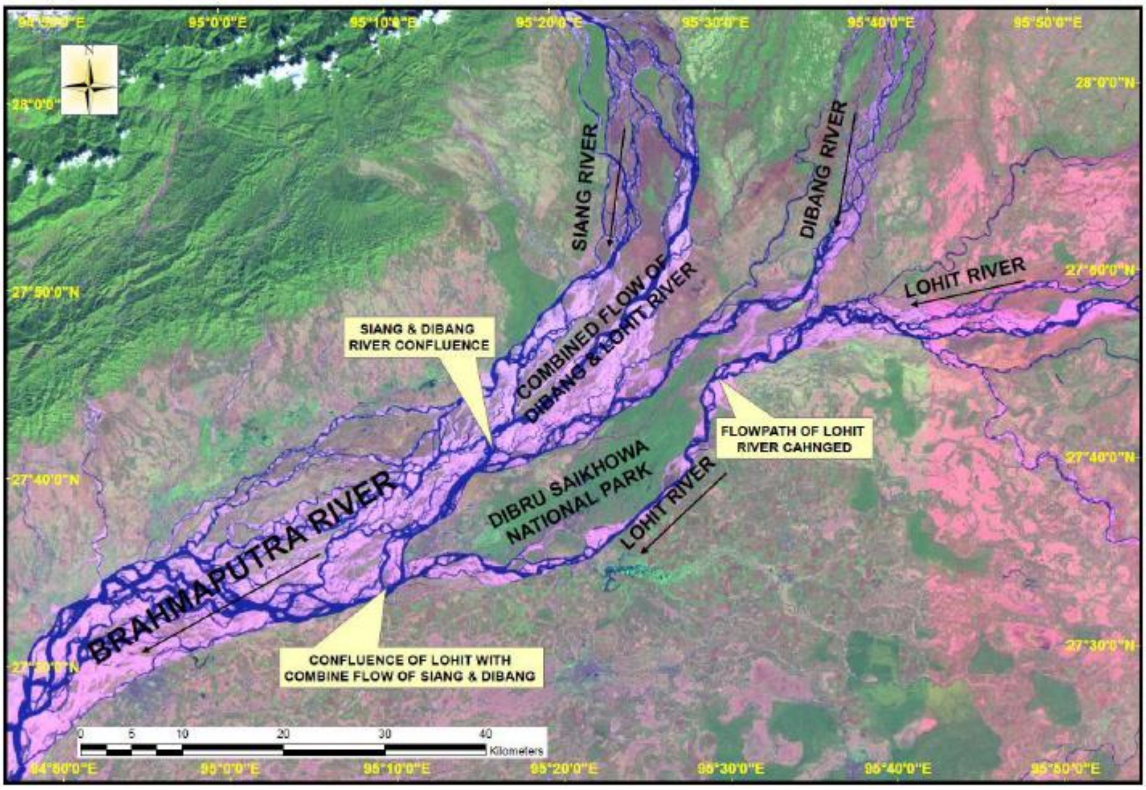


Figure-9.2: Flow scenario on Brahmaputra River after 2003

9.4.2 Flow data

The river discharge data in the lean season is controlled by the reservoirs with environmental flow outside the power production period and maximum capacity flow during the power production.

9.4.3 Scenarios

A MIKE11 model is set up for two different scenarios. The model is combined of all three rivers (Dibang, Lohit and Siang). For each scenario five different cases are simulated and the same are listed as below:

- When only Demwe Lower is constructed and is doing peaking for 3 hours in a day while Dibang and Siang are flowing in their natural regimes.
- When only Lower Siang is constructed and is doing peaking for 3 hours in a day while Lohit and Dibang are flowing in their natural regimes.
- When only Dibang is constructed and is doing peaking for 3 hours in a day while Lohit and Siang are flowing in their natural regimes.
- All three projects are constructed and are peaking for 3 hours.
- No Project scenario.

9.4.4 Discharge Data

For normal flow condition constant discharge as listed in Table-9.16 was used. The monthly River flows for the average year for each of the three projects at their respective dam sites are as tabulated below. As the time period of concern is the non-monsoon period, the discharge corresponding to January is used.

Table-9.16: Monthly averaged normal flow for the three projects

S. No.	Month	Discharge of Siang River at Lower Siang dam site (cumec)	Discharge of Lohit River at Demwe Lower dam site (cumec)	Discharge of Dibang River at Dibang dam site (cumec)
1	June	3408.37	831.00	1548.6
2	July	6327.50	1536.33	603.2
3	Aug	8870.13	1519.33	1111.5
4	Sep	7473.13	756.00	484.1
5	Oct	6769.60	709.33	799.6
6	Nov	4064.73	551.67	462.7
7	Dec	1936.30	439.67	310.4
8	Jan	1285.17	384.00	352
9	Feb	1020.80	358.00	384.5
10	Mar	1004.13	330.67	502.4
11	Apr	1283.93	445.00	817.2
12	May	2039.70	830.00	838.5

The design discharge (flow release) during full power production at the three dams is given in Table-9.17.

Table-9.17: Design discharge (release flow) for the three projects

Dam	**Discharge (cumec) of Siang River at Lower Siang dam site**	**Discharge (cumec) of Lohit River at Demwe Lower dam site**	**Discharge (cumec) of Dibang River at Dibang dam site**
Design discharge	5440	1729	1431.61

9.4.5 Results and Discussions

The model wais run for five different cases and was simulated for six days. There is no data to calibrate the model. Thus, sensitivity analysis is done with different values of manning's n. Three River cross sections at Dibru-Saikowa have been considered to study the impact of the flow variations. These sections are named Dibru-saikowa cross section -I, Dibrusaikowa cross section -II and Dibru-Saikowacross section -III. These cross-sections are of Brahamputra River and Lohit River. From the cross sections of Brahamputra at Dibru-Saikowa it is seen that the riverine islands are fairly stable and the lowest elevations of the Dibru-Saikowa Park at these 3 sections are at the following elevations are given in Table-9.18.

Table-9.18: Minimum elevations at three sites

Name of Section	**Dibru -Saikowa Cross section no -I**	**Dibru -Saikowa Cross section no -II**	**Dibru -Saikowa Cross section no -III**
Lowest Brahamputra River Elevation (rnasl)	112.09	108.00	107.89
Lowest Lohit River Elevation (masl)	116.13	114.00	111.25
Lowest Bank elevation; Lowest Elevation of the Park (masl)	125.70	117.30	115.50

9.4.6 Summary for the Present Case scenario

Water level and discharge for all five cases with different Manning's n is presented in Table-9.19.

Table-9.19: Simulated water levels and discharges at the three sites assuming river alignment based on the present case

Present											
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**			**Lohit**		
						X-I	**X-II**	**X-III**	**X-I**	**X-II**	**X-III**
					Min Bed Level, m	112.09	108.00	107.89	116.13	114.00	111.25
Case-1: Only Demwe Lower is constructed	0.033	Siang =	1004.13	4.66	Max WL, m	116.27	114.11	112.49	117.8	116.068	112.491
					Min WL, m	116.27	114.11	112.41	117.49	115.715	112.41
					Max Discharge, m^3/s	1459.62	1459.15	1925.14	462.03	467.35	472.08
					Min Discharge, m^3/s	1459.62	1459.15	1782.30	295.14	306.5	318.46
	0.04	Dibang =	330.67	120.05	Max WL, m	116.70	114.35	112.67	117.904	116.194	112.7
					Min WL, m	116.70	114.35	112.64	117.675	115.95	112.643
					Max Discharge, m^3/s	1459.66	1459.35	1901.30	427.38	441.4	446.8
					Min Discharge, m^3/s	1459.66	1459.35	1810.30	326.56	336.12	347.35
	0.05	Lohit =	Max - 1729, Min- 66.2	122.27	Max WL, m	117.29	114.68	112.97	118.067	116.365	112.964
					Min WL, m	117.29	114.68	112.93	117.913	116.226	112.934
					Max Discharge, m^3/s	1459.62	1459.15	1879.00	413.407	417.335	423.6
					Min Discharge, m^3/s	1459.62	1459.15	1833.75	350.97	360.6	371.6
Case-2: Only Siang Lower is constructed	0.033	Siang =	Max - 5440, Min- 197	4.66	Max WL, m	117.19	114.54	112.76	117.849	116.133	112.756
					Min WL, m	114.92	113.20	112.14	117.849	116.133	112.14
					Max Discharge, m^3/s	2242.94	2059.82	2419.28	500.75	493.67	532.82

Present											
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**			**Lohit**		
						X-I	**X-II**	**X-III**	**X-I**	**X-II**	**X-III**
					Min Discharge, m^3/s	721.20	784.71	1355.20	500.75	493.67	458.19
	0.04	Dibang =	330.67	120.05	Max WL, m	117.43	114.68	112.90	118.022	116.32	112.9
					Min WL, m	115.40	113.65	112.36	118.022	116.32	112.359
					Max Discharge, m^3/s	2021.80	1886.79	2257.68	500.63	493.67	531.3
					Min Discharge, m^3/s	770.90	836.72	1407.47	500.63	493.67	467.65
	0.05	Lohit =	384.5	122.27	Max WL, m	117.69	114.90	113.10	118.264	116.55	113.1
					Min WL, m	116.06	114.09	112.70	118.264	116.55	112.7
					Max Discharge, m^3/s	1838.41	1752.73	2160.00	500.4	493.65	527.11
					Min Discharge, m^3/s	837.93	923.23	1510.00	500.4	493.65	478.59
Case-3: Only Dibang MPP is constructed	0.033	Siang =	1004.13	4.66	Max WL, m	116.40	114.12	112.54	117.849	116.136	112.544
					Min WL, m	115.89	113.83	112.39	117.849	116.136	112.394
					Max Discharge, m^3/s	1569.93	1530.54	2013.40	493.69	500.38	514.6
					Min Discharge, m^3/s	1229.50	1242.00	1759.31	493.69	500.38	498.83
	0.04	Dibang =	Max - 1431.61, Min- 75.5	120.05	Max WL, m	116.77	114.38	112.74	118.023	116.317	112.744
					Min WL, m	116.35	114.17	112.63	118.023	116.317	112.627
					Max Discharge, m^3/s	1522.37	1492.21	1977.46	493.39	500.18	513.81

Present											
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**			**Lohit**		
						X-I	**X-II**	**X-III**	**X-I**	**X-II**	**X-III**
					Min Discharge, m^3/s	1249.14	1263.76	1786.14	493.39	500.18	500.83
	0.05	Lohit =	384.5	122.27	Max WL, m	117.28	114.66	113.005	118.27	116.56	113.005
					Min WL, m	116.96	114.53	112.928	118.27	116.56	112.926
					Max Discharge, m^3/s	1522.30	1491.14	2013.41	493.85	500.4	513.83
					Min Discharge, m^3/s	1249.17	1263.84	1761.40	493.85	500.4	500.8
Case-4: All projects are constructed	0.033	Siang =	Max - 5440, Min- 197	4.66	Max WL, m	117.07	114.48	112.64	117.796	116.058	112.637
					Min WL, m	114.44	112.83	112.01	117.492	115.721	112.007
					Max Discharge, m^3/s	2140.73	1969.66	2203.32	464.52	467.37	485.27
					Min Discharge, m^3/s	496.78	596.92	1151.86	294.81	306.61	334.69
	0.04	Dibang =	Max - 1431.61, Min- 75.5	120.05	Max WL, m	117.26	114.59	112.78	117.902	116.179	112.775
					Min WL, m	114.99	113.39	112.23	117.675	115.951	112.226
					Max Discharge, m^3/s	1892.41	1767.64	2040.99	438.03	441.83	450.32
					Min Discharge, m^3/s	588.29	706.15	1235.90	325.55	335.29	365.9
	0.05	Lohit =	Max - 1729, Min- 66.2	122.27	Max WL, m	117.54	114.77	112.97	118.066	116.354	112.973
					Min WL, m	115.80	113.95	112.55	117.913	116.226	112.549
					Max Discharge, m^3/s	1674.42	1588.40	1888.07	412.93	416.81	411.31

Present											
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**			**Lohit**		
						X-I	**X-II**	**X-III**	**X-I**	**X-II**	**X-III**
					Min Discharge, m^3/s	714.69	838.56	1321.74	351.01	360.69	386.96
Case-5: No project is constructed	0.033	Siang =	1004.13	4.66	WL, m	116.266	115.02	112.518	117.849	116.136	112.519
					Discharge, m^3/s	1459.11	1459.66	1967.4	493.61	500.32	508.8
	0.04	Dibang =	330.67	120.05	WL, m	116.69	114.35	112.74	118.022	116.318	112.74
					Discharge, m^3/s	1459.11	1459.66	1967.4	493.61	500.32	508.8
	0.05	Lohit =	384.5	122.27	WL, m	117.289	114.68	113.02	118.25	116.54	113.03
					Discharge, m^3/s	1459.11	1459.66	1967.4	493.61	500.32	508.8

9.4.7 Summary for the 1998 river alignment scenario

Water level and discharge for all five cases with different Manning's n is presented in Table-9.20.

Table-9.20: Simulated water levels and discharges at the three sites assuming river alignment based on the before 1998

1998								
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**		
						X-I	**X-II**	**X-III**
					Min Bed Level, m	112.09	108.00	107.89
Case-1: Only Demwe Lower is constructed	0.033	Siang =	1030.17	4.62	Max WL, m	116.77	114.94	112.64
					Min WL, m	116.59	114.83	112.57
					Max Discharge, m^3/s	1892.30	1886.01	1881.84
					Min Discharge, m^3/s	1755.78	1763.24	1767.55
	0.04	Dibang =	330.8	60.87	Max WL, m	117.24	115.24	112.84
					Min WL, m	117.12	115.17	112.80
					Max Discharge, m^3/s	1865.99	1861.05	1857.24
					Min Discharge, m^3/s	1783.74	1788.64	1793.14
	0.05	Lohit =	Max - 1729, Min- 70	118.9	Max WL, m	117.85	115.611	113.101
					Min WL, m	117.79	115.58	113.08
					Max Discharge, m^3/s	1845.56	1842.79	1841.06
					Min Discharge, m^3/s	1806.83	1809.09	1809.78
Case-2: Only Siang Lower is constructed	0.033	Siang =	Max - 5462, Min- 328	4.62	Max WL, m	117.92	115.58	113.03
					Min WL, m	115.60	114.13	112.18
					Max Discharge, m^3/s	2984.41	2775.08	2619.48
					Min Discharge, m^3/s	1179.32	1204.84	1229.50
	0.04	Dibang =	330.8	60.87	Max WL, m	118.22	115.78	113.17
					Min WL, m	116.11	114.53	112.43
					Max Discharge, m^3/s	2734.27	2597.93	2458.65
					Min Discharge, m^3/s	1203.11	1239.56	1269.41
	0.05	Lohit =	302.87	118.9	Max WL, m	118.57	116.05	113.35
					Min WL, m	116.82	115.03	112.75
					Max Discharge, m^3/s	2538.95	2405.37	2290.03
					Min Discharge, m^3/s	1245.42	1299.38	1359.01
Case-3: Only Dibang MPP is	0.033	Siang =	1030.17	4.62	Max WL, m	116.78	114.95	112.63
					Min WL, m	116.34	114.67	112.48
					Max Discharge, m^3/s	1915.41	1892.00	1877.40

1998								
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**		
						X-I	**X-II**	**X-III**
constructed					Min Discharge, m^3/s	1604.52	1615.21	1622.08
	0.04	Dibang =	Max - 1426.8, Min- 50	50.0	Max WL, m	117.21	115.22	112.82
					Min WL, m	116.87	115.02	112.70
					Max Discharge, m^3/s	1862.88	1845.33	1832.11
					Min Discharge, m^3/s	1626.22	1637.73	1648.11
	0.05	Lohit =	302.87	118.9	Max WL, m	117.78	115.57	113.07
					Min WL, m	117.56	115.46	113.00
					Max Discharge, m^3/s	1811.39	1801.53	1794.56
					Min Discharge, m^3/s	1665.84	1676.15	1686.13
Case-4: All project is constructed	0.033	Siang =	Max - 5462, Min- 328	4.62	Max WL, m	117.64	115.42	112.91
					Min WL, m	115.30	113.90	112.06
					Max Discharge, m^3/s	2777.17	2536.54	2396.73
					Min Discharge, m^3/s	1015.87	1059.07	1096.93
	0.04	Dibang =	Max - 1426.8, Min- 50	60.87	Max WL, m	117.96	115.61	113.05
					Min WL, m	115.83	114.35	112.33
					Max Discharge, m^3/s	2522.49	2343.88	2224.65
					Min Discharge, m^3/s	1059.21	1113.23	1158.34
	0.05	Lohit =	Max - 1729, Min- 70	118.9	Max WL, m	118.35	115.88	113.24
					Min WL, m	116.59	114.89	112.66
					Max Discharge, m^3/s	2322.40	2203.66	2093.78
					Min Discharge, m^3/s	1127.00	1192.91	1259.64
Case-5: No project is constructed	0.033	Siang =	1030.17	4.62	WL, m	116.71	114.91	112.62
					Discharge, m^3/s	1848.00		
	0.04	Dibang =	330.8	60.87	WL, m	117.21	115.23	112.84
					Discharge, m^3/s	1848.00		
	0.05	Lohit =	302.87	118.9	WL, m	117.86	115.61	113.10
					Discharge, m^3/s	1848.00		

9.4.8 Conclusions

It is clear from Tables-9.19 and 9.20 that the variation is within 1 m when all projects will be working simultaneously. Water level is well below the minimum elevation of Dibru-Saikowa Park for all cases.

9.5 IMPACTS ON AQUATIC ECOLOGY DUE TO MODIFICATION LOW REGIME

As mentioned earlier in section 9.3, the commissioning of a hydroelectric project, significantly affects the hydrologic regime. The proposed hydroelectric projects in the basin area too will have similar impacts on hydrologic regime, with a corresponding impact on riverine ecology including fisheries.

The free flowing water regime will be completely disturbed over a stretch of about 110 km. The six dams will store water to enable peaking power generation. As a result, barring for a period from May to October, the river Lohit will have dry periods from few hours to upto few days for generation of peaking power. This storage period will result in drying up of the river, downstream of the dam sites. The dry period will be followed by a wet or flow period with uniform flow corresponding to the number of units/turbines generating hydropower. Thus, the riverine ecology will be severely affected on account of modification in hydrologic regime. This change can have significant impact on the riverine fisheries affecting physiological readiness to migrate, mature and spawn.

The dry phase in the river stretch will result in stranding of fish in temporary pools. Similarly, drying of the river bed will lead to exposure of spawning substrates resulting in exposure and desiccation of fish eggs as well. The increased discharge especially in the lean season on account of flow of rated discharge will sweep the larvae past their suitable habitat.

The presence of variety of species makes it impossible to consider flow needs individually, it is convenient to operate at some level of aggregation, the most convenient of which is a simple behavioural, ecological or functional guild structure. Ecological guilds have been defined differently in various parts of the world. Regier, Welcomme, Steedman & Henderson (1989) proposed an early classification based on the traditional South East Asian usage for tropical systems, and Bain, Finn and Booke (1988) developed a classification of functional groupings for US rivers. Aarts, Van den Brink and Nienhuis (2004) summarize the classification for major European rivers. The combined elements of these together with some of Balon's (1975) reproductive guilds to illustrate the way in which each of the guilds responds to characteristic changes in the river that result from changes in flow is given in Table-9.21. The three main groups of fish and their sub-groups respond to changes to natural hydrographs that result from increased control over water in very different ways, which generally favour eurytopic species at the expense of the limnophilic and rheophilic ones.

Table – 9.21: Response of the main behavioural guilds to changes in flow regimes

Behavioural guild	**Typical behavior**		**Reaction to changes in hydrograph**
	General	**Specific**	
Black fish – limnophilic species	• Floodplain residents move little between floodplain pools, swamps and inundated floodplain. • Repeat breeders with specialised reproductive behaviour. • Predominantly polyphils, nest builders, parental carers or live bearers. • Tolerant of low dissolved oxygen or anoxia (auxiliary breathing adaptations)	**A** • Tolerant of low dissolved oxygen tensions only	• Tend to disappear when floodplain disconnected and desiccated through poldering and levee construction. • May increase in number in shallow, isolated wetlands, rice-fields and drainage ditches.
		B • Tolerant of Complete Anoxia	• Persist in residual floodplain water bodies • Principal component of rice field and ditch faunas
White fish – rheophilic species	• Long distance migrants • One breeding season a year • Intolerant of low oxygen.	A • Main channel residents not entering floodplain • Predominantly psammophils, lithophils or pelagophils. • Often have drifting eggs and larvae	• Tend to disappear when river dammed to prevent migration, • When timing of flood inappropriate to their breeding seasonality and • If flow excessive or too slow for the needs of drifting larvae.

Behavioural guild	Typical behavior		Reaction to changes in hydrograph
	General	Specific	
		B • Use floodplain for breeding, nursery grounds and feeding of juvenile and adult fish • Predominantly phytophils • Usually spawn at floodplain margin or on floodplain; sometimes have drifting eggs and larvae	• Tend to disappear when river dammed to prevent migration, • Damaged when access to floodplain denied to developing fry and juveniles.
Grey fish – eurytopic species	• Tolerant of low dissolved oxygen • Repeat breeders • Predominantly phytophils but some nesters or parental carers • Short distance migrants often with local populations.	A • Occupy main channel generally benthic	• Able to adapt behaviourally to altered hydrograph • Generally increase in number as other species decline • Impacted negatively to flows that change depositional siltation processes and alter the nature of the bottom
		B • Occupy riparian vegetation	• Able to adapt behaviourally to altered hydrograph • Generally increase in number as other species decline • Impacted negatively by flows and management that changes riparian structure

Behavioural guild	Typical behavior		Reaction to changes in hydrograph
	General	Specific	
		C • Occupy larger and better oxygenated floodplain water bodies	• Sensitive to isolation of floodplain water body but can colonise river if flow slowed sufficiently • Often form basic colonisers of reservoirs and dams

As rivers change in response to human efforts to control flow they pass through a series of stages that can be characterized according to the degree of modification. The degree of modification is summarized in Table-9.22.

Table - 9.22: Characteristics of various developmental stages of a river, impacts on flood regimes and form of lowland rivers

Development stage	Flood regime	State of river channel	State of floodplain	Human habitation
Unmodified	Natural hydrograph with seasonal alternation of flood and dry seasons. Water quality is good	Freely meandering or anastomosing often with islands. Diverse	Usually forested interspersed with floodplain water bodies.	Migratory human settlement in temporary camps, on high ground only or in stilt houses
Slightly modified	Natural hydrograph with seasonal alternation of flood and dry seasons. Water quality is good	Freely meandering or anastomosing often with islands. Obstructions removed from channel. Some simplification of channels. Diverse	Some forests usually savannah with floodplain grasses	Human settlement in temporary camps on floodplain, villages on levees or stilt houses.

Development stage	Flood regime	State of river channel	State of floodplain	Human habitation
Modified	Natural hydrograph persists in many reaches of river but can be locally modified below dams with reduced amplitude and duration of seasonal floods. Can also be modified around poldered areas. Water quality affected around settlements.	Locally regulated with some damming and leveeing but with some reaches still relatively unregulated. Tendency to suppress branches in favour of a single main channel. Some backwaters persist.	Floodplain partially modified, deforested: floodplain water bodies sometimes isolated. Local poldering and flood control structures	Human settlement beginning to intensify on artificially constructed mounds or areas protected by flood defences.
Highly modified	Hydrograph completely modified suppressing and altering timing of flood peaks and quantity of water in system. Water quality often severely reduced in whole river	Often heavily dammed sometimes in cascades: Fully regulated and channelised often with revetted banks and dredged navigation channels, Backwaters eliminated. Habitat diversity low.	Floodplain dry or completely controlled with extensive drainage and irrigation canals. Off channel water bodies largely eliminated or isolated Maybe heavily poldered	Heavy human settlement of whole former floodplain area.

On completion of the proposed hydroelectric projects in the basin, would render river Lohit as highly modified, on account of :

- Hydrographs getting completely modified
- Modification of floods including suppression and alteration of flood peaks.
- Conversion of free flowing stretch of river into reservoir.

However, no major impact on water quality is anticipated on account of modification in hydrologic regime, as there are no major sources of water pollution in the study area.

The modification of downstream river flow characteristics (regime) by an impoundment can have a variety of negative effects upon fish species. These include:

- loss of stimuli for migration
- loss of migration routes and spawning grounds
- decreased survival of eggs and juveniles
- diminished food production.

Regulation of stream flow during the migratory period can alter the seasonal and daily dynamics of migration. Regulation of a river can lead to a sharp decrease in a migratory population, or even to its complete elimination.

9.6 IMPACTS ON FISHERIES DUE TO FLUCTUATIONS IN WATER LEVEL

Variable flow regime resulting from operation of hydroelectric power-dams can have significant consequences for fish fauna : daily 2 m to 3 m fluctuation of Colorado river-levels below the Glen Canyon dam may have contributed to the decline in endemic fish (Petts, 1988). The native species have been replaced by the introduced species and spawning of the native species is restricted to tributaries.

Walker *et al*. (1979) related the disappearance of *Tandanus tandanus* in the Murray river, Australia to short-term fluctuations in water level caused by reservoir releases in response to downstream water user requirements. In the proposed hydroelectric projects, releases on account of peaking power requirement shall result in fluctuations in water level. This could result in significant reduction in native species.

The fluctuations of water-level and velocities due to power demand could have disastrous effects on fish: spawning behaviour could be inhibited, juveniles could be swept downstream by high flows, sudden reductions in flow could leave eggs or juveniles stranded (Petts, 1988).Althouogh, experimental data on the impacts on fish species present in river Lohit is not available but it can be concluded that daily fluctuation in water level will have significant adverse impacts on fisheries.

9.7 IMPACTS ON FISH MIGRATION

Fish populations are highly dependent upon the characteristics of the aquatic habitat which supports all their biological functions. This dependence is most marked in migratory fish which require discrete environments for the main phases of their life cycle which are reproduction, production of juveniles, growth and sexual maturation. The species has to move from one environment to another in order to survive. The fish composition in the project area are represented by potadromous species i.e. the species which occur only in freshwater system and their reproduction and feeding zones are separated by distances that could vary from few meters to hundreds of kilometers.

The building of a dam generally has a major impact on fish populations: migrations and other fish movements can be stopped or delayed, the quality, quantity and accessibility of their habitat, which plays an important role in population sustainability. Fish can suffer major damage during their transit through hydraulic turbines or over spillways. Changes in discharge regime or water quality can also have indirect impacts on fish species. Increased upstream and downstream predation on migratory fish is also linked to dams, fish being delayed and concentrated due to the presence of the dam and the habitat becoming more favourable to certain predatory species.

One of the major effects of the construction of a dam on fish populations is the decline of migratory fish species. The dam prevents migration between feeding and breeding zones. The effect can become severe, leading to the extinction of species, where no spawning grounds are present in the river or its tributary downstream of the dam.

The impact of river valley projects has been extensively studied for river Bees as a result of damming at pong and Pandoh under the Beas-Sutlej Link Project. Sehgal and Sar (1989) and Sehgal (1990) have found subtle and irreversible changes in abiotic and biotic parameters. The migratory routes of *Tor putitora* and *Schizothorax richardsonii* have been obstructed due to construction of various dams. These species which were migrating to higher elevation, were obstructed. *Schizothorax richardsonii* which used to migrate from higher reaches to lower reaches was unable to do so on account of construction of dam at Pandoh. The contribution of *Schizothorax richardsonii* in the river Beas reduced from 10.2 – 13.5% between Mandi and

Nodomn towns prior to construction of project reduced to 0.5 – 1% after project.

The commissioning of the proposed hydroelectric projects would seriously impede the migratory route of fisheries. The migration characteristics of various fish species observed in the study area is given in Table-9.23.

Table-9.23: Migration distance, spawning season and spawning substrate of fish species

Family	Species	Migration distance	Spawning season	Spawning substrate
Cyprinidae	*Schizothorax richardsonii*	Short to Mid	Aug-Sep	Gravelly substrate
Cyprinidae	*Neolissochilus hexagonolepis*	Short to Mid	May-July	Gravelly substrate
Cyprinidae	*Labeo pangusia*	Short to Mid	May -July	Gravelly substrate
Cyprinidae	*Chagunius chagunio*	Short to Mid	May-June	Gravelly substrate
Cyprinidae	*Tor putitora*	Long	Sep -Oct	Gravelly substrate
Cyprinidae	*Tor tor*	Long	Sep -Oct	Gravelly substrate
Cyprinidae	*Garra gotyla*	Short to Mid	May - Jul	Gravelly substrate
Cyprinidae	*Garra annandalei*	Short to Mid	Jul - Aug	Gravelly substrate
Bolitoridae	*Aborichthys elongatus*	Short	May – Jul	Gravelly substrate
Cobitidae	*Botia dario*	Short	Jun - Aug	Gravelly substrate
Siluridae	*Silurus afgana*	Short	Jun -Aug	Gravelly substrate
Amblycipitidae	*Amblyceps sp.*	Short	Jun-Aug	Gravelly substrate
Sisoridae	*Glyptothorax sp.*	Short	May- Jul	Gravelly substrate
Channidae	*Channa orientalis*	Short	Jun- Aug	Gravelly substrate

The migratory fish species observed in the study area are listed as below:

- *Schizothorax richardsonii*
- *Acrossocheilus hexagondepsis*
- *Tor putitora*
- *Tor tor*
- *Labeo pangusia*

The species *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* migrate from lower elevation to higher elevation in summer months and return to lower elevation in winter months. These species were observed at various sampling locations of all the six hydroelectric projects.

The dam of Demwe Lower hydroelectric project would block the upward migratory movement of various fish species in winter season. Similarly, Kalai hydroelectric project, stage-1 would impede the downward movement of migratory fish species in summer season. It is likely that the migration of fish species namely, *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* in the stretch of 109 km would be severely affected on account of construction of the proposed hydroelectric projects. Likewise, migration of fish species from tributaries to river Lohit, would be severely affected on account of creation of reservoirs due to construction of proposed hydroelectric projects. Thus, the project will lead to significant adverse impact on migratory fish species. The fish migration would be restricted only in the following stretches:

- Upstream of dam site of Kalai hydroelectric project, stage-1
- Downstream of dam site of Demwe Lower hdroelectric project
- Tributaries confluencing in the outfalling in the with river Lohit between dam site of Kalai hydroelectric project, stage-1 and dam site of Demwe Lower hdroelectric project.

The fish species such as *Tor Putitora*, *Tor tor* and *Labeo pangusia* migrate to lower elevation in summer months and undertake the reverse journey in winter months. These species were observed only in the vicinity of the following projects:

- Hutong hydroelectric project, stage-1
- Hutong hydroelectric project, stage-2
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project

These species are not reported in Kalai hydroelectric projects, which could be attributed to lower water temperature at higher elevations. The construction of the above referred four projects would impede the migratory movement of *Tor tor*, *Tor putitora*, *Labeo pangusia*. Thus, in the river stretch of 69 km for Hutong hydroelectric project stage-1 site to Demwe Lower site, the movement of these fish species would be severely affected and their number would decrease significantly.

9.8 IMPACTS ON FISHERIES DUE TO HYDRAULIC TURBINES

Fish can suffer major damage during their transit through hydraulic turbines or over spillways. Fish passing through hydraulic turbines are subject to various forms of stress likely to cause high mortality i.e., probability of shocks from moving or stationary parts of the turbine (guide vanes, vanes or blades on the wheel), sudden acceleration or deceleration, very sudden variations in pressure and cavitation. Passage through spillways may be a direct cause of injury or mortality, or an indirect cause (increased susceptibility of disorientated or shocked fish to predation). Mortality in migrating fishes could be due to shearing effects, abrasion against spillway surfaces, turbulence in the stilling basin at the base of the dam, sudden variations in velocity and pressure as the fish hits the water, physical impact against energy dissipators.

Fish passing through hydraulic turbines are subject to various forms of stress likely to cause high mortality: probability of shocks from moving or stationary parts of the turbine (guide vanes, vanes or blades on the wheel), sudden acceleration or deceleration, very sudden variations in pressure and cavitation. The impacts of hydraulic turbines on snow trout, , Mahaseer etc. have not been studied. However, numerous experiments have been conducted in various countries (USA, Canada, Sweden, Netherlands, Germany and France), mainly on juvenile salmonids and less frequently on clupeids and eels, to determine the mortality rate due to their passage through the main types of turbine (Bell, 1981; Monten, 1985; Eicher, 1987; Larinier and Dartiguelongue, 1989; EPRI, 1992).

The mortality rate for juvenile salmonids in Francis and Kaplan turbines varies greatly, depending on the properties of the wheel (diameter, speed of rotation, etc), their conditions of operation, the head, and the species and size of the fish concerned. The mortality rate varies from under 5% to over 90% in Francis turbines. On an average, it is lower in Kaplan turbines, from under 5% to approximately 20%. The difference between the two types of turbines is due to the fact that Francis turbines are generally installed under higher heads.

The mortality rate may be 4 to 5 times higher than in juvenile salmonids, reaching a minimum of 10% to 20% in large low-head turbines (as against a few per cent in juvenile salmonids). (Desrochers, 1994; Hadderingh and Bakker, 1998; Monten, 1985; Larinier and Dartiguelongue, 1989). Similar impacts, i.e. fish mortality is anticipated in the proposed hydroelectric projects as well. However, in absence of experimental data, quantification of impacts on this account cannot be made.

9.9 IMPACTS ON FISHERIES DUE TO SPILLWAYS

Passage through spillways may be a direct cause of injury or mortality, or an indirect cause (increased susceptibility of disorientated or shocked fish to predation). The mortality rate varies greatly from one location to another: between 0% and 4% for the Bonneville, McNary and John Day dams (about 30 m high spillways) on the Columbia River, 8% at the Glines dam (60 m high spillway) and 37% at the Lower Elwha dam (30 m high spillway) on the Elwha river for juvenile salmonids (Bell and Delacy, 1972; Ruggles and Murray, 1983).

Mortalities have several causes: shearing effects, abrasion against spillway surfaces, turbulence in the stilling basin at the base of the dam, sudden variations in velocity and pressure as the fish hits the water, physical impact against energy dissipators. The manner in which energy is dissipated in the spillway can have a determinant effect on fish mortality rates. Experiments have shown that significant damage occurs (with injuries to gills, eyes and internal organs) when the impact velocity of the fish on the water surface in the downstream pool exceeds 16 m/s, whatever its size (Bell & Delacy, 1972). A column of water reaches the critical velocity for fish after a drop of 13 m. Beyond this limit injuries may become significant and mortality will increase rapidly in proportion to the drop (100% mortality for a drop of 50-60 m). In the proposed hydroelectric projects, except for Hutong hydroelectric project, stage 1, the fall in water is more than 50-60 m in the other projects. Passage through a spillway under free-fall conditions (i.e. free from the column of water) is always less hazardous for small fish, insofar as their terminal velocity is less than the critical velocity. For larger fish, the hazards are identical whether they pass under free-fall conditions or are contained in the column of water.

9.10 IMPACTS ON FEEDING BIOLOGY AND GROWTH RATES OF FISH SPECIES

Studies on Golden Mahaseers in rivers Alaknanda, Nayar and Saung in Uttarakhand have seen that in extensively regulated river stretches of river Ganga, Mahaseer was found to consume relatively lesser animal matter (40-100%) as compared to fish species in free flowing rivers, e.g. Nayar (72.1 – 89.8%) or Saung (74.3 – 90%). Insects generally occur as macrozoobenthic community, the density of which was found to be lower in rivers with regulated flows. However, the food habits did not get altered to the extent of showing a shift from carnivorous to omnivorous diet. Similar impacts are envisaged in the study area as well. The fish species in the river with regulated flow will be forced to eat higher percentage of plant matter, as a result of decrease in macro-zoobenthic community.

Another impact envisaged is that large sized fish species which are potential brooders may migrate in the tributaries for breeding. Thus, large sized fish may become virtually absent in the breeding season from the regulated stretches of river flows.

9.11 IMPACTS ON ECONOMICALLY IMPORTANT PLANTS

a) Hydroelectric Projects on River Lohit

The economic dependence of the local people in Arunachal Himalaya which comprises mostly tribals, is primarily plant resource based. They use various wild plants in their day to day life as food, medicine, fiber, fodder, fuel wood and timber and to some extent horticultural purposes. The usage of various plant species by the local tribes varies with the altitude and availability of resources in the surrounding areas. A comprehensive account of these plant resources is given in the following sections:

The forests of Arunachal Pradesh are endowed with many useful plant species viz., timber yielding species, medicinal plants, bamboos, rattans, wild ornamental plants, etc. The state can be termed as a repository of medicinal plants (Haridasan et at. 1996). The indigenous people in the state live in close association with the forests and have accumulated a vast treasure of knowledge related to utilization of plants. This knowledge of medicinal plants is becoming a potential source of information for the pharmaceutical industries. The list of economically important plant species observed at various sampling sites in the area of various hydroelectric projects is given in Table-9.24.

Table-9.24: List of Economically important plant species observed at various sampling sites

S. No.	Species	Uses
A.	**Kalai Hydroelectric Project, Stage-1**	
1	*Ficus cunia*	Fodder
2	*Macaranga denticulata*	Fuel
3	*Nephrolepis cordifolia*	Medicinal
4	*Alnus nepalensis*	Fuel
5	*Rubus* spp.	Edible
6	*Thysanolaena maxima*	Broom industry, fodder
7	*Saurauria nepalensis*	Fodder
B.	**Kalai Hydroelectric Project, Stage-2**	
1	*Ficus cunia*	Fodder
2	*Macaranga denticulata*	Fuel
3	*Nephrolepis cordifolia*	Medicinal
4	*Pandanus odoratissima*	Fibre
5	*Rubus* spp.	Edible
6	*Thysanolaena maxima*	Broom industry, fodder
7	*Saurauria nepalensis*	Fodder
C.	**Hutong Hydroelectric Project, Stage-1**	
1	*Ficus cunia*	Fodder fuel
2	*Macaranga denticulata*	

S. No.	Species	Uses
3	*Nephrolepis cordifolia*	Medicinal
4	*Rubus* spp.	Edible
5	*Thysanolaena maxima*	Broom industry, fodder
D.	**Hutong Hydroelectric Project Stage-2**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Ficus cunia*	Fodder
3	*Macaranga denticulata*	Fuel
4	*Nephrolepis cordifolia*	Medicinal
5	*Rubus* spp.	Edible
6	*Terminalia myriocarpa*	Timber
7	*Thysanolaena maxima*	Broom industry, fodder
8	*Saurauria nepalensis*	Fodder
9	*Spondias axillaries*	Fruits edible
E.	**Demwe Upper Hydroelectric Project**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Ficus cunia*	Fodder
3	*Ficus roxburqhii*	Fodder, fruits edible
4	*Macaranga sp.*	Fuel
5	*Nephrolepis cordifolia*	Medicinal
6	*Pandanus odoratissima*	Fibre
7	*Rubus* spp.	Edible
8	*Terminalia myriocarpa*	Timber
9	*Thysanolaena maxima*	Broom industry, fodder
10	*Saurauria nepalensis*	Fodder
11	*Sapium baccatum*	Timber
12	*Spondias axillaries*	Fruits edible
F.	**Demwe Lower Hydroelectric Project**	
1.	*Syzygium cumini*	Medicinal, leaves edible
2.	*Ficus roxburghii*	Fodder, fruits edible
3.	*Macaranga spp.*	Fuel
4.	*Nephrolepis cordifolia*	Medicinal
5.	*Kydia calycina*	Fuel, timber
6.	*Rubus sp.*	Edible
7.	*Terminalia myriocarpa*	Timber, fuel
8.	*Dalbergia sissoo*	Timber
9.	*Spondias pinnata*	Fruits edible, medicinal
10.	*Emblica officinalis*	Fruits edible, medicinal

In Kalai Hydroelectric Project, Stage-1, seven economically important plant species were recorded. They were namely, *Ficus cunia*, *Macaranga denticuiata*, *Nephrolepis cordifolia*, *Alnus nepalensis*, *Rubus* spp., *Thysanolaena maxima* and *Saurauria nepalensis*.

At Kalai Hydroelectric Project, Stage-2, various plants of economic importance such as timber, medicinal, edible fruits were commonly observed. *Pandanus odoratissima* is a fiber yielding tree species & *Nephrolepis cordifolia has medicinal values*. These are seen commonly here and there at the project sites.

Five economically important plants were recorded from Hutong Hydroelectric Project, Stage-1 viz., *Ficus cunia*, *Macaranga denticuiata*, *Nephrolepis cordifolia*, *Rubus* spp. and *Thysanolaena maxima.*

About 9 economically important plant species were recorded from the study area in Hutong Hydroelectric Project, Stage-2. These include *Clerodendron colebrookianum*, *Ficus cunia*, *Macaranga denticulata*, *Nephrolepis cordifolia*, *Rubus* spp., *Terminalia myriocarpa*, *Thysanolaena maxima*, *Saurauria nepalensis* and *Spondias pinnata*.

About 12 economically important plant species we re recorded from the study area in Demwe Upper Hydroelectric Project. These species include *Clerodendron colebrookianum, Ficus cunia, Ficus roxburghii, Macaranga sp., Nephrolepis cordifolia, Pandanus odoratissima, Rubus spp., Terminalia myriocarpa, Thysanolaena maxima, Saurauria nepalensis, Sapium baccatum and Spondias axillaries.*

Ten economically important plant species were recorded from the study area in Demwe Lower Hydroelectric Project. Plant of economical importance such as timber (*Terminalia myriocarpa*, *Dalbergia sissoo,),* medicinal *(Nephrolepis cordifolia, Spondias pinnata*), edible fruits (*Ficus roxburhghii, Rubus* sp.*)* and *Macaranga spp*. known for fuel wood value were commonly seen here and there at the project site.

b) Hydroelectric Projects on tributaries of river Lohit

Medicinal Plants

The list of some medicinally important plant species found in the project area is given in **Table-9.25.**

Table-9.25: List of medicinal plants found in the study area of projects on tributaries of river Lohit

Plant Species	Parts used	Uses
Rhaphidophora decursiva	Leaves, flower	Malarial fever, backache, stomach disorder, aphrodisiac
Ageratum conyzoides	Whole plant	Eye treatment to stop bleeding in Cuts and wounds to check bleeding and early healing
Bidens pilosa	Leaves, roots	Jaundice,stomach disorder, aphrodisiac

Plant Species	Parts used	Uses
Begonia sp.	Entire plant	Stomach,Vomiting,Diarrhoea
Borreria articularis	Leaves	Cold,cough,fever
Costos speciosus	Rhizomes	Strong anthelmintic
Curcuma caesia	Rhizomes	Cold,cough,fever
Alocasiamacrorrhiza	Seeds, rhizomes	Treatment of insectbite
Cuscuta reflexa	Whole plant	Antidote
Artemisia nilagirica	Flower & leaves	Stomachdisorder
Sida rhombifolia	Roots & leaves	Antidoteinsnakebite
Zanthoxylum acanthopodium	Seeds & leaves	Toothache,stomachdisorder,Cold,cough
Gynocardiaodorata	Barks	Teeth extraction, fruit used as poison for killing insects,wormsandfishes
Oroxylum indicum	Seeds & barks	BlooddysenteryandDiarrhoea
Spilanthespaniculata	Leaves	Tooth-ache, cough
Solanum torvum	Leaves & fruit	Stomachpain
Macaranga denticulata	Stem barks	Fracture
Phylanthus emblica	Fruits	Bloodpurifier,abdominalpain,gastric,and improved in digestion
Dendrocalamusstrictus	Young shoot	Injuries,wound or cut
Engelhardtia spicata	Stem barks	Fracture
Cinnamomum sp.	Leaves, roots & barks	Liverandurinarytroubles

Food Plants

The people of Arunachal Pradesh collect a large number of wild edible plants in the form of tubers, rhizomes, shoots, flowers, fruits, berries, seeds, etc. as the natural supplement for their diet. These wild edible species are very rich in carbohydrates, starch, protein, sugar and oil. Among the wild edible plants consumed are the leaves and young twigs of *Aconogonum molle, Amaranthus spinosus, Cardamine hirsuta, Chenopodium album, Fagopyrum esculentum, Girardinia diversifolia* and *Urtica urdance*. The various edible vegetables collected from the forests are bamboo shoot (*Dendrocalamus hamiltonii*), wild banana (*Musa balbasiana*) flowers. Other wild species consumed as vegetables are *Zanthoxyllum rhetsa*, *Clerodendrum colebrookianum*, *Alpinia allughas, Alocasia indica, Piper pedicellatum* and *Colocasia esculenta*. Young shoots of *Bambusa tulda* and *Dendrocalamus hamiltonii* are used as food ingredients. Flower buds of *Bauhinia purpurea* and *Oroxylum indicum* are used as vegetables. Fruits of *Garcinia pedunculata, Phylanthus emblica, Rubus ellipticus,* *Ficus semicordata*, *Prunus cerasoides, Musa* sp., are eaten raw or cooked as vegetables. Paddy (*Oryza sativa*), maize (*Zea mays*), millets (*Pennisetum typhoides*), potato (*Solanum tuberosum*), ginger (*Zingiber officinale*) are main crops of this region.

Timber and Fuelwood Trees

Forest is the most important source of timber in the study area. Most important timber yielding species of the area are *Terminalia myriocarpa, Duabanga grandiflora, Bischofia javanica, Castanopsi indica, Canarium strictum,Toona ciliata, Gynocardia odorata, Pterospermum acerifolium ,* and *Tetrameles nudiflora* etc. *Phoebe cooperiana, Alnus nepalensis* and *Altingia excelsa* are the other timber yielding species which are also made use of. *Macaranga denticulata*) and *Callicarpa arborea* are commonly used for making poles for house constructions. Species like *Callicarpa arborea, Macaranga denticulate* are highly preferred for use as fire wood. These are very light woods, easily combustible, leave less smoke while burning and dry easily. In addition to these, many inferior wood species are also made use of for fuel wood purposes. In addition to these trees, some bamboos like *Bambusa tulda* and *Dendrocalamus hamiltonii* are commonly used for house construction. It also comes in very handy as stilts, struts, purlins and rafters in the same along with the woody species.

Fodder Plants

The human population of the area depends essentially on naturally growing trees, shrubs, herbs and grasses for the fodder requirements of their cattle and livestock. Major fodder species used by the local community are *Ficus roxburghii, Debregeasia longifolia, Gynocardia odorata, Ficus semicordata, Alangium chinensis, Thysanolaena maxima, Digitaria ciliaris, Arundo donax* and wild banana or *Musa* sp. (*kulung*), the former for being palatable, easy to digest and for its milk enhancing properties and the latter for its easy availability and palatability. In addition bamboo foliage also acts as a supplementary fodder in this region.

9.12 FLORA UNDER THREATENED CATEGORY

Shifting cultivation, over exploitation of medicinal and other useful economic plants, various developmental activities are some of the major threats to the flora of Arunachal Pradesh. As a result of the impact of these biotic and abiotic factors, a number of species have become rare, vulnerable, threatened or endangered (Hajra *et* al., 1996). Some of the plant species of the state which fall under these categories include *Alniphyllum fortune, Ardisia rhynchophylla, Boehmeria tirapensis, Bulbophyllum depressum, B. virens Cymbidium* *hookerianum, Buddleja yunnanensis, Dioscorea laurifolia, Diplomeris hirsute, Eria discolor, Ilex venulosa, Leptodermis scabrida, Sapria himalayana, Saurauia griffithii* etc. However none of these species were recorded from the study area during field studies.

9.13 IMPACTS ON WILDLIFE

The Kamlang Wildlife Sanctuary is situated closed to the left bank of the reservoir of the Demwe Lower hydroelectric project. It is in continuity to the Namdapha National Park. Wildlife in the entire region is already under stress due to customary hunting and killing for living by locals. The Mishmi tribes, which inhabit the area, follow hunting as a custom. The bodies and parts/organs of various higher mammals get pride of place in the Mishmi household.

This aspect needs to be considered while planning the Environmental Management Plan for the project, wherein special emphasis needs to be given for Bio-diversity conservation and Wildlife Management Plan.

The land acquisition for various project appurtenances could lead to adverse impacts on wildlife. Effects needs to be made for identification of non-location specific project requirements lead to minimum impacts on flora and fauna. The sites selected for various project appurtenances, e.g. project colony, labour camps, muck disposal sites, roads, waste disposal sites, etc. should be:

- Free from dense vegetation
- Away from wildlife habitats including breeding sites
- Water holes for wildlife
- Away from river banks

The various hydroelectric projects are not expected to adversely affect the migratory routes of wildlife, because river Lohit itself acts barrier to wildlife movement in pre-project plans. Thus, there is no wildlife movement across river Lohit, even in the pre-project phase itself. The impacts due to blasting is another source of adverse impacts on wildlife during construction phase of any hydroelectric project. Similar adverse impacts are anticipated in the proposed projects as well. Thus, appropriate measures need to be implemented as a part of Environmental Management Plan.

9.14 IMPACTS ON PROTECTED AREAS

The Kamlang Wildlife Sanctuary (KWLS) is one of the 12 protected areas in Arunachal Pradesh raised for the protection and conservation of the biodiversity of the State and it falls within the 10 km radius from the reservoir tip of the Demwe Lower H.E. Project. Around 80.36 sq km area of the Sanctuary (only 10.26 % of the total area of the Wildlife Sanctuary) falls within the 10 km radius from the reservoir of the project.

The minimum distance from main river Lohit to the Sanctuary is around 4.12 km along the Lang river. In order to avoid disturbance within the Kamlang Wildlife Sanctuary, the Demwe H.E. project has earlier been bifurcated in two projects namely Demwe Lower H.E. project and Demwe Upper H.E. Project. The FRL/MWL of Demwe Lower was fixed in such a way that no submergence occurs in the Kamlang Wildlife Sanctuary. The proposed dam site of Demwe Lower HEP is located at an aerial distance of about 9.3 km from Sanctuary.

CHAPTER-10
ENVIRONMENTAL MANAGEMENT PLAN

CHAPTER-10

ENVIRONMENTAL MANAGEMENT PLAN

10.1 INTRODUCTION

The aim of the Environmental Management Plan (EMP) is to ensure that the impacts due to stress/load on the ecosystem are ameliorated to the extent possible. The most reliable way to achieve the above objective is to incorporate the management plan into the overall planning and implementation of the proposed hydroelectric projects in the study area.

10.2 MANAGEMENT PLAN FOR FISHERIES

Various measures outlined for sustenance of riverine fisheries are described in the following paragraphs.

10.2.1 Release of minimum flow

The Building Block Methodology has been used in the present study to formulate a synthetic hydrograph which must satisfy the water requirements in the river for maintaining a desired condition. The hydrograph simulates the natural conditions in the river to fulfill the different flow regimes present through out the year. The identification and incorporation of these important flow characteristics will help to maintain the river's channel structure, diversity of the physical biotopes and processes.

The diversion of water for hydropower generation in the proposed hydroelectric projects will lead to drying or reduction of flow river stretch of upto tailrace disposal. The effect will be more pronounced in the lean season. There are no major users of water in the intervening stretches, as river flows through a gorge and requires pumping for use at point of consumption. As a result, there are no major users of water of river Tagurshit in the intervening stretch. Thus, no major adverse impacts are anticipated on downstream water users. However, there will be significant adverse impacts on riverine ecology, which needs to be ameliorated through the release of Environmental Flows.

The requirements of Environmental flows considered are:

- Irrigation water requirements
- Drinking water requirements
- Flow required to maintain water quality
- Flow required to sustain riverine ecology including fisheries

Irrigation and drinking water requirements

The proposed project is located in an area with low population density with no major sources of pollution. The major source of water for meeting irrigation and drinking requirements in the project area are rivers or nallahs which flow adjacent to the habitations. The water is conveyed to the point of consumption. Thus, no water is abstracted from river Lohit or its tributaries namely, Dav, Dalai, Tidding and Kamlang.

Flow required maintaining water quality

There are no sources of pollution in the area; hence, no flows are required to maintain water quality.

Flow required sustaining riverine ecology including fisheries

The river Lohit and its tributaries are typically hilly river, which has a fast water current with rich dissolved Oxygen.

Criteria for Sustenance of Mahaseer and Snow Trout

The minimum depth requirements are for Mahaseer and Snow Trout are given in Table-10.1.

Table-10.1: Minimum Depth Requirements

S.No.	Season	Depth Requirement (m)	
		Mahaseer Zone	Trout Zone
1.	Monsoon season	1.2 – 1.4	1.0
2.	Lean Season	0.5	0.4
3.	Non-monsoon Non-lean season	0.9 – 1.0	0.65 – 0.70

Reduction in water depth and flow width should not be more than 50% of pre-project levels. Pre-project water depth and water width are assessed by reviewing the results of 100% release scenario.

As a part of the study, four main seasons have been identified in a calendar. These are listed as below:

Season I: This season is considered as high flow season influenced by monsoon. It covers the months from June to September. The minimum flow during this period is assumed as 30% of average flow (10 daily or monthly).

Season II: This season is considered as average flow period. It covers the months from October to November in which the proposed minimum flow is taken as 25% of average flow. This period is a transitional period between the wet and dry period.

Season III: This season is considered as low or lean or dry flow season. It covers the months from December to March. The proposed minimum flow is taken as 20% of average flow during this period.

Season IV: This season is considered as average flow period and is same as that of season II. It covers the months from April to May in which the proposed minimum flow is taken as 25% of average flow. This period is a transitional period between the dry and wet period.

Out of 7 hydroelectric projects on main river Lohit under review as a part of the present study, 6 hydroelectric projects (except for Hutong hydroelectric project stage-1) have a dam toe power house. All the five hydroelectric projects on tributaries of Lohit Basin have head Race tunnel as water diversion arrangement. The proposed hydroelectric project would require filling up reservoir upto its live storage capacity, which would then be used for peaking power. The discharge for 90% dependable year for hydroelectric projects on main river Lohit and projects on tributaries of Lohit river are given in Tables-10.2 and 10.3 respectively.

Table-10.2: 90% Dependable Year for HEPS on main river Lohit

Month		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Anjaw HEP	Demwe Lower HEP
June	I	695.12	710	1192.87	1224.88	1072	696	1126
	II	767.36	798	1233.91	1267	1578	805	1657
	III	756.05	784	1455.55	1494.59	1737	788	1824
July	I	1002.64	841	2138.15	2195.51	2142	809	2249
	II	1023.38	1124	1922.42	1973.99	1277	1157	1341
	III	781.37	1189	1645.75	1689.9	918	1238	964
August	I	819.29	861	1160.34	1191.46	745	877	783
	II	816.91	863	1129.17	1159.45	688	879	723
	III	616.19	619	1025.83	1053.24	726	579	762
September	I	553.61	539	752.96	773.15	727	484	764
	II	526.8	506	657.18	674,81	697	444	732
	III	913.31	975	636.76	653.84	601	1022	631
October	I	622.18	758	533.39	547.69	556	765	584
	II	399	487	471.73	484.38	527	431	553
	III	374.18	457	376.93	387.04	493	394	517
November	I	345.66	358	358.09	367.7	439	403	461
	II	316.13	353	307.26	315.5	418	375	438
	III	284.9	307	293.12	300.98	398	346	418
December	I	268.99	294	423.31	434.67	382	332	401
	II	256.2	283	388.49	398.91	365	320	383
	III	240.43	270	397.74	405.33	351	305	368
January	I	225.49	258	269.5	276.73	341	291	358
	II	203.35	239	278.58	286.06	340	271	357
	III	216.93	251	227.26	233.36	341	283	358
February	I	221.81	255	219.88	225.77	315	288	330
	II	224.6	257	226.01	232.06	310	290	325
	III	226.21	258	304.24	312.4	320	292	336
March	I	217.62	251	170.86	175.44	353	284	371
	II	257.71	285	200.78	206.16	314	321	330
	III	246.99	276	221.81	227.75	603	312	634
April	I	419.78	322	474.29	487.01	600	360	630
	II	445.8	337	572.66	588.02	819	376	860
	III	449.27	347	612.98	629.42	951	388	998
May	I	570.08	550	715.77	734.96	780	506	820
	II	748.43	766	805.53	837.24	740	773	777
	III	764.87	786	820.5	842.51	852	797	895

Table-10.3: Discharge for 90% dependable year for various Hydro-electric Projects on tributaries of river Lohit

Month		Gmiliang HEP	Raigam HEP	Tidding-I HEP	Tidding-II HEP	Kamalang HEP
June	I	21.85	98.17	45.18	36.18	290
	II	24.74	111.02	51 16	40.96	165
	III	24.32	109.16	50.29	40.27	195
July	I	26.56	119.21	54.92	43.98	107
	II	35.9	160.63	74.24	59.44	135
	III	38.07	170.26	78.73	63.04	117
August	I	26.36	118.40	54.51	43.65	172
	II	26.4	118.57	54.59	43.71	86
	III	18.36	82.91	37.97	30.40	79
Septembei	I	16.23	73.10	33.56	26.87	84
	II	15.16	68.36	31.35	25.10	43
	III	30.64	136.99	63.36	50.73	41
October	I	24.48	109.08	50.62	40.53	36
	II	15.53	69.35	32.12	25.71	28
	III	14.54	64.96	30.07	24.08	25
November	I	11.82	52.4	24.44	19.57	21
	II	11.02	48.85	22.79	18.25	18
	III	10.14	44.96	20.97	16.79	16
December	I	9.72	43.1	20.10	16.09	15
	II	9.38	41.58	19.40	15.53	13
	III	8.92	39.55	18.45	14.77	15
January	I	8.54	37.86	17.66	14.14	13
	II	7.93	35.16	16.40	13.13	12
	III	8.27	36.68	17 10	13.69	24
February	I	8.42	37.35	17.41	13.94	22
	II	8.5	37.69	17.58	14.07	23
	III	8.54	37.86	17.66	14.14	24
March	I	8.31	36.87	17 18	13.76	61
	II	9.41	41.78	19.46	15.58	45
	III	9.11	40.42	18.84	15.08	82
April	I	10.5	46.83	21.71	17.39	45
	II	11.00	49.03	22.75	18.21	43
	III	11.34	50.55	23.45	18.78	37
May	I	17.55	78.45	36.29	29.06	125
	II	24.72	110.23	51.12	40.93	95
	III	25.36	113.10	52.44	41.99	322

Note: Discharge data for Kamlang HEP is for 75% Dependable Year

Kalai hydroelectric Project Stage-1

The number of hours for which peaking power will be available, in 90% dependable year shall range from 12.2 to 23.8 hours in the monsoon season from May to September. In the months of October and April, peaking will be available for a period of 8.7 to 14.5 hours and 9.8 to 10.4 hours respectively.

In lean season, from November to March peaking will be available for a period of 4.7 to 8.0 hours in 90% dependable year. It can be observed that in lean season, river water will be stored for a period of 16 to 19 hours. As a result, downstream stretch of river from the dam site will be remain dry for a period of 16 to 19 hours, which will be followed by a continuous flow equal to rated discharge of 1033 cumec for a period of 5 to 8 hours.

Kalai hydroelectric Project Stage-2

In Kalai hydroelectric project stage-2, peaking power will be available for a period of 13.6 hours to 24 hours for 90% dependable year in monsoon season. In the months of October and April, peaking power is available for a period of 8.1 to 13.1 hours. In lean season, peaking power is available for a period of 3.7 to 9.1 hours in 90% dependable year. Thus, in lean season river water will be stored for a period of 15 to 20 hours. As a result, downstream stretch of river from the dam site will remain dry for a period of 15 to 20 hours. This will be followed by a continuous flow of 1112.27 cumec (rated discharge) for a period of 4 to 9 hours.

Hutong Hydroelectric Project Stage-1

The peaking power will be available for a period of 10.7 to 24 hours for 90% dependable year in monsoon season. In lean season, peaking power will be available for a period of 2.9 to 7.1 hours. Thus, in lean season, river water will be stored in the reservoir for a period of 17 to 21 hours. As a result, river will remain dry for the corresponding period downstream of dam site. This will be followed by a continuous discharge of 1423 cumec (rated discharge) for a period of 3 to 7 hours.

Hutong Hydroelectric Project Stage-2

The details of number of hours of availability of peaking power available in 90% dependable year in monsoon season for Hutong Hydroelectric Project, stage-2 shall range from 11 to 24 hours. In lean season, the number of hours for which peaking power will be available shall range from 3 to 7.3 hours. Thus, river water will be stored for a period of 17 to 21 hours, resulting in drying of river Lohit downstream of dam site. This will be following by a continuous discharge of 1423 cumec for a period of 3 to7 hours.

Anjaw Hydroelectric Project

The number of hours of availability of peaking power for Demwe Upper hydroelectric project in 90% dependable year is expected to be 14.6 to 21.5 hours in monsoon season. On the other hand, peaking power will be available for 5.7 to 6.8 hours in lean season. Thus, river flow will be used to fill up the reservoir in lean season for 17 to 18 hours. Thus, river will remain dry for this period in lean season. This will be followed by a continuous discharge of 1141.15 cumec of about 6 to 7 hours.

Demwe Upper Hydroelectric Project

The number of hours of availability of peaking power for Demwe Upper hydroelectric project in 90% dependable year is expected to be 9.5 to 24 hours in monsoon season. On the other hand, peaking power will be available for 4.9 to 9.6 hours in lean season. Thus, river flow will be used to fill up the reservoir in lean season for 14 to 19 hours. Thus, river will remain dry for this period in lean season. This will be followed by a continuous discharge of 1513 cumec of about 5 to 10 hours.

Demwe Lower Hydroelectric Project

The number of peaking power availability in monsoon and lean season shall be 7.3 to 24 hours and 4.5 to 13.9 hours respectively. As a result in lean season the river will remain dry for a period of 10 to 19 hours followed by 5 to 14 hours of design discharge (1729 cumec).

Gmiliang Hydroelectric Project

The number of peaking power availability in monsoon and lean season shall be 14.95 to 24 hours and 6.76 to 8.02 hours respectively. As a result in lean season the river will remain dry for a period of 7 to 8 hours followed by 17 to 18 hours of design discharge (28.17 cumec).

Raigam Hydroelectric Project

The number of peaking power availability in monsoon and lean season shall be 13.3 to 24 hours and 2.0 to 8.1 hours respectively. As a result in lean season the river will remain dry for a period of 2.0 to 8 hours followed by 22 to 16 hours of design discharge (123.43 cumec).

Tidding-I Hydroelectric Project

The number of peaking power availability in monsoon and lean season shall be 13.46 to 24 hours and 7.04 to 8.63 hours respectively. As a result in lean season, river will remain dry for a period of 7 to 9 hours followed by 15 to 17 hours of design discharge (55.90 cumec).

Tiding-II Hydroelectric Project

The number of peaking power availability in monsoon and lean season shall be 13.05 to 24 hours and 6.83 to 8.37 hours respectively. As a result in lean season the river will remain dry for a period of 7 to 8 hours followed by 16 to 17 hours of design discharge (46.16 cumec).

Kamlang Hydroelectric Project

The number of peaking power availability in monsoon and lean season shall be 11.57 to 24 hours and 3.39 to 6.77 hours respectively. As a result in lean season the river will remain dry for a period of 3 to 7 hours followed by 17 to 21 hours of design discharge (85.06 cumec).

The recommended Environmental Flows for hydroelectric projects on main Lohit river are given in Tables-10.4 to 10.7.

Table-10.4: Environmental Flows for HEPs on main Lohit river in Monsoon season (Unit: cumec)

Months		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Anjaw HEP	Demwe Lower HEP
June	I	695.12	710	1192.87	1224.88	1072	696	1126
	II	767.36	798	1233.91	1267	1578	805	1657
	III	756.05	784	1455.55	1494.59	1737	788	1824
July	I	1002.64	841	2138.15	2195.51	2142	809	2249
	II	1023.38	1124	1922.42	1973.99	1277	1157	1341
	III	781.37	1189	1645.75	1689.9	918	1238	964
August	I	819.29	861	1160.34	1191.46	745	877	783
	II	816.91	863	1129.17	1159.45	688	879	723
	III	616.19	619	1025.83	1053.24	726	579	762
September	I	553.61	539	752.96	773.15	727	484	764
	II	526.8	506	657.18	674,81	697	444	732
	III	913.31	975	636.76	653.84	601	1022	631
Avg		**772.67**	**817.42**	**1245.91**	**1334.27**	**1075.67**	**812.8**	**1129.67**
E.F. (30%)		**231.80**	**245.23**	**373.77**	**400.28**	**322.70**	**243.84**	**338.90**
E.F. (25%)		**193.17**	**204.35**	**311.48**	**333.57**	**268.92**	**203.2**	**282.42**
E.F. (20%)		**154.53**	**163.48**	**249.18**	**266.85**	**215.13**	**162.56**	**225.93**

Table-10.5 : Environmental Flows for HEPs on main Lohit river in Non Monsoon Non Lean Season (Unit: cumec)

Months		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Anjaw HEP	Demwe Lower HEP
October	I	622.18	758	533.39	547.69	556	765	584
	II	399	487	471.73	484.38	527	431	553
	III	374.18	457	376.93	387.04	493	394	517
November	I	345.66	358	358.09	367.7	439	403	461
	II	316.13	353	307.26	315.5	418	375	438
	III	284.9	307	293.12	300.98	398	346	418
Avg		**390.34**	**453.33**	**390.09**	**400.55**	**471.83**	**452.3**	**495.17**
E.F. (25%)		**97.59**	**113.33**	**97.52**	**100.14**	**117.96**	**113.08**	**123.79**
E.F. (20%)		**78.07**	**90.67**	**78.02**	**80.11**	**94.37**	**90.41**	**99.03**

`

Table-10.6: Environmental Flows for HEPs on main Lohit river in Lean season (Unit: cumec)

Months		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Anjaw HEP	Demwe Lower HEP
December	I	268.99	294	423.31	434.67	382	322	401
	II	256.2	283	388.49	398.91	365	320	383
	III	240.43	270	397.74	405.33	351	305	368
January	I	225.49	258	269.5	276.73	341	291	358
	II	203.35	239	278.58	286.06	340	271	357
	III	216.93	251	227.26	233.36	341	283	358

Months		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Anjaw HEP	Demwe Lower HEP
February	I	221.81	255	219.88	225.77	315	288	330
	II	224.6	257	226.01	232.06	310	290	325
	III	226.21	258	304.24	312.4	320	292	336
March	I	217.62	251	170.86	175.44	353	284	371
	II	257.71	285	200.78	206.16	314	321	330
	III	246.99	276	221.81	227.75	603	312	634
Avg		**233.86**	**264.75**	**277.37**	**284.55**	**361.25**	**298.25**	**379.25**
E.F. (20%)		**46.77**	**52.95**	**55.47**	**56.91**	**72.25**	**59.64**	**75.85**
E.F. (15%)		**35.08**	**39.71**	**41.61**	**42.68**	**54.19**	**44.73**	**56.89**
E.F. (10%)		**23.39**	**26.48**	**27.74**	**28.46**	**36.13**	**29.82**	**37.93**

Table-10.7 : Environmental Flows for HEPs on main Lohit river in Non Monsoon Non Lean Season (unit: cumec)

Months		Kalai HEP Stage-1	Kalai HEP Stage-2	Hutong HEP Stage-1	Hutong HEP Stage-2	Demwe Upper HEP	Anjaw HEP	Demwe Lower HEP
May	I	419.78	322	474.29	487.01	600	360	630
	II	445.8	337	572.66	588.02	819	376	860
	III	449.27	347	612.98	629.42	951	388	998
April	I	570.08	550	715.77	734.96	780	506	820
	II	748.43	766	805.53	837.24	740	773	777
	III	764.87	786	820.5	842.51	852	797	895
Avg		**566.37**	**518.00**	**666.96**	**686.53**	**790.33**	**533.33**	**830.00**
E.F. (25%)		**141.59**	**129.50**	**166.74**	**171.63**	**197.58**	**133.33**	**207.50**
E.F. (20%)		**113.27**	**103.60**	**133.39**	**137.31**	**158.07**	**106.66**	**166.00**

The recommended Environmental Flows for hydroelectric projects on tributaries of river Lohit are given in Tables-10.8 to 10.11.

Table-10.8: Environmental Flows for HEPs on tributaries of river Lohit in Monsoon season

Months		Gimliang HEP	Raigam HEP	Tidding-I HEP	Tidding-II HEP	Kamlang HEP
June	I	21.85	98.17	45.18	36.18	125
	II	24.74	111.02	51.16	40.96	95
	III	24.32	109.16	50.29	40.27	322
July	I	26.56	119.21	54.92	43.98	290
	II	35.9	160.63	74.24	59.44	165
	III	38.07	170.26	78.73	63.04	195
August	I	26.36	118.4	54.51	43.65	107
	II	26.4	118.57	54.59	43.71	135
	III	18.36	82.91	37.97	30.4	117

Months		**Gimliang HEP**	**Raigam HEP**	**Tidding-I HEP**	**Tidding-II HEP**	**Kamlang HEP**
September	I	16.23	73.1	33.56	26.87	172
	II	15.16	68.36	31.35	25.1	86
	III	30.64	136.99	63.36	50.73	79
Avg		**25.38**	**113.90**	**52.49**	**42.03**	**157.33**
E.F. (30%)		**7.61**	**34.17**	**15.75**	**12.61**	**47.20**
E.F. (25%)		**6.35**	**28.47**	**13.12**	**10.51**	**39.33**
E.F. (20%)		**5.08**	**22.78**	**10.50**	**8.41**	**31.47**

Table-10.9 : Environmental Flows for HEPs on tributaries of river Lohit in Non Monsoon Non Lean Season

Months		**Gimliang HEP**	**Raigam HEP**	**Tidding-I HEP**	**Tidding-II HEP**	**Kamlang HEP**
October	I	24.48	109.08	50.62	40.53	84
	II	15.53	69.35	32.12	25.71	43
	III	14.54	64.96	30.07	24.08	41
November	I	11.82	52.4	24.44	19.57	36
	II	11.02	48.85	22.79	18.25	28
	III	10.14	44.96	20.97	16.79	25
Avg		**14.59**	**64.93**	**30.17**	**24.16**	**42.83**
E.F. (25%)		**3.65**	**16.23**	**7.54**	**6.04**	**10.71**
E.F. (20%)		**2.92**	**12.99**	**6.03**	**4.83**	**8.57**

Table-10.10: Environmental Flows for HEPs on tributaries of river Lohit in Lean season

Months		**Gimliang HEP**	**Raigam HEP**	**Tidding-I HEP**	**Tidding-II HEP**	**Kamlang HEP**
December	I	9.72	43.1	20.1	16.09	21
	II	9.38	41.58	19.4	15.53	18
	III	8.92	39.55	18.45	14.77	16
January	I	8.54	37.86	17.66	14.14	15
	II	7.93	35.16	16.4	13.13	13
	III	8.27	36.68	17.1	13.69	15
February	I	8.42	37.35	17.41	13.94	13
	II	8.5	37.69	17.58	14.07	12
	III	8.54	37.86	17.66	14.14	24
March	I	8.31	36.87	17.18	13.76	22
	II	9.41	41.78	19.46	15.58	23
	III	9.11	40.42	18.84	15.08	24
Avg		**8.75**	**38.83**	**18.10**	**14.49**	**18.00**
E.F. (20%)		**1.75**	**7.77**	**3.62**	**2.90**	**3.60**

Months		**Gimliang HEP**	**Raigam HEP**	**Tidding-I HEP**	**Tidding-II HEP**	**Kamlang HEP**
E.F. (15%)		**1.31**	**5.82**	**2.72**	**2.17**	**2.70**
E.F. (10%)		**0.88**	**3.88**	**1.81**	**1.45**	**1.80**

Table-10.11 : Environmental Flows for HEPs on tributaries of river Lohit in Non Monsoon Non Lean Season

Months		**Gimliang HEP**	**Raigam HEP**	**Tidding-I HEP**	**Tidding-II HEP**	**Kamlang HEP**
May	I	17.55	78.45	36.29	29.06	45
	II	24.72	110.23	51.12	40.93	43
	III	25.36	113.1	52.44	41.99	37
April	I	10.5	46.83	21.71	17.39	61
	II	11	49.03	22.75	18.21	45
	III	11.34	50.55	23.45	18.78	82
Avg		**16.75**	**74.70**	**34.63**	**27.73**	**52.17**
E.F. (25%)		**4.19**	**18.67**	**8.66**	**6.93**	**13.04**
E.F. (20%)		**3.35**	**14.94**	**6.93**	**5.55**	**10.43**

HYDROLOGICAL MODELLING

Methodology

1-D mathematical model has been developed for assessing the changes in hydraulic parameters corresponding to design flood. The model is based on the solution of St. Venant's equation of continuity and momentum. US Army Corps of Engineers, Hydrologic Engineering Centre software HECRAS, which is in public domain, has been used to carry out the studies.

Boundary Conditions

Steady Flow Simulation has been done with normal depth at the downstream section as boundary condition.

Manning's 'N' Value

Bed of main channel at the study area is granular sand and that of flood plains are consisted of silt mixed with sand. Value of Manning's 'n' has been adopted as 0.04.

Model Studies

Steady state simulation runs have been carried out with the 1-D mathematical model with Environmental flows proposed to be released in various seasons. The results of steady simulation runs for average flow in various seasons for 90% dependable year are given in Table-10.12 to 10.22.

Table-10.12: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Kalai HEP Stage-1

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
Kalai-I 50 m D/s of dam axis	M(100%)	772.7	918.32	920.8	2.48	193.17	118.57
	M(30%)	231.8	918.32	919.74	1.42	78.71	90.83
	M(29%)	224.08	918.32	919.72	1.4	76.74	89.86
	M(28%)	216.36	918.32	919.7	1.38	74.8	88.78
	M(27%)	208.63	918.32	919.68	1.36	72.95	87.73
	M(26%)	200.9	918.32	919.65	1.33	70.53	86.33
	M(25%)	193.17	918.32	919.63	1.31	68.62	85.22
	M(24%)	185.45	918.32	919.6	1.28	66.45	83.94
	M(23%)	177.72	918.32	919.57	1.25	64.26	82.62
	M(22%)	169.99	918.32	919.54	1.22	61.76	81.1
	M(21%)	162.27	918.32	919.51	1.19	59.45	79.66
	M(20%)	154.53	918.32	919.49	1.17	57.56	78.46
	L(100%)	233.9	918.32	919.75	1.43	79.36	91.14
	L(20%)	46.8	918.32	918.95	0.63	22.45	51.43
	L(19%)	44.44	918.32	918.93	0.61	21.57	50.57
	L(18%)	42.1	918.32	918.91	0.59	20.62	49.62
	L(17%)	39.76	918.32	918.9	0.58	19.81	48.79
	L(16%)	37.42	918.32	918.88	0.56	18.83	47.77
	L(15%)	35.1	918.32	918.86	0.54	17.98	46.87
	NMNL1(100%)	566.4	918.32	920.46	2.14	154.32	112.56
	NMNL1(25%)	141.6	918.32	919.44	1.12	53.73	75.98
	NMNL1(24%)	135.94	918.32	919.42	1.1	52.02	74.85
	NMNL1(23%)	130.27	918.32	919.39	1.07	50.11	73.56
	NMNL1(22%)	124.61	918.32	919.37	1.05	48.3	72.32
	NMNL1(21%)	118.94	918.32	919.34	1.02	46.67	71.18
	NMNL1(20%)	113.3	918.32	919.32	1	44.79	69.85
	NMNL2(100%)	390.3	918.32	920.13	1.81	118.27	106.78
	NMNL2(25%)	97.6	918.32	919.25	0.93	39.92	66.27
	NMNL2(24%)	93.67	918.32	919.23	0.91	38.61	65.27
	NMNL2(23%)	89.77	918.32	919.21	0.89	37.34	64.29
	NMNL2(22%)	85.87	918.32	919.19	0.87	36.02	63.26
	NMNL2(21%)	81.96	918.32	919.17	0.85	34.75	62.25
	NMNL2(20%)	78.1	918.32	919.15	0.83	33.48	61.22
Kalai-I 100 m D/s of dam axis	M(100%)	772.7	916.6	920.24	3.64	199.46	101.62
	M(30%)	231.8	916.6	918.7	2.1	79.39	61.6
	M(29%)	224.08	916.6	918.67	2.07	77.48	60.96
	M(28%)	216.36	916.6	918.64	2.04	75.54	60.31
	M(27%)	208.63	916.6	918.61	2.01	73.57	59.64
	M(26%)	200.9	916.6	918.57	1.97	71.6	58.96
	M(25%)	193.17	916.6	918.54	1.94	69.6	58.26
	M(24%)	185.45	916.6	918.5	1.9	67.58	57.55
	M(23%)	177.72	916.6	918.47	1.87	65.54	56.82

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
	M(22%)	169.99	916.6	918.43	1.83	63.48	56.08
	M(21%)	162.27	916.6	918.39	1.79	61.4	55.31
	M(20%)	154.53	916.6	918.36	1.76	59.28	54.53
	L(100%)	233.9	916.6	918.71	2.11	79.92	61.77
	L(20%)	46.8	916.6	917.66	1.06	26.04	42.17
	L(19%)	44.44	916.6	917.64	1.04	25.18	41.89
	L(18%)	42.1	916.6	917.62	1.02	24.31	41.6
	L(17%)	39.76	916.6	917.6	1	23.42	41.31
	L(16%)	37.42	916.6	917.57	0.97	22.52	41.01
	L(15%)	35.1	916.6	917.55	0.95	21.6	40.71
	NMNL1(100%)	566.4	916.6	919.72	3.12	152.46	82.31
	NMNL1(25%)	141.6	916.6	918.29	1.69	55.68	53.16
	NMNL1(24%)	135.94	916.6	918.26	1.66	54.08	52.54
	NMNL1(23%)	130.27	916.6	918.23	1.63	52.46	51.91
	NMNL1(22%)	124.61	916.6	918.2	1.6	50.82	51.26
	NMNL1(21%)	118.94	916.6	918.16	1.56	49.16	50.6
	NMNL1(20%)	113.3	916.6	918.13	1.53	47.49	49.92
	NMNL2(100%)	390.3	916.6	919.25	2.65	116.02	72.73
	NMNL2(25%)	97.6	916.6	918.03	1.43	42.69	47.84
	NMNL2(24%)	93.67	916.6	918.01	1.41	41.46	47.29
	NMNL2(23%)	89.77	916.6	917.98	1.38	40.21	46.73
	NMNL2(22%)	85.87	916.6	917.95	1.35	38.92	46.15
	NMNL2(21%)	81.96	916.6	917.92	1.32	37.71	45.78
	NMNL2(20%)	78.1	916.6	917.9	1.3	36.51	45.43

Note:

M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.13: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Kalai HEP Stage-2

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
Kalai-II 200 m D/s of Dam axis	M(100%)	1237.46	775	781.5	6.5	344.9	70.13
	M(30%)	371.24	775	779.01	4.01	180.12	59.61
	M(29%)	358.86	775	778.96	3.96	176.9	59.24
	M(28%)	346.49	775	778.9	3.9	173.65	58.87
	M(27%)	334.11	775	778.84	3.84	170.31	58.48
	M(26%)	321.74	775	778.79	3.79	166.94	58.09
	M(25%)	309.37	775	778.73	3.73	163.52	57.69

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
	M(24%)	296.99	775	778.67	3.67	160.02	57.28
	M(23%)	284.62	775	778.6	3.6	156.47	56.85
	M(22%)	272.24	775	778.54	3.54	152.89	56.43
	M(21%)	259.87	775	778.48	3.48	149.18	55.98
	M(20%)	247.49	775	778.41	3.41	145.43	55.52
	L(100%)	275.24	775	778.56	3.56	153.74	56.53
	L(20%)	55.05	775	776.71	1.71	60.91	43.34
	L(19%)	52.3	775	776.66	1.66	58.96	42.93
	L(18%)	49.54	775	776.62	1.62	56.96	42.51
	L(17%)	46.79	775	776.57	1.57	54.91	42.08
	L(16%)	44.04	775	776.52	1.52	52.79	41.62
	L(15%)	41.29	775	776.46	1.46	50.61	41.15
	NMNL1(100%)	387.45	775	779.08	4.08	184.28	60.08
	NMNL1(25%)	96.86	775	777.26	2.26	86.09	47.72
	NMNL1(24%)	92.99	775	777.22	2.22	84.04	47.43
	NMNL1(23%)	89.11	775	777.17	2.17	81.93	47.13
	NMNL1(22%)	85.24	775	777.13	2.13	79.78	46.82
	NMNL1(21%)	81.36	775	777.08	2.08	77.57	46.5
	NMNL1(20%)	77.49	775	777.03	2.03	75.3	46.16
	NMNL2(100%)	662.44	775	780.06	5.06	246.6	66.48
	NMNL2(25%)	165.61	775	777.88	2.88	117.24	51.96
	NMNL2(24%)	158.99	775	777.83	2.83	114.59	51.62
	NMNL2(23%)	152.36	775	777.78	2.78	111.87	51.26
	NMNL2(22%)	145.74	775	777.73	2.73	109.09	50.89
	NMNL2(21%)	139.11	775	777.67	2.67	106.25	50.51
	NMNL2(20%)	132.49	775	777.61	2.61	103.31	50.11
Kalai-II 300 m D/s of Dam axis	M(100%)	1237.46	774	781.45	7.45	407.23	90.44
	M(30%)	371.24	774	778.9	4.9	194.34	73.49
	M(29%)	358.86	774	778.85	4.85	190.4	72.96
	M(28%)	346.49	774	778.79	4.79	186.4	72.43
	M(27%)	334.11	774	778.74	4.74	182.33	71.88
	M(26%)	321.74	774	778.68	4.68	178.22	71.31
	M(25%)	309.37	774	778.62	4.62	174.07	70.74
	M(24%)	296.99	774	778.56	4.56	169.81	70.15
	M(23%)	284.62	774	778.5	4.5	165.53	69.55
	M(22%)	272.24	774	778.44	4.44	161.18	68.94
	M(21%)	259.87	774	778.37	4.37	156.74	68.31

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
	M(20%)	247.49	774	778.31	4.31	152.23	67.66
	L(100%)	275.24	774	778.45	4.45	162.21	69.08
	L(20%)	55.05	774	776.64	2.64	59.1	42.62
	L(19%)	52.3	774	776.6	2.6	57.24	41.9
	L(18%)	49.54	774	776.55	2.55	55.34	41.16
	L(17%)	46.79	774	776.5	2.5	53.42	40.4
	L(16%)	44.04	774	776.45	2.45	51.44	39.6
	L(15%)	41.29	774	776.4	2.4	49.44	38.77
	NMNL1(100%)	387.45	774	778.97	4.97	199.45	74.17
	NMNL1(25%)	96.86	774	777.18	3.18	84.36	51.34
	NMNL1(24%)	92.99	774	777.14	3.14	82.2	50.65
	NMNL1(23%)	89.11	774	777.09	3.09	80.02	49.95
	NMNL1(22%)	85.24	774	777.05	3.05	77.8	49.22
	NMNL1(21%)	81.36	774	777	3	75.54	48.47
	NMNL1(20%)	77.49	774	776.95	2.95	73.24	47.7
	NMNL2(100%)	662.44	774	779.96	5.96	277.83	83.87
	NMNL2(25%)	165.61	774	777.79	3.79	118.86	61.28
	NMNL2(24%)	158.99	774	777.74	3.74	115.79	60.46
	NMNL2(23%)	152.36	774	777.69	3.69	112.67	59.62
	NMNL2(22%)	145.74	774	777.63	3.63	109.5	58.75
	NMNL2(21%)	139.11	774	777.58	3.58	106.28	57.85
	NMNL2(20%)	132.49	774	777.52	3.52	103.01	56.93
Kalai-II 1160 m D/s of Dam axis	M(100%)	1237.46	774	778.84	4.84	277.45	90.18
	M(30%)	371.24	774	777.03	3.03	125.28	75.62
	M(29%)	358.86	774	776.99	2.99	122.44	75.16
	M(28%)	346.49	774	776.95	2.95	119.39	74.36
	M(27%)	334.11	774	776.91	2.91	116.3	73.55
	M(26%)	321.74	774	776.86	2.86	113.19	72.73
	M(25%)	309.37	774	776.82	2.82	110.04	71.88
	M(24%)	296.99	774	776.78	2.78	106.86	71.02
	M(23%)	284.62	774	776.73	2.73	103.64	70.13
	M(22%)	272.24	774	776.68	2.68	100.39	69.23
	M(21%)	259.87	774	776.64	2.64	97.1	68.3
	M(20%)	247.49	774	776.59	2.59	93.77	67.34
	L(100%)	275.24	774	776.69	2.69	101.19	69.45
	L(20%)	55.05	774	775.48	1.48	31.84	43.04
	L(19%)	52.3	774	775.45	1.45	30.64	42.22

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
	L(18%)	49.54	774	775.42	1.42	29.42	41.37
	L(17%)	46.79	774	775.39	1.39	28.19	40.5
	L(16%)	44.04	774	775.36	1.36	26.94	39.59
	L(15%)	41.29	774	775.33	1.33	25.67	38.65
	NMNL1(100%)	387.45	774	777.07	3.07	128.84	76.05
	NMNL1(25%)	96.86	774	775.82	1.82	48.01	51.55
	NMNL1(24%)	92.99	774	775.79	1.79	46.6	50.87
	NMNL1(23%)	89.11	774	775.77	1.77	45.19	50.18
	NMNL1(22%)	85.24	774	775.74	1.74	43.75	49.47
	NMNL1(21%)	81.36	774	775.71	1.71	42.29	48.74
	NMNL1(20%)	77.49	774	775.68	1.68	40.82	47.99
	NMNL2(100%)	662.44	774	777.77	3.77	183.64	82.39
	NMNL2(25%)	165.61	774	776.22	2.22	70.51	60.26
	NMNL2(24%)	158.99	774	776.19	2.19	68.5	59.61
	NMNL2(23%)	152.36	774	776.15	2.15	66.48	58.95
	NMNL2(22%)	145.74	774	776.12	2.12	64.44	58.27
	NMNL2(21%)	139.11	774	776.08	2.08	62.36	57.58
	NMNL2(20%)	132.49	774	776.05	2.05	60.26	56.87

Note:

M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.14: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Hutong HEP Stage-2

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m3/s)	(m)	(m)	(m)	(m2)	(m)
Hutong-II 300 m D/s of dam axis	M(100%)	1279.3	591.1	594.61	3.51	403.56	162.95
	M(30%)	383.8	591.1	593.19	2.09	195.5	129.09
	M(29%)	371	591.1	593.16	2.06	191.61	128.54
	M(28%)	358.2	591.1	593.13	2.03	187.65	127.98
	M(27%)	345.41	591.1	593.1	2	183.66	127.4
	M(26%)	332.62	591.1	593.07	1.97	179.55	126.81
	M(25%)	319.83	591.1	593.03	1.93	175.36	126.21
	M(24%)	307.03	591.1	593	1.9	171.12	125.59
	M(23%)	294.24	591.1	592.96	1.86	166.75	124.95
	M(22%)	281.45	591.1	592.93	1.83	162.32	124.3
	M(21%)	268.65	591.1	592.89	1.79	157.75	123.63
	M(20%)	255.86	591.1	592.85	1.75	153.1	122.94

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m3/s)	(m)	(m)	(m)	(m2)	(m)
	L(100%)	284.6	591.1	592.94	1.84	163.41	124.46
	L(20%)	56.9	591.1	592.01	0.91	57.6	100.22
	L(19%)	54.07	591.1	591.99	0.89	55.69	99.4
	L(18%)	51.23	591.1	591.97	0.87	53.73	98.41
	L(17%)	48.38	591.1	591.95	0.85	51.73	97.38
	L(16%)	45.54	591.1	591.93	0.83	49.69	96.33
	L(15%)	42.7	591.1	591.9	0.8	47.6	95.24
	NMNL1(100%)	686.5	591.1	593.78	2.68	274.63	139.56
	NMNL1(25%)	171.6	591.1	592.57	1.47	118.87	117.68
	NMNL1(24%)	164.76	591.1	592.54	1.44	115.76	116.86
	NMNL1(23%)	157.9	591.1	592.52	1.42	112.57	116.01
	NMNL1(22%)	151.03	591.1	592.49	1.39	109.35	115.14
	NMNL1(21%)	144.17	591.1	592.46	1.36	106.08	114.26
	NMNL1(20%)	137.3	591.1	592.43	1.33	102.76	113.35
	NMNL2(100%)	400.5	591.1	593.23	2.13	200.46	129.79
	NMNL2(25%)	100.1	591.1	592.26	1.16	83.56	107.97
	NMNL2(24%)	96.12	591.1	592.24	1.14	81.37	107.34
	NMNL2(23%)	92.12	591.1	592.22	1.12	79.13	106.68
	NMNL2(22%)	88.11	591.1	592.19	1.09	76.85	106.02
	NMNL2(21%)	84.11	591.1	592.17	1.07	74.54	105.34
	NMNL2(20%)	80.1	591.1	592.15	1.05	72.18	104.64
Hutong-II 508 m D/s of dam axis	M(100%)	1279.3	590.73	593.56	2.83	368.28	183.69
	M(30%)	383.8	590.73	592.2	1.47	155.13	129.96
	M(29%)	371	590.73	592.17	1.44	151.64	129.19
	M(28%)	358.2	590.73	592.15	1.42	148.12	128.41
	M(27%)	345.41	590.73	592.12	1.39	144.56	127.62
	M(26%)	332.62	590.73	592.09	1.36	140.97	126.82
	M(25%)	319.83	590.73	592.06	1.33	137.34	126.01
	M(24%)	307.03	590.73	592.03	1.3	133.66	125.18
	M(23%)	294.24	590.73	592	1.27	129.94	124.33
	M(22%)	281.45	590.73	591.97	1.24	126.16	123.47
	M(21%)	268.65	590.73	591.94	1.21	122.34	122.59
	M(20%)	255.86	590.73	591.91	1.18	118.47	121.69
	L(100%)	284.6	590.73	591.98	1.25	127.1	123.68
	L(20%)	56.9	590.73	591.25	0.52	44.96	103.05
	L(19%)	54.07	590.73	591.24	0.51	43.54	102.65
	L(18%)	51.23	590.73	591.23	0.5	42.08	102.2
	L(17%)	48.38	590.73	591.21	0.48	40.55	101.54
	L(16%)	45.54	590.73	591.2	0.47	39.03	101.07
	L(15%)	42.7	590.73	591.18	0.45	37.48	100.6
	NMNL1(100%)	686.5	590.73	592.76	2.03	233.38	150.83
	NMNL1(25%)	171.6	590.73	591.68	0.95	91.18	115.13
	NMNL1(24%)	164.76	590.73	591.66	0.93	88.8	114.54
	NMNL1(23%)	157.9	590.73	591.64	0.91	86.38	113.94

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m3/s)	(m)	(m)	(m)	(m2)	(m)
	NMNL1(22%)	151.03	590.73	591.61	0.88	83.93	113.33
	NMNL1(21%)	144.17	590.73	591.59	0.86	81.43	112.7
	NMNL1(20%)	137.3	590.73	591.57	0.84	78.9	112.06
	NMNL2(100%)	400.5	590.73	592.23	1.5	159.62	130.94
	NMNL2(25%)	100.1	590.73	591.44	0.71	64.38	108.3
	NMNL2(24%)	96.12	590.73	591.42	0.69	62.73	107.87
	NMNL2(23%)	92.12	590.73	591.41	0.68	61.06	107.42
	NMNL2(22%)	88.11	590.73	591.39	0.66	59.34	106.97
	NMNL2(21%)	84.11	590.73	591.38	0.65	57.61	106.5
	NMNL2(20%)	80.1	590.73	591.36	0.63	55.85	106.03

Note:
M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.15: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Anjaw HEP

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
Anjaw 415 m D/s of Dam axis	M(100%)	814.83	546.8	549.9	3.1	329.95	117.82
	M(30%)	244.45	546.8	548.41	1.61	156.48	113.91
	M(29%)	236.3	546.8	548.38	1.58	153.13	113.83
	M(28%)	228.15	546.8	548.35	1.55	149.72	113.75
	M(27%)	220	546.8	548.32	1.52	146.3	113.68
	M(26%)	211.86	546.8	548.29	1.49	142.75	113.59
	M(25%)	203.71	546.8	548.25	1.45	139.15	113.51
	M(24%)	195.56	546.8	548.22	1.42	135.51	113.43
	M(23%)	187.41	546.8	548.19	1.39	131.81	113.34
	M(22%)	179.26	546.8	548.16	1.36	128.06	113.26
	M(21%)	171.11	546.8	548.12	1.32	124.24	113.17
	M(20%)	162.97	546.8	548.09	1.29	120.27	113.08
	L(100%)	299.08	546.8	548.59	1.79	177.83	114.4
	L(20%)	59.82	546.8	547.56	0.76	60.98	111.7
	L(19%)	56.83	546.8	547.54	0.74	58.88	111.65
	L(18%)	53.83	546.8	547.52	0.72	56.76	111.6
	L(17%)	50.84	546.8	547.5	0.7	54.57	111.55
	L(16%)	47.85	546.8	547.48	0.68	52.38	111.5
	L(15%)	44.86	546.8	547.46	0.66	50.12	111.44

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
	NMNL1(100%)	452.33	546.8	549.05	2.25	229.86	115.58
	NMNL1(25%)	113.08	546.8	547.86	1.06	94.22	112.47
	NMNL1(24%)	108.56	546.8	547.83	1.03	91.66	112.41
	NMNL1(23%)	104.04	546.8	547.81	1.01	89.07	112.35
	NMNL1(22%)	99.51	546.8	547.79	0.99	86.41	112.29
	NMNL1(21%)	94.99	546.8	547.76	0.96	83.73	112.23
	NMNL1(20%)	90.47	546.8	547.74	0.94	80.99	112.17
	NMNL2(100%)	533.33	546.8	549.26	2.46	254.43	116.13
	NMNL2(25%)	133.33	546.8	547.96	1.16	105.28	112.73
	NMNL2(24%)	128	546.8	547.93	1.13	102.45	112.66
	NMNL2(23%)	122.67	546.8	547.9	1.1	99.59	112.6
	NMNL2(22%)	117.33	546.8	547.88	1.08	96.64	112.53
	NMNL2(21%)	112	546.8	547.85	1.05	93.61	112.46
	NMNL2(20%)	106.67	546.8	547.82	1.02	90.58	112.39
Anjaw 615 m D/s of Dam axis	M(100%)	814.83	546	548.9	2.9	240.88	89.01
	M(30%)	244.45	546	547.65	1.65	130.13	87.21
	M(29%)	236.3	546	547.62	1.62	127.83	87.17
	M(28%)	228.15	546	547.59	1.59	125.44	87.13
	M(27%)	220	546	547.56	1.56	123.04	87.09
	M(26%)	211.86	546	547.54	1.54	120.59	87.05
	M(25%)	203.71	546	547.51	1.51	118.11	87.01
	M(24%)	195.56	546	547.48	1.48	115.58	86.97
	M(23%)	187.41	546	547.45	1.45	113	86.93
	M(22%)	179.26	546	547.42	1.42	110.33	86.88
	M(21%)	171.11	546	547.39	1.39	107.62	86.84
	M(20%)	162.97	546	547.36	1.36	104.87	86.79
	L(100%)	299.08	546	547.81	1.81	144.72	87.45
	L(20%)	59.82	546	546.83	0.83	59.77	86.05
	L(19%)	56.83	546	546.81	0.81	58.02	86.02
	L(18%)	53.83	546	546.79	0.79	56.21	85.99
	L(17%)	50.84	546	546.77	0.77	54.36	85.96
	L(16%)	47.85	546	546.75	0.75	52.38	85.93
	L(15%)	44.86	546	546.73	0.73	50.42	85.89
	NMNL1(100%)	452.33	546	548.2	2.2	178.93	88.01
	NMNL1(25%)	113.08	546	547.14	1.14	85.78	86.48
	NMNL1(24%)	108.56	546	547.11	1.11	83.88	86.45
	NMNL1(23%)	104.04	546	547.09	1.09	81.95	86.42

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
	NMNL1(22%)	99.51	546	547.07	1.07	79.8	86.38
	NMNL1(21%)	94.99	546	547.04	1.04	77.78	86.35
	NMNL1(20%)	90.47	546	547.02	1.02	75.7	86.31
	NMNL2(100%)	533.33	546	548.38	2.38	194.59	88.26
	NMNL2(25%)	133.33	546	547.23	1.23	93.84	86.61
	NMNL2(24%)	128	546	547.2	1.2	91.78	86.58
	NMNL2(23%)	122.67	546	547.18	1.18	89.67	86.54
	NMNL2(22%)	117.33	546	547.16	1.16	87.51	86.51
	NMNL2(21%)	112	546	547.13	1.13	85.33	86.47
	NMNL2(20%)	106.67	546	547.1	1.1	83.08	86.43
Anjaw 815 m D/s of Dam axis	M(100%)	814.83	545	548.67	3.67	376.87	107.82
	M(30%)	244.45	545	547.49	2.49	251.21	105.26
	M(29%)	236.3	545	547.47	2.47	248.64	105.2
	M(28%)	228.15	545	547.45	2.45	245.98	105.15
	M(27%)	220	545	547.42	2.42	243.28	105.09
	M(26%)	211.86	545	547.39	2.39	240.57	105.04
	M(25%)	203.71	545	547.37	2.37	237.82	104.98
	M(24%)	195.56	545	547.34	2.34	235	104.92
	M(23%)	187.41	545	547.31	2.31	232.14	104.86
	M(22%)	179.26	545	547.29	2.29	229.18	104.8
	M(21%)	171.11	545	547.26	2.26	226.18	104.74
	M(20%)	162.97	545	547.23	2.23	223.16	104.67
	L(100%)	299.08	545	547.65	2.65	267.56	105.59
	L(20%)	59.82	545	546.75	1.75	173.27	103.63
	L(19%)	56.83	545	546.73	1.73	171.33	103.59
	L(18%)	53.83	545	546.71	1.71	169.34	103.55
	L(17%)	50.84	545	546.69	1.69	167.31	103.51
	L(16%)	47.85	545	546.67	1.67	165.08	103.46
	L(15%)	44.86	545	546.65	1.65	162.91	103.42
	NMNL1(100%)	452.33	545	548.01	3.01	305.92	106.38
	NMNL1(25%)	113.08	545	547.02	2.02	201.95	104.23
	NMNL1(24%)	108.56	545	547	2	199.88	104.19
	NMNL1(23%)	104.04	545	546.98	1.98	197.77	104.15
	NMNL1(22%)	99.51	545	546.96	1.96	195.3	104.09
	NMNL1(21%)	94.99	545	546.94	1.94	193.09	104.05
	NMNL1(20%)	90.47	545	546.92	1.92	190.82	104
	NMNL2(100%)	533.33	545	548.18	3.18	323.67	106.74

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
	NMNL2(25%)	133.33	545	547.11	2.11	210.82	104.42
	NMNL2(24%)	128	545	547.09	2.09	208.56	104.37
	NMNL2(23%)	122.67	545	547.07	2.07	206.24	104.32
	NMNL2(22%)	117.33	545	547.04	2.04	203.87	104.27
	NMNL2(21%)	112	545	547.02	2.02	201.47	104.22
	NMNL2(20%)	106.67	545	547	2	198.99	104.17
Anjaw 1515 m D/s of Dam axis	M(100%)	814.83	530	532.74	2.74	213.84	139.62
	M(30%)	244.45	530	531.86	1.86	95.79	110.55
	M(29%)	236.3	530	531.83	1.83	92.96	107.76
	M(28%)	228.15	530	531.81	1.81	90.1	104.86
	M(27%)	220	530	531.78	1.78	87.26	102.79
	M(26%)	211.86	530	531.75	1.75	84.54	101.01
	M(25%)	203.71	530	531.73	1.73	81.91	99.27
	M(24%)	195.56	530	531.7	1.7	79.31	97.51
	M(23%)	187.41	530	531.67	1.67	76.53	95.15
	M(22%)	179.26	530	531.64	1.64	73.65	92.63
	M(21%)	171.11	530	531.61	1.61	70.6	89.9
	M(20%)	162.97	530	531.57	1.57	67.48	87.01
	L(100%)	299.08	530	532.02	2.02	115.21	135.26
	L(20%)	59.82	530	531	1	29.53	46.79
	L(19%)	56.83	530	530.98	0.98	28.43	46.03
	L(18%)	53.83	530	530.95	0.95	27.36	45.29
	L(17%)	50.84	530	530.93	0.93	26.29	44.54
	L(16%)	47.85	530	530.9	0.9	25.2	43.76
	L(15%)	44.86	530	530.88	0.88	24.09	42.96
	NMNL1(100%)	452.33	530	532.27	2.27	148.55	136.75
	NMNL1(25%)	113.08	530	531.36	1.36	50.59	71.34
	NMNL1(24%)	108.56	530	531.33	1.33	48.95	69.74
	NMNL1(23%)	104.04	530	531.31	1.31	47.28	68.07
	NMNL1(22%)	99.51	530	531.28	1.28	45.59	66.34
	NMNL1(21%)	94.99	530	531.26	1.26	43.88	64.53
	NMNL1(20%)	90.47	530	531.23	1.23	42.14	62.65
	NMNL2(100%)	533.33	530	532.38	2.38	164.43	137.45
	NMNL2(25%)	133.33	530	531.45	1.45	57.75	77.94
	NMNL2(24%)	128	530	531.43	1.43	55.9	76.29
	NMNL2(23%)	122.67	530	531.4	1.4	54.02	74.57
	NMNL2(22%)	117.33	530	531.38	1.38	52.13	72.8

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
	NMNL2(21%)	112	530	531.35	1.35	50.2	70.96
	NMNL2(20%)	106.67	530	531.32	1.32	48.25	69.04
Anjaw 2015 m D/s of Dam axis	M(100%)	814.83	525.9	528.58	2.68	274.1	133.78
	M(30%)	244.45	525.9	527.48	1.58	128.88	129.4
	M(29%)	236.3	525.9	527.46	1.56	126.18	129.32
	M(28%)	228.15	525.9	527.44	1.54	123.45	129.24
	M(27%)	220	525.9	527.42	1.52	120.68	129.15
	M(26%)	211.86	525.9	527.4	1.5	117.88	129.07
	M(25%)	203.71	525.9	527.37	1.47	115.04	128.98
	M(24%)	195.56	525.9	527.35	1.45	112.15	128.89
	M(23%)	187.41	525.9	527.33	1.43	109.23	128.8
	M(22%)	179.26	525.9	527.31	1.41	106.25	128.71
	M(21%)	171.11	525.9	527.28	1.38	103.23	128.62
	M(20%)	162.97	525.9	527.26	1.36	100.14	128.52
	L(100%)	299.08	525.9	527.61	1.71	146.19	129.93
	L(20%)	59.82	525.9	526.81	0.91	49.28	89.77
	L(19%)	56.83	525.9	526.79	0.89	47.46	87.96
	L(18%)	53.83	525.9	526.77	0.87	45.61	86.07
	L(17%)	50.84	525.9	526.74	0.84	43.72	84.12
	L(16%)	47.85	525.9	526.72	0.82	41.83	82.1
	L(15%)	44.86	525.9	526.7	0.8	39.88	79.98
	NMNL1(100%)	452.33	525.9	527.95	2.05	189.48	131.25
	NMNL1(25%)	113.08	525.9	527.1	1.2	79.92	127.89
	NMNL1(24%)	108.56	525.9	527.08	1.18	77.8	124.33
	NMNL1(23%)	104.04	525.9	527.06	1.16	75.43	120.24
	NMNL1(22%)	99.51	525.9	527.04	1.14	72.87	115.65
	NMNL1(21%)	94.99	525.9	527.02	1.12	70.17	110.62
	NMNL1(20%)	90.47	525.9	526.99	1.09	67.36	106.08
	NMNL2(100%)	533.33	525.9	528.1	2.2	210.13	131.87
	NMNL2(25%)	133.33	525.9	527.17	1.27	88.45	128.16
	NMNL2(24%)	128	525.9	527.15	1.25	86.27	128.09
	NMNL2(23%)	122.67	525.9	527.13	1.23	84.03	128.02
	NMNL2(22%)	117.33	525.9	527.11	1.21	81.75	127.95
	NMNL2(21%)	112	525.9	527.1	1.2	79.41	127.05
	NMNL2(20%)	106.67	525.9	527.08	1.18	76.83	122.67

Note:

M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.16: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Upper Demwe HEP

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
Upper Demwe 600 m D/s of Dam axis	M(100%)	1075.67	441	444.29	3.29	334.87	227.59
	M(30%)	322.7	441	443.05	2.05	128.44	119.32
	M(29%)	311.94	441	443.02	2.02	125.29	117.87
	M(28%)	301.19	441	442.99	1.99	122.07	116.37
	M(27%)	290.43	441	442.96	1.96	118.8	114.82
	M(26%)	279.67	441	442.94	1.94	115.52	113.26
	M(25%)	268.92	441	442.91	1.91	112.2	111.64
	M(24%)	258.16	441	442.88	1.88	108.81	109.98
	M(23%)	247.4	441	442.84	1.84	105.43	108.29
	M(22%)	236.65	441	442.81	1.81	101.97	106.53
	M(21%)	225.89	441	442.78	1.78	98.46	104.72
	M(20%)	215.13	441	442.75	1.75	94.9	102.79
	L(100%)	361.25	441	443.14	2.14	139.54	124.29
	L(20%)	72.25	441	442.06	1.06	39.94	59.73
	L(19%)	68.64	441	442.03	1.03	38.58	59.01
	L(18%)	65.03	441	442.01	1.01	37.19	58.23
	L(17%)	61.41	441	441.98	0.98	35.76	57.26
	L(16%)	57.8	441	441.96	0.96	34.3	56.24
	L(15%)	54.19	441	441.93	0.93	32.81	55.18
	NMNL1(100%)	471.83	441	443.37	2.37	169.64	136.74
	NMNL1(25%)	117.96	441	442.31	1.31	55.94	68.71
	NMNL1(24%)	113.24	441	442.28	1.28	54.39	67.07
	NMNL1(23%)	108.52	441	442.26	1.26	52.83	66.39
	NMNL1(22%)	103.8	441	442.23	1.23	51.26	65.68
	NMNL1(21%)	99.08	441	442.21	1.21	49.64	64.95
	NMNL1(20%)	94.37	441	442.18	1.18	48.01	64.21
	NMNL2(100%)	790.33	441	443.89	2.89	250.1	172.9
	NMNL2(25%)	197.58	441	442.69	1.69	88.95	99.31
	NMNL2(24%)	189.68	441	442.66	1.66	86.2	97.67
	NMNL2(23%)	181.78	441	442.63	1.63	83.42	95.97

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
	NMNL2(22%)	173.87	441	442.6	1.6	80.61	94.22
	NMNL2(21%)	165.97	441	442.57	1.57	77.75	92.41
	NMNL2(20%)	158.07	441	442.54	1.54	74.73	90.47
Upper Demwe 900 m D/s of Dam axis	M(100%)	1075.67	439	442.2	3.2	354.15	301.31
	M(30%)	322.7	439	441.07	2.07	105.16	109.23
	M(29%)	311.94	439	441.01	2.01	99.53	98.36
	M(28%)	301.19	439	440.97	1.97	95.06	94.49
	M(27%)	290.43	439	440.94	1.94	92.71	93.09
	M(26%)	279.67	439	440.91	1.91	89.86	91.35
	M(25%)	268.92	439	440.88	1.88	86.69	89.39
	M(24%)	258.16	439	440.84	1.84	83.88	87.6
	M(23%)	247.4	439	440.81	1.81	80.95	85.71
	M(22%)	236.65	439	440.77	1.77	77.63	83.58
	M(21%)	225.89	439	440.74	1.74	74.7	81.7
	M(20%)	215.13	439	440.7	1.7	71.75	79.76
	L(100%)	361.25	439	441.27	2.27	131.35	149.62
	L(20%)	72.25	439	440	1	28.74	45.18
	L(19%)	68.64	439	439.98	0.98	27.74	44.48
	L(18%)	65.03	439	439.95	0.95	26.42	43.53
	L(17%)	61.41	439	439.92	0.92	25.27	42.69
	L(16%)	57.8	439	439.89	0.89	24.15	41.86
	L(15%)	54.19	439	439.86	0.86	22.91	40.92
	NMNL1(100%)	471.83	439	441.53	2.53	177.81	202.83
	NMNL1(25%)	117.96	439	440.28	1.28	43.25	57.77
	NMNL1(24%)	113.24	439	440.26	1.26	41.77	56.39
	NMNL1(23%)	108.52	439	440.23	1.23	40.25	54.95
	NMNL1(22%)	103.8	439	440.2	1.2	38.74	53.48
	NMNL1(21%)	99.08	439	440.17	1.17	37.21	51.9
	NMNL1(20%)	94.37	439	440.14	1.14	35.58	50.06
	NMNL2(100%)	790.33	439	442	3	294.93	296.63
	NMNL2(25%)	197.58	439	440.64	1.64	66.92	76.47
	NMNL2(24%)	189.68	439	440.61	1.61	64.69	74.91
	NMNL2(23%)	181.78	439	440.58	1.58	62.43	73.29
	NMNL2(22%)	173.87	439	440.55	1.55	60.16	71.63
	NMNL2(21%)	165.97	439	440.51	1.51	57.85	69.9
	NMNL2(20%)	158.07	439	440.48	1.48	55.52	68.1

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
Upper Demwe 1500 m D/s of Dam axis	M(100%)	1075.67	429	432.97	3.97	255.98	97.25
	M(30%)	322.7	429	431.26	2.26	111.08	71.97
	M(29%)	311.94	429	431.22	2.22	108.51	71.37
	M(28%)	301.19	429	431.19	2.19	105.91	70.76
	M(27%)	290.43	429	431.15	2.15	103.29	70.14
	M(26%)	279.67	429	431.11	2.11	100.63	69.51
	M(25%)	268.92	429	431.07	2.07	97.94	68.86
	M(24%)	258.16	429	431.03	2.03	95.23	68.2
	M(23%)	247.4	429	430.99	1.99	92.47	67.52
	M(22%)	236.65	429	430.95	1.95	89.68	66.83
	M(21%)	225.89	429	430.91	1.91	86.86	66.13
	M(20%)	215.13	429	430.87	1.87	84	65.4
	L(100%)	361.25	429	431.38	2.38	120.09	73.9
	L(20%)	72.25	429	430.09	1.09	39.07	49.25
	L(19%)	68.64	429	430.06	1.06	37.7	48.64
	L(18%)	65.03	429	430.03	1.03	36.31	48
	L(17%)	61.41	429	430	1	34.9	47.35
	L(16%)	57.8	429	429.97	0.97	33.47	46.68
	L(15%)	54.19	429	429.94	0.94	32.01	45.99
	NMNL1(100%)	471.83	429	431.7	2.7	144.5	78.87
	NMNL1(25%)	117.96	429	430.39	1.39	55.1	55.96
	NMNL1(24%)	113.24	429	430.36	1.36	53.53	55.34
	NMNL1(23%)	108.52	429	430.34	1.34	51.95	54.71
	NMNL1(22%)	103.8	429	430.31	1.31	50.35	54.06
	NMNL1(21%)	99.08	429	430.28	1.28	48.72	53.4
	NMNL1(20%)	94.37	429	430.24	1.24	47.09	52.72
	NMNL2(100%)	790.33	429	432.44	3.44	206.53	89.82
	NMNL2(25%)	197.58	429	430.79	1.79	79.25	64.18
	NMNL2(24%)	189.68	429	430.76	1.76	77.07	63.62
	NMNL2(23%)	181.78	429	430.72	1.72	74.84	63.03
	NMNL2(22%)	173.87	429	430.69	1.69	72.54	62.36
	NMNL2(21%)	165.97	429	430.65	1.65	70.18	61.54
	NMNL2(20%)	158.07	429	430.61	1.61	67.79	60.7
Upper Demwe	M(100%)	1075.67	423.06	427.11	4.05	321.24	193.1
	M(30%)	322.7	423.06	425.81	2.75	128.64	119.45

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m^3/s)	(m)	(m)	(m)	(m2)	(m)
2600 m D/s of Dam axis	M(29%)	311.94	423.06	425.79	2.73	125.45	118.03
	M(28%)	301.19	423.06	425.76	2.7	122.23	116.58
	M(27%)	290.43	423.06	425.73	2.67	118.98	115.1
	M(26%)	279.67	423.06	425.7	2.64	115.7	113.58
	M(25%)	268.92	423.06	425.67	2.61	112.39	112.03
	M(24%)	258.16	423.06	425.64	2.58	109.03	110.44
	M(23%)	247.4	423.06	425.61	2.55	105.6	108.56
	M(22%)	236.65	423.06	425.58	2.52	102	106.41
	M(21%)	225.89	423.06	425.54	2.48	98.33	104.08
	M(20%)	215.13	423.06	425.51	2.45	94.59	101.65
	L(100%)	361.25	423.06	425.9	2.84	139.87	124.32
	L(20%)	72.25	423.06	424.56	1.5	32.73	36.73
	L(19%)	68.64	423.06	424.52	1.46	31.43	35.83
	L(18%)	65.03	423.06	424.48	1.42	30.11	34.9
	L(17%)	61.41	423.06	424.44	1.38	28.75	33.9
	L(16%)	57.8	423.06	424.4	1.34	27.37	32.82
	L(15%)	54.19	423.06	424.36	1.3	25.96	31.68
	NMNL1(100%)	471.83	423.06	426.13	3.07	168.62	132.75
	NMNL1(25%)	117.96	423.06	424.93	1.87	48.43	46.88
	NMNL1(24%)	113.24	423.06	424.9	1.84	46.86	45.89
	NMNL1(23%)	108.52	423.06	424.86	1.8	45.26	44.86
	NMNL1(22%)	103.8	423.06	424.83	1.77	43.65	43.79
	NMNL1(21%)	99.08	423.06	424.79	1.73	42.01	42.69
	NMNL1(20%)	94.37	423.06	424.75	1.69	40.4	41.61
	NMNL2(100%)	790.33	423.06	426.65	3.59	242.55	151.83
	NMNL2(25%)	197.58	423.06	425.44	2.38	88.39	97.49
	NMNL2(24%)	189.68	423.06	425.41	2.35	85.55	95.52
	NMNL2(23%)	181.78	423.06	425.38	2.32	82.68	93.49
	NMNL2(22%)	173.87	423.06	425.35	2.29	79.78	91.39
	NMNL2(21%)	165.97	423.06	425.32	2.26	76.84	89.22
	NMNL2(20%)	158.07	423.06	425.29	2.23	73.86	86.96

Note:

M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.17: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Lower Demwe HEP

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m3/s)	(m)	(m)	(m)	(m2)	(m)
Lower Demwe 500 m D/s of dam axis	M(100%)	1129.7	299	302.76	3.76	316.31	135.71
	M(30%)	338.9	299	301.22	2.22	129.07	103.58
	M(29%)	327.61	299	301.19	2.19	125.64	102.68
	M(28%)	316.32	299	301.16	2.16	122.17	101.75
	M(27%)	305.02	299	301.12	2.12	118.66	100.81
	M(26%)	293.72	299	301.09	2.09	115.06	99.41
	M(25%)	282.42	299	301.05	2.05	111.4	97.89
	M(24%)	271.13	299	301.01	2.01	107.66	96.31
	M(23%)	259.83	299	300.97	1.97	103.89	94.69
	M(22%)	248.53	299	300.93	1.93	100.06	93.02
	M(21%)	237.24	299	300.89	1.89	96.2	91.3
	M(20%)	225.93	299	300.85	1.85	92.26	89.18
	L(100%)	379.3	299	301.34	2.34	140.85	106.63
	L(20%)	75.9	299	300.01	1.01	36.25	47.43
	L(19%)	72.07	299	299.98	0.98	34.91	46.67
	L(18%)	68.27	299	299.95	0.95	33.57	45.9
	L(17%)	64.48	299	299.92	0.92	32.21	45.11
	L(16%)	60.69	299	299.89	0.89	30.83	44.29
	L(15%)	56.9	299	299.86	0.86	29.44	43.45
	NMNL1(100%)	830	299	302.29	3.29	253.47	128.32
	NMNL1(25%)	207.5	299	300.77	1.77	85.65	85.12
	NMNL1(24%)	199.2	299	300.73	1.73	82.65	83.21
	NMNL1(23%)	190.9	299	300.7	1.7	79.63	81.24
	NMNL1(22%)	182.6	299	300.66	1.66	76.58	79.21
	NMNL1(21%)	174.3	299	300.62	1.62	73.45	77.07
	NMNL1(20%)	166	299	300.58	1.58	70.3	74.85
	NMNL2(100%)	495.2	299	301.62	2.62	172.22	114.35
	NMNL2(25%)	123.8	299	300.34	1.34	54.29	62.39
	NMNL2(24%)	118.85	299	300.31	1.31	52.38	60.74
	NMNL2(23%)	113.9	299	300.28	1.28	50.46	59.02
	NMNL2(22%)	108.94	299	300.25	1.25	48.52	57.24
	NMNL2(21%)	103.99	299	300.21	1.21	46.56	55.38
	NMNL2(20%)	99	299	300.18	1.18	44.58	53.43
Lower Demwe 1000 m D/s of dam axis	M(100%)	1129.7	293.15	299.23	6.08	245.36	89.66
	M(30%)	338.9	293.15	297.26	4.11	99.98	57.72
	M(29%)	327.61	293.15	297.22	4.07	97.62	57.21
	M(28%)	316.32	293.15	297.17	4.02	95.24	56.69
	M(27%)	305.02	293.15	297.13	3.98	92.83	56.16
	M(26%)	293.72	293.15	297.09	3.94	90.38	55.6
	M(25%)	282.42	293.15	297.04	3.89	87.84	54.92
	M(24%)	271.13	293.15	296.99	3.84	85.28	54.23
	M(23%)	259.83	293.15	296.95	3.8	82.7	53.52

Location	Profile	Q Total	Deepest Bed Level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
		(m3/s)	(m)	(m)	(m)	(m2)	(m)
	M(22%)	248.53	293.15	296.9	3.75	80.08	52.79
	M(21%)	237.24	293.15	296.85	3.7	77.44	52.05
	M(20%)	225.93	293.15	296.79	3.64	74.76	51.28
	L(100%)	379.3	293.15	297.4	4.25	108.28	59.49
	L(20%)	75.9	293.15	295.85	2.7	33.42	35.07
	L(19%)	72.07	293.15	295.81	2.66	32.13	34.36
	L(18%)	68.27	293.15	295.77	2.62	30.8	33.53
	L(17%)	64.48	293.15	295.73	2.58	29.37	32.4
	L(16%)	60.69	293.15	295.68	2.53	27.91	31.22
	L(15%)	56.9	293.15	295.63	2.48	26.42	29.96
	NMNL1(100%)	830	293.15	298.66	5.51	196.73	81.99
	NMNL1(25%)	207.5	293.15	296.71	3.56	70.33	49.99
	NMNL1(24%)	199.2	293.15	296.67	3.52	68.29	49.39
	NMNL1(23%)	190.9	293.15	296.62	3.47	66.24	48.77
	NMNL1(22%)	182.6	293.15	296.58	3.43	64.16	48.14
	NMNL1(21%)	174.3	293.15	296.54	3.39	62.05	47.49
	NMNL1(20%)	166	293.15	296.49	3.34	59.92	46.82
	NMNL2(100%)	495.2	293.15	297.76	4.61	130.92	64.06
	NMNL2(25%)	123.8	293.15	296.23	3.08	48.35	42.51
	NMNL2(24%)	118.85	293.15	296.2	3.05	46.89	41.84
	NMNL2(23%)	113.9	293.15	296.16	3.01	45.41	41.15
	NMNL2(22%)	108.94	293.15	296.13	2.98	43.9	40.44
	NMNL2(21%)	103.99	293.15	296.09	2.94	42.39	39.71
	NMNL2(20%)	99	293.15	296.05	2.9	40.84	38.95

Note:

M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.18: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Gmiliang hydroelectric project

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
3.27	M(100%)	25.38	839.04	839.37	0.33	13.99	42.23
3.27	M(30%)	7.61	839.04	839.19	0.15	6.28	41.88
3.27	M(29%)	7.36	839.04	839.19	0.15	6.14	41.87
3.27	M(28%)	7.11	839.04	839.18	0.14	6	41.86
3.27	M(27%)	6.85	839.04	839.18	0.14	5.85	41.86
3.27	M(26%)	6.6	839.04	839.17	0.13	5.5	41.84
3.27	M(25%)	6.35	839.04	839.17	0.13	5.41	41.83
3.27	M(24%)	6.09	839.04	839.17	0.13	5.36	41.83

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
3.27	M(23%)	5.84	839.04	839.17	0.13	5.24	41.83
3.27	M(22%)	5.58	839.04	839.16	0.12	5.11	41.82
3.27	M(21%)	5.33	839.04	839.16	0.12	4.96	41.81
3.27	M(20%)	5.08	839.04	839.15	0.11	4.77	41.81
3.27	NMNL1(100%)	14.59	839.04	839.27	0.23	9.72	42.03
3.27	NMNL1(25%)	3.65	839.04	839.14	0.1	4.26	41.78
3.27	NMNL1(24%)	3.5	839.04	839.14	0.1	4.22	41.78
3.27	NMNL1(23%)	3.36	839.04	839.14	0.1	4.06	41.77
3.27	NMNL1(22%)	3.21	839.04	839.14	0.1	4.06	41.77
3.27	NMNL1(21%)	3.06	839.04	839.14	0.1	4.06	41.77
3.27	NMNL1(20%)	2.92	839.04	839.12	0.08	3.31	41.74
3.27	L(100%)	8.75	839.04	839.22	0.18	7.39	41.93
3.27	L(20%)	1.75	839.04	839.1	0.06	2.42	41.7
3.27	L(19%)	1.66	839.04	839.1	0.06	2.3	41.69
3.27	L(18%)	1.58	839.04	839.09	0.05	2.2	41.69
3.27	L(17%)	1.49	839.04	839.09	0.05	2.08	41.68
3.27	L(16%)	1.4	839.04	839.09	0.05	2.16	41.68
3.27	L(15%)	1.31	839.04	839.09	0.05	1.92	41.67
3.27	L(14%)	1.23	839.04	839.09	0.05	2.09	41.68
3.27	L(13%)	1.14	839.04	839.08	0.04	1.61	41.66
3.27	L(12%)	1.05	839.04	839.08	0.04	1.71	41.66
3.27	L(11%)	0.96	839.04	839.08	0.04	1.55	41.65
3.27	L(10%)	0.88	839.04	839.08	0.04	1.54	41.65
3.27	NMNL2(100%)	16.75	839.04	839.29	0.25	10.61	42.08
3.27	NMNL2(25%)	4.19	839.04	839.14	0.1	4.01	41.77
3.27	NMNL2(24%)	4.02	839.04	839.14	0.1	4.36	41.79
3.27	NMNL2(23%)	3.85	839.04	839.14	0.1	4.23	41.77
3.27	NMNL2(22%)	3.68	839.04	839.14	0.1	4.13	41.78
3.27	NMNL2(21%)	3.52	839.04	839.14	0.1	4.22	41.78
3.27	NMNL2(20%)	3.35	839.04	839.14	0.1	4.06	41.77
4.85	M(100%)	25.38	790.98	791.34	0.36	13.6	38.15
4.85	M(30%)	7.61	790.98	791.15	0.17	6.05	37.72
4.85	M(29%)	7.36	790.98	791.14	0.16	5.89	37.71
4.85	M(28%)	7.11	790.98	791.14	0.16	5.69	37.69
4.85	M(27%)	6.85	790.98	791.13	0.15	5.6	37.69
4.85	M(26%)	6.6	790.98	791.13	0.15	5.5	37.68
4.85	M(25%)	6.35	790.98	791.13	0.15	5.37	37.68
4.85	M(24%)	6.09	790.98	791.12	0.14	5.23	37.67
4.85	M(23%)	5.84	790.98	791.12	0.14	5.09	37.66
4.85	M(22%)	5.58	790.98	791.11	0.13	4.76	37.64
4.85	M(21%)	5.33	790.98	791.11	0.13	4.72	37.64
4.85	M(20%)	5.08	790.98	791.11	0.13	4.59	37.63
4.85	NMNL1(100%)	14.59	790.98	791.23	0.25	9.36	37.9
4.85	NMNL1(25%)	3.65	790.98	791.08	0.1	3.44	37.57

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
4.85	NMNL1(24%)	3.5	790.98	791.08	0.1	3.47	37.57
4.85	NMNL1(23%)	3.36	790.98	791.08	0.1	3.52	37.57
4.85	NMNL1(22%)	3.21	790.98	791.08	0.1	3.73	37.58
4.85	NMNL1(21%)	3.06	790.98	791.07	0.09	3.19	37.55
4.85	NMNL1(20%)	2.92	790.98	791.07	0.09	3.07	37.54
4.85	L(100%)	8.75	790.98	791.16	0.18	6.65	37.75
4.85	L(20%)	1.75	790.98	791.04	0.06	2.28	37.5
4.85	L(19%)	1.66	790.98	791.04	0.06	2.18	37.49
4.85	L(18%)	1.58	790.98	791.04	0.06	2.15	37.49
4.85	L(17%)	1.49	790.98	791.04	0.06	2.02	37.48
4.85	L(16%)	1.4	790.98	791.04	0.06	2.07	37.49
4.85	L(15%)	1.31	790.98	791.04	0.06	2.01	37.48
4.85	L(14%)	1.23	790.98	791.03	0.05	1.86	37.47
4.85	L(13%)	1.14	790.98	791.03	0.05	1.79	37.47
4.85	L(12%)	1.05	790.98	791.03	0.05	1.81	37.47
4.85	L(11%)	0.96	790.98	791.03	0.05	1.81	37.47
4.85	L(10%)	0.88	790.98	791.03	0.05	1.6	37.46
4.85	NMNL2(100%)	16.75	790.98	791.26	0.28	10.3	37.96
4.85	NMNL2(25%)	4.19	790.98	791.09	0.11	4.03	37.6
4.85	NMNL2(24%)	4.02	790.98	791.09	0.11	3.91	37.59
4.85	NMNL2(23%)	3.85	790.98	791.08	0.1	3.72	37.58
4.85	NMNL2(22%)	3.68	790.98	791.08	0.1	3.47	37.57
4.85	NMNL2(21%)	3.52	790.98	791.08	0.1	3.82	37.59
4.85	NMNL2(20%)	3.35	790.98	791.08	0.1	3.67	37.58
6.43	M(100%)	25.38	743.08	743.47	0.39	13.09	34.13
6.43	M(30%)	7.61	743.08	743.25	0.17	5.82	33.6
6.43	M(29%)	7.36	743.08	743.25	0.17	5.7	33.59
6.43	M(28%)	7.11	743.08	743.25	0.17	5.58	33.58
6.43	M(27%)	6.85	743.08	743.24	0.16	5.44	33.57
6.43	M(26%)	6.6	743.08	743.24	0.16	5.31	33.56
6.43	M(25%)	6.35	743.08	743.24	0.16	5.17	33.55
6.43	M(24%)	6.09	743.08	743.23	0.15	4.99	33.54
6.43	M(23%)	5.84	743.08	743.24	0.16	5.23	33.55
6.43	M(22%)	5.58	743.08	743.22	0.14	4.74	33.52
6.43	M(21%)	5.33	743.08	743.22	0.14	4.6	33.51
6.43	M(20%)	5.08	743.08	743.21	0.13	4.45	33.5
6.43	NMNL1(100%)	14.59	743.08	743.35	0.27	9.03	33.83
6.43	NMNL1(25%)	3.65	743.08	743.19	0.11	3.58	33.43
6.43	NMNL1(24%)	3.5	743.08	743.18	0.1	3.47	33.42
6.43	NMNL1(23%)	3.36	743.08	743.18	0.1	3.35	33.42
6.43	NMNL1(22%)	3.21	743.08	743.18	0.1	3.2	33.4
6.43	NMNL1(21%)	3.06	743.08	743.17	0.09	3	33.39
6.43	NMNL1(20%)	2.92	743.08	743.18	0.1	3.25	33.41
6.43	L(100%)	8.75	743.08	743.27	0.19	6.41	33.64

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
6.43	L(20%)	1.75	743.08	743.15	0.07	2.21	33.33
6.43	L(19%)	1.66	743.08	743.15	0.07	2.16	33.33
6.43	L(18%)	1.58	743.08	743.14	0.06	2.01	33.32
6.43	L(17%)	1.49	743.08	743.14	0.06	1.98	33.31
6.43	L(16%)	1.4	743.08	743.14	0.06	1.9	33.31
6.43	L(15%)	1.31	743.08	743.14	0.06	1.83	33.3
6.43	L(14%)	1.23	743.08	743.13	0.05	1.75	33.3
6.43	L(13%)	1.14	743.08	743.13	0.05	1.66	33.29
6.43	L(12%)	1.05	743.08	743.13	0.05	1.64	33.29
6.43	L(11%)	0.96	743.08	743.13	0.05	1.58	33.28
6.43	L(10%)	0.88	743.08	743.12	0.04	1.34	33.27
6.43	NMNL2(100%)	16.75	743.08	743.38	0.3	9.89	33.9
6.43	NMNL2(25%)	4.19	743.08	743.2	0.12	3.87	33.45
6.43	NMNL2(24%)	4.02	743.08	743.19	0.11	3.79	33.45
6.43	NMNL2(23%)	3.85	743.08	743.19	0.11	3.7	33.44
6.43	NMNL2(22%)	3.68	743.08	743.19	0.11	3.59	33.43
6.43	NMNL2(21%)	3.52	743.08	743.18	0.1	3.44	33.42
6.43	NMNL2(20%)	3.35	743.08	743.18	0.1	3.35	33.42

Note:

M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.19: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Raigam hydroelectric project

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
3.51	M(100%)	113.9	694.55	695.08	0.53	50.54	95.45
3.51	M(30%)	34.17	694.55	694.81	0.26	24.59	94.75
3.51	M(29%)	33.03	694.55	694.81	0.26	24.13	94.74
3.51	M(28%)	31.89	694.55	694.8	0.25	23.69	94.73
3.51	M(27%)	30.75	694.55	694.8	0.25	23.17	94.71
3.51	M(26%)	29.61	694.55	694.79	0.24	22.7	94.7
3.51	M(25%)	28.47	694.55	694.79	0.24	22.34	94.69
3.51	M(24%)	27.34	694.55	694.78	0.23	21.62	94.67
3.51	M(23%)	26.2	694.55	694.78	0.23	21.3	94.66
3.51	M(22%)	25.06	694.55	694.77	0.22	20.89	94.65
3.51	M(21%)	23.92	694.55	694.76	0.21	20.04	94.63
3.51	M(20%)	22.78	694.55	694.75	0.2	18.92	94.6
3.51	NMNL1(100%)	64.93	694.55	694.93	0.38	36.03	95.06
3.51	NMNL1(25%)	16.23	694.55	694.72	0.17	16	94.52
3.51	NMNL1(24%)	15.58	694.55	694.72	0.17	15.67	94.51

Distance from barrage	**Profile**	**Q Total**	**Deepest bed level**	**Water Surface Elevation**	**Depth of flow**	**Flow Area**	**Top Width**
(km)		**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m2)**	**(m)**
3.51	NMNL1(23%)	14.93	694.55	694.71	0.16	15.03	94.49
3.51	NMNL1(22%)	14.29	694.55	694.7	0.15	14.48	94.48
3.51	NMNL1(21%)	13.64	694.55	694.7	0.15	13.93	94.46
3.51	NMNL1(20%)	12.99	694.55	694.7	0.15	13.78	94.46
3.51	L(100%)	38.83	694.55	694.83	0.28	26.5	94.8
3.51	L(20%)	7.77	694.55	694.65	0.1	9.88	94.35
3.51	L(19%)	7.38	694.55	694.65	0.1	9.46	94.34
3.51	L(18%)	6.99	694.55	694.65	0.1	9.3	94.34
3.51	L(17%)	6.6	694.55	694.65	0.1	9.3	94.34
3.51	L(16%)	6.21	694.55	694.65	0.1	9.01	94.33
3.51	L(15%)	5.82	694.55	694.64	0.09	8.48	94.32
3.51	L(14%)	5.44	694.55	694.64	0.09	8.09	94.3
3.51	L(13%)	5.05	694.55	694.64	0.09	8.03	94.3
3.51	L(12%)	4.66	694.55	694.63	0.08	7.52	94.29
3.51	L(11%)	4.27	694.55	694.63	0.08	7.11	94.28
3.51	L(10%)	3.88	694.55	694.62	0.07	6.69	94.27
3.51	NMNL2(100%)	74.7	694.55	694.96	0.41	39.2	95.15
3.51	NMNL2(25%)	18.67	694.55	694.73	0.18	16.89	94.54
3.51	NMNL2(24%)	17.93	694.55	694.73	0.18	16.8	94.54
3.51	NMNL2(23%)	17.18	694.55	694.73	0.18	16.61	94.54
3.51	NMNL2(22%)	16.43	694.55	694.72	0.17	15.97	94.52
3.51	NMNL2(21%)	15.69	694.55	694.71	0.16	15.28	94.5
3.51	NMNL2(20%)	14.94	694.55	694.71	0.16	15.43	94.5
5.00	M(100%)	113.9	672.71	673.23	0.52	50.92	97.7
5.00	M(30%)	34.17	672.71	672.96	0.25	24.61	97.01
5.00	M(29%)	33.03	672.71	672.96	0.25	24.14	96.99
5.00	M(28%)	31.89	672.71	672.95	0.24	23.56	96.98
5.00	M(27%)	30.75	672.71	672.95	0.24	23	96.96
5.00	M(26%)	29.61	672.71	672.94	0.23	22.27	96.95
5.00	M(25%)	28.47	672.71	672.93	0.22	21.7	96.93
5.00	M(24%)	27.34	672.71	672.93	0.22	21.14	96.92
5.00	M(23%)	26.2	672.71	672.92	0.21	20.52	96.9
5.00	M(22%)	25.06	672.71	672.92	0.21	20.04	96.89
5.00	M(21%)	23.92	672.71	672.91	0.2	19.67	96.88
5.00	M(20%)	22.78	672.71	672.9	0.19	18.8	96.85
5.00	NMNL1(100%)	64.93	672.71	673.08	0.37	36.22	97.31
5.00	NMNL1(25%)	16.23	672.71	672.87	0.16	15.33	96.76
5.00	NMNL1(24%)	15.58	672.71	672.87	0.16	15.1	96.76
5.00	NMNL1(23%)	14.93	672.71	672.87	0.16	15.01	96.75
5.00	NMNL1(22%)	14.29	672.71	672.86	0.15	14.86	96.75
5.00	NMNL1(21%)	13.64	672.71	672.86	0.15	14.3	96.74
5.00	NMNL1(20%)	12.99	672.71	672.85	0.14	13.86	96.72
5.00	L(100%)	38.83	672.71	672.98	0.27	26.53	97.06
5.00	L(20%)	7.77	672.71	672.81	0.1	9.82	96.62

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
5.00	L(19%)	7.38	672.71	672.81	0.1	9.92	96.62
5.00	L(18%)	6.99	672.71	672.81	0.1	9.29	96.6
5.00	L(17%)	6.6	672.71	672.81	0.1	9.48	96.61
5.00	L(16%)	6.21	672.71	672.8	0.09	8.82	96.59
5.00	L(15%)	5.82	672.71	672.8	0.09	8.42	96.58
5.00	L(14%)	5.44	672.71	672.8	0.09	8.3	96.58
5.00	L(13%)	5.05	672.71	672.79	0.08	7.8	96.56
5.00	L(12%)	4.66	672.71	672.79	0.08	7.37	96.55
5.00	L(11%)	4.27	672.71	672.79	0.08	7.5	96.56
5.00	L(10%)	3.88	672.71	672.78	0.07	6.44	96.53
5.00	NMNL2(100%)	74.7	672.71	673.12	0.41	39.44	97.4
5.00	NMNL2(25%)	18.67	672.71	672.89	0.18	17.03	96.81
5.00	NMNL2(24%)	17.93	672.71	672.89	0.18	16.95	96.81
5.00	NMNL2(23%)	17.18	672.71	672.88	0.17	16.28	96.79
5.00	NMNL2(22%)	16.43	672.71	672.87	0.16	15.56	96.77
5.00	NMNL2(21%)	15.69	672.71	672.87	0.16	15.17	96.76
5.00	NMNL2(20%)	14.94	672.71	672.86	0.15	14.42	96.74
7.00	M(100%)	113.9	643.4	643.93	0.53	50.5	95.16
7.00	M(30%)	34.17	643.4	643.66	0.26	24.65	94.38
7.00	M(29%)	33.03	643.4	643.66	0.26	24.14	94.37
7.00	M(28%)	31.89	643.4	643.65	0.25	23.61	94.35
7.00	M(27%)	30.75	643.4	643.65	0.25	23.17	94.34
7.00	M(26%)	29.61	643.4	643.64	0.24	22.8	94.33
7.00	M(25%)	28.47	643.4	643.63	0.23	21.82	94.3
7.00	M(24%)	27.34	643.4	643.62	0.22	21.07	94.27
7.00	M(23%)	26.2	643.4	643.62	0.22	21.22	94.28
7.00	M(22%)	25.06	643.4	643.62	0.22	20.32	94.25
7.00	M(21%)	23.92	643.4	643.61	0.21	19.62	94.23
7.00	M(20%)	22.78	643.4	643.6	0.2	18.95	94.21
7.00	NMNL1(100%)	64.93	643.4	643.78	0.38	35.99	94.72
7.00	NMNL1(25%)	16.23	643.4	643.57	0.17	16.36	94.13
7.00	NMNL1(24%)	15.58	643.4	643.56	0.16	15.3	94.1
7.00	NMNL1(23%)	14.93	643.4	643.56	0.16	14.86	94.09
7.00	NMNL1(22%)	14.29	643.4	643.55	0.15	14.35	94.07
7.00	NMNL1(21%)	13.64	643.4	643.55	0.15	14.29	94.07
7.00	NMNL1(20%)	12.99	643.4	643.55	0.15	13.76	94.05
7.00	L(100%)	38.83	643.4	643.68	0.28	26.52	94.44
7.00	L(20%)	7.77	643.4	643.5	0.1	9.87	93.94
7.00	L(19%)	7.38	643.4	643.5	0.1	9.74	93.93
7.00	L(18%)	6.99	643.4	643.5	0.1	9.53	93.93
7.00	L(17%)	6.6	643.4	643.5	0.1	9.34	93.92
7.00	L(16%)	6.21	643.4	643.5	0.1	9.08	93.91
7.00	L(15%)	5.82	643.4	643.49	0.09	8.5	93.89
7.00	L(14%)	5.44	643.4	643.49	0.09	8.11	93.88

Distance from barrage	**Profile**	**Q Total**	**Deepest bed level**	**Water Surface Elevation**	**Depth of flow**	**Flow Area**	**Top Width**
(km)		**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m2)**	**(m)**
7.00	L(13%)	5.05	643.4	643.49	0.09	8.1	93.88
7.00	L(12%)	4.66	643.4	643.48	0.08	7.49	93.86
7.00	L(11%)	4.27	643.4	643.47	0.07	7.09	93.85
7.00	L(10%)	3.88	643.4	643.47	0.07	6.69	93.84
7.00	NMNL2(100%)	74.7	643.4	643.81	0.41	39.15	94.82
7.00	NMNL2(25%)	18.67	643.4	643.58	0.18	17.11	94.15
7.00	NMNL2(24%)	17.93	643.4	643.58	0.18	16.86	94.15
7.00	NMNL2(23%)	17.18	643.4	643.58	0.18	16.85	94.15
7.00	NMNL2(22%)	16.43	643.4	643.57	0.17	15.65	94.11
7.00	NMNL2(21%)	15.69	643.4	643.56	0.16	15.39	94.1
7.00	NMNL2(20%)	14.94	643.4	643.56	0.16	14.74	94.08

Note:

M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.20: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Tidding-I hydroelectric project

Distance from barrage	**Profile**	**Q Total**	**Deepest bed level**	**Water Surface Elevation**	**Depth of flow**	**Flow Area**	**Top Width**
(km)		**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m2)**	**(m)**
2.75	M(100%)	52.49	545.65	546.28	0.63	21.94	37.63
2.75	M(30%)	15.75	545.65	545.94	0.29	9.59	34.78
2.75	M(29%)	15.22	545.65	545.93	0.28	9.37	34.73
2.75	M(28%)	14.7	545.65	545.92	0.27	9.18	34.68
2.75	M(27%)	14.17	545.65	545.92	0.27	9.11	34.66
2.75	M(26%)	13.65	545.65	545.92	0.27	8.95	34.63
2.75	M(25%)	13.12	545.65	545.9	0.25	8.47	34.51
2.75	M(24%)	12.6	545.65	545.9	0.25	8.24	34.45
2.75	M(23%)	12.07	545.65	545.9	0.25	8.32	34.47
2.75	M(22%)	11.55	545.65	545.89	0.24	8.04	34.4
2.75	M(21%)	11.02	545.65	545.88	0.23	7.63	34.3
2.75	M(20%)	10.5	545.65	545.88	0.23	7.56	34.29
2.75	NMNL1(100%)	30.17	545.65	546.09	0.44	14.88	36.03
2.75	NMNL1(25%)	7.54	545.65	545.84	0.19	6.1	33.93
2.75	NMNL1(24%)	7.24	545.65	545.83	0.18	5.95	33.89
2.75	NMNL1(23%)	6.94	545.65	545.83	0.18	5.82	33.86
2.75	NMNL1(22%)	6.64	545.65	545.82	0.17	5.49	33.78
2.75	NMNL1(21%)	6.34	545.65	545.82	0.17	5.68	33.83
2.75	NMNL1(20%)	6.03	545.65	545.82	0.17	5.58	33.8
2.75	L(100%)	18.1	545.65	545.96	0.31	10.51	35
2.75	L(20%)	3.62	545.65	545.77	0.12	3.94	33.4
2.75	L(19%)	3.44	545.65	545.76	0.11	3.65	33.32

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
2.75	L(18%)	3.26	545.65	545.76	0.11	3.74	33.34
2.75	L(17%)	3.08	545.65	545.76	0.11	3.61	33.31
2.75	L(16%)	2.9	545.65	545.75	0.1	3.34	33.25
2.75	L(15%)	2.72	545.65	545.75	0.1	3.37	33.25
2.75	L(14%)	2.53	545.65	545.74	0.09	3.06	33.17
2.75	L(13%)	2.35	545.65	545.74	0.09	3.06	33.18
2.75	L(12%)	2.17	545.65	545.74	0.09	2.77	33.1
2.75	L(11%)	1.99	545.65	545.74	0.09	2.79	33.11
2.75	L(10%)	1.81	545.65	545.73	0.08	2.53	33.04
2.75	NMNL2(100%)	34.63	545.65	546.13	0.48	16.38	36.37
2.75	NMNL2(25%)	8.66	545.65	545.86	0.21	6.91	34.13
2.75	NMNL2(24%)	8.31	545.65	545.85	0.2	6.48	34.03
2.75	NMNL2(23%)	7.96	545.65	545.84	0.19	6.2	33.96
2.75	NMNL2(22%)	7.62	545.65	545.84	0.19	6.14	33.94
2.75	NMNL2(21%)	7.27	545.65	545.83	0.18	5.98	33.9
2.75	NMNL2(20%)	6.93	545.65	545.82	0.17	5.69	33.83
4.1	M(100%)	52.49	520.74	521.5	0.76	19.93	28.52
4.1	M(30%)	15.75	520.74	521.09	0.35	8.69	25.93
4.1	M(29%)	15.22	520.74	521.08	0.34	8.46	25.88
4.1	M(28%)	14.7	520.74	521.07	0.33	8.25	25.83
4.1	M(27%)	14.17	520.74	521.07	0.33	8.05	25.78
4.1	M(26%)	13.65	520.74	521.06	0.32	7.89	25.74
4.1	M(25%)	13.12	520.74	521.05	0.31	7.68	25.69
4.1	M(24%)	12.6	520.74	521.04	0.3	7.47	25.63
4.1	M(23%)	12.07	520.74	521.04	0.3	7.25	25.58
4.1	M(22%)	11.55	520.74	521.03	0.29	7.08	25.54
4.1	M(21%)	11.02	520.74	521.02	0.28	6.93	25.5
4.1	M(20%)	10.5	520.74	521.01	0.27	6.59	25.42
4.1	NMNL1(100%)	30.17	520.74	521.27	0.53	13.55	27.08
4.1	NMNL1(25%)	7.54	520.74	520.96	0.22	5.33	25.1
4.1	NMNL1(24%)	7.24	520.74	520.96	0.22	5.42	25.13
4.1	NMNL1(23%)	6.94	520.74	520.96	0.22	5.27	25.09
4.1	NMNL1(22%)	6.64	520.74	520.95	0.21	5.08	25.04
4.1	NMNL1(21%)	6.34	520.74	520.94	0.2	4.92	25
4.1	NMNL1(20%)	6.03	520.74	520.93	0.19	4.69	24.94
4.1	L(100%)	18.1	520.74	521.12	0.38	9.53	26.13
4.1	L(20%)	3.62	520.74	520.88	0.14	3.37	24.61
4.1	L(19%)	3.44	520.74	520.88	0.14	3.42	24.62
4.1	L(18%)	3.26	520.74	520.88	0.14	3.26	24.58
4.1	L(17%)	3.08	520.74	520.87	0.13	3.23	24.57
4.1	L(16%)	2.9	520.74	520.86	0.12	2.96	24.5
4.1	L(15%)	2.72	520.74	520.86	0.12	2.94	24.5
4.1	L(14%)	2.53	520.74	520.86	0.12	2.76	24.45
4.1	L(13%)	2.35	520.74	520.85	0.11	2.65	24.43

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m2)**	**(m)**
4.1	L(12%)	2.17	520.74	520.85	0.11	2.58	24.41
4.1	L(11%)	1.99	520.74	520.85	0.11	2.58	24.41
4.1	L(10%)	1.81	520.74	520.84	0.1	2.31	24.34
4.1	NMNL2(100%)	34.63	520.74	521.33	0.59	14.97	27.41
4.1	NMNL2(25%)	8.66	520.74	520.98	0.24	5.84	25.23
4.1	NMNL2(24%)	8.31	520.74	520.97	0.23	5.7	25.2
4.1	NMNL2(23%)	7.96	520.74	520.97	0.23	5.55	25.16
4.1	NMNL2(22%)	7.62	520.74	520.96	0.22	5.41	25.13
4.1	NMNL2(21%)	7.27	520.74	520.96	0.22	5.39	25.12
4.1	NMNL2(20%)	6.93	520.74	520.96	0.22	5.26	25.09
5.51	M(100%)	52.49	494.73	495.75	1.02	17.58	19.59
5.51	M(30%)	15.75	494.73	495.2	0.47	7.51	16.96
5.51	M(29%)	15.22	494.73	495.19	0.46	7.37	16.92
5.51	M(28%)	14.7	494.73	495.18	0.45	7.18	16.86
5.51	M(27%)	14.17	494.73	495.17	0.44	6.98	16.81
5.51	M(26%)	13.65	494.73	495.15	0.42	6.73	16.74
5.51	M(25%)	13.12	494.73	495.15	0.42	6.65	16.71
5.51	M(24%)	12.6	494.73	495.14	0.41	6.47	16.66
5.51	M(23%)	12.07	494.73	495.12	0.39	6.25	16.6
5.51	M(22%)	11.55	494.73	495.11	0.38	6.07	16.54
5.51	M(21%)	11.02	494.73	495.1	0.37	5.88	16.49
5.51	M(20%)	10.5	494.73	495.09	0.36	5.7	16.44
5.51	NMNL1(100%)	30.17	494.73	495.45	0.72	11.84	18.14
5.51	NMNL1(25%)	7.54	494.73	495.02	0.29	4.51	16.09
5.51	NMNL1(24%)	7.24	494.73	495.01	0.28	4.42	16.06
5.51	NMNL1(23%)	6.94	494.73	495	0.27	4.29	16.02
5.51	NMNL1(22%)	6.64	494.73	495	0.27	4.16	15.98
5.51	NMNL1(21%)	6.34	494.73	494.99	0.26	4.04	15.95
5.51	NMNL1(20%)	6.03	494.73	494.99	0.26	4.05	15.95
5.51	L(100%)	18.1	494.73	495.25	0.52	8.31	17.18
5.51	L(20%)	3.62	494.73	494.91	0.18	2.87	15.59
5.51	L(19%)	3.44	494.73	494.91	0.18	2.75	15.56
5.51	L(18%)	3.26	494.73	494.9	0.17	2.71	15.54
5.51	L(17%)	3.08	494.73	494.9	0.17	2.66	15.53
5.51	L(16%)	2.9	494.73	494.89	0.16	2.44	15.46
5.51	L(15%)	2.72	494.73	494.89	0.16	2.47	15.47
5.51	L(14%)	2.53	494.73	494.88	0.15	2.4	15.45
5.51	L(13%)	2.35	494.73	494.87	0.14	2.22	15.39
5.51	L(12%)	2.17	494.73	494.87	0.14	2.19	15.38
5.51	L(11%)	1.99	494.73	494.86	0.13	2.01	15.33
5.51	L(10%)	1.81	494.73	494.85	0.12	1.91	15.29
5.51	NMNL2(100%)	34.63	494.73	495.51	0.78	13.06	18.46
5.51	NMNL2(25%)	8.66	494.73	495.05	0.32	4.98	16.23
5.51	NMNL2(24%)	8.31	494.73	495.04	0.31	4.85	16.19

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
5.51	NMNL2(23%)	7.96	494.73	495.03	0.3	4.7	16.14
5.51	NMNL2(22%)	7.62	494.73	495.02	0.29	4.55	16.1
5.51	NMNL2(21%)	7.27	494.73	495.01	0.28	4.43	16.06
5.51	NMNL2(20%)	6.93	494.73	495	0.27	4.29	16.02

Note:

M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.21: Depth of flow for the proposed Minimum Flow on the basis of average flow during 90% dependable year for Tidding-II hydroelectric project

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
2.67	M(100%)	42.03	746.6	747.03	0.43	22.58	63.98
2.67	M(30%)	12.61	746.6	746.81	0.21	9.56	51.63
2.67	M(29%)	12.19	746.6	746.81	0.21	9.77	51.85
2.67	M(28%)	11.77	746.6	746.8	0.2	9.1	51.14
2.67	M(27%)	11.35	746.6	746.8	0.2	9.01	51.04
2.67	M(26%)	10.93	746.6	746.79	0.19	8.59	50.58
2.67	M(25%)	10.51	746.6	746.78	0.18	8.25	50.22
2.67	M(24%)	10.09	746.6	746.78	0.18	8.35	50.33
2.67	M(23%)	9.67	746.6	746.78	0.18	8.14	50.1
2.67	M(22%)	9.25	746.6	746.78	0.18	7.98	49.92
2.67	M(21%)	8.83	746.6	746.77	0.17	7.58	49.48
2.67	M(20%)	8.41	746.6	746.76	0.16	7.16	49.01
2.67	NMNL1(100%)	24.16	746.6	746.91	0.31	15.04	57.15
2.67	NMNL1(25%)	6.04	746.6	746.74	0.14	5.96	47.65
2.67	NMNL1(24%)	5.8	746.6	746.73	0.13	5.63	47.26
2.67	NMNL1(23%)	5.56	746.6	746.73	0.13	5.49	47.11
2.67	NMNL1(22%)	5.31	746.6	746.73	0.13	5.51	47.13
2.67	NMNL1(21%)	5.07	746.6	746.72	0.12	5.43	47.03
2.67	NMNL1(20%)	4.83	746.6	746.72	0.12	5.28	46.86
2.67	L(100%)	14.49	746.6	746.82	0.22	10.41	52.52
2.67	L(20%)	2.9	746.6	746.69	0.09	3.68	44.94
2.67	L(19%)	2.75	746.6	746.68	0.08	3.57	44.81
2.67	L(18%)	2.61	746.6	746.68	0.08	3.54	44.78
2.67	L(17%)	2.46	746.6	746.68	0.08	3.5	44.72
2.67	L(16%)	2.32	746.6	746.68	0.08	3.4	44.61
2.67	L(15%)	2.17	746.6	746.67	0.07	2.87	43.94
2.67	L(14%)	2.03	746.6	746.67	0.07	3.06	44.19
2.67	L(13%)	1.88	746.6	746.67	0.07	2.93	44.02
2.67	L(12%)	1.74	746.6	746.66	0.06	2.68	43.71

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
2.67	L(11%)	1.59	746.6	746.66	0.06	2.67	43.7
2.67	L(10%)	1.45	746.6	746.66	0.06	2.43	43.4
2.67	NMNL2(100%)	27.73	746.6	746.94	0.34	16.66	58.68
2.67	NMNL2(25%)	6.93	746.6	746.75	0.15	6.65	48.43
2.67	NMNL2(24%)	6.65	746.6	746.74	0.14	6.25	47.98
2.67	NMNL2(23%)	6.38	746.6	746.74	0.14	6.09	47.8
2.67	NMNL2(22%)	6.1	746.6	746.74	0.14	6.15	47.87
2.67	NMNL2(21%)	5.82	746.6	746.74	0.14	5.99	47.69
2.67	NMNL2(20%)	5.55	746.6	746.73	0.13	5.67	47.31
3.96	M(100%)	42.03	720.6	721.06	0.46	21.86	58.81
3.96	M(30%)	12.61	720.6	720.82	0.22	9.12	46.82
3.96	M(29%)	12.19	720.6	720.82	0.22	9.25	46.96
3.96	M(28%)	11.77	720.6	720.81	0.21	8.69	46.37
3.96	M(27%)	11.35	720.6	720.82	0.22	8.94	46.64
3.96	M(26%)	10.93	720.6	720.81	0.21	8.72	46.4
3.96	M(25%)	10.51	720.6	720.8	0.2	8.21	45.85
3.96	M(24%)	10.09	720.6	720.8	0.2	8.03	45.65
3.96	M(23%)	9.67	720.6	720.8	0.2	8	45.62
3.96	M(22%)	9.25	720.6	720.78	0.18	7.32	44.88
3.96	M(21%)	8.83	720.6	720.78	0.18	7.15	44.69
3.96	M(20%)	8.41	720.6	720.78	0.18	7.22	44.77
3.96	NMNL1(100%)	24.16	720.6	720.93	0.33	14.56	52.28
3.96	NMNL1(25%)	6.04	720.6	720.74	0.14	5.61	42.94
3.96	NMNL1(24%)	5.8	720.6	720.75	0.15	5.83	43.2
3.96	NMNL1(23%)	5.56	720.6	720.74	0.14	5.32	42.6
3.96	NMNL1(22%)	5.31	720.6	720.73	0.13	5.28	42.55
3.96	NMNL1(21%)	5.07	720.6	720.73	0.13	5.09	42.33
3.96	NMNL1(20%)	4.83	720.6	720.72	0.12	4.85	42.06
3.96	L(100%)	14.49	720.6	720.84	0.24	10.02	47.77
3.96	L(20%)	2.9	720.6	720.7	0.1	3.71	40.69
3.96	L(19%)	2.75	720.6	720.69	0.09	3.38	40.28
3.96	L(18%)	2.61	720.6	720.69	0.09	3.47	40.39
3.96	L(17%)	2.46	720.6	720.68	0.08	3.14	39.99
3.96	L(16%)	2.32	720.6	720.69	0.09	3.25	40.12
3.96	L(15%)	2.17	720.6	720.68	0.08	3.1	39.93
3.96	L(14%)	2.03	720.6	720.68	0.08	2.95	39.74
3.96	L(13%)	1.88	720.6	720.67	0.07	2.73	39.47
3.96	L(12%)	1.74	720.6	720.67	0.07	2.55	39.25
3.96	L(11%)	1.59	720.6	720.67	0.07	2.49	39.16
3.96	L(10%)	1.45	720.6	720.67	0.07	2.49	39.16
3.96	NMNL2(100%)	27.73	720.6	720.96	0.36	16.12	53.74
3.96	NMNL2(25%)	6.93	720.6	720.76	0.16	6.48	43.94
3.96	NMNL2(24%)	6.65	720.6	720.75	0.15	5.93	43.31
3.96	NMNL2(23%)	6.38	720.6	720.75	0.15	6.09	43.5

Distance from barrage	**Profile**	**Q Total**	**Deepest bed level**	**Water Surface Elevation**	**Depth of flow**	**Flow Area**	**Top Width**
(km)		**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m2)**	**(m)**
3.96	NMNL2(22%)	6.1	720.6	720.75	0.15	5.92	43.3
3.96	NMNL2(21%)	5.82	720.6	720.75	0.15	5.83	43.2
3.96	NMNL2(20%)	5.55	720.6	720.74	0.14	5.54	42.86
5.36	M(100%)	42.03	692.6	693.1	0.5	21.47	54.7
5.36	M(30%)	12.61	692.6	692.84	0.24	8.84	42.48
5.36	M(29%)	12.19	692.6	692.84	0.24	8.78	42.41
5.36	M(28%)	11.77	692.6	692.83	0.23	8.4	41.99
5.36	M(27%)	11.35	692.6	692.82	0.22	8.2	41.76
5.36	M(26%)	10.93	692.6	692.83	0.23	8.33	41.91
5.36	M(25%)	10.51	692.6	692.82	0.22	8.01	41.55
5.36	M(24%)	10.09	692.6	692.81	0.21	7.62	41.11
5.36	M(23%)	9.67	692.6	692.8	0.2	7.35	40.8
5.36	M(22%)	9.25	692.6	692.8	0.2	7.23	40.66
5.36	M(21%)	8.83	692.6	692.8	0.2	7.31	40.76
5.36	M(20%)	8.41	692.6	692.79	0.19	6.87	40.24
5.36	NMNL1(100%)	24.16	692.6	692.96	0.36	14.21	48.06
5.36	NMNL1(25%)	6.04	692.6	692.76	0.16	5.48	38.59
5.36	NMNL1(24%)	5.8	692.6	692.75	0.15	5.37	38.45
5.36	NMNL1(23%)	5.56	692.6	692.75	0.15	5.1	38.11
5.36	NMNL1(22%)	5.31	692.6	692.75	0.15	5.15	38.18
5.36	NMNL1(21%)	5.07	692.6	692.74	0.14	5	37.99
5.36	NMNL1(20%)	4.83	692.6	692.74	0.14	4.68	37.59
5.36	L(100%)	14.49	692.6	692.86	0.26	9.67	43.39
5.36	L(20%)	2.9	692.6	692.7	0.1	3.5	36.09
5.36	L(19%)	2.75	692.6	692.7	0.1	3.24	35.75
5.36	L(18%)	2.61	692.6	692.7	0.1	3.28	35.8
5.36	L(17%)	2.46	692.6	692.69	0.09	3	35.44
5.36	L(16%)	2.32	692.6	692.69	0.09	3.05	35.5
5.36	L(15%)	2.17	692.6	692.69	0.09	2.94	35.35
5.36	L(14%)	2.03	692.6	692.69	0.09	2.82	35.2
5.36	L(13%)	1.88	692.6	692.68	0.08	2.68	35.01
5.36	L(12%)	1.74	692.6	692.68	0.08	2.55	34.82
5.36	L(11%)	1.59	692.6	692.67	0.07	2.41	34.64
5.36	L(10%)	1.45	692.6	692.67	0.07	2.23	34.39
5.36	NMNL2(100%)	27.73	692.6	692.99	0.39	15.65	49.45
5.36	NMNL2(25%)	6.93	692.6	692.77	0.17	5.85	39.03
5.36	NMNL2(24%)	6.65	692.6	692.77	0.17	6	39.22
5.36	NMNL2(23%)	6.38	692.6	692.76	0.16	5.52	38.63
5.36	NMNL2(22%)	6.1	692.6	692.76	0.16	5.71	38.86
5.36	NMNL2(21%)	5.82	692.6	692.75	0.15	5.38	38.46
5.36	NMNL2(20%)	5.55	692.6	692.75	0.15	5.3	38.37

Note:

M – Monsoon Season

NMNL1 – Non Monsoon Non Lean Season (October & November)

L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

Table-10.22: Depth of flow for the proposed Minimum Flow on the basis of average flow during 75% dependable year for Kamlang hydroelectric project

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
1	M(100%)	157.33	394.83	398.89	4.06	143.41	48.48
1	M(30%)	47.2	394.83	397.52	2.69	80.91	40.93
1	M(29%)	45.63	394.83	397.49	2.66	79.65	40.7
1	M(28%)	44.05	394.83	397.45	2.62	78.36	40.47
1	M(27%)	42.48	394.83	397.42	2.59	77.06	40.23
1	M(26%)	40.91	394.83	397.39	2.56	75.73	39.98
1	M(25%)	39.33	394.83	397.35	2.52	74.36	39.73
1	M(24%)	37.76	394.83	397.32	2.49	72.98	39.47
1	M(23%)	36.19	394.83	397.28	2.45	71.59	39.21
1	M(22%)	34.61	394.83	397.25	2.42	70.12	38.93
1	M(21%)	33.04	394.83	397.21	2.38	68.64	38.65
1	M(20%)	31.47	394.83	397.17	2.34	67.15	38.36
1	NMNL1(100%)	42.83	394.83	397.43	2.6	77.35	40.28
1	NMNL1(25%)	10.71	394.83	396.46	1.63	41.31	34.3
1	NMNL1(24%)	10.28	394.83	396.43	1.6	40.56	34.18
1	NMNL1(23%)	9.85	394.83	396.41	1.58	39.79	34.07
1	NMNL1(22%)	9.42	394.83	396.39	1.56	39	33.95
1	NMNL1(21%)	9	394.83	396.36	1.53	38.19	33.82
1	NMNL1(20%)	8.57	394.83	396.34	1.51	37.36	33.69
1	L(100%)	18	394.83	396.77	1.94	52.17	35.9
1	L(20%)	3.6	394.83	395.97	1.14	25.33	30.6
1	L(19%)	3.42	394.83	395.95	1.12	24.76	30.33
1	L(18%)	3.24	394.83	395.93	1.1	24.19	30.03
1	L(17%)	3.06	394.83	395.91	1.08	23.59	29.73
1	L(16%)	2.88	394.83	395.89	1.06	22.98	29.43
1	L(15%)	2.7	394.83	395.87	1.04	22.35	29.13
1	L(14%)	2.52	394.83	395.85	1.02	21.7	28.82
1	L(13%)	2.34	394.83	395.82	0.99	21.03	28.49
1	L(12%)	2.16	394.83	395.8	0.97	20.34	28.15
1	L(11%)	1.98	394.83	395.77	0.94	19.61	27.79
1	L(10%)	1.8	394.83	395.74	0.91	18.86	27.41
1	NMNL2(100%)	52.17	394.83	397.61	2.78	84.8	41.63
1	NMNL2(25%)	13.04	394.83	396.57	1.74	45.13	34.87
1	NMNL2(24%)	12.52	394.83	396.54	1.71	44.32	34.75
1	NMNL2(23%)	12	394.83	396.52	1.69	43.48	34.62
1	NMNL2(22%)	11.48	394.83	396.49	1.66	42.62	34.5
1	NMNL2(21%)	10.96	394.83	396.47	1.64	41.74	34.36
1	NMNL2(20%)	10.43	394.83	396.44	1.61	40.81	34.22
1.5	M(100%)	157.33	394.22	398.83	4.61	206.42	78.22

Distance from barrage	**Profile**	**Q Total**	**Deepest bed level**	**Water Surface Elevation**	**Depth of flow**	**Flow Area**	**Top Width**
(km)		**(m3/s)**	**(m)**	**(m)**	**(m)**	**(m2)**	**(m)**
1.5	M(30%)	47.2	394.22	397.49	3.27	116.95	56.7
1.5	M(29%)	45.63	394.22	397.46	3.24	115.24	56.27
1.5	M(28%)	44.05	394.22	397.43	3.21	113.5	55.84
1.5	M(27%)	42.48	394.22	397.39	3.17	111.74	55.4
1.5	M(26%)	40.91	394.22	397.36	3.14	109.98	54.95
1.5	M(25%)	39.33	394.22	397.33	3.11	108.14	54.48
1.5	M(24%)	37.76	394.22	397.29	3.07	106.3	54
1.5	M(23%)	36.19	394.22	397.26	3.04	104.41	53.63
1.5	M(22%)	34.61	394.22	397.22	3	102.48	53.28
1.5	M(21%)	33.04	394.22	397.19	2.97	100.51	52.91
1.5	M(20%)	31.47	394.22	397.15	2.93	98.5	52.54
1.5	NMNL1(100%)	42.83	394.22	397.4	3.18	112.13	55.49
1.5	NMNL1(25%)	10.71	394.22	396.45	2.23	64.36	45.06
1.5	NMNL1(24%)	10.28	394.22	396.43	2.21	63.38	44.84
1.5	NMNL1(23%)	9.85	394.22	396.4	2.18	62.38	44.61
1.5	NMNL1(22%)	9.42	394.22	396.38	2.16	61.37	44.38
1.5	NMNL1(21%)	9	394.22	396.36	2.14	60.34	44.14
1.5	NMNL1(20%)	8.57	394.22	396.33	2.11	59.26	43.89
1.5	L(100%)	18	394.22	396.75	2.53	78.57	48.19
1.5	L(20%)	3.6	394.22	395.96	1.74	43.81	40.12
1.5	L(19%)	3.42	394.22	395.95	1.73	43.07	39.93
1.5	L(18%)	3.24	394.22	395.93	1.71	42.32	39.73
1.5	L(17%)	3.06	394.22	395.91	1.69	41.53	39.53
1.5	L(16%)	2.88	394.22	395.89	1.67	40.74	39.2
1.5	L(15%)	2.7	394.22	395.87	1.65	39.92	38.84
1.5	L(14%)	2.52	394.22	395.84	1.62	39.06	38.45
1.5	L(13%)	2.34	394.22	395.82	1.6	38.18	38.05
1.5	L(12%)	2.16	394.22	395.8	1.58	37.27	37.62
1.5	L(11%)	1.98	394.22	395.77	1.55	36.32	37.18
1.5	L(10%)	1.8	394.22	395.74	1.52	35.31	36.7
1.5	NMNL2(100%)	52.17	394.22	397.58	3.36	122.19	57.98
1.5	NMNL2(25%)	13.04	394.22	396.56	2.34	69.33	46.18
1.5	NMNL2(24%)	12.52	394.22	396.53	2.31	68.27	45.95
1.5	NMNL2(23%)	12	394.22	396.51	2.29	67.16	45.7
1.5	NMNL2(22%)	11.48	394.22	396.48	2.26	66.05	45.45
1.5	NMNL2(21%)	10.96	394.22	396.46	2.24	64.91	45.19
1.5	NMNL2(20%)	10.43	394.22	396.43	2.21	63.71	44.92
2	M(100%)	157.33	394.48	398.71	4.23	184.25	71.86
2	M(30%)	47.2	394.48	397.43	2.95	100.19	59.96
2	M(29%)	45.63	394.48	397.4	2.92	98.44	59.68
2	M(28%)	44.05	394.48	397.37	2.89	96.66	59.41
2	M(27%)	42.48	394.48	397.34	2.86	94.85	59.12
2	M(26%)	40.91	394.48	397.31	2.83	93.04	58.83
2	M(25%)	39.33	394.48	397.28	2.8	91.14	58.53

Distance from barrage	Profile	Q Total	Deepest bed level	Water Surface Elevation	Depth of flow	Flow Area	Top Width
(km)		(m3/s)	(m)	(m)	(m)	(m2)	(m)
2	M(24%)	37.76	394.48	397.25	2.77	89.23	58.03
2	M(23%)	36.19	394.48	397.21	2.73	87.28	57.41
2	M(22%)	34.61	394.48	397.18	2.7	85.29	56.77
2	M(21%)	33.04	394.48	397.14	2.66	83.26	56.11
2	M(20%)	31.47	394.48	397.11	2.63	81.2	55.43
2	NMNL1(100%)	42.83	394.48	397.35	2.87	95.26	59.18
2	NMNL1(25%)	10.71	394.48	396.43	1.95	47.9	42.79
2	NMNL1(24%)	10.28	394.48	396.41	1.93	47	42.39
2	NMNL1(23%)	9.85	394.48	396.39	1.91	46.08	41.99
2	NMNL1(22%)	9.42	394.48	396.36	1.88	45.15	41.57
2	NMNL1(21%)	9	394.48	396.34	1.86	44.21	41.15
2	NMNL1(20%)	8.57	394.48	396.32	1.84	43.24	40.7
2	L(100%)	18	394.48	396.72	2.24	61.36	48.32
2	L(20%)	3.6	394.48	395.96	1.48	29.82	33.99
2	L(19%)	3.42	394.48	395.94	1.46	29.21	33.66
2	L(18%)	3.24	394.48	395.92	1.44	28.59	33.31
2	L(17%)	3.06	394.48	395.9	1.42	27.95	32.95
2	L(16%)	2.88	394.48	395.88	1.4	27.3	32.57
2	L(15%)	2.7	394.48	395.86	1.38	26.62	32.19
2	L(14%)	2.52	394.48	395.84	1.36	25.93	31.78
2	L(13%)	2.34	394.48	395.82	1.34	25.21	31.35
2	L(12%)	2.16	394.48	395.79	1.31	24.46	30.91
2	L(11%)	1.98	394.48	395.77	1.29	23.69	30.43
2	L(10%)	1.8	394.48	395.74	1.26	22.89	29.94
2	NMNL2(100%)	52.17	394.48	397.52	3.04	105.5	60.78
2	NMNL2(25%)	13.04	394.48	396.53	2.05	52.53	44.77
2	NMNL2(24%)	12.52	394.48	396.51	2.03	51.53	44.35
2	NMNL2(23%)	12	394.48	396.49	2.01	50.5	43.91
2	NMNL2(22%)	11.48	394.48	396.47	1.99	49.47	43.47
2	NMNL2(21%)	10.96	394.48	396.44	1.96	48.41	43.01
2	NMNL2(20%)	10.43	394.48	396.41	1.93	47.3	42.53

Note:

M – Monsoon Season
NMNL1 – Non Monsoon Non Lean Season (October & November)
L – Lean Season
NMNL2 – Non Monsoon Non Lean Season (April & May)

The depth of flow for Mahaseer and snow trout in various seasons is given in Table-10.1. The minimum depth for various seasons is not available even with 100% flow. Hence, in such a scenario, top width has been considered.

Considering the fact that top width does not reduce to less than 50% of the pre-project top width, recommended Environmental flows are:

Monsoon Season	:	30% of Average Monsoon season flow for 90% dependable year
Non-Monsoon Non-Lean Season	:	25% of Average Non-monsoon non-lean season flow for 90% dependable year.
Lean Season	:	20% of average lean Season flow for 90% dependable year.

10.2.2 Length of River with minimum flow

The construction of the hydroelectric projects would lead to conversion of free flowing river into a series of reservoirs interested with dams/diversion structure of various hydroelectric projects. As present, the free flow stretch will be available for a stretch of 19.1 km out of a total stretch of 109 km. It is recommended to drop Hutong hydroelectric project, stage 1 so that free flowing river stretch increases to 49.9 km. Hutong hydroelectric project, stage 1 was recommended to be dropped as it is at the elevation where both Mahaseer and Snow Trout are observed. The dropping of the project will provide the free stretch of 19.1 km for migration of both these species. The site is also not geologically stable. Hence, it is recommended to drop the Hutong-I HEP. The details are given in Table-10.23.

Table-10.23: Details of length of free flow of river in the study area with exclusion of Hutong HEP stage-1

S. No.	Projects	Length of free flow of river (km)
1.	International boundary to submergence of Kalai Stage 1	32.0
2.	Between Kalai HEP Stage-1 and Kalai HEP Stage-2	1.0
3.	Between Kalai HEP Stage-2 and Hutong HEP Stage-2	9.5
4.	Between Hutong Stage - 2 and Anjaw HEP	1.8
5.	Between Anjaw HEP and Demwe Upper HEP	3.8
6.	Between Demwe Upper HEP and Demwe Lower HEP	1.8
	Total	**49.9**

On tributaries Dav, Dalai and Kamlang are hydroelectric project each is proposed. The distance of confluence of Power House Tail Race Disposal Sites for projects on Dav, Dalai and Kamlong are 4.5 km, 4.0 km and 15.0 km respectively.

On river Tidding, two hydroelectric projects are proposed the distance between confluence are Power House or TRT disposal site of Tidding-II HEP is 2.2 km. The distance between FRL of Tidding-II HEP and TWL of Tidding-I HEP is about 8 km. The details of cascade development of hydroelectric projects on tributaries of Lohit Basin are depicted in Figure-9.2.

Normally, under such circumstances, adverse impacts on water quality as well, increases the residence time in the reservoir. As a result, there could be adverse impacts on water quality. In the study area, the pollution loading is virtually negligible, on account of low population density, low cropping intensity with minimal use of agro-chemicals and absence of industrialization in the area. Thus, the pollution loading is low, and as a result no major impacts on reservoir water quality is anticipated.

10.2.3 Commissioning of Base Load Power Station

Since Hutong hydroelectric project stage 1 has been recommended to be dropped, all the five remaining hydroelectric projects are dam to power projects. For these projects, using Building Block Methodology, Environmental Flows have been recommended. It is suggested that for optimal utilization of Environmental Flows, base load stations of appropriate capacity be commissioned in each of the remaining five hydroelectric projects. This will ensure optimal utilization of Environmental Flows. The capacity of base load stations can be estimated as a part of DPR preparation of individual hydroelectric projects.

10.2.4 Management plan for Sustenance of Fish Species

Based on the field studies, the following migratory fish species are observed in the study area:

- *Schizothorax richardsonii*
- *Acrossocheilus hexagondepsis*
- *Tor putitora*
- *Tor tor*
- *Labeo pangusia*

The species *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* migrate from lower elevation to higher elevation in summer months and return to lower elevation in winter months. These species were observed at various sampling locations of all the six hydroelectric projects.

The fish species such as *Tor Putitora*, *Tor tor* and *Labeo pangusia* migrate to lower elevation in summer months and undertake the return journey in winter months. These species were observed only in the vicinity of the following projects:

- Hutong hydroelectric project, stage-2
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project
- Gmiliang Hydroelectric Project
- Raigam Hydroelectric Project
- Tidding-I Hydroelectric Project
- Tidding-II Hydroelectric Project
- Kamlang Hydroelectric Project

It is proposed to construct separate hatcheries for snow trout and mahaseer the study area. These hatcheries can be developed by the Department of Fisheries, state government of Arunachal Pradesh. The stocking program shall comprise of the following:

- Acclimatization stocking (a new fish species is introduced in a water course)
- Supplementary stocking (a species already living in a water body)
- Transfer stocking (transportation of mature fish from one water body to another)

- Repetitive stocking (species which do not propagate in natural conditions).

Hatchery Units

A fish hatchery is the centre of ova production. It helps in propagating the ova of required species and stocking of fish fingerlings to different water bodies. A hatchery can play an important role in the conservation of threatened species and sustenance fishery.

It is proposed to stock the reservoirs of all the six projects with fingerlings of *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis.* The rate of stocking shall be 50 per ha.

It is proposed to stock the reservoirs of the following projects with fingerlings of *Tor putitora, Tor tor and Labeo pangusia:*

- Hutong hydroelectric project, stage-2
- Demwe Upper hydroelectric project
- Demwe Lower hydroelectric project
- Tidding-II Hydroelectric Project
- Kamlang Hydroelectric Project

The rate of stocking shall be 50 per ha.

The number of fingerlings of *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* required for reservoir stocking are about 0.235 million. The details are given in Table-10.24.

Table-10.24: Details of fingerlings of *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* required for reservoir stocking

S. No.	Name of the project	Submergence Area (ha)	Stocking rate (no./ha)	Total fingerlings required
1.	Kalai Hydroelectric Project, Stage-1	745	50	37250
2.	Kalai Hydroelectric Project, Stage-2	660	50	33000
3.	Hutong Hydroelectric Project, Stage-2	651	50	32550
4.	Demwe Upper Hydroelectric Project	1440	50	72000
5.	Demwe Lower hydroelectric Project	1134	50	56700
6.	Gmiliang Hydroelectric Project	1.04	50	50
7.	Raigam Hydroelectric Project	9.65	50	500
8.	Tidding-I Hydroelectric Project	6.0	50	300
9.	Tidding-II Hydroelectric Project	4.0	50	200
	Total			**232550**

The number of fingerlings of *Tor putitora, Tor tor and Labeo pangusia* required for reservoir stocking are about 0.165 million. The details are given in Table-10.25.

Table-10.25: Details of fingerlings of *Tor putitora, Tor tor and Labeo pangusia* required for reservoir stocking

S. No.	Name of the project	Submergence Area (ha)	Stocking rate (no./ha)	Total fingerlings required
1.	Hutong Hydroelectric Project, Stage-2	651	50	32550

S. No.	Name of the project	Submergence Area (ha)	Stocking rate (no./ha)	Total fingerlings required
2.	Demwe Upper Hydroelectric Project	1440	50	72000
3.	Demwe Lower hydroelectric Project	1134	50	56700
4.	Tidding-II Hydroelectric Project	4	50	200
	Total			**161450**

The dimension of the hatcheries, nurseries and rearing units for *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis* is given in Table-10.23. The dimension of the hatcheries, nurseries and rearing units for *Tor putitora, Tor tor and Labeo pangusia* are given in Table-10.26.

Table-10.26:Dimensions of units required for development of hatcheries for *Schizothorax richardsonii* and *Acrossocheilus hexagonolepis*

Farm Component	Area (m)	Number	Rate of flow (lpm)
Hatchery building	25x 10 x 4	1	-
Hatching trough each with 4 trays each	5.0x1.0x 0.5	20	3.0-5.0
Nursery ponds (Cement lined)	9.0 x 1.5 x 0.5	9	25-50
Rearing tanks (cement lined)	10.0x 1.5 x 1.0	30	75-100
Stock raceways (cement lined)	30.0 x 6.0x 1.5	8	150-200
Storage – cum – Silting tank	6.0 x 4.0	1	-
Office store & laboratory room	8.0 x 6.0	3	-
Watchmen hut	4.0 x 4.0	1	-

Table-10.27:Dimensions of units required for development of hatcheries for *Tor putitora, Tor tor and Labeo pangusia*

Farm Component	Area (m)	Number	Rate of flow (lpm)
Hatchery building	25x 10 x 4	1	-
Hatching trough each with 4 trays each	4.0x1.0x 0.5	20	3.0-5.0
Nursery ponds (Cement lined)	9.0 x 1.5 x 0.5	6	25-50
Rearing tanks (cement lined)	9.0x 1.5 x 1.0	20	75-100
Stock raceways (cement lined)	30.0 x 6.0x 1.5	6	150-200
Storage – cum – Silting tank	6.0 x 4.0	1	-
Office store & laboratory room	8.0 x 6.0	3	-
Watchmen hut	4.0 x 4.0	1	-

The cost for fisheries development shall be shared amongst all the various hydro-electric projects proposed to be developed in the study area.

A Steering Committee of the project would be constituted for the monitoring of the project as listed in Table-10.28.

Table-10.28:Steering Committee constituted for the monitoring of fisheries development

S. No.	Officer	Position
1	Secretary (Fisheries) to the Government of Arunchal Pradesh	Chairman
2	Representative of District Collector	Member
3	Representative of Department of Power, state government of Arunachal Pradesh	Member
4	Nominated representative of local public	Member
5	Nominated representative of proponents of various hydroelectric projects	Member
6	Assistant Director of Fisheries, state government of Arunachal Pradesh	Member Secretary

The main tasks of the Committee shall be:

- Review of the progress and adequacy of various measures being implemented for sustenance of riverine fisheries.
- Consideration of the need for any mid-course change in the project component.

10.3 CONSERVATION OF THREATENED FLORA

During the course of survey, only one species i.e., *Lagerstroemia muniticarpa* classified as endangered plant species as per IUCN Red list. The density of *Lagerstroemia muniticarpa* in the submergence area of various hydroelectric projects is given in Table-10.29.

Table-10.29: Density of *Lagerstroemia muniticarpa* observed at various sampling sites

Name of the project	Density (No./ha)
Kalai Hydroelectric Project,Stage-1	-
Kalai Hydroelectric Project,Stage-2	-
Hutong Hydroelectric Project,Stage-1	-
Hutong Hydroelectric Project,Stage-2	5
Demwe Upper Hydroelectric Project	10
Demwe Lower hydroelectric Project	-

The *Lagerstoremia muniticarpa* is present in the submergence area of Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project. The density of this species is quite low, i.e. 5 to 10 trees/ha. A detailed study is recommended as a part of the CEIA study of individual projects to ascertain the impacts on *Lagerstoremia muniticarpa* and suggest appropriate management measures on this account.

10.4 RECOMEMNDATIONS

10.4.1 Maintenance of free flow of river

The biggest impact on hydrologic regime is on account of change in the free flowing condition of the river. With the construction of the proposed hydroelectric projects, the free flowing river shall be available on an intermittent basis only for a length of 10 km in a stretch of 109 km. It is recommended to drop Hutong HEP Stage-1. This will increase the length of free flow of river from 19.1 km to 49.9 km. Hutong hydroelectric project, stage 1 was recommended to be dropped as it is at the elevation where both Mahaseer and Snow Trout are observed. The dropping of the project will provide the free stretch of 19.1 km for migration of both these species. The details are given in Table-10.30.

Table-10.30:Details of length of free flow of river in the study area with exclusion of Hutong HEP stage-1

S. No.	Projects	Length of free flow of river (km)
1.	International boundary to submergence of Kalai Stage 1	32.0
2.	Between Kalai HEP Stage-1 and Kalai HEP Stage-2	1.0
3.	Between Kalai HEP Stage-2 and Hutong HEP Stage-2	9.5
4.	Between Hutong Stage - 2 and Anjaw HEP	1.8
5.	Between Anjaw HEP and Demwe Upper HEP	3.8
6.	Between Demwe Upper HEP and Demwe Lower HEP	1.8
	Total	**49.9**

10.4.2 Environmental Flows

The recommended Environmental Flows for various HEPs main river Lohit and its tributaries are given in Table-10.31 and 10.32 respectively.

Table-10.31: Recommended Environmental Flows of Discharge for 90% dependable year for various Hydro-electric Projects

Month	Kalai HEP Stage-1	Kalai HEP Stage-II	Hutong HEP Stage-2	Anjaw HEP	Demwe Upper HEP	Demwe Lower HEP
Monsoon Season	21% *(162.26m^3/s)*	20% *(163.48 m^3/s)*	22% *(293.54 m^3/s)*	20% *(162.56 m^3/s)*	20% *(215.13 m^3/s)*	20% *(225.93 m^3/s)*
Lean season	18% *(42.09 m^3/s)*	15% *(39.71 m^3/s)*	18% *(51.22 m^3/s)*	15% *(44.73 m^3/s)*	15% *(54.19 m^3/s)*	15% *(56.89 m^3/s)*
Non-Monsoon non lean season* (April-May)	21% *(118.9 m^3/s)*	20% *(103.60 m^3/s)*	21% *(140.06 m^3/s)*	20% *(133.33 m^3/s)*	20% *(158.07 m^3/s)*	20% *(166.0 m^3/s)*
Non-	21%	20%	21%	20%	20%	20%

Monsoon non lean season* (October-November)	*(81.97 m^3/s)*	*(90.67 m^3/s)*	*(84.11 m^3/s)*	*(90.41 m^3/s)*	*(94.37 m^3/s)*	*(99.02 m^3/s)*

Note: *Minimum depth for fisheries is not available even with 100% flow in pre project scenario. In such a scenario, top width has been considered.*

Table-10.32: Recommended Environmental Flows of Discharge for 90% dependable year for various Hydro-electric Projects

Month	**Gmiliang HEP**	**Raigam HEP**	**Tidding-I HEP**	**Tidding-II HEP**	**Kamlang HEP (75% dependable year)**
Monsoon Season	30% *(7.61 m^3/s)*	30% *(34.17 m^3/s)*	30% *(15.75 m^3/s)*	30% *(12.61 m^3/s)*	20% *(31.47 m^3/s)*
Lean season	20% *(1.75 m^3/s)*	20% *(7.77 m^3/s)*	20% *(3.62 m^3/s)*	20% *(2.90 m^3/s)*	15% (2.70 m^3/s))
Non-Monsoon non lean season* (April-May)	25% *(4.19m^3/s)*	25% *(18.67m^3/s)*	25% *(8.66 m^3/s)*	25% *(6.93 m^3/s)*	20% *(10.43 m^3/s)*
Non-Monsoon non lean season* (October-November)	25% *(3.65m^3/s)*	25% *(16.23m^3/s)*	25% *(7.54 m^3/s)*	25% *(6.04 m^3/s)*	20% *(8.57 m^3/s)*

Note: *Minimum depth for fisheries is not available even with 100% flow in pre project scenario. In such a scenario, top width has been considered.*

10.4.3 Conservation of Flora of under threatened category

During the course of survey, only one species i.e., *Lagerstroemia muniticarpa* classified as endangered plant species as per IUCN Red list. *Lagerstoremia muniticarpa* is present in the submergence area of Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project. The density of this species is quite low, i.e. 5 to 10 trees/ha. *Lagerstoremia muniticarpa* is present in the submergence area of Hutong hydroelectric project, stage-2 and Demwe Upper hydroelectric project. A detailed study is recommended as a part of the CEIA study of these two projects to ascertain the impacts on *Lagerstoremia muniticarpa* and suggest appropriate management measures on this account.

The lower elevations of the study area are presently degraded due to high human pressure, large scale lopping and removal of fodder and timber species, grazing, construction of road, etc. Nayar and Sastry (1987-1990) have reported 35 species of rare and endangered plant species from Arunachal Pradesh. Of these threatened species *Acer oblongum* var. *microcarpum, Begonia burkillii, Calanthe manii, Dioscorea deltoidea, Paphiopedilum wardii* and *Phoenix rupicola* have been reported from low hills in the altitudinal range of 300-1200 m. The details are given in Table-10.33. There is a possibility that some or all of these species may be present in the project area though the present surveys were not able to record these in the field. As per the findings of the Ecological Survey conducted for Demwe Lower hydroelectric project, the floral species were not observed in the Study Area.

Table-10.33 : Rare, vulnerable and endangered plants reported in the Study Area

S. No.	Species	Family	Altitude (m)	Habit	Status
1.	*Acer oblongum* var. *microcarpum*	Acerceae	500-1200	Tree	Endangered
2.	*Begonia burkillii*	Begoniaceae	300-1000	Herb	Rare
3.	*Calanthe manii*	Orchidaceae	Up to 1000	Herb	Rare
4.	*Dioscorea deltoidea*	Dioscoreaceae	300-3000	Climber	Endangered
5.	*Paphiopedilum wardii*	Orchidaceae	Up to 1000	Herb	Rare
6.	*Phoenix rupicola*	Arecaceae	Up to 450	Tree	Rare

Source: *CEIA Report, Demwe Lower hydroelectric project*

It is thus recommended that a detailed study be conducted as a part of the CEIA study for other hydroelectric projects in the basin. If these species are observed, then an appropriate conservation plan needs to be prepared.

10.4.4 Conservation of economically important plant species

The density of various economically important plant species in the submergence area of various hydroelectric projects is given in Table-8.10 of this report.

Five economically important plants were recorded from Hutong Hydroelectric Project, Stage-1 viz., *Ficus cunia, Macaranga denticulata, Nephrolepis cordifolia, Rubus* spp. and *Thysanolaena maxima*.

About 9 economically important plant species were recorded from the study area in Hutong Hydroelectric Project, Stage-2. These include *Clerodendron colebrookianum, Ficus cunia, Macaranga denticulata, Nephrolepis cordifolia, Rubus* spp., *Terminalia myriocarpa, Thysanolaena maxima, Saurauria nepalensis* and *Spondias axillaries*.

In Kalai Hydroelectric Project, Stage-1, seven economically important plant species were recorded. They were namely, *Ficus cunia, Macaranga denticulata, Nephrolepis cordifolia, Alnus nepalensis, Rubus* spp., *Thysanolaena maxima* and *Saurauria nepalensis*.

At various sampling sites, Kalai Hydroelectric Project, Stage-2, various plants of economic importance such as timber, medicinal, edible fruits were commonly observe. *Canarium strictum* is a very good incense yielding tree and *Pandanus* species is a fiber yielding tree species. These are seen commonly here and there at the project sites.

About 12 economically important plant species were recorded from the study area in Demwe Upper Hydroelectric Project. These species include *Clerodendron colebrookianum, Ficus cunia, Ficus roxburghii, Macaranga sp., Nephrolepis cordifolia, Pandanus odoratissima,*
Rubus spp., *Terminalia myriocarpa, Thysanolaena maxima, Saurauria nepalensis, Sapium baccatum* and *Spondias axillaries*.

Twelve economically important plant species were recorded from the study area of Demwe Lower Hydroelectric Project. Plants of economic importance such as timber (*Terminalia myriocarpa, Sapium baccatum*), medicinal (*Nephrolepis cordifolia*), edible fruits (*Emblica officinalis, Pegia nitida, Spondias axillaris*) and *Pandanus odoratissima* a fiber yielding tree species were seen commonly here and there at the project site. It is recommended that the economically important plant species be grown as a part of Compensatory Afforestation Programme, which is to be implemented as a part of Environmental Management Plan for each hydroelectric project proposed to the developed in the basin area.

10.4.5 Afforestation

The total forest to be acquired for various project appurtenances needs to be ascertained as a part of the project related studies. The Indian Forest Conservation Act (1980) stipulates:

- If non-forest land is not available, compensatory afforestation are to be established on degraded forest lands, which must be twice the forest area affected or lost, and
- If non- forest land is available, compensatory forest are to be raised over an area equivalent to the forest area affected or lost.

Compensatory afforestation, NPV and cost of trees need to be included as a part of the Environmental Management Plan to be prepare as a part of the CEIA study of individual hydroelectric projects in the study area.

10.4.6 Measures to prevent degradation due to increased labour population

Keeping in view the sudden influx of labour population in the 'wildlife rich areas, the following actions are suggested for the conservation of flora and fauna in the region.

- The project authorities would ensure that strict vigil is kept especially during the breeding season of animals i.e. from October- December and when young ones are born/nesting season, i.e. from March-June. Activities like blasting or heavy machine operations producing noise levels more than 80-100 dB(A) will be restricted during this period. Heavy penalties would be imposed for violation of this conduct by contractors/labourers, etc. during this period. These aspects shall be included in the Tender Document for the Contractor involved in construction works.
- Information dissemination emphasizing the need of conservation and legal

consequences on violation of Forest and Wildlife (Protection) Acts will be prioritised and publicised.

- Awareness would also be imparted to the labourers engaged in construction activities for exerting great restraint especially during critical months of breeding and nesting of animals and birds.
- The signboards/Notice boards highlighting penalties for violation of rules, will be put nearby habitation areas of labourers.
- Strict monitoring of laborers and associated workers for any activity related to endangering the life or habitat of wild animals and birds.
- Strict restrictions will be imposed on the workers at project sites to ensure that they do not harvest any produce from the natural forests and cause any danger or harm to the animals and birds in wild.
- Minimum levels of noise during construction activities will be maintained and no activity will be carried out at night since where the project site is in the close vicinity of natural animal/bird habitats.
- Fuel wood to the laborers will be provided from plantations meant for the purpose and/or the provision has been made for the supply of the free subsidized kerosene/LPG from the depots being set up for this purpose to avoid forest degradation and animal habitats.
- Interference of human population would be kept to the minimum and it would be ensured that the contractors do not set up laborer colonies in the vicinity of forests and wilderness areas.

10.4.7 Anti-Poaching Measures

During construction phase for each hydroelectric project in and around the main construction areas where construction workers congregate, some disturbance to the wildlife population may occur. Therefore, marginal impacts may be on wildlife due to various construction activities. In view of this it is recommended that 2 adequate check posts be developed in the major construction area and in vicinity labour camps for each project to prevent anti-poaching activities in the area. Each check post shall have 4 guards to ensure that poaching does not take place in the area. The guards will be supervised by a range officer. It is also recommended that the staff manning these check posts have adequate communication equipment and other facilities. Apart from inter-linking of check posts, communication link needs to be extended to Divisional Forest Office and the local police station also.

CHAPTER-11
RECOMMENDATIONS

CHAPTER-11
RECOMMENDATIONS

Recommendations for the basin study are following:

Length of River with minimum flow

- Construction of the hydroelectric projects would lead to conversion of free flowing river into a series of reservoirs interested with dams/diversion structure of various hydroelectric projects.
- As present, free flow stretch will be available for a stretch of 19.1 km out of a total stretch of 109 km.
- It is recommended to drop Hutong hydroelectric project, stage 1 so that free flowing river stretch increases to 49.9 km
- Hutong hydroelectric project, stage 1 was recommended to be dropped as it is at the elevation where both Mahaseer and Snow Trout are observed. The dropping of the project will provide the free stretch of 19.1 km for migration of both these species. The site is also not geologically stable. Hence, it is recommended to drop the Hutong-I HEP.
- Free stretch for more than 1 km is available in HEP's located in tributaries.
- All the projects on tributaries are recommended for development, with no change in operating level

Details of length of free flow of river in the study area with exclusion of Hutong HEP Stage-1

S. No.	Projects	Length of free flow of river (km)
1.	International boundary to submergence of Kalai Stage 1	32.0
2.	Between Kalai HEP Stage-1 and Kalai HEP Stage-2	1.0
3.	Between Kalai HEP Stage-2 and Hutong HEP Stage-2	9.5
4.	Between Hutong Stage - 2 and Anjaw HEP	1.8
5.	Between Anjaw HEP and Demwe Upper HEP	3.8
6.	Between Demwe Upper HEP and Demwe Lower HEP	1.8
	Total	**49.9**

- The depth of flow for Mahaseer and snow trout in various seasons is given in Table-10.1. The minimum depth for various seasons is not available even with 100% flow. Hence, in such a scenario, top width has been considered.

The recommended Environmental Flows for various HEPs main river Lohit and its tributaries are given in Table-11.2 and 11.3 respectively.

Table-11.2: Recommended Environmental Flows of Discharge for 90% dependable year for various Hydro-electric Projects

Month	Kalai HEP Stage-1	Kalai HEP Stage-II	Hutong HEP Stage-2	Anjaw HEP	Demwe Upper HEP	Demwe Lower HEP
Monsoon Season	21% *(162.26m^3/s)*	20% *(163.48 m^3/s)*	22% *(293.54 m^3/s)*	20% *(162.56 m^3/s)*	20% *(215.13 m^3/s)*	20% *(225.93 m^3/s)*
Lean season	18% *(42.09 m^3/s)*	15% *(39.71 m^3/s)*	18% *(51.22 m^3/s)*	15% *(44.73 m^3/s)*	15% *(54.19 m^3/s)*	15% *(56.89 m^3/s)*
Non-Monsoon non lean season* (April-May)	21% *(118.9 m^3/s)*	20% *(103.60 m^3/s)*	21% *(140.06 m^3/s)*	20% *(133.33 m^3/s)*	20% *(158.07 m^3/s)*	20% *(166.0 m^3/s)*
Non-Monsoon non lean season* (October-November)	21% *(81.97 m^3/s)*	20% *(90.67 m^3/s)*	21% *(84.11 m^3/s)*	20% *(90.41 m^3/s)*	20% *(94.37 m^3/s)*	20% *(99.02 m^3/s)*

Note: *Minimum depth for fisheries is not available even with 100% flow in pre project scenario. In such a scenario, top width has been considered.*

Table-11.3: Recommended Environmental Flows of Discharge for 90% dependable year for various Hydro-electric Projects

Month	Gmiliang HEP	Raigam HEP	Tidding-I HEP	Tidding-II HEP	Kamlang HEP (75% dependable year)
Monsoon Season	30% *(7.61 m^3/s)*	30% *(34.17 m^3/s)*	30% *(15.75 m^3/s)*	30% *(12.61 m^3/s)*	20% *(31.47 m^3/s)*
Lean season	20% *(1.75 m^3/s)*	20% *(7.77 m^3/s)*	20% *(3.62 m^3/s)*	20% *(2.90 m^3/s)*	15% (2.70 m^3/s))
Non-Monsoon non lean season* (April-May)	25% *(4.19m^3/s)*	25% *(18.67m^3/s)*	25% *(8.66 m^3/s)*	25% *(6.93 m^3/s)*	20% *(10.43 m^3/s)*
Non-Monsoon non lean season* (October-November)	25% *(3.65m^3/s)*	25% *(16.23m^3/s)*	25% *(7.54 m^3/s)*	25% *(6.04 m^3/s)*	20% *(8.57 m^3/s)*

Note: *Minimum depth for fisheries is not available even with 100% flow in pre project scenario. In such a scenario, top width has been considered.*

The recommendations of the basin study are given as below:

- As present, free flow stretch will be available for a stretch of 19.1 km out of a total stretch of 109 km in Main River.
- It is recommended to drop Hutong hydroelectric project, stage 1 so that free flowing river stretch increases to 49.9 km
- Hutong hydroelectric project, stage 1 was recommended to be dropped as it is at the elevation where both Mahaseer and Snow Trout are observed. The dropping of the project will provide the free stretch of 19.1 km for migration of both these species. The site is also not geologically stable. Hence, it is recommended to drop the Hutong-I HEP.
- Free stretch for more than 1 km is available in HEP's located on tributaries
- All the projects on tributaries are recommended for development, with no change in operating level

WAPCOS LIMITED

(A Government of India Undertaking)

76 C, Sector 18, Gurgaon - 122015, Haryana, INDIA

Tel. 0124-2397396, Fax. 0124-2397392

Email: environment@wapcos.co.in

AUGUST 2016

MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE, GOVERNMENT OF INDIA

सत्यमेव जयते




CARRYING CAPACITY AND CUMULATIVE IMPACT ASSESSMENT STUDIES FOR HYDROELECTRIC PROJECTS ON THE TRIBUTARIES OF LOHIT RIVER BASIN IN ARUNACHAL PRADESH

VOLUME-II : ANNEXURES

Prepared by:

WAPCOS LIMITED

(A Government of India Undertaking)

76 C, Sector 18, Gurgaon - 122015, Haryana, INDIA

Tel. +91-124-2397396, Fax. +91-124-2397392

Email: environment@wapcos.co.in

AUGUST 2016

CONTENTS

CONTENTS

LIST OF ANNEXURES

ANNEXURE-I
Community characteristics of the vegetation at various sampling locations of Kalai Hydroelectric Project, Stage-1

ANNEXURE-I

Community characteristics of the vegetation at various sampling locations of Kalai Hydroelectric Project,Stage-1

1. Dam site

S. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1.	*Albizia* sp.	60	180	0.52	59.82
2.	*Albizia* sp.	10	10	0.64	12.92
3.	*Alnus nepaulensis*	10	20	0.15	8.92
4.	*Betula alnoides*	20	20	0.4	15.52
5.	*Ficus cunia*	10	10	0.1	6.65
6.	*Grewia* sp.	10	60	0.08	15.11
7.	*Gynocardia odorata*	10	10	0.39	9.97
8.	*Itea macrophylla*	20	30	0.05	13.27
9.	*Lagerstroemia muniticarpa*	30	30	4.12	64.15
10.	*Macaranga denticulata*	40	50	0.63	30.87
11.	*Schfellera hypoleuca*	10	10	0.1	6.59
12.	*Sterculia* sp.	10	20	1.12	20.19
13.	*Wallichiana* sp. (Palm)	20	100	0.18	27.03
14.	Unidentified sp.	10	20	0.16	9.01
	Total		**570**		**300.02**

S. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1.	*Artemisia nilagirica*	40	100	15.03
2.	*Boehmeria longifolia*	60	700	51.57
3.	*Boehmeria macrophylla*	30	210	18.40
4.	*Debregessia longifolia*	80	380	39.56
5.	*Rubus ellipticus*	20	20	5.93
6.	*Rubus* sp.	10	30	4.02
7.	*Solanum nigrum*	20	30	6.46
8.	*Solanum xanthocarpum*	20	20	5.93
9.	*Solanum xanthocarpum*	20	80	9.10
10	*Spirea* sp.	70	80	21.29
11	*Inula cappa*	10	35	4.29
12	*Urena lobata*	30	210	18.40
	Total		**1895**	**199.98**

Sl. no.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	30	102000	34.42
2.	*Anaphalis* sp.	10	4000	3.31
3.	*Crossesophelum crepezoides*	10	3000	3.04
4.	*Elatostemma* sp.	30	66000	24.63
5.	*Fagopyrum dibotrys*	50	27000	18.46
6.	*Imperata cylindrica*	20	39500	15.19
7.	*Inula cappa*	30	4000	7.76
8.	*Lygodium flexuosum*	40	5000	10.25
9.	*Nephrolepis cordifolia*	60	43000	25.03
10.	*Phyrnium pubinerve*	10	7000	4.13
11.	*Pilea umbrosa*	30	27000	14.01
12.	*Polygonum capitatum*	30	22000	12.65
13.	*Saccharum spontaneum*	40	83000	31.47
14.	*Senecio cappa*	30	6000	8.30
15.	*Thysanolaena maxima*	30	21000	12.38
16.	*Urtica dioca*	20	9000	6.89
17.	*Trichosanthes* sp.	10	1000	2.49
18.	*Periploca* sp.	20	20	4.45
		450	**367500**	**200.00**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	40	128000	38.36
2.	*Anaphalis sp.*	20	9000	6.10
3.	*Begonia sp.*	15	2500	3.56
4.	*Commelina paludosa*	15	6000	4.40
5.	*Crossesophelum crepezoides*	20	6000	5.39
6.	*Elatostemma sp.*	30	72500	23.18
7.	*Fagopyrum dibotrys*	50	37000	18.70
8.	*Imperata cylindrica*	20	44500	14.54
9.	*Inula cappa*	30	4500	7.01
10.	*Lygodium flexuosum*	40	6000	9.35
11.	*Nephrolepis cordifolia*	60	45000	22.58
12.	*Periploca sp.*	20	2500	4.55
13.	*Phyrnium pubinerve*	10	8500	4.00
14.	*Pilea umbrosa*	30	28500	12.72
15.	*Polygonum capitatum*	30	24000	11.65
16.	*Saccharum spontaneum*	40	87500	28.73
17.	*Senecio cappa*	30	7000	7.61

18.	*Thysanolaena maxima*	35	28000	13.59
19.	*Trichosanthes sp.*	10	1500	2.34
20.	*Urtica dioca*	20	10500	6.46
		505	**420500**	**200.00**

2. Submergence Area

S. No.	**Trees**	**Frequency %**	**Density (No./ha)**	**Basal area (m^2/ha)**	**IVI**
1	*Albizzia* sp.	10	10	0.11	8.13
2	*Alnus nepaulensis*	20	30	0.28	18.8
3	*Betula alnoides*	10	10	0.25	9.95
4	*Ficus cunia*	50	170	0.66	63.57
5	*Grewia* sp.	10	40	0.08	13.06
6	*Macaranga denticulata*	20	20	0.32	17.51
7	*Mallotus* sp.	10	10	0.06	7.42
8	*Pinus* sp.	50	220	5.17	133.57
9	*Quercus* sp.	10	10	0.34	11.12
10	*Saurauria napalensis*	20	30	0.14	16.84
	Total		**550**		**299.97**

S. No.	**Shrubs**	**Frequency %**	**Density (No./ha)**	**IVI**
1.	*Artemisia nilagirica*	70	710	47.36
2.	*Boehmeria longifolia*	80	190	26.44
3.	*Debregessia longifolia*	90	560	45.17
4.	*Inula cappa*	30	40	8.52
5.	*Piper* sp.	15	140	9.61
6.	*Rubus ellipticus*	20	20	5.39
7.	*Solanum nigrum*	30	130	12.53
8.	*Solanum xanthocarpum*	10	10	2.69
9.	*Spirea* sp.	30	180	14.76
10	*Trichosanthes* sp.	40	35	10.55
11	*Unidentified* sp.	30	230	16.99
	Total		**2245**	**200.01**

Sl. No.	**Herbs (April)**	**Frequency %**	**Density (No./ha)**	**IVI**
1.	*Ageratum conyzoides*	60	83000	32.64
2.	*Carex* sp.	10	2500	2.80
3.	*Elatostemma* sp.	30	74000	23.88
4.	*Imperata cylindrica*	70	108000	40.67
5.	*Lygodium flexuosum*	50	8000	12.97
6.	*Nephrolepis cordifolia*	40	60000	22.84
7.	*Ophiopogon intermedius*	10	2500	2.80
8.	*Periploca* sp.	20	2000	4.91

9.	*Pilea umbrosa*	50	58000	24.60
10	*Polygonum capitatum*	50	9000	13.20
11	*Thysanolaena maxima*	30	12000	9.46
12	*Urtica dioca*	30	11000	9.22
	Total		**430000**	**199.99**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	70	89000	32.35
2.	*Carex sp.*	15	3500	3.91
3.	*Elatostemma sp.*	30	75000	21.03
4.	*Imperata cylindrica*	70	158500	45.86
5.	*Lygodium flexuosum*	50	8500	12.40
6.	*Nephrolepis cordifolia*	40	62000	20.65
7.	*Ophiopogon intermedius*	10	3000	2.73
8.	*Periploca sp.*	20	2500	4.79
9.	*Pilea umbrosa*	50	60000	22.41
10.	*Polygonum capitatum*	50	19000	14.45
11.	*Thysanolaena maxima*	30	17500	9.85
12.	*Urtica dioca*	30	16000	9.56
		465	**514500**	**200.00**

3. Upstream Area

S. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1.	*Pinus merkusii*	100	280	18.23	287.23
2.	*Quercus* sp.	10	10	0.05	12.79
	Total		**290**		**300.02**

S. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1.	*Artemisia nilagirica*	80	570	64.23
2.	*Artemisia* sp.	90	300	46.41
3.	*Boehmeria longifolia*	50	120	22.25
4.	*Crotolaria* sp.	20	50	9.05
5.	*Debregessia longifolia*	70	140	29.03
6.	*Inula cappa*	10	30	4.90
7.	*Rubus ellipticus*	20	50	9.05
8.	*Rubus* sp.	20	30	7.54
9.	*Senecio cappa*	20	30	7.54
	Total		**1320**	**200**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	70	38000	25.72
2.	*Carex* sp.	10	2500	3.06
3.	*Imperata cylindrica*	100	350500	99.11
4.	*Lygodium flexuosum*	90	21000	27.21
5.	*Nephrolepis cordifolia*	50	38000	20.66
6.	*Ophiopogon intermedius*	5	1000	1.48
7.	*Polygonum capitatum*	30	9000	9.49
8.	*Thysanolaena maxima*	40	15000	13.28
	Total		**475000**	**200.01**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	60	32000	23.93
2.	*Carex* sp.	15	2500	4.58
3.	*Imperata cylindrica*	100	280500	97.69
4.	*Lygodium flexuosum*	80	19000	25.89
5.	*Nephrolepis cordifolia*	55	36000	23.63
6.	*Ophiopogon intermedius*	5	1500	1.70
7.	*Polygonum capitatum*	25	7500	8.49
8.	*Thysanolaena maxima*	40	14000	14.09
		380	**393000**	**200.00**

4. 1 km downstream of dam site

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Ficus cunea*	55	90	0.40	53.66
2	*Saurauria nepalensis*	30	45	0.15	27.49
3	*Macaranga denticulata*	25	40	0.19	24.21
4	*Alnus nepalensis*	10	10	0.04	7.57
5	*Betula alnoides*	10	10	0.08	7.90
6	*Pinus merkusii*	10	15	0.36	11.80
7	*Sterculia villosa*	15	20	0.64	17.83
8	*Vitex peduncularis*	15	15	1.57	24.24
9	*Lagerstroemia muniticarpa*	20	40	5.45	66.99
10	*Toona ciliata*	10	10	0.75	13.68
11	*Albizzia* sp.	10	15	0.62	14.04
12	*Spondias pinnata*	5	5	0.46	7.58
13	*Canarium strictum*	5	5	0.67	9.36
14	*Euvodia* sp.	10	10	0.31	9.85
15	*Grewia* sp.	5	5	0.02	3.82
	Total		**335**	**11.71**	**300.02**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Artemisia nilagirica*	85	2430	78.81
2	*Boehmeria longifolia*	70	600	30.73
3	*Boehmeria macrophylla*	35	270	14.63
4	*Debregessia longifolia*	60	280	20.62
5	*Rubus ellipticus*	20	40	5.57
6	*Rubus sp.*	10	20	2.79
7	*Solanum nigrum*	15	30	4.18
8	*Solanum xanthocarpum*	20	60	6.06
9	*Spirea sp.*	70	60	17.56
10	*Inula cappa*	10	25	2.91
11	*Urena lobata*	30	270	13.48
12	*Oxospora paniculata*	10	15	2.66
	Total		**4100**	**200.00**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Ageratum conyzoides*	80	52500	38.94
2	*Anaphalis sp.*	35	5000	9.86
3	*Crossesophelum crepezoides*	10	4000	3.84
4	*Elatostemma sp.*	30	19000	14.33
5	*Fagopyrum dibotrys*	60	18000	20.67
6	*Imperata cylindrica*	50	60500	35.39
7	*Lygodium flexuosum*	15	2000	4.17
8	*Nephrolepis cordifolia*	65	37500	29.58
9	*Pilea umbrosa*	15	7500	6.36
10	*Polygonum capitatum*	60	24000	23.06
11	*Saccharum spontaneum*	45	44500	27.88
12	*Thysanolaena maxima*	30	20000	14.73
13	*Urtica dioca*	20	7500	7.49
14	*Trichosanthes sp.*	10	1000	2.65
15	*Periploca sp.*	20	20	4.50
	Total		**250500**	**200.00**

S. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	70	94500	31.81
2.	*Anaphalis* sp.	35	9000	8.00
3.	*Crossesophelum crepezoides*	20	6000	4.75
4.	*Elatostemma* sp.	30	29000	11.25
5.	*Fagopyrum dibotrys*	60	30000	16.72
6.	*Imperata cylindrica*	50	178000	45.55
7.	*Drymaria cordata*	40	48000	16.93
8.	*Inula cappa*	25	3500	5.11
9.	*Lygodium flexuosum*	40	7000	8.46
10.	*Nephrolepis cordifolia*	65	44500	20.60
11.	*Pilea umbrosa*	35	12000	8.62
12.	*Polygonum capitatum*	50	25500	14.04
13.	*Saccharum spontaneum*	35	52500	16.99
14.	*Senecio cappa*	25	3500	5.11
15.	*Thysanolaena maxima*	30	25500	10.53
16.	*Urtica dioca*	20	9000	5.37
17.	*Trichosanthes* sp.	10	1000	1.96
18.	*Periploca* sp.	20	25	3.51
	Total		**484000**	**200.00**

5. 3 km downstream of Wallang village

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Ficus cunea*	50	100	0.43	69.13
2	*Brassiopsis glomerata*	20	25	0.06	20.80
3	*Macaranga denticulata*	25	35	0.15	28.57
4	*Litsea citrata*	10	10	0.03	9.52
5	*Pinus* sp.	50	135	4.34	156.89
6	*Betula alnoides*	5	5	0.05	5.48
7	*Grewia* sp.	10	10	0.03	9.57
	Total		**320**	**5.09**	**299.96**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1.	*Artemisia nilagirica*	90	1080	73.32
2.	*Artemisia sp.*	70	525	42.93
3.	*Boehmeria longifolia*	55	270	27.36
4.	*Crotolaria sp.*	25	85	10.75
5.	*Debregessia longifolia*	75	205	30.01

6.	*Rubus ellipticus*	20	30	6.90
7.	*Rubus sp.*	25	40	8.73
	Total		**2235**	**200.00**

S. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	60	25500	20.82
2.	*Carex sp.*	25	4000	7.26
3.	*Imperata cylindrica*	100	375500	105.70
4.	*Lygodium flexuosum*	75	17000	22.86
5.	*Nephrolepis cordifolia*	40	24000	15.37
6.	*Ophiopogon intermedius*	15	2500	4.38
7.	*Polygonum capitatum*	35	7500	10.57
8.	*Thysanolaena maxima*	40	13000	13.03
	Total		**469000**	**200.00**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	50	13500	18.23
2.	*Carex sp.*	25	4500	8.33
3.	*Imperata cylindrica*	100	215500	102.38
4.	*Lygodium flexuosum*	60	10500	19.89
5.	*Nephrolepis cordifolia*	40	22500	18.68
6.	*Ophiopogon intermedius*	15	2000	4.75
7.	*Polygonum capitatum*	40	7000	13.26
8.	*Thysanolaena maxima*	40	10500	14.48
	Total		**286000**	**200.00**

ANNEXURE-II

Community characteristics of the vegetation at various sampling locations of Kalai Hydroelectric Project,Stage-2

ANNEXURE-II
Community characteristics of the vegetation at various sampling locations of Kalai Hydroelectric Project,Stage-2

A. Dam Site

Trees	**Frequency %**	**Density (No./ha)**	**Basal area (m^2/ha)**	**IVI**
Albizzia sp.	15	15	0.50	13.32
Altingia excelsa	15	15	0.73	15.76
Brassiopsis gromerulata	45	60	0.26	29.66
Callicarpa arborea	10	10	0.12	6.63
Canarium strictum	15	25	2.22	33.60
Ficus cunea	25	70	0.80	30.64
Grewia sp.	35	80	0.91	37.12
Gynocardia odorata	10	10	0.28	8.31
Macaranga denticulata	25	30	0.62	20.92
Mallotos	20	35	0.36	17.41
Pandanas odoratissima	30	90	1.44	42.97
Rhus acuminata	35	40	0.95	29.71
Saurauria nepalensis	15	35	0.19	13.95
		515	**9.38**	**300**

Shrubs	**Frequency %**	**Density (No./ha)**	**IVI**
Acacia pinnata	15	30	7.19
Artemesia nilagirica	15	120	13.23
Boehmeria longifolia	65	405	49.60
Boehmeria macrophylla	15	90	11.21
Debregessia longifolia	55	285	38.09
Mussanda roxburghii	15	30	7.19
Oxospora paniculata	20	90	12.94
Rubus ellipticus	20	35	9.25
Solanum nigrum	25	55	12.31
Solanum xanthocarpum	15	35	7.52
Urena lobata	30	315	31.49
		1490	**200**

Herbs (April)	**Frequency %**	**Density (No./ha)**	**IVI**
Begonia sp.	10	2500	2.27
Bidens pilosa	30	14000	8.64
Commelina sp.	15	7500	4.46
Costos speciosus	5	1000	1.07
Crossocephalum sp.	20	5000	4.55
Cyanotis vaga	5	2000	1.35
Drymria cordata	70	60000	27.78
Elatostemma sp.	20	14000	7.06
Forrestica sp.	20	3000	3.99
Gerardinia sp.	15	12000	5.71
Hydrocotyl javanica	35	12500	9.00

Lygodium flexuosum	15	4000	3.48
Galinsoga parviflora	30	29000	12.82
Nephrolepis cordifolia	60	43500	21.60
Ophiopogon intermedius	20	4000	4.27
Paderia foetida	20	3500	4.13
Phyrnium pubinerve	10	8500	3.95
Pilea umbrosa	35	33500	14.87
Pogonotherum sp.	20	12500	6.64
Polygonum capitatum	30	7000	6.68
Pteris sp.	10	4000	2.69
Saccharum spontaneum	35	19000	10.82
Periploca callosa	10	1500	1.99
Siegesosbekia orientalis	20	9000	5.66
Spilanthes paniculata	50	28500	15.83
Thladanthia sp.	10	4000	2.69
Thysanolaena maxima	15	13000	5.99
		358000	**200**

Herbs (August)	**Frequency %**	**Density (No./ha)**	**IVI**
Begonia sp.	10	3500	2.28
Bidens pilosa	30	35000	12.55
Commelina sp.	25	12500	6.58
Costos speciosus	10	2500	2.05
Crossocephalum sp.	20	9000	5.03
Cyanotis vaga	25	10500	6.12
Drymria cordata	70	63000	24.95
Elatostemma sp.	20	20500	7.71
Forrestica sp.	20	10500	5.38
Galinsoga parviflora	30	25000	10.23
Gerardinia sp.	15	10500	4.65
Hydrocotyl javanica	40	20500	10.65
Lygodium flexuosum	15	4000	3.14
Nephrolepis cordifolia	60	44500	19.17
Ophiopogon intermedius	25	6000	5.07
Paderia foetida	15	3500	3.02
Periploca callosa	10	1500	1.82
Phyrnium pubinerve	10	8500	3.45
Pilea umbrosa	35	35000	13.29
Pogonotherum sp.	25	10500	6.12
Polygonum capitatum	35	7000	6.77
Pteris sp.	15	4000	3.14
Saccharum spontaneum	25	20000	8.33
Siegesosbekia orientalis	20	12000	5.73
Spilanthes paniculata	50	32500	14.91
Thladanthia sp.	10	4000	2.40
Thysanolaena maxima	15	14000	5.46
		430000	**200.00**

B. Upstream site

Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
Albizzia sp.	60	180	0.52	59.82
Albizzia sp.	10	10	0.64	12.92
Alnus nepaulensis	10	20	0.15	8.92
Betula alnoides	20	20	0.4	15.52
Ficus cunia	10	10	0.1	6.65
Grewia sp.	10	60	0.08	15.11
Gynocardia odorata	10	10	0.39	9.97
Itea macrophylla	20	30	0.05	13.27
Lagerstroemia muniticarpa	30	30	4.12	64.15
Macaranga denticulata	40	50	0.63	30.87
Schfellera hypoleuca	10	10	0.1	6.59
Sterculia sp.	10	20	1.12	20.19
Wallichiana sp. (Palm)	20	100	0.18	27.03
Unidentified sp.	10	20	0.16	9.01
		570	**8.64**	**300**

Shrubs	Frequency %	Density (No./ha)	IVI
Artemisia nilagirica	40	100	15.03
Boehmeria longifolia	60	700	51.57
Boehmeria macrophylla	30	210	18.40
Debregessia longifolia	80	380	39.56
Rubus ellipticus	20	20	5.93
Rubus sp.	10	30	4.02
Solanum nigrum	20	30	6.46
Solanum sp.	20	20	5.93
Solanum xanthocarpum	20	80	9.10
Spirea sp.	70	80	21.29
Inula cappa	10	35	4.29
Urena lobata	30	210	18.40
		1895	**200**

Herbs (April)	Frequency %	Density (No./ha)	IVI
Ageratum conyzoides	75	62000	29.41
Anaphalis sp.	40	16000	11.34
Crossesophelum crepezoides	40	12000	10.33
Elatostemma sp.	25	13500	7.98
Fagopyrum dibotrys	50	28000	16.22
Imperata cylindrica	60	125500	42.84
Inula cappa	15	2000	3.24
Lygodium flexuosum	15	2500	3.36
Nephrolepis cordifolia	45	49000	20.65
Periploca callosa	10	1500	2.20
Phyrnium pubinerve	20	10000	6.18

Pilea umbrosa	40	24000	13.38
Polygonum capitatum	25	6000	6.07
Saccharum spontaneum	30	16000	9.53
Senecio cappa	10	1000	2.07
Thysanolaena maxima	25	10500	7.22
Trichosanthes sp.	10	1500	2.20
Urtica dioca	15	12000	5.78
		393000	**200.00**

Herbs (August)	**Frequency %**	**Density (No./ha)**	**IVI**
Ageratum conyzoides	70	77000	26.30
Anaphalis sp.	40	20000	10.80
Crossesophelum crepezoides	40	28000	12.21
Elatostemma sp.	25	28000	9.48
Fagopyrum dibotrys	50	51000	18.08
Imperata cylindrica	60	187500	43.95
Inula cappa	15	2500	3.17
Lygodium flexuosum	15	3500	3.34
Nephrolepis cordifolia	50	54500	18.69
Periploca callosa	10	1500	2.08
Phyrnium pubinerve	20	14000	6.10
Pilea umbrosa	40	29500	12.47
Polygonum capitatum	25	12000	6.66
Saccharum spontaneum	30	24000	9.68
Senecio cappa	10	3000	2.35
Thysanolaena maxima	25	14500	7.10
Trichosanthes sp.	10	1500	2.08
Urtica dioca	15	15500	5.46
		567500	**200.00**

C. Submergence

Trees	**Frequency %**	**Density (No./ha)**	**BA (m^2/ha)**	**IVI**
Pandanas odoratissima	25	30	0.28	20.15
Saurauria nepalensis	65	135	0.40	51.84
Mallotus tetracoccus	40	70	0.38	33.72
Ficus cunea	45	80	0.47	39.46
Betula alnoides	40	60	0.35	31.21
Alnus nepalensis	25	35	0.14	16.82
Rhus acuminata	15	20	0.24	14.55
Grewia sp.	20	25	0.15	14.08
Callicarpa arborea	30	60	0.31	27.39
Brassiopsis gromerulata	30	45	0.14	19.54
Albizzia sp.	20	30	0.22	17.03
Ficus roxburghii	15	15	0.11	9.85
Gynocardia odorata	5	5	0.07	4.31
		610	**3.25**	**299.95**

Shrubs	**Frequency %**	**Density (No./ha)**	**IVI**
Accacia pinnata	15	25	3.98
Artemesia nilagirica	70	1075	50.10
Boehmeria longifolia	60	390	25.46
Boehmeria macrophylla	25	105	8.72
Clerodendron coolebrokianum	40	60	10.39
Debregessia longifolia	50	225	17.93
Desmodium laxiflora	15	40	4.47
Mussanda roxburghii	15	20	3.82
Oxospora paniculata	35	80	10.00
Rubus ellipticus	15	20	3.82
Rubus mollucanus	10	15	2.60
Solanum nigrum	25	50	6.91
Solanum xanthocarpum	15	25	3.98
Tetrastigma sp.	10	10	2.43
Urena lobata	75	900	45.39
		3040	**200.00**

Herbs (April)	**Frequency %**	**Density (No./ha)**	**IVI**
Bidens pilosa	40	29000	15.04
Commelina sp.	25	10500	7.08
Crossocephalum sp.	20	4000	4.32
Cyanotis vaga	30	21000	11.05
Drymria cordata	15	9000	5.07
Elatostemma sp.	25	16000	8.75
Forrestica sp.	20	3000	4.02
Gerardinia sp.	15	10000	5.37
Hydrocotyl javanica	45	7000	9.11
Lygodium flexuosum	15	2500	3.09
Galinsoga	40	35000	16.87
Nephrolepis cordifolia	65	49000	25.02
Ophiopogon intermedius	15	2000	2.94
Paderia foetida	5	1000	1.08
Pilea sp.	30	22500	11.51
Pogonotherum sp.	20	8000	5.54
Polygonum capitatum	65	19000	15.87
Pteris sp.	10	3000	2.47
Saccharum spontaneum	35	10000	8.48
Periploca sp.	10	1500	2.01
Spilanthes paniculata	75	51500	27.33

Thladanthia sp.	10	1000	1.86
Thysanolaena maxima	15	12500	6.14
		328000	**200.00**

Herbs (August)	**Frequency %**	**Density (No./ha)**	**IVI**
Begonia sp.	15	4000	2.93
Bidens pilosa	35	42500	13.77
Commelina sp.	25	19500	7.57
Costos speciosus	20	3500	3.53
Crossocephalum sp.	20	6000	4.05
Cyanotis vaga	30	32000	10.88
Drymria cordata	65	56000	20.78
Elatostemma sp.	25	18000	7.25
Forrestica sp.	20	4000	3.63
Gerardinia sp.	15	11000	4.39
Hydrocotyl javanica	35	10500	7.09
Lygodium flexuosum	15	3500	2.83
Galinsoga	40	47500	15.51
Nephrolepis cordifolia	65	50500	19.63
Ophiopogon intermedius	15	2000	2.52
Paderia foetida	5	1000	0.91
Pilea sp.	30	28000	10.04
Pogonotherum sp.	20	10000	4.88
Polygonum capitatum	65	28000	14.94
Pteris sp.	10	2500	1.92
Saccharum spontaneum	35	15000	8.03
Periploca sp.	10	1500	1.71
Spilanthes paniculata	75	67000	24.48
Thladanthia sp.	10	1500	1.71
Thysanolaena maxima	15	14000	5.02
		479000	**200.00**

D. 1km downstream of Hawai

Trees	**Frequency %**	**Density (No./ha)**	**BA (mha)**	**IVI**
Pandanas odoratissima	40	65	0.60	42.75
Saurauria nepalensis	50	75	0.22	34.43
Mallotus tetracoccus	20	25	0.10	13.16
Ficus cunea	70	130	0.70	65.89
Rhus acuminata	15	15	0.11	10.49
Grewia sp.	55	100	0.49	49.33
Callicarpa arborea	30	40	0.25	23.67
Brassiopsis gromerulata	40	65	0.18	28.44
Albizzia sp.	10	15	0.09	8.56
Ficus roxburghii	15	25	0.10	11.88
Macropanax disperma	10	10	0.05	6.33
Wendlendia sp	10	10	0.01	4.92
		575	**2.92**	**300.0**

Shrub	**Frequency %**	**Density (No./ha)**	**IVI**
Accacia pinnata	10	25	3.89
Artemesia nilagirica	50	1225	57.10
Boehmeria longifolia	50	370	27.82
Boehmeria macrophylla	20	60	8.12
Debregessia longifolia	50	270	24.40
Mussanda roxburghii	10	15	3.54
Oxospora paniculata	25	95	10.83
Rubus ellipticus	10	25	3.89
Solanum nigrum	30	60	11.15
Solanum xanthocarpum	20	45	7.60
Urena lobata	55	730	41.67
		2920	**200.00**

Herbs (April)	**Frequency %**	**Density (No./ha)**	**IVI**
Ageratum conyzoides	50	42500	21.93
Bidens pilosa	60	49000	25.67
Commelina sp.	20	7500	5.72
Crossocephalum sp.	25	12500	8.15
Cyanotis vaga	10	3500	2.78
Drymria cordata	15	17000	7.95
Elatostemma sp.	20	12500	7.33
Forrestica sp.	20	2000	3.95
Gerardinia sp.	25	13000	8.31
Hydrocotyl javanica	20	8500	6.04

Lygodium flexuosum	25	3500	5.26
Galinsoga	20	9000	6.20
Nephrolepis cordifolia	50	41000	21.45
Ophiopogon intermedius	25	3500	5.26
Pilea sp.	35	19000	11.89
Polygonum capitatum	65	17000	16.21
Pteris sp.	20	4000	4.59
Saccharum spontaneum	25	14000	8.63
Periploca sp.	10	1000	1.97
Spilanthes paniculata	50	22500	15.50
Thysanolaena maxima	15	8500	5.21
	605	**311000**	**200.00**

Herbs (August)	**Frequency %**	**Density (No./ha)**	**IVI**
Begonia sp.	10	2500	1.78
Ageratum conyzoides	60	62500	19.90
Bidens pilosa	70	66000	21.87
Commelina sp.	35	12500	6.95
Crossocephalum sp.	40	20500	9.15
Cyanotis vaga	5	4000	1.42
Drymria cordata	70	66000	21.87
Elatostemma sp.	20	13000	5.11
Forrestica sp.	20	6000	3.75
Gerardinia sp.	25	14000	5.95
Hydrocotyl javanica	30	10000	5.82
Hedychium sp.	10	2000	1.68
Lygodium flexuosum	25	4500	4.10
Galinsoga	50	62000	18.51
Nephrolepis cordifolia	50	42500	14.72
Ophiopogon intermedius	25	4000	4.00
Pilea sp.	35	25000	9.38
Polygonum capitatum	70	29500	14.77
Pteris sp.	25	6000	4.39
Saccharum spontaneum	25	17500	6.63
Periploca sp.	10	1500	1.58
Spilanthes paniculata	50	32500	12.77
Thysanolaena maxima	15	10000	3.88
	775	**514000**	**200.00**

E. 3-5 km downstream

Sl. No.	**Trees**	**Frequency %**	**Density (No./ha)**	**Basal area (m^2/ha)**	**IVI**
1.	*Albizia* sp.	30	40	0.35	20.01
2.	*Alnus nepalensis*	45	60	0.54	30.49
3.	*Aralia thomsonii*	30	35	0.10	14.30
4.	*Betula alnoides*	40	50	0.89	34.77
5.	*Brassiopsis glomerulata*	45	75	0.22	26.20
6.	*Ficus cunia*	75	140	0.91	57.03
7.	*Macaranga denticulata*	45	60	0.61	31.89
8.	*Rhus acuminata*	40	45	0.22	20.47
9.	*Mallotus tetracoccus*	20	25	0.19	12.22
10.	*Pandanas odoratissima*	20	25	0.39	16.33
11.	*Grewia* sp.	50	75	0.50	33.12
12.	*Macropanax dispermus*	5	10	0.03	3.27
			640	**4.95**	**300**

Shrubs	**Frequency %**	**Density (No./ha)**	**IVI**
Accacia pinnata	15	20	4.27
Artemesia nilagirica	40	605	35.11
Boehmeria longifolia	75	490	38.12
Boehmeria macrophylla	15	60	5.99
Clerodendron colebrokianum	30	40	8.54
Debregessia longifolia	65	310	28.11
Desmodium laxiflora	15	25	4.48
Maesa indica	30	90	10.69
Mussanda roxburghii	10	20	3.13
Oxospora paniculata	30	140	12.84
Rubus ellipticus	10	20	3.13
Solanum nigrum	25	40	7.40
Solanum xanthocarpum	20	40	6.27
Tetrastigma sp.	15	20	4.27
Urena lobata	45	405	27.65
		2325	**200.00**

Herbs (April)	**Frequency %**	**Density (No./ha)**	**IVI**
Ageratum conyzoides	60	43000	19.43
Bidens pilosa	50	32500	15.36
Commelina sp.	45	9000	8.77
Cyanotis vaga	45	12000	9.52

Drymaria cordata	15	12000	5.17
Elatostemma sp.	45	49000	18.76
Equisetum sp.	20	19000	7.64
Galinsoga parviflora	70	42500	20.76
Hydrocotyl javanica	15	3000	2.92
Lygodium flexuosum	25	3500	4.50
Nephrolepis cordifolia	65	47000	21.16
Ophiopogon intermedius	10	2500	2.07
Paderia foetida	15	1500	2.55
Periploca sp.	10	1000	1.70
Phyrnium pubinerve	5	2500	1.35
Pilea sp.	45	40000	16.51
Polygonum capitatum	45	14000	10.02
Saccharum spontaneum	45	34000	15.01
Spilanthes paniculata	60	32500	16.81
Thysanolaena maxima	20	10000	5.40
	690	**400500**	**200.00**

Herbs (August)	**Frequency %**	**Density (No./ha)**	**IVI**
Ageratum conyzoides	60	64000	17.89
Begonia sp.	20	6000	3.54
Bidens pilosa	50	49000	14.23
Commelina sp.	40	18000	8.04
Costos speciosus	10	2500	1.69
Cyanotis vaga	40	14000	7.40
Drymaria cordata	60	104500	24.29
Elatostemma sp.	45	60000	15.32
Equisetum sp.	20	27000	6.86
Forrestica sp.	15	6000	2.90
Galinsoga parviflora	60	53500	16.24
Hydrocotyl javanica	15	6000	2.90
Lygodium flexuosum	25	4500	3.96
Nephrolepis cordifolia	70	54000	17.61
Ophiopogon intermedius	10	1500	1.54
Paderia foetida	10	1500	1.54
Periploca sp.	10	1000	1.46
Phyrnium pubinerve	5	3000	1.12
Pilea sp.	45	43500	12.71

Polygonum capitatum	45	20000	9.00
Pteris sp.	10	3000	1.77
Saccharum spontaneum	45	43500	12.71
Spilanthes paniculata	60	47500	15.29
Symethea ciliata	15	4000	2.58
Thysanolaena maxima	20	14000	4.81
	770	**633500**	**200.00**

Annexure-III
Community characteristics of the vegetation at various sampling locations at different sites of Hutong hydroelectric project, stage-1

Annexure-III
Community characteristics of the vegetation at various sampling locations at different sites of Hutong hydroelectric project, stage-1

A. Dam Site

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1.	*Albizzia sp.*	35	60	1.38	44.20
2.	*Alnus nepalensis*	55	100	1.71	63.48
3.	*Aralia thomsonii*	15	15	0.06	8.48
4.	*Betula alnoides*	10	10	0.13	7.08
5.	*Brassiopsis glomerulata*	55	80	0.27	37.17
6.	*Ficus cunea*	75	120	1.31	67.47
7.	*Macaranga denticulata*	50	75	1.03	46.47
8.	*Rhus acuminata*	30	40	0.54	25.65
	Total		**500**		**300.01**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1.	*Acacia pinnata*	10	15	4.42
2.	*Artemesia nilagirica*	15	90	11.02
3.	*Boehmeria longifolia*	70	485	55.63
4.	*Boehmeria macrophylla*	10	45	6.37
5.	*Debregessia longifolia*	60	295	39.85
6.	*Mussanda roxburghii*	15	20	6.47
7.	*Oxospora paniculata*	25	155	18.69
8.	*Rubus ellipticus*	10	20	4.75
9.	*Solanum nigrum*	15	25	6.80
10	*Solanum xanthocarpum*	20	35	9.17
11	*Urena lobata*	40	355	36.85
	Total		**1540**	**200.02**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	40	52000	16.75
2.	*Begonia sp.*	10	2500	2.15
3.	*Bidens pilosa*	20	14000	6.05
4.	*Commelina sp.*	35	17000	9.13
5.	*Costos speciosus*	10	2500	2.15
6.	*Cyanotis vaga*	20	7500	4.79
7.	*Drymaria cordata*	60	70000	23.58
8.	*Elatostemma sp.*	35	50000	15.53
9.	*Equisetum sp.*	25	46000	13.09
10.	*Forrestica sp.*	10	4000	2.44
11.	*Galinsoga parviflora*	40	33500	13.17
12.	*Hydrocotyl javanica*	10	7500	3.12
13.	*Lygodium flexuosum*	20	5000	4.30
14.	*Nephrolepis cordifolia*	60	47000	19.12

15.	*Ophiopogon intermedius*	10	2500	2.15
16.	*Paderia foetida*	20	3500	4.01
17.	*Periploca sp.*	10	1000	1.86
18.	*Phyrnium pubinerve*	5	5000	1.80
19.	*Pilea sp.*	35	43000	14.17
20.	*Polygonum capitatum*	40	21000	10.74
21.	*Pteris sp.*	10	3500	2.35
22.	*Saccharum spontaneum*	25	23500	8.73
23.	*Spilanthes paniculata*	50	54000	18.81
24.	*Symethea ciliata*	15	6000	3.66
25.	*Thysanolaena maxima*	25	14000	6.88
		600	**515500**	**200.00**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	50	73000	19.02
2.	*Begonia sp.*	15	3500	2.77
3.	*Bidens pilosa*	20	16000	5.50
4.	*Commelina sp.*	35	17500	7.94
5.	*Costos speciosus*	10	2000	1.79
6.	*Cyanotis vaga*	20	9000	4.38
7.	*Drymaria cordata*	60	78000	21.29
8.	*Elatostemma sp.*	40	56000	14.84
9.	*Equisetum sp.*	25	48000	11.35
10.	*Forrestica sp.*	15	5000	3.01
11.	*Galinsoga parviflora*	40	42500	12.68
12.	*Hydrocotyl javanica*	10	9000	2.91
13.	*Lygodium flexuosum*	20	6000	3.90
14.	*Nephrolepis cordifolia*	60	48500	16.58
15.	*Ophiopogon intermedius*	10	3000	1.95
16.	*Paderia foetida*	20	3500	3.50
17.	*Periploca sp.*	10	1500	1.71
18.	*Phyrnium pubinerve*	5	5500	1.61
19.	*Pilea sp.*	35	44500	12.26
20.	*Polygonum capitatum*	40	23000	9.56
21.	*Pteris sp.*	10	4500	2.19
22.	*Saccharum spontaneum*	25	26000	7.83
23.	*Spilanthes paniculata*	50	63000	17.42
24.	*Symethea ciliata*	30	21000	7.77
25.	*Thysanolaena maxima*	25	16000	6.23
		680	**625500**	**200.00**

2. Upstream Area

S. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Albizzia sp.*	15	15	0.50	13.32
2	*Altingia excelsa*	15	15	0.73	15.76
3	*Brassiopsis glomerulata*	45	60	0.26	29.66

4	*Callicarpa arborea*	10	10	0.12	6.63
5	*Canarium strictum*	15	25	2.22	33.60
6	*Ficus cunea*	25	70	0.80	30.64
7	*Grewia sp.*	35	80	0.91	37.12
8	*Gynocardia odorata*	10	10	0.28	8.31
9	*Macaranga denticulata*	25	30	0.62	20.92
10	*Mallotos*	20	35	0.36	17.41
11	*Pandanas odoratissima*	30	90	1.44	42.97
12	*Rhus acuminata*	35	40	0.95	29.71
13	*Saurauria nepalensis*	15	35	0.19	13.95
	Total		**515**		**300**

S. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1.	*Acacia pinnata*	15	30	7.19
2.	*Artemesia nilagirica*	15	120	13.23
3.	*Boehmeria longifolia*	65	405	49.60
4.	*Boehmeria macrophylla*	15	90	11.21
5.	*Debregessia longifolia*	55	285	38.09
6.	*Mussanda roxburghii*	15	30	7.19
7.	*Oxospora paniculata*	20	90	12.94
8.	*Rubus ellipticus*	20	35	9.25
9.	*Solanum nigrum*	25	55	12.31
10.	*Solanum xanthocarpum*	15	35	7.52
11.	*Urena lobata*	30	315	31.49
	Total		**1490**	**200.02**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1.	*Begonia sp.*	10	2500	2.27
2.	*Bidens pilosa*	30	14000	8.64
3.	*Commelina sp.*	15	7500	4.46
4.	*Costos speciosus*	5	1000	1.07
5.	*Crossocephalum crepezoides*	20	5000	4.55
6.	*Cyanotis vaga*	5	2000	1.35
7.	*Drymria cordata*	70	60000	27.78
8.	*Elatostemma* sp.	20	14000	7.06
9.	*Forrestica sp.*	20	3000	3.99
10.	*Gerardinia sp.*	15	12000	5.71
11.	*Hydrocotyl javanica*	35	12500	9.00
12.	*Lygodium flexuosum*	15	4000	3.48
13.	*Galinsoga parviflora*	30	29000	12.82
14.	*Nephrolepis cordifolia*	60	43500	21.60
15.	*Ophiopogon intermedius*	20	4000	4.27
16.	*Paderia foetida*	20	3500	4.13
17.	*Phyrnium pubinerve*	10	8500	3.95

18.	*Pilea umbrosa*	35	33500	14.87
19.	*Pogonotherum sp.*	20	12500	6.64
20.	*Polygonum capitatum*	30	7000	6.68
21.	*Pteris* sp.	10	4000	2.69
22.	*Saccharum spontaneum*	35	19000	10.82
23.	*Periploca sp.*	10	1500	1.99
24.	*Siegesosbekia orientalis*	20	9000	5.66
25.	*Spilanthes paniculata*	50	28500	15.83
26.	*Thladanthia* sp.	10	4000	2.69
27.	*Thysanolaena maxima*	15	13000	5.99
	Total		**358000**	**199.99**

Sl. No.	**Herbs (August)**	**Frequency %**	**Density (No./ha)**	**IVI**
1.	*Begonia sp.*	15	3000	2.78
2.	*Bidens pilosa*	35	18000	8.87
3.	*Commelina sp.*	25	23000	8.54
4.	*Costos speciosus*	10	2000	1.85
5.	*Crossocephalum sp.*	20	9500	4.90
6.	*Cyanotis vaga*	15	19000	6.25
7.	*Drymria cordata*	75	72500	26.36
8.	*Elatostemma sp.*	25	16000	7.02
9.	*Forrestica sp.*	25	7000	5.06
10.	*Gerardinia sp.*	15	14000	5.16
11.	*Hydrocotyl javanica*	35	16000	8.44
12.	*Lygodium flexuosum*	15	4500	3.10
13.	*Galinsoga*	35	30500	11.58
14.	*Nephrolepis cordifolia*	60	46000	18.49
15.	*Ophiopogon intermedius*	20	5000	3.92
16.	*Paderia foetida*	20	4500	3.81
17.	*Phyrnium pubinerve*	10	9500	3.48
18.	*Pilea sp.*	35	35000	12.56
19.	*Pogonotherum* sp.	25	17500	7.34
20.	*Polygonum capitatum*	30	12000	6.86
21.	*Pteris sp.*	15	6000	3.43
22.	*Saccharum spontaneum*	35	21000	9.52
23.	*Periploca sp.*	10	1500	1.74
24.	*Siegesosbekia orientalis*	20	10500	5.11
25.	*Spilanthes paniculata*	50	37500	15.23
26.	*Thladanthia sp.*	15	5000	3.21
27.	*Thysanolaena maxima*	15	15000	5.38
		705	461000	200.00

3. Submergence Area

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Albizzia* sp.	30	40	0.35	20.01
2	*Alnus nepalensis*	45	60	0.54	30.49
3	*Aralia thomsonii*	30	35	0.10	14.30
4	*Betula alnoides*	40	50	0.89	34.77
5	*Brassiopsis glomerulata*	45	75	0.22	26.20
6	*Ficus cunea*	75	140	0.91	57.03
7	*Macaranga denticulata*	45	60	0.61	31.89
8	*Rhus acuminata*	40	45	0.22	20.47
9	*Mallotos tetraccos*	20	25	0.19	12.22
10	*Pandanas odoratissima*	20	25	0.39	16.33
11	*Grewia* sp.	50	75	0.50	33.12
12	*Macropanax disperma*	5	10	0.03	3.27
	Total		**640**	**4.95**	**300.10**

S. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1.	*Accacia pinnata*	15	20	4.27
2.	*Artemesia nilagirica*	40	605	35.11
3.	*Boehmeria longifolia*	75	490	38.12
4.	*Boehmeria macrophylla*	15	60	5.99
5.	*Clerodendron colebrokianum*	30	40	8.54
6.	*Debregessia longifolia*	65	310	28.11
7.	*Desmodium laxiflora*	15	25	4.48
8.	*Maesa indica*	30	90	10.69
9.	*Mussanda roxburghii*	10	20	3.13
10.	*Oxospora paniculata*	30	140	12.84
11.	*Rubus ellipticus*	10	20	3.13
12.	*Solanum nigrum*	25	40	7.40
13.	*Solanum xanthocarpum*	20	40	6.27
14.	*Tetrastigma sp.*	15	20	4.27
15.	*Urena lobata*	45	405	27.65
	Total		**2325**	**200.00**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	60	43000	19.43
2.	*Bidens pilosa*	50	32500	15.36
3.	*Commelina sp.*	45	9000	8.77
4.	*Cyanotis vaga*	45	12000	9.52

5.	*Drymaria cordata*	15	12000	5.17
6.	*Elatostemma sp.*	45	49000	18.76
7.	*Equisetum sp.*	20	19000	7.64
8.	*Galinsoga parviflora*	70	42500	20.76
9.	*Hydrocotyl javanica*	15	3000	2.92
10.	*Lygodium flexuosum*	25	3500	4.50
11.	*Nephrolepis cordifolia*	65	47000	21.16
12.	*Ophiopogon intermedius*	10	2500	2.07
13.	*Paderia foetida*	15	1500	2.55
14.	*Periploca sp.*	10	1000	1.70
15.	*Phyrnium pubinerve*	5	2500	1.35
16.	*Pilea sp.*	45	40000	16.51
17.	*Polygonum capitatum*	45	14000	10.02
18.	*Saccharum spontaneum*	45	34000	15.01
19.	*Spilanthes paniculata*	60	32500	16.81
20.	*Thysanolaena maxima*	20	10000	5.40
	Total		**400500**	**200.00**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	60	64000	17.89
2.	*Begonia sp.*	20	6000	3.54
3.	*Bidens pilosa*	50	49000	14.23
4.	*Commelina sp.*	40	18000	8.04
5.	*Costos speciosus*	10	2500	1.69
6.	*Cyanotis vaga*	40	14000	7.40
7.	*Drymaria cordata*	60	104500	24.29
8.	*Elatostemma sp.*	45	60000	15.32
9.	*Equisetum sp.*	20	27000	6.86
10.	*Forrestica sp.*	15	6000	2.90
11.	*Galinsoga parviflora*	60	53500	16.24
12.	*Hydrocotyl javanica*	15	6000	2.90
13.	*Lygodium flexuosum*	25	4500	3.96
14.	*Nephrolepis cordifolia*	70	54000	17.61
15.	*Ophiopogon intermedius*	10	1500	1.54
16.	*Paderia foetida*	10	1500	1.54
17.	*Periploca sp.*	10	1000	1.46
18.	*Phyrnium pubinerve*	5	3000	1.12
19.	*Pilea sp.*	45	43500	12.71
20.	*Polygonum capitatum*	45	20000	9.00

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
21.	*Pteris sp.*	10	3000	1.77
22.	*Saccharum spontaneum*	45	43500	12.71
23.	*Spilanthes paniculata*	60	47500	15.29
24.	*Symethea ciliata*	15	4000	2.58
25.	*Thysanolaena maxima*	20	14000	4.81
	Total		**633500**	**200.00**

D. 1 km downstream of dam site

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1.	*Albizzia* sp.	25	25	0.30	14.79
2.	*Alnus nepalensis*	75	150	0.96	55.67
3.	*Aralia thomsonii*	25	30	0.09	11.22
4.	*Betula alnoides*	60	95	1.28	51.31
5.	*Brassiopsis glomerulata*	30	55	0.15	16.94
6.	*Ficus cunea*	70	150	0.84	52.14
7.	*Macaranga denticulata*	30	40	0.54	22.68
8.	*Rhus acuminata*	35	45	0.19	17.55
9.	*Mallotos tetraccos*	30	40	0.13	14.58
1(	*Pandanas odoratissima*	15	15	0.19	8.98
1:	*Grewia* sp.	60	90	0.33	31.82
1:	*Macropanax disperma*	5	5	0.03	2.34
	Total		**740**		**300.03**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1.	*Accacia pinnata*	15	20	2.82
2.	*Artemesia nilagirica*	60	1225	40.88
3.	*Boehmeria longifolia*	75	390	21.62
4.	*Boehmeria macrophylla*	20	180	7.73
5.	*Clerodendron coolebrokianum*	30	70	6.42
6.	*Debregessia longifolia*	65	375	19.69
7.	*Desmodium laxiflorum*	15	45	3.47
8.	*Dioscorea sp.*	5	10	1.03
9.	*Maesa indica*	45	100	9.51
10.	*Melastoma sp.*	60	225	15.04
11.	*Mussanda roxburghii*	15	20	2.82
12.	*Oxospora paniculata*	45	145	10.67
13.	*Peuraria wallichii*	10	15	1.93
14.	*Piper sp.*	30	340	13.40
15.	*Rubus ellipticus*	30	45	5.78

16.	*Rubus sp.*	30	40	5.65
17.	*Solanum nigrum*	25	45	5.01
18.	*Solanum xanthocarpum*	10	15	1.93
19.	*Tetrastigma sp.*	20	25	3.72
20.	*Urena lobata*	45	540	20.88
		650	**3870**	**200.00**

S. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	75	42500	21.55
2.	*Bidens pilosa*	60	28000	15.69
3.	*Commelina sp.*	30	12000	7.33
4.	*Cyanotis vaga*	30	9000	6.55
5.	*Drymaria cordata*	25	7000	5.33
6.	*Elatostemma sp.*	50	49000	19.70
7.	*Forrestica sp.*	15	2500	2.76
8.	*Galinsoga parviflora*	50	27000	14.02
9.	*Hydrocotyl javanica*	25	9000	5.85
10.	*Lygodium flexuosum*	15	3000	2.89
11.	*Nephrolepis cordifolia*	60	48500	20.98
12.	*Ophiopogon intermedius*	15	4000	3.15
13.	*Paderia foetida*	15	2500	2.76
14.	*Periploca sp.*	15	1500	2.50
15.	*Phyrnium pubinerve*	10	6000	2.96
16.	*Pilea sp.*	40	40000	15.97
17.	*Polygonum capitatum*	55	17500	12.27
18.	*Pteris sp.*	15	2500	2.76
19.	*Saccharum spontaneum*	45	35500	15.51
20.	*Spilanthes paniculata*	65	40000	19.49
21.	*Thysanolaena maxima*	15	7500	4.05
	Total		**387000**	**200.00**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	70	66000	19.82
2.	*Begonia sp.*	10	1500	1.51
3.	*Bidens pilosa*	60	45000	15.06
4.	*Commelina sp.*	30	15000	6.28
5.	*Costos speciosus*	10	1500	1.51
6.	*Cyanotis vaga*	30	12000	5.78

7.	*Drymaria cordata*	70	105500	26.42
8.	*Elatostemma sp.*	50	56500	15.72
9.	*Forrestica sp.*	20	4000	3.18
10.	*Galinsoga parviflora*	50	54500	15.39
11.	*Hydrocotyl javanica*	25	12000	5.15
12.	*Lygodium flexuosum*	15	3500	2.47
13.	*Nephrolepis cordifolia*	60	50500	15.98
14.	*Ophiopogon intermedius*	25	4000	3.81
15.	*Paderia foetida*	20	2500	2.93
16.	*Periploca sp.*	15	2000	2.22
17.	*Phyrnium pubinerve*	10	7000	2.43
18.	*Pilea sp.*	40	43500	12.29
19.	*Polygonum capitatum*	60	24500	11.64
20.	*Pteris sp.*	15	3000	2.39
21.	*Saccharum spontaneum*	45	40000	12.34
22.	*Spilanthes paniculata*	65	45000	15.69
23.	*Symethea ciliata*	15	6000	2.89
24.	*Thysanolaena maxima*	15	8500	3.31
	Total		**599000**	**200.00**

ANNEXURE-IV

Community characteristics of the vegetation at various sampling locations at different sites of Hutong Hydroelectric project, Stage-2

ANNEXURE-IV

Community characteristics of the vegetation at various sampling locations at different sites of Hutong Hydroelectric project, Stage-2

1 Dam site

S. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Albizzia sp*	25	55	1.10	23.82
2	*Albizzia sp*	10	10	0.52	8.18
3	*Altingia excelsa*	25	35	2.61	30.77
4	*Canarium strictum*	5	5	0.19	3.66
5	*Eurya acuminate*	5	20	0.13	5.53
6	*Ficus cunea*	40	70	0.66	27.94
7	*Gynocardia odorata*	10	10	0.25	6.41
8	*Lagerstroemia muniticarpa*	20	20	3.02	29.63
9	*Litsea monopetala*	10	10	0.24	6.33
10	*Macaranga denticulate*	20	45	0.31	15.41
11	*Micromelon intigrefolia*	5	5	0.05	2.69
12	*Musa* sp	40	235	2.98	69.07
13	*Pterospermum acerifolium*	5	5	0.25	4.06
14	*Quercus griffithii*	15	20	0.45	10.88
15	*Rhus acuminate*	30	35	0.62	19.13
16	*Saurauria napalensis*	20	30	0.31	13.06
17	*Spondias pinnata*	5	5	0.14	3.32
18	*Terminalia myriocarpa*	10	10	0.57	8.55
19	*Wallichiana (palm)*	5	10	0.12	3.95
20	*Wendlandia* sp	10	10	0.43	7.59
	Total		**645**		**299.98**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia pinnata*	50	190	15.78
2	*Acacia pruniscens*	15	145	6.46
3	*Artemesia nilagirica*	50	2005	51.44
4	*Boehmeria longifolia*	20	90	6.59
5	*Boehmeria macrophylla*	10	60	3.59
6	*Buddleja asiatica*	5	15	1.50
7	*Clerodendron coolebrokianum*	20	50	5.80
8	*Debregessia longifolia*	15	35	4.30
9	*Desmodium sp*	5	10	1.40
10	*Grewia disperma*	10	35	3.10
11	*Laportea crenulata*	5	15	1.50
12	*Maesa indica*	20	40	5.61
13	*Murraya paniculata*	5	15	1.50
14	*Oxospora paniculata*	15	90	5.38
15	*Piper* sp	30	535	17.74
16	*Rhynchotecium* sp.	10	60	3.59

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
17	*Rubus ellipticus*	15	35	4.30
18	*Smilax* sp	15	20	4.01
19	*Solanum nigrum*	15	50	4.60
20	*Solanum xanthocarpum*	30	40	8.01
21	*Urena lobata*	50	1545	42.40
22	*Zanthoxylum* sp.	5	10	1.40
	Total			

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Ageratum conyzoides*	70	153000	39.93
2	*Borreria articularis*	50	36500	15.42
3	*Polygonum capitata*	60	28500	15.75
4	*Crassocephalum crepezoides*	20	9000	5.16
5	*Bidens pilosa*	30	36500	11.88
6	*Nephrolepis cordifolia*	40	24500	11.49
7	*Dicrenopteris linearis*	20	7500	4.89
8	*Fagopyrum dibotrys*	40	56000	17.16
9	*Spilanthus paniculata*	30	41000	12.69
10	*Carex* sp.	15	2500	3.10
11	*Gnaphalium* sp.	15	10000	4.46
12	*Impatiens* sp.	10	4500	2.58
13	*Tetrastigma* sp.	15	3500	3.28
14	*Paderia foetida*	20	6000	4.62
15	*Thysanolaena maxima*	15	13500	5.09
16	*Saccharum spontaneum*	30	48000	13.95
17	*Ophiopogon intermedius*	10	2500	2.22
18	*Periploca callosa*	10	1500	2.04
19	*Begonia* sp.	5	1500	1.15
20	*Pothos scandens*	5	3500	1.52
21	*Urtica dioca*	10	16500	4.74
22	*Phyrnium pubinerve*	5	4000	1.61
23	*Oplismenus* sp.	10	9000	3.39
24	*Pilea umbrosa*	20	29500	8.85
25	*Mikania micrantha*	10	7000	3.03
	Total		**555500**	**200**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	80	160500	37.90
2.	*Begonia sp.*	15	4500	2.94
3.	*Bidens pilosa*	40	39000	12.23
4.	*Borreria articularies*	50	55000	16.31
5.	*Carex*	10	2500	1.88
6.	*Costos speciosus*	10	1500	1.71
7.	*Crossocephalum crepezoides*	20	9000	4.41
8.	*Drymaria cordata*	35	25500	9.30
9.	*Elatostemma dissectum*	20	14000	5.22
10.	*Fagopyrum dibotrys*	50	50500	15.58
11.	*Hedychium sp.*	20	4000	3.59
12.	*Mikania micrantha*	25	6000	4.65
13.	*Nephrolepis cordifolia*	40	25000	9.95
14.	*Ophiopogon intermedius*	10	2500	1.88
15.	*Opliomenus sp.*	20	18000	5.87
16.	*Paderia foetida*	20	6500	4.00
17.	*Phrynium pubinerve*	10	5000	2.28
18.	*Pilea umbrosa*	25	30000	8.56
19.	*Polygonum capitatum*	60	29500	13.63
20.	*Pothos scandens*	5	4000	1.39
21.	*Pratia begonifolia*	10	4000	2.12
22.	*Pteris sp.*	5	1000	0.90
23.	*Rubia cordifolia*	5	1500	0.98
24.	*Saccarum spoteneum*	30	43000	11.42
25.	*Spilanthes paniculata*	30	47000	12.07
26.	*Thysonolena maxima*	20	14500	5.30
27.	*Urtica dioca*	15	10500	3.92
		680	614000	200.00

2. Submergence Area

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Albizia* sp	15	15	0.40	10.45
2	*Altingia excelsa*	15	20	0.65	13.13
3	*Brassiopsis glomerulata*	10	15	0.05	6.21
4	*Callicarpa arborea*	10	10	0.12	5.86
5	*Castanopsis purpurella*	10	10	0.76	10.57
6	*Dendrocalamus sp*	20	200	0.56	43.38
7	*Erythrina stricta*	5	20	3.62	31.53
8	*Ficus cunea*	40	60	1.66	35.47

9	*Gynocardia odorata*	10	10	0.26	6.92
10	*Itea* sp.	10	30	0.06	8.68
11	*Lagerstroemia muniticarpa*	5	5	0.40	5.43
12	*Litsea monopetala*	30	65	2.31	37.71
13	*Macaranga denticulata*	20	25	0.32	13.17
14	*Mangletia* sp.	5	5	0.14	3.56
15	*Musa* sp.	5	20	0.25	6.76
16	*Prunus* sp.	5	5	0.02	2.62
17	*Quercus griffithii*	15	15	1.18	16.17
18	*Rhus acuminata*	20	25	0.25	12.65
19	*Saurauria nepalensis*	10	10	0.05	5.41
20	*Spondias pinnata*	5	5	0.05	2.87
21	*Talauma hodgsonii*	5	5	0.10	3.24
22	*Unidentified plant*	10	20	0.30	8.81
23	*Wendlendia* sp.	15	20	0.14	9.38
	Total		**615**		**300**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia pinnata*	40	75	8.08
2	*Acacia pruniscens*	30	90	6.56
3	*Artemesia nilagirica*	70	2535	50.04
4	*Boehmeria longifolia*	15	70	3.65
5	*Boehmeria macrophylla*	15	85	3.88
6	*Buddleja asiatica*	10	35	2.26
7	*Clerodendron coolebrokianum*	40	70	8.00
8	*Debregessia longifolia*	15	90	3.95
9	*Desmodium longifolia*	10	15	1.96
10	*Grewia disperma*	15	45	3.28
11	*Inula cappa*	10	35	2.26
12	*Laportea cunia*	15	35	3.13
13	*Maesa indica*	45	70	8.87
14	*Murraya paniculata*	10	20	2.04
15	*Oxospora paniculata*	45	1050	23.51
16	*Piper* sp	40	1535	29.88
17	*Rubus ellipticus*	20	35	4.00
18	*Smilax* sp	10	15	1.96
19	*Solanum nigrum*	20	60	4.37
20	*Solanum xanthocarpum*	15	35	3.13
21	*Toddelia asiatica*	5	5	0.94
22	*Urena lobata*	45	535	15.82
23	*Vernonia volkemarifolia*	5	10	1.02
24	*Zanthoxylum* sp	30	145	7.38
	Total		**6695**	**199.97**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Ageratum conyzoides*	50	54500	22.69
2	*Begonia* sp	10	4500	3.02
3	*Bidens pilosa*	20	25500	9.95
4	*Borreria articularis*	35	29500	13.84
5	*Carex* sp	15	4000	3.89
6	*Crassocephalum crepezoides*	20	6000	5.34
7	*Dicrenopteris linearis*	15	5000	4.12
8	*Fagopyrum dibotrys*	15	13500	6.13
9	*Gnaphalium* sp	15	6000	4.36
10	*Impatiens* sp.	10	2500	2.55
11	*Melastoma* sp.	5	1000	1.22
12	*Mikania micrantha*	15	9000	5.07
13	*Nephrolepis cordifolia*	35	40500	16.44
14	*Ophiopogon intermedius*	15	4000	3.89
15	*Oplismenus* sp	10	15500	5.63
16	*Paderia foetida*	15	2500	3.53
17	*Periploca callosa*	5	1000	1.22
18	*Phyrnium pubinerve*	5	6000	2.40
19	*Polygonum capitata*	50	31500	17.25
20	*Pothos scandens*	10	6000	3.38
21	*Saccharum spontaneum*	35	56500	20.22
22	*Spilanthus paniculata*	60	68500	27.96
23	*Tetrastigma* sp	20	2500	4.51
24	*Thysanolaena maxima*	10	8500	3.97
25	*Urtica dioca*	15	19000	7.43
	Total		**423000**	**200.01**

Herbs (August)	Frequency %	Density (No./ha)	IVI
Ageratum conyzoides	55	98000	29.39
Begonia sp.	15	4500	3.60
Bidens pilosa	25	39000	12.26
Borreria articularies	35	32500	12.77
Carex	15	4000	3.50
Costos speciosus	10	1500	2.10
Crossocephalum crepezoides	20	10500	5.69
Dicrenopteris linearis	15	10500	4.79
Fagopyrum dibotrys	15	10500	4.79
Gnaphalium crepezoides	20	6500	4.90
Impatiens sp.	10	2500	2.30
Melostoma sp.	5	1500	1.20
Mikania micrantha	15	6000	3.90
Nephrolepis cordifolia	35	41000	14.46

Ophiopogon intermedius	10	3500	2.50
Opliomenus sp.	15	16000	5.88
Paderia foetida	20	3000	4.20
Periploca callosa	5	1000	1.10
Phrynium pubinerve	5	6000	2.09
Polygonum capitatum	60	34000	17.57
Pothos scandens	10	6000	2.99
Pratia begonifolia	10	6000	2.99
Pteris sp.	5	1000	1.10
Saccarum spoteneum	35	58000	17.84
Spilanthes paniculata	60	71000	24.93
Thysonolena maxima	10	9000	3.59
urtica dioca	20	20000	7.58
	555	503000	200.00

3. Upstream Area

S. No.	**Trees**	**Frequency %**	**Density (No./ha)**	**Basal area (m^2/ha)**	**IVI**
1	*Albizia* sp.	35	60	1.38	44.20
2	*Alnus nepalensis*	55	100	1.71	63.48
3	*Aralia thomsonii*	15	15	0.06	8.48
4	*Betula alnoides*	10	10	0.13	7.08
5	*Brassiopsis glomerulata*	55	80	0.27	37.17
6	*Ficus cunea*	75	120	1.31	67.47
7	*Macaranga denticulata*	50	75	1.03	46.47
8	*Rhus acuminata*	30	40	0.54	25.65
	Total	**325**	**500**	**6.42**	**300**

Sl. No.	**Shrubs**	**Frequency %**	**Density (No./ha)**	**IVI**
1	*Acacia pinnata*	10	15	4.42
2	*Artemesia nilagirica*	15	90	11.02
3	*Boehmeria longifolia*	70	485	55.63
4	*Boehmeria macrophylla*	10	45	6.37
5	*Debregessia longifolia*	60	295	39.85
6	*Mussanda roxburghii*	15	20	6.47
7	*Oxospora paniculata*	25	155	18.69
8	*Rubus ellipticus*	10	20	4.75
9	*Solanum nigrum*	15	25	6.80
10	*Solanum xanthocarpum*	20	35	9.17
11	*Urena lobata*	40	355	36.85
	Total		**1540**	**200.02**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Ageratum conyzoides*	40	52000	16.75
2	*Begonia* sp.	10	2500	2.15
3	*Bidens pilosa*	20	14000	6.05
4	*Commelina* sp.	35	17000	9.13
5	*Costos speciosus*	10	2500	2.15
6	*Cyanotis vaga*	20	7500	4.79
7	*Drymaria cordata*	60	70000	23.58
8	*Elatostemma* sp.	35	50000	15.53
9	*Equisetum sp.*	25	46000	13.09
10	*Forrestica* sp.	10	4000	2.44
11	*Galinsoga parviflora*	40	33500	13.17
12	*Hydrocotyl javanica*	10	7500	3.12
13	*Lygodium flexuosum*	20	5000	4.30
14	*Nephrolepis cordifolia*	60	47000	19.12
15	*Ophiopogon intermedius*	10	2500	2.15
16	*Paderia foetida*	20	3500	4.01
17	*Periploca callosa*	10	1000	1.86
18	*Phyrnium pubinerve*	5	5000	1.80
19	*Pilea* sp.	35	43000	14.17
20	*Polygonum capitatum*	40	21000	10.74
21	*Pteris* sp.	10	3500	2.35
22	*Saccharum spontaneum*	25	23500	8.73
23	*Spilanthes paniculata*	50	54000	18.81
24	*Symethea ciliate*	15	6000	3.66
25	*Thysanolaena maxima*	25	14000	6.88
	Total		**535500**	**210.53**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	40	56000	15.50
2.	*Begonia sp.*	10	3000	2.05
3.	*Bidens pilosa*	20	14000	5.42
4.	*Commelina sp.*	35	17500	8.33
5.	*Costos speciosus*	15	2500	2.74
6.	*Cyanotis vaga*	20	10500	4.84
7.	*Drymaria cordata*	60	78000	22.25
8.	*Elatostemma sp.*	35	50500	13.81
9.	*Equisetum sp.*	25	47500	11.76
10.	*Forrestica*	10	6500	2.63
11.	*Galinsoga parviflora*	40	44500	13.59
12.	*Hydrocotyl javanica*	10	8000	2.88
13.	*Lygodium flexuosum*	20	5500	4.01

14.	*Nephrolepis cordifolia*	60	49000	17.44
15.	*Ophiopogon intermedius*	10	3500	2.13
16.	*Paderia foetida*	20	4000	3.76
17.	*Periploca callosa*	10	1500	1.80
18.	*Phrynium pubinerve*	5	5500	1.69
19.	*Pilea sp.*	35	47500	13.31
20.	*Polygonum capitatum*	40	29000	11.01
21.	*Pteris sp.*	10	1500	1.80
22.	*Saccharum spontaneum*	25	28000	8.52
23.	*Spilanthes paniculata*	50	56000	17.05
24.	*Symethea ciliata*	15	10500	4.07
25.	*Thysanolaena maxima*	25	22500	7.61
		645	**602500**	**200.00**

4. 1 km downstream of damsite

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Macaranga denticulata*	25	40	0.43	17.04
2	*Musa* sp.	40	270	3.77	73.59
3	*Altingia excelsa*	25	45	4.19	33.46
4	*Terminalia myriocarpa*	15	15	1.08	12.17
5	*Saurauria nepalensis*	15	25	0.12	9.84
6	*Rhus acuminata*	20	25	0.34	12.49
7	*Quercus griffithii*	10	10	0.61	7.65
8	*Litsea monopetala*	5	5	0.07	2.86
9	*Wendlandia* sp.	5	5	0.05	2.78
10	*Micromelon integifolia*	5	10	0.06	3.62
11	*Ficus cunea*	20	25	0.27	12.21
12	*Pterospermum acerifolium*	10	10	0.61	7.66
13	*Canarium strictum*	10	10	0.99	9.26
14	*Albizia* sp.	35	50	2.06	28.96
15	*Lagerstroemia muniticarpa*	35	60	8.88	58.87
16	*Spondias pinnata*	10	10	0.58	7.55
	Total		**615**		**300**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Accacia* sp.	50	90	10.56
2	*Artemesia* sp.	50	730	27.83
3	*Artimesia nilagirica*	70	1005	38.51
4	*Boehmeria macrophylla*	30	210	10.55
5	*Boehmeria* sp.	55	280	16.50
6	*Clerodendron coolebrokianum*	45	60	8.94
7	*Debregessia longifolia*	60	350	19.20
8	*Desmodium laxiflorum*	5	10	1.08
9	*Dioscorea* sp.	5	5	0.95
10	*Melastoma* sp.	50	225	14.20
11	*Maesa indica*	30	50	6.23
12	*Oxospora paniculata*	35	60	7.31
13	*Peuraria wallichii*	10	15	2.03
14	*Piper* sp.	25	150	8.11
15	*Rubus ellipticus*	20	25	3.93
16	*Rubus* sp.	10	15	2.03
17	*Rubus* sp.	10	10	1.90
18	*Solanum* sp.	20	35	4.20
19	*Urena lobata*	35	380	15.95
	Total	**615**	**3705**	**200.00**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Achyranthes aspera*	20	6000	3.33
2	*Ageratum conyzoides*	60	60000	17.88
3	*Bidens pilosa*	30	14000	5.94
4	*Borreria articularies*	45	27000	10.03
5	*Crossocephalum crepezoides*	20	3000	2.77
6	*Drymaria cordata*	15	6000	2.78
7	*Elatostemma dissectum*	35	32500	9.96
8	*Fagopyrum dibotrys*	45	17000	8.16
9	*Lygodium flexus*	35	6000	4.99
10	*Mikania micrantha*	60	40500	14.22
11	*Nephrolepis cordifolia*	80	87000	25.15
12	*Ophiopogon intermedius*	30	3500	3.97
13	*Opliomenus sp.*	45	21000	8.91
14	*Paderia foetida*	35	5000	4.80
15	*Phrynium pubinerve*	25	40000	10.26
16	*Pilea umbrosa*	45	54500	15.19
17	*Polygonum capitatum*	60	15000	9.44
18	*Polygonum sp.*	25	3000	3.32
19	*Pratia begonifolia*	30	4000	4.06
20	*Pteris sp.*	35	5500	4.90

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
21	*Rubia cordifolia*	5	500	0.65
22	*Saccharum spontaneum*	35	22500	8.08
23	*Spilanthes paniculata*	60	42500	14.60
24	*Urtica dioca*	10	5000	2.04
25	*Thysanolaena maxima*	20	12500	4.55
	Total		**533500**	**200.00**

S. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1	*Achyranthes aspera*	20	8000	3.23
2	*Ageratum conyzoides*	60	121500	22.59
3	*Begonia sp.*	15	3000	2.03
4	*Bidens pilosa*	25	17500	5.03
5	*Borreria articularies*	45	51000	11.64
6	*Costos speciosus*	10	2000	1.35
7	*Crossocephalum crepezoides*	15	6000	2.42
8	*Drymaria cordata*	25	28000	6.42
9	*Elatostemma dissectum*	30	30000	7.23
10	*Fagopyrum dibotrys*	30	19000	5.77
11	*Hedychium sp.*	10	3000	1.48
12	*Lygodium flexus*	35	9500	5.06
13	*Mikania micrantha*	60	52500	13.47
14	*Nephrolepis cordifolia*	80	90000	20.60
15	*Ophiopogon intermedius*	30	4000	3.79
16	*Opliomenus sp.*	30	40000	8.55
17	*Paderia foetida*	35	6000	4.60
18	*Phrynium pubinerve*	25	42500	8.34
19	*Pilea umbrosa*	35	60000	11.74
20	*Polygonum capitatum*	60	22500	9.50
21	*Polygonum sp.*	25	4000	3.25
22	*Pratia begonifolia*	30	7000	4.19
23	*Pteris sp.*	35	6000	4.60
24	*Rubia cordifolia*	10	2000	1.35
25	*Saccharum spontaneum*	35	28000	7.51
26	*Spilanthes paniculata*	60	60000	14.46
27	*Urtica dioca*	10	6000	1.88
28	*Thysanolaena maxima*	40	27000	7.92
	Total		**756000**	**200.00**

E. Confluence point of Lohit and Dau River

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Ficus cunea*	45	70	0.56	38.06
2	*Grewia* sp.	25	35	0.23	19.65
3	*Euvodia* sp.	5	5	0.03	3.34
4	*Saurauria nepalensis*	20	30	0.12	15.76
5	*Castanopsis* sp.	10	10	0.10	7.00
6	*Pandanas odoratissima*	5	5	0.06	3.56
7	*Ostodes paniculata*	15	15	0.18	10.72
8	*Lagerstroemia muniticarpa*	30	50	3.49	48.27
9	*Engelhardtia spicata*	5	5	0.25	4.96
10	*Talauma hodgsonii*	5	5	0.22	4.74
11	*Albizzia* sp.	5	5	0.36	5.69
12	*Macaranga denticulata*	20	40	1.23	25.93
13	*Vitex peduncularis*	5	10	1.96	18.23
14	*Canarium strictum*	5	5	1.61	14.60
15	*Pterospermum acerifolium*	5	10	0.54	8.15
16	*Altingia excelsa*	15	20	1.72	22.84
17	*Musa* sp.	20	100	1.27	40.04
18	*Callicarpa arborea*	10	15	0.14	8.44
	Total		**435**		**299.97**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Accacia* sp.	55	95	12.16
2	*Artemesia* sp.	30	340	14.98
3	*Artimesia nilagirica*	40	940	34.08
4	*Boehmeria macrophylla*	30	220	11.51
5	*Boehmeria* sp.	50	265	16.23
6	*Clerodendron coolebrokianum*	45	85	10.16
7	*Debregessia longifolia*	50	340	18.40
8	*Desmodium laxiflorum*	5	10	1.14
9	*Dioscorea* sp.	5	10	1.14
10	*Melastoma* sp.	50	275	16.52
11	*Maesa indica*	25	60	6.01
12	*Oxospora paniculata*	20	45	4.72
13	*Peuraria wallichii*	25	30	5.14
14	*Piper* sp.	20	165	8.20
15	*Rubus ellipticus*	35	45	7.29
16	*Rubus sp.*	10	15	2.14

17	*Rubus sp.*	10	10	2.00
18	*Smilax sp.*	5	10	1.14
19	*Solanum sp.*	45	75	9.87
20	*Urena lobata*	30	415	17.16
	Total	**585**	**3450**	**200.00**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Achyranthes aspera*	20	5000	3.16
2	*Ageratum conyzoides*	60	68500	18.31
3	*Bidens pilosa*	25	7500	4.16
4	*Borreria articularies*	40	49000	12.76
5	*Costos speciosus*	5	1000	0.75
6	*Crossocephalum crepezoides*	15	4500	2.50
7	*Drymaria cordata*	10	9000	2.65
8	*Elatostemma dissectum*	30	29000	8.29
9	*Equisetum sp.*	10	10500	2.90
10	*Fagopyrum dibotrys*	20	9000	3.82
11	*Lygodium flexus*	35	4500	4.84
12	*Mikania micrantha*	75	50500	17.10
13	*Nephrolepis cordifolia*	80	99000	25.68
14	*Ophiopogon intermedius*	35	5000	4.92
15	*Opliomenus* sp.	10	4000	1.83
16	*Paderia foetida*	40	6000	5.67
17	*Phrynium pubinerve*	20	42500	9.35
18	*Pilea umbrosa*	30	48000	11.42
19	*Polygonum capitatum*	55	17000	9.24
20	*Polygonum sp.*	20	4000	3.00
21	*Pratia begonifolia*	25	5000	3.75
22	*Pteris sp.*	45	9000	6.75
23	*Rubia cordifolia*	10	1000	1.33
24	*Saccharum spontaneum*	45	30000	10.21
25	*Spilanthes paniculata*	50	52000	14.42
26	*Urtica dioca*	20	12000	4.32
27	*Thysanolaena maxima*	25	24000	6.88
	Total		**606500**	**200.00**

Sl. No.	**Herbs (August)**	**Frequency %**	**Density (No./ha)**	**IVI**
1.	*Achyranthes aspera*	20	6500	2.87
2.	*Ageratum conyzoides*	55	101500	17.77
3.	*Begonia sp.*	15	3000	1.93
4.	*Bidens pilosa*	25	19000	4.87
5.	*Borreria articularies*	40	60000	11.29
6.	*Costos speciosus*	20	3000	2.46
7.	*Crossocephalum crepezoides*	15	3500	1.99
8.	*Drymaria cordata*	25	24500	5.52
9.	*Elatostemma dissectum*	30	30500	6.76
10.	*Equisetum sp.*	20	38500	6.65
11.	*Fagopyrum dibotrys*	20	18500	4.29
12.	*Hedychium* sp.	20	3000	2.46
13.	*Lygodium flexus*	35	8500	4.69
14.	*Mikania micrantha*	75	69500	16.10
15.	*Nephrolepis cordifolia*	80	104000	20.70
16.	*Ophiopogon intermedius*	35	6000	4.39
17.	*Opliomenus* sp.	30	44500	8.41
18.	*Paderia foetida*	40	6500	4.98
19.	*Phrynium pubinerve*	20	52500	8.30
20.	*Pilea umbrosa*	30	60500	10.30
21.	*Polygonum capitatum*	55	21000	8.27
22.	*Polygonum* sp.	20	4000	2.58
23.	*Pratia begonifolia*	25	9000	3.69
24.	*Pteris sp.*	45	10500	5.98
25.	*Rubia cordifolia*	15	2500	1.87
26.	*Saccharum spontaneum*	45	36000	8.99
27.	*Spilanthes paniculata*	50	57000	11.99
28.	*Urtica dioca*	20	14500	3.82
29.	*Thysanolaena maxima*	25	29000	6.06
	Total		**847000**	**200.00**

ANNEXURE-V
Community characteristics of the vegetation at various sampling locations at different sites in Upper Demwe Hydroelectric Project

ANNEXURE-V

Community characteristics of the vegetation at various sampling locations at different sites in Upper Demwe Hydroelectric Project

1. Dam site

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Duabanga grandiflora*	25	40	2.85	35.19
2	*Albizia chinensis*	20	35	1.45	24.03
3	*Macaranga denticulata*	25	35	1.37	25.42
4	*Ficus cunia*	15	15	0.67	12.94
5	*Delbergia pinnata*	5	5	0.14	3.84
6	*Callicarpa arborea*	10	10	0.29	7.68
7	*Aralia* sp.	15	20	0.14	11.01
8	*Scheffelera hypoleuca*	5	10	0.09	4.73
9	*Saurauria nepalensis*	5	5	0.02	3.14
10	*Betula alnoides*	10	20	1.26	15.74
11	*Brassiopsis glomerulata*	5	5	0.02	3.14
12	*Laportea* sp.	5	5	0.19	4.14
13	*Cinnamomum obtusifolia*	5	5	0.08	3.48
14	*Musa* sp.	10	35	0.46	14.66
15	*Euvodia* sp.	10	15	0.24	8.59
16	*andanas odoratissima*	5	15	0.15	6.25
17	*Itea macrophylla*	10	15	0.15	8.07
18	*Pterospermum acerifolium*	15	25	1.83	22.09
19	*Lagerstroemia muniticarpa*	5	10	0.60	7.67
20	*Gaurga gamblei*	5	5	0.48	5.81
21	*Ostodes paniculata*	5	10	0.60	7.67
22	*Altingia excelsa*	5	10	0.17	5.16
23	*Ailanthus intigrefolia*	15	15	0.69	13.06
24	*Mallotus tetracoccus*	10	10	0.20	7.20
25	*Terminalia myriocarpa*	10	15	1.97	18.67
26	*Acrocarpus fraxinifolius*	5	5	0.48	5.81
27	*Cyathea spinulosa*	5	10	0.10	4.76
28	*Kydia calycina*	5	5	0.32	4.88
29	*Meliosma simplicifolia*	5	10	0.16	5.14
	Total		**420**		**299.97**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia pennata*	10	15	3.44
2	*Acacia pruinescens*	10	25	4.22
3	*Ardisia* sp.	10	20	3.83
4	*Artimesia nilagirica*	55	245	31.57
5	*Boehmeria longifolia*	15	75	9.25
6	*Boehmeria macrophylla*	15	50	7.30
7	*Buddleja asiatica*	20	50	8.44

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
8	*Calamus leptospadix*	10	35	5.00
9	*Clerodendron coolebrokianum*	25	35	8.41
10	*Debregessia longifolia*	50	175	24.98
11	*Desmodium laxiflorum*	15	35	6.13
12	*Embelia* sp.	10	15	3.44
13	*Eupatorium odoratum*	10	25	4.22
14	*Grewia disperma*	20	50	8.44
15	*Maesa indica*	20	40	7.66
16	*Mucana sp.*	10	15	3.44
17	*Murraya paniculata*	20	35	7.27
18	*Oxospora paniculata*	15	100	11.19
19	*Piper* sp.	10	120	11.61
20	*Rhaphidophora* sp.	10	15	3.44
21	*Rubus ellipticus*	15	15	4.58
22	*Rubus mollucanus*	10	10	3.05
23	*Senecio cappa*	15	25	5.35
24	*Solanum viarum*	10	10	3.05
25	*Solanum xanthocarpum*	10	10	3.05
26	*Tetrastigma* sp.	20	40	7.66
	Total		**1285**	**200.02**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Begonia* sp.	10	1500	2.22
2	*Bidens pilosa*	10	12000	6.16
3	*Commelina* sp.	35	37000	19.69
4	*Costos speciosus*	10	2500	2.59
5	*Crossocephalum crepezoides*	5	1500	1.39
6	*Cyanotis vaga*	20	4000	4.81
7	*Drymria cordata*	10	17500	8.23
8	*Elatostemma sp.*	20	20000	10.82
9	*Forrestica* sp.	10	2500	2.59
10	*Gerardinia* sp.	10	4000	3.16
11	*Hydrocotyl javanica*	15	5000	4.36
12	*Lygodium flexuosum*	35	7000	8.42
13	*Mikania micrantha*	50	12000	12.78
14	*Molineria cucurboides*	15	2500	3.42
15	*Nephrolepis cordifolia*	40	12000	11.12
16	*Nycandra physalis*	10	1000	2.03
17	*Ophiopogon intermedius*	20	3500	4.62
18	*Paderia foetida*	60	7000	12.55
19	*Photos scandens*	10	3500	2.97
20	*Phyrnium pubinerve*	10	4000	3.16
21	*Pilea* sp.	25	17000	10.52
22	*Pogonotherum* sp.	15	3500	3.80
23	*Polygonum capitatum*	10	2500	2.59

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
24	*Pteris* sp.	10	2000	2.40
25	*Saccharum spontaneum*	65	54000	31.04
26	*Periploca callosa*	15	2500	3.42
27	*Siegesosbekia orientalis*	15	2500	3.42
28	*Spilanthes paniculata*	25	18000	10.90
29	*Thladanthia sp.*	5	1500	1.39
30	*Thysanolaena maxima*	15	2500	3.42
	Total		**266000**	**199.99**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Begonia sp.*	15	2500	2.75
2.	*Bidens pilosa*	30	21000	9.58
3.	*Commelina sp.*	35	40500	15.26
4.	*Costos speciosus*	15	3000	2.88
5.	*Crossocephalum sp.*	15	12500	5.30
6.	*Cyanotis vaga*	25	17500	7.99
7.	*Drymria cordata*	25	30500	11.30
8.	*Elatostemma sp.*	25	29500	11.05
9.	*Forrestica sp.*	10	4500	2.56
10.	*Gerardinia sp.*	10	5000	2.68
11.	*Hydrocotyl javanica*	15	10500	4.79
12.	*Lygodium flexuosum*	35	7500	6.84
13.	*Mikania micrantha*	60	14500	12.15
14.	*Molineria cucurboides*	15	2500	2.75
15.	*Nephrolepis cordifolia*	40	20000	10.74
16.	*Nycandra physalis*	10	3000	2.17
17.	*Ophiopogon intermedius*	20	5000	4.09
18.	*Paderia foetida*	60	8000	10.49
19.	*Periploca sp.*	15	3000	2.88
20.	*Photos scandens*	10	5000	2.68
21.	*Phyrnium pubinerve*	10	5000	2.68
22.	*Pilea sp.*	25	19500	8.50
23.	*Pogonotherum* sp.	15	7000	3.90
24.	*Polygonum capitatum*	10	5000	2.68
25.	*Pteris sp.*	10	2500	2.05
26.	*Saccharum spontaneum*	65	56000	23.44
27.	*Siegesosbekia orientalis*	20	6000	4.35
28.	*Spilanthes paniculata*	50	34000	15.72
29.	*Thladanthia sp.*	5	1000	0.96
30.	*Thysanolaena maxima*	15	10500	4.79
		710	**392000**	**200.00**

2. Submergence area

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Altingia excelsa*	10	20	0.76	7.69
2	*Dysoxylon hamiltonii*	10	15	0.48	5.82
3	*Populas gamblei*	10	15	0.30	4.95
4	*Acrocarpus fraxinifolius*	10	10	0.80	6.87
5	*Biscofia javanica*	10	10	0.74	6.55
6	*Kydia calcynia*	15	15	0.52	7.02
7	*Albizia chinensis*	45	90	0.93	22.58
8	*Duabanga grandiflora*	30	110	0.95	21.72
9	*Ficus cunia*	30	40	0.86	14.16
10	*Terminalia myriocarpa*	15	20	2.27	15.96
11	*Betula alnoides*	15	20	0.67	8.26
12	*Canarium strictum*	15	20	2.98	19.36
13	*Alangium begonifolium*	35	65	0.27	14.86
14	*Callicarpa arborea*	35	65	0.96	18.21
15	*Ostodes paniculata*	10	15	0.27	4.83
16	*Saurauria nepalensis*	35	65	0.33	15.16
17	*Macaranga denticulata*	35	55	0.98	17.27
18	*Ficus roxburghii*	10	15	0.34	5.16
19	*Hoveonia acerba.*	10	10	0.20	3.97
20	*Melia azedarach*	5	5	0.29	2.89
21	*tea macrophylla*	20	20	0.11	6.54
22	*Pterospermum acerifolium*	15	25	1.33	11.93
23	*Caryota urens*	5	5	0.22	2.58
24	*Dendrocalamus hamiltonii*	10	110	0.13	13.82
25	*Laportea* sp.	10	15	0.26	4.75
26	*Lagerstroemia muniticarpa*	10	10	1.96	12.45
27	*Brassiopsis glomerulata*	10	15	0.07	3.86
28	*Musa* sp.	10	70	0.21	10.13
29	*Euvodia* sp.	10	15	0.22	4.55
30	*Aralia* sp.	5	5	0.04	1.67
31	*Mallotus tetracoccus*	5	5	0.25	2.73
32	*Meliosma simplicifolia*	5	5	0.05	1.73
	Total		**980**		**300.03**

S. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia pennata*	15	35	5.19
2	*Acacia pruinescens*	10	15	3.00
3	*Artimesia nilagirica*	60	740	53.93
4	*Boehmeria longifolia*	25	120	12.06
5	*Boehmeria macrophylla*	10	25	3.56

6	*Buddleja asiatica*	10	40	4.38
7	*Calamus leptospadix*	15	50	6.02
8	*Clerodendron coolebrokianum*	25	40	7.64
9	*Debregessia longifolia*	20	80	8.77
10	*Desmodium laxiflorum*	25	50	8.20
11	*Embelia* sp.	15	25	4.64
12	*Entada phaseoloides*	10	15	3.00
13	*Gnetum sp.*	5	10	1.64
14	*Grewia disperma*	15	35	5.19
15	*Maesa indica*	25	50	8.20
16	*Mucana* sp.	5	15	1.92
17	*Murraya paniculata*	15	25	4.64
18	*Oxospora paniculata*	15	75	7.40
19	*Peuraria wallichii*	10	20	3.28
20	*Piper* sp.	20	175	14.02
21	*Ardisia* sp.	10	10	2.73
22	*Rhaphidophora* sp.	15	25	4.64
23	*Rubus ellipticus*	10	20	3.28
24	*Rubus mollucanus*	15	25	4.64
25	*Solanum viarum*	20	25	5.73
26	*Solanum xanthocarpum*	15	20	4.37
27	*Tetrastigma* sp.	25	45	7.92
	Total		**1810**	**199.99**

Sl. No.	**Herbs (April)**	**Frequency %**	**Density (No./ha)**	**IVI**
1	*Begonia* sp.	5	1500	1.20
2	*Bidens pilosa*	10	12000	4.02
3	*Commelina* sp.	10	6000	2.95
4	*Costos speciosus*	5	4000	1.65
5	*Crossocephalum crepezoides*	10	2500	2.32
6	*Cyanotis vaga*	10	7500	3.21
7	*Drymria cordata*	50	278000	59.21
8	*Elatostemma* sp.	25	22500	8.71
9	*Forrestica* sp.	25	15000	7.36
10	*Gerardinia* sp.	10	5000	2.77
11	*Globba clarkeii*	10	6000	2.95
12	*Hydrocotyl javanica*	10	5000	2.77
13	*Lygodium flexuosum*	10	2000	2.23
14	*Mikania micrantha*	40	24500	11.87
15	*Molineria cucurboides*	15	3500	3.43
16	*Nephrolepis cordifolia*	60	52500	20.63
17	*Nycandra physalis*	10	1500	2.14
18	*Ophiopogon intermedius*	15	2500	3.25
19	*Paderia foetida*	20	3000	4.28

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
20	*Periploca callosa*	10	2500	2.32
21	*Photos scandens*	10	7500	3.21
22	*Phyrnium pubinerve*	5	2000	1.29
23	*Pilea* sp.	20	17500	6.88
24	*Pogonotherum* sp.	10	2000	2.23
25	*Polygonum capitatum*	15	5000	3.70
26	*Pteris* sp.	10	2000	2.23
27	*Saccharum spontaneum*	55	44500	18.26
28	*Senecio cappa*	15	3500	3.43
29	*Siegesosbekia orientalis*	10	1000	2.05
30	*Spilanthes paniculata*	20	14000	6.25
31	*Thladanthia* sp.	5	1500	1.20
32	*Thysanolaena maxima*	35	9000	8.16
	Total		**566500**	**208.16**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Begonia sp.*	10	2500	2.10
2.	*Bidens pilosa*	30	32500	10.33
3.	*Commelina sp.*	15	9000	3.99
4.	*Costos speciosus*	5	1500	1.09
5.	*Crossocephalum sp.*	10	4000	2.34
6.	*Cyanotis vaga*	10	9000	3.15
7.	*Drymria cordata*	60	287500	56.54
8.	*Elatostemma sp.*	30	27000	9.44
9.	*Forrestica sp.*	25	14000	6.50
10.	*Gerardinia sp.*	10	4000	2.34
11.	*Globba clarkeii*	10	5000	2.50
12.	*Hydrocotyl javanica*	10	6000	2.66
13.	*Lygodium flexuosum*	10	2000	2.02
14.	*Mikania micrantha*	40	25500	10.89
15.	*Molineria cucurboides*	15	3500	3.11
16.	*Nephrolepis cordifolia*	60	54500	18.96
17.	*Nycandra physalis*	10	2500	2.10
18.	*Ophiopogon intermedius*	15	3000	3.03
19.	*Paderia foetida*	20	3000	3.87
20.	*Periploca sp.*	10	2500	2.10
21.	*Photos scandens*	10	9000	3.15
22.	*Phyrnium pubinerve*	5	4000	1.49
23.	*Pilea sp.*	20	21000	6.78
24.	*Pogonotherum* sp.	10	6000	2.66

25.	*Polygonum capitatum*	15	7000	3.67
26.	*Pteris sp.*	10	2500	2.10
27.	*Saccharum spontaneum*	55	47000	16.90
28.	*Senecio cappa*	15	4500	3.27
29.	*Siegesosbekia orientalis*	10	2500	2.10
30.	*Spilanthes paniculata*	25	16000	6.82
31.	*Thladanthia sp.*	10	2000	2.02
32.	*Thysanolaena maxima*	35	12000	7.87
		590	**620000**	**200.00**

3. Upstream area

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Canarium strictum*	30	40	4.46	25.25
2	*Altingia excelsa*	35	40	4.31	25.90
3	*Trema orientalis*	15	20	1.41	10.33
4	*Albizia chinensis*	15	15	0.72	7.59
5	*Ficus* sp.	5	10	1.49	6.83
6	*Talauma hodgsonii*	10	10	0.26	4.45
7	*Sapium baccatum*	5	5	0.29	2.66
8	*Pterospermum acerifolium*	35	45	3.72	25.03
9	*Duabanga grandiflora*	10	10	0.54	5.22
10	*Terminalia myriocarpa*	30	35	3.82	22.66
11	*Ostodes paniculata*	20	20	0.90	9.96
12	*Cyathea spinulosa*	10	10	0.39	4.81
13	*Hoveonia acerba*	10	10	0.28	4.51
14	*Spondias axallaris*	5	5	0.48	3.21
15	*Lagerstroemia muniticarpa*	10	10	0.73	5.77
16	*Bamboo* sp.	5	50	0.49	10.38
17	*Quercus* sp.	5	10	0.26	3.38
18	*Callicarpa arborea*	10	10	0.26	4.45
19	*Macaranga denticulata*	20	20	1.50	11.65
20	*Caryota urens*	5	5	0.17	2.33
21	*Alangium begonifolium*	5	5	0.03	1.95
22	*Chukrassia tubalaris*	5	5	0.48	3.21
23	*Sapindus rarak*	10	10	0.47	5.03
24	*Brassiopsis glomerulata*	10	10	0.05	3.84
25	*Macropanax sp.*	5	10	0.20	3.20
26	*Aralia* sp.	10	10	0.05	3.86
27	*Kydia calycina*	15	20	1.06	9.34
28	*Bischofia javanica*	15	25	1.54	11.47
29	*Ammora wallichii*	10	15	1.03	7.41
30	*Acrocarpus fraxinifolius*	5	10	0.49	4.03
31	*Dysoxylon hamiltonii*	25	25	1.21	12.67
32	*Mallotus tetracoccus*	20	20	1.17	10.71

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
33	*Castanopsis* sp.	10	15	0.39	5.61
34	*Saurauria nepalensis*	15	25	0.23	7.82
35	*Musa* sp.	10	35	0.58	9.31
36	*Litsea* sp.	5	5	0.02	1.92
37	*Syzygium tetragonum*	5	5	0.14	2.26
	Total		**630**		**300.01**

S. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia pennata*	5	10	1.54
2	*Acacia pruinescens*	5	5	1.27
3	*Ardisia* sp.	10	15	2.81
4	*Boehmeria longifolia*	35	150	14.94
5	*Boehmeria macrophylla*	15	35	4.87
6	*Calamas erectus*	40	235	20.42
7	*Calamus leptospadix*	35	60	10.22
8	*Clerodendron coolebrokianum*	20	50	6.67
9	*Debregessia sp.*	25	60	8.20
10	*Desmodium laxiflorum*	10	10	2.55
11	*Dracena* sp.	10	85	6.48
12	*Embelia* sp.	10	15	2.81
13	*Entada phaseoloides*	20	35	5.88
14	*Gnetum* sp.	15	20	4.08
15	*Grewia disperma*	15	25	4.34
16	*Grewia disperma*	5	10	1.54
17	*Maesa indica*	30	70	9.74
18	*Mucana* sp.	10	15	2.81
19	*Murraya paniculata*	20	30	5.62
20	*Oxospora paniculata*	10	40	4.12
21	*Peuraria wallichii*	15	20	4.08
22	*Phlogancanthus tubiflorus*	5	40	3.11
23	*Piper* sp.	55	735	49.69
24	*Rhaphidophora* sp.	15	35	4.87
25	*Rubus ellipticus*	5	10	1.54
26	*Rubus mollucanus*	10	25	3.33
27	*Solanum viarum*	10	10	2.55
28	*Solanum xanthocarpum*	10	10	2.55
29	*Tetrastigma sp.*	25	45	7.41
	Total			

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Begonia* sp.	15	3500	3.37
2	*Commelina* sp.	60	73500	27.65
3	*Costos speciosus*	10	2500	2.29
4	*Cyanotis vaga*	50	48000	19.89
5	*Drymaria cordata*	10	35000	10.02
6	*Elatostemma* sp.	50	88500	29.52
7	*Forrestica* sp.	25	22500	9.59
8	*Gerardinia* sp.	10	2500	2.29
9	*Globba clarkeii*	15	7500	4.33
10	*Hydrocotyl javanica*	20	12000	6.24
11	*Lygodium flexuosum*	15	3500	3.37
12	*Mikania micrantha*	10	3500	2.53
13	*Molineria cucurboides*	25	5000	5.43
14	*Nephrolepis cordifolia*	55	28500	16.10
15	*Nycandra physalis*	5	1000	1.09
16	*Ophiopogon intermedius*	25	9000	6.38
17	*Paderia foetida*	10	3500	2.53
18	*Periploca callosa*	5	1000	1.09
19	*Photos scandens*	20	14000	6.72
20	*Phyrnium pubinerve*	10	2500	2.29
20	*Pilea* sp.	25	19000	8.76
21	*Pogonotherum* sp.	10	2500	2.29
22	*Polygonum capitatum*	15	3500	3.37
23	*Pteris* sp.	25	6000	5.66
24	*Senecio cappa*	10	3500	2.53
25	*Siegesosbekia orientalis*	10	2500	2.29
26	*Spilanthes paniculata*	15	10000	4.92
27	*Thladanthia sp.*	10	1500	2.05
28	*Thysanolaena maxima*	25	5000	5.43
	Total		**420500**	**200.02**

Sl. no.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Begonia sp.*	15	5000	3.45
2.	*Commelina sp.*	60	82000	26.90
3.	*Costos speciosus*	10	2500	2.13
4.	*Cyanotis vaga*	50	50500	18.65
5.	*Drymria cordata*	25	35000	11.38
6.	*Elatostemma sp.*	50	92500	27.51
7.	*Forrestica sp.*	25	20000	8.22
8.	*Gerardinia sp.*	10	3000	2.23
9.	*Globba clarkeii*	15	6000	3.67
10.	*Hydrocotyl javanica*	20	14000	6.15
11.	*Lygodium flexuosum*	15	4000	3.24

12.	*Mikania micrantha*	10	4500	2.55
13.	*Molineria cucurboides*	25	6000	5.27
14.	*Nephrolepis cordifolia*	55	30500	15.23
15.	*Nycandra physalis*	10	2500	2.13
16.	*Ophiopogon intermedius*	30	12000	7.33
17.	*Paderia foetida*	15	4000	3.24
18.	*Periploca sp.*	5	1000	1.01
19.	*Photos scandens*	20	15000	6.36
20.	*Phyrnium pubinerve*	10	5000	2.65
21.	*Pilea sp.*	25	21000	8.43
22.	*Pogonotherum* sp.	10	5000	2.65
23.	*Polygonum capitatum*	15	6000	3.67
24.	*Pteris sp.*	25	6000	5.27
25.	*Senecio cappa*	10	4000	2.44
26.	*Siegesosbekia orientalis*	15	6000	3.67
27.	*Spilanthes paniculata*	25	20500	8.32
28.	*Thladanthia sp.*	10	1500	1.92
29.	*Thysanolaena maxima*	15	9000	4.30
		625	**474000**	**200.00**

4. 1 km downstream of Tidding and Lohit river confluence point

Sl. No.	**Trees**	**Frequency %**	**Density (No./ha)**	**Basal area (m^2/ha)**	**IVI**
1	*Brassiopsis glomerulata*	25	35	0.11	15.65
2	*Duabanga grandiflora*	20	20	0.52	16.35
3	*Ficus cunia*	50	75	0.28	32.90
4	*Kydia* sp.	15	15	0.18	9.80
5	*Musa* sp.	45	335	4.12	116.74
6	*Ficus roxburghii*	10	15	0.13	7.46
7	*Dysoxylon* sp.	15	15	0.13	9.22
8	*Ailanthus excelsa*	5	5	0.46	8.01
9	*Terminalia myriocarpa*	10	10	0.80	14.48
10	*Gynocardia odorata*	15	15	0.49	13.44
11	*Toona ciliata*	5	5	0.45	7.81
12	*Macropanax disperma*	20	30	0.25	14.72
13	*Ostodes paniculata*	10	10	0.07	6.01
14	*Pandanas odoratissima*	15	30	0.32	13.75
15	*Albizzia* sp.	20	25	0.23	13.72
	Total	**280**	**640**	**8.53**	**300.05**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia pennata*	25	60	5.69
2	*Acacia pruinescens*	10	15	1.94
3	*Ardisia* sp.	10	15	1.94
4	*Boehmeria longifolia*	60	240	17.23
5	*Boehmeria macrophylla*	25	60	5.69
6	*Calamas erectus*	40	235	14.29
7	*Calamus leptospadix*	35	60	7.07
8	*Clerodendron coolebrokianum*	45	70	8.82
9	*Debregessia* sp.	55	85	10.76
10	*Desmodium laxiflorum*	10	20	2.13
11	*Dracena* sp.	10	85	4.55
12	*Embelia* sp.	5	10	1.06
13	*Entada phaseoloides*	5	10	1.06
14	*Gnetum* sp.	5	10	1.06
15	*Grewia disperma*	60	95	11.82
16	*Maesa indica*	45	90	9.57
17	*Mucana* sp.	5	10	1.06
18	*Murraya paniculata*	30	50	6.00
19	*Oxospora paniculata*	40	70	8.13
20	*Peuraria wallichii*	15	20	2.82
21	*Phlogancanthus tubiflorus*	10	45	3.06
22	*Piper* sp.	70	675	34.84
23	*Rubus ellipticus*	15	35	3.37
24	*Rubus mollucanus*	10	25	2.31
25	*Solanum viarum*	25	40	4.94
26	*Solanum xanthocarpum*	30	505	22.98
27	*Tetrastigma* sp.	30	45	5.82
		725	**2680**	**200.00**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Commelina* sp.	35	13000	9.24
2	*Cyanotis vaga*	40	12500	9.83
3	*Drymria cordata*	55	28000	16.88
4	*Elatostemma* sp.	75	78000	35.45
5	*Forrestica* sp.	10	4500	2.89
6	*Gerardinia* sp.	10	5500	3.20
7	*Hydrocotyl javanica*	20	7500	5.30

8	*Lygodium flexuosum*	25	4000	4.95
9	*Mikania micrantha*	15	3500	3.31
10	*Molineria cucurboides*	30	6000	6.32
11	*Nephrolepis cordifolia*	60	54500	25.89
12	*Nycandra physalis*	10	1000	1.79
13	*Ophiopogon intermedius*	25	5000	5.26
14	*Paderia foetida*	35	4500	6.59
15	*Periploca sp.*	10	2000	2.11
16	*Photos scandens*	20	10000	6.08
17	*Phyrnium pubinerve*	10	9000	4.29
18	*Pilea* sp.	25	12500	7.60
19	*Pogonotherum* sp.	10	2500	2.26
20	*Polygonum capitatum*	55	19500	14.23
21	*Pteris* sp.	15	4500	3.63
22	*Spilanthes paniculata*	40	10500	9.20
23	*Thladanthia sp.*	15	2500	3.00
24	*Thysanolaena maxima*	30	20000	10.68
	Total	**675**	**320500**	**200.00**

Sl. No.	**Herbs (August)**	**Frequency %**	**Density (No./ha)**	**IVI**
1	*Begonia sp.*	15	2500	2.39
2	*Commelina sp.*	40	60500	16.32
3	*Costos speciosus*	10	2500	1.74
4	*Cyanotis vaga*	40	48500	14.10
5	*Drymria cordata*	60	52500	17.41
6	*Elatostemma sp.*	75	90500	26.36
7	*Forrestica sp.*	40	45000	13.45
8	*Gerardinia sp.*	10	6000	2.39
9	*Globba clarkeii*	20	10500	4.51
10	*Hydrocotyl javanica*	20	10500	4.51
11	*Lygodium flexuosum*	30	6000	4.96
12	*Mikania micrantha*	15	5000	2.85
13	*Molineria cucurboides*	30	6000	4.96
14	*Nephrolepis cordifolia*	60	56500	18.15
15	*Nycandra physalis*	10	2500	1.74
16	*Ophiopogon intermedius*	25	6000	4.32
17	*Paderia foetida*	35	5000	5.41
18	*Periploca sp.*	10	2000	1.65
19	*Photos scandens*	20	12500	4.88
20	*Phyrnium pubinerve*	10	6000	2.39

21	*Pilea sp.*	25	20500	7.00
22	*Pogonotherum* sp.	10	3000	1.84
23	*Polygonum capitatum*	55	23500	11.40
24	*Pteris sp.*	15	6000	3.03
25	*Senecio cappa*	15	3500	2.57
26	*Siegesosbekia orientalis*	10	2500	1.74
27	*Spilanthes paniculata*	30	19500	7.45
28	*Thladanthia sp.*	15	2500	2.39
29	*Thysanolaena maxima*	30	23000	8.10
	Total	**780**	**540500**	**200.00**

5. Confluence point of Dalai and Lohit

S. No.	**Trees**	**Freque ncy %**	**Density (No./ha)**	**Basal area (m^2/ha)**	**IVI**
1	*Euvodia* sp.	15	20	0.04	7.19
2	*Pandanas odoratissima*	60	145	1.33	45.50
3	*Vitex peduncularis*	20	25	0.96	14.35
4	*Talauma hodgsonii*	10	15	0.01	5.00
5	*Pterospermum acerifolium*	5	5	0.45	4.54
6	*Ficus cunea*	35	40	0.27	16.74
7	*Polyalthia jenkensii*	10	15	0.18	5.90
8	*Glochidium* sp.	5	5	0.02	2.20
9	*Calophyllum polyanthium*	5	5	0.67	5.76
10	*Mallotus* sp.	20	35	0.58	13.84
11	*Altingia excelsa*	25	35	1.58	20.60
12	*Wendlandia* sp.	5	5	0.03	2.22
13	*Callicarpa arborea*	30	45	0.56	17.86
14	*Ostodes paniculata*	10	10	0.11	4.73
15	*Macaranga denticulata*	25	55	2.07	26.41
16	*Stercularia villosa*	20	30	0.54	12.84
17	*Gynocardia odorata*	15	15	0.66	9.84
18	*Brassiopsis glomerulata*	15	30	0.08	9.03
19	*Albizzia* sp.	20	30	1.30	17.00
20	*Macropanax disperma*	10	15	0.09	5.40
21	*Saurauria nepalensis*	5	5	0.04	2.27
22	*Lagerstroemia muniticarpa*	25	50	6.65	50.81
	Total	**390**	**635**	**18.21**	**300.00**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Accacia pinnata*	15	60	3.69
2	*Ardisia sp.*	15	25	2.94
3	*Artemesia nilagirica*	60	690	24.49
4	*Artemesia sp.*	20	245	8.49
5	*Bauhinia sp.*	5	5	0.91
6	*Boehmeria macrophylla*	20	160	6.65
7	*Boehmeria sp.*	60	675	24.16
8	*Boehmeria sp.*	30	280	10.84
9	*Buddlejia asiatica*	25	45	4.97
10	*Clerodendron coolebrokianum*	25	45	4.97
11	*Debregessia longifolia*	30	105	7.07
12	*Dioscorea sp.*	5	5	0.91
13	*Gerardinia sp.*	15	105	4.67
14	*Melastoma sp.*	30	90	6.74
15	*Maesa indica*	40	70	7.91
16	*Oxospora paniculata*	25	105	6.27
17	*Peuraria wallichii*	15	40	3.26
18	*Piper sp.*	35	1065	28.58
19	*Plectranthus striatus*	50	565	20.19
20	*Rubus ellipticus*	15	25	2.94
21	*Rubus sp.*	10	10	1.82
22	*Rubus sp.*	5	10	1.02
23	*Smilax sp.*	10	20	2.03
24	*Solanum sp.*	20	70	4.71
25	*Solanum sp.2*	10	25	2.14
26	*Tetrastigma sp.*	20	35	3.96
27	*Urena lobata*	15	60	3.69
	Total	**625**	**4635**	**200.00**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1.	*Achyranthes aspera*	10	1500	1.71
2.	*Ageratum conyzoides*	60	51000	21.33
3.	*Bidens pilosa*	35	17000	9.08
4.	*Commelina paludosa*	25	6000	4.87
5.	*Crossocephalum crepezoides*	10	3500	2.24
6.	*Cyanotis vaga*	10	10500	4.08
7.	*Drymaria cordata*	60	37000	17.64
8.	*Elatostemma dissectum*	25	28000	10.67
9.	*Equisetum sp.*	15	9000	4.35

10.	*Hydrocotyl javanica*	25	3500	4.21
11.	*Lygodium flexus*	40	6000	6.84
12.	*Nephrolepis cordifolia*	60	40000	18.43
13.	*Ophiopogon intermedius*	15	2000	2.50
14.	*Opliomenus sp.*	30	24000	10.27
15.	*Paderia foetida*	20	3500	3.55
16.	*Pilea umbrosa*	25	12000	6.45
17.	*Polygonum capitatum*	35	12500	7.90
18.	*Polygonum sp.*	45	7000	7.77
19.	*Polygonum sp.*	10	2500	1.97
20.	*Pratia begonifolia*	45	6000	7.50
21.	*Pteris sp.*	25	3500	4.21
22.	*Rubia cordifolia*	10	1000	1.58
23.	*Saccharum spontaneum*	40	40000	15.80
24.	*Spilanthes paniculata*	25	7500	5.27
25.	*Thysanolaena maxima*	30	35000	13.17
26.	*Urtica dioca*	30	10000	6.58
	Total	**760**	**379500**	**200.00**

Sl. No.	**Herbs (August)**	**Frequency %**	**Density (No./ha)**	**IVI**
1.	*Achyranthes aspera*	10	1500	1.44
2.	*Ageratum conyzoides*	70	73500	21.02
3.	*Begonia sp.*	15	5000	2.63
4.	*Bidens pilosa*	35	17000	7.07
5.	*Commelina paludosa*	25	42000	10.25
6.	*Costos speciosus*	10	1000	1.35
7.	*Crossocephalum crepezoides*	10	3500	1.79
8.	*Cyanotis vaga*	10	10500	3.00
9.	*Drymaria cordata*	75	84000	23.43
10.	*Elatostemma dissectum*	25	40500	9.98
11.	*Equisetum sp.*	15	11000	3.68
12.	*Forrestica sp.*	10	4000	1.87
13.	*Hydrocotyl javanica*	25	9000	4.51
14.	*Impatiens sp.*	10	2000	1.52
15.	*Lygodium flexus*	40	8500	6.18
16.	*Nephrolepis cordifolia*	60	42500	14.45
17.	*Ophiopogon intermedius*	15	2000	2.11
18.	*Opliomenus sp.*	30	41000	10.66
19.	*Paderia foetida*	20	4000	3.05
20.	*Pilea umbrosa*	25	14000	5.38

21.	*Polygonum capitatum*	45	20500	8.86
22.	*Polygonum sp.*	45	7000	6.51
23.	*Polygonum sp.*	25	3500	3.55
24.	*Pratia begonifolia*	45	11500	7.29
25.	*Pteris sp.*	20	5000	3.22
26.	*Rubia cordifolia*	10	1500	1.44
27.	*Saccharum spontaneum*	40	42000	12.01
28.	*Spilanthes paniculata*	25	14000	5.38
29.	*Thysanolaena maxima*	30	39500	10.40
30.	*Urtica dioca*	30	14000	5.96
	Total	**850**	**575000**	**200.00**

ANNEXURE-VI

Community characteristics of the vegetation at various sampling locations at different sites in Lower Demwe hydroelectric project

ANNEXURE-VI

Community characteristics of the vegetation at various sampling locations at different sites in Lower Demwe hydroelectric project

1. **Dam site**

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Alangium begoniaefolia*	40	50	0.78	22.04
2	*Albizia chinensis*	90	240	8.19	103.75
3	*Brassiopsis glomerulata*	10	10	0.10	4.60
4	*Dalbergia sisso*	70	80	2.20	41.62
5	*Dalbergia* sp.	10	10	0.39	6.09
6	*Duabanga grandiflora*	60	70	3.45	43.90
7	*Gynocardia odorata*	10	10	0.29	5.57
8	*Macaranga denticulata*	20	20	0.90	12.80
9	*Mallotus tetracoccus*	20	20	0.30	9.72
10	*Pandanus odoratissima*	20	30	0.19	10.87
11	*Pterospermum acerifolia*	20	20	1.36	15.16
12	*Stercularia villosa*	30	30	0.31	13.92
13	*Terminalia myriocarpa*	10	10	1.15	9.95
	Total		**600**		**299.99**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia penneta*	30	30	5.30
2	*Acacia pruiniscens*	20	20	3.54
3	*Boehmeria longifolia*	60	290	21.41
4	*Calamus lactospadix*	60	340	23.75
5	*Clerodendron coolebrokianum*	10	20	2.24
6	*Cratena* sp.	20	30	4.01
7	*Debregessia longifolia*	40	100	9.89
8	*Entada phaseoloides*	40	60	8.01
9	*Glochidion* sp.	20	30	4.01
10	*Glycosmis* sp.	30	60	6.71
11	*Gnetum* sp.	30	30	5.30
12	*Gnetum* sp.	20	20	3.54
13	*Grewia disperma*	20	20	3.54
14	*Jasminium dispermum*	30	30	5.30
15	*Laportea crenulata*	30	40	5.77
16	*Maesa indica*	70	100	13.79
17	*Monerelia cucuboides*	10	20	2.24
18	*Murraya paniculata*	30	50	6.24
19	*Peuraria* sp.	30	50	6.24
20	*Piper mellusa*	80	620	39.50
21	*Sarcandra glabra*	30	80	7.65
22	*Smilax* sp.	20	20	3.54
23	*Tinospora crispa*	40	70	8.48
	Total		**2130**	**200**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Begonia* sp.	60	8000	15.22
2	*Elatostemma* sp.	60	21500	20.04
3	*Equisetum* sp.	40	42000	23.22
4	*Imperata cylindrical*	40	66000	31.78
5	*Lygodium flexusum*	15	6000	5.23
6	*Mikania micrantha*	15	12000	7.37
7	*Molineria cucorboides*	20	2000	4.84
8	*Nephrolepis cordifolia*	20	8000	6.98
9	*Ophiopogon intermedius*	20	4000	5.55
10	*Paderia foetida*	40	10000	11.81
11	*Paspalam sp.*	15	12000	7.37
12	*Periploca callosa*	10	1500	2.60
13	*Photos scandens*	15	14000	8.08
14	*Phyrium pubinerve*	20	10000	7.69
15	*Polypodium sp.*	15	8000	5.94
16	*Pteris sp.*	15	6000	5.23
17	*Saccharum spontaneum*	20	27000	13.75
18	*Senecio cappa*	10	4000	3.49
19	*Sonchus* sp.	10	9500	5.45
20	*Thladanthia sp.*	15	6000	5.23
21	*Thysanolaena maxima*	10	3000	3.13
	Total		**280500**	**200**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Begonia* sp.	40	8000	9.92
2.	*Elatostemma* sp.	70	28000	21.50
3.	*Equisetum* sp.	40	42500	20.14
4.	*Imperata cylindrica*	40	72500	29.03
5.	*Lygodium* sp.	25	7500	6.94
6.	*Mikania micrantha*	25	14500	9.01
7.	*Molineria cucurboides*	20	2500	4.51
8.	*Nephrolepis cordifolia*	30	13000	9.51
9.	*Ophiopogon* sp.	20	4500	5.11
10.	*Paderia foetida*	40	10500	10.66
11.	*Paspalam* sp.	15	17500	8.02
12.	*Periploca callosa*	10	2000	2.48
13.	*Photos scandens*	20	16000	8.51
14.	*Phyrium pubinerve*	20	17500	8.96
15.	*Polypodium* sp.	15	9000	5.50
16.	*Pteris* sp.	15	7500	5.05
17.	*Saccharum* sp.	30	39000	17.22
18.	*Senecio cappa*	10	4500	3.22
19.	*Sonchus* sp.	20	10500	6.88
20.	*Thladanthia* sp.	15	4500	4.16

21.	*Thysanolaena maxima*	10	6000	3.66
			337500	**200.00**

2. Power House site

S. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Albizia chinensis*	60	120	52.71	49.06
2	*Bombax cieba*	10	10	143.18	18.41
3	*Callicarpa arborea*	10	10	1.08	5.02
4	*Cinnamomum* sp.	10	10	0.00	5.00
5	*Cyanometra polyandra*	10	10	4.03	5.61
6	*Dalbergia sisso*	20	50	21.95	19.16
7	*Dalbergia* sp.	20	100	12.91	26.74
8	*Engelhardtia spicata*	30	50	22.07	22.34
9	*Ficus* sp.	10	10	35.49	8.52
10	*Garuga gamblei*	20	20	304.26	41.74
11	*Gynocardia odorata*	10	10	6.32	5.86
12	*Kydia calycina*	20	20	4.38	10.40
13	*Laportea* sp.	10	10	4.47	5.61
14	*Macaranga denticulata*	10	20	2.00	7.03
15	*Macropanax dispermus*	10	10	0.72	4.90
16	*Pouzolzia fulgens*	20	20	0.00	9.95
17	*Pterospermum acerifolium*	10	10	69.30	12.10
18	*Sapindus rarak*	20	30	73.67	21.37
19	*Talauma hodgsonii*	10	10	0.78	4.95
20	*Trema orientalis*	10	10	0.00	4.80
21	*Vitex pedencularis*	10	10	63.14	11.45
	Total		**550**		**300.02**

S. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia penneta*	20	20	3.64
2	*Acacia pruiniscens*	20	20	3.64
3	*Boehmeria longifolia*	20	120	7.58
4	*Budlejja asiatica*	20	30	4.04
5	*Calamus lactospadix*	30	740	33.42
6	*Clerodendron coolebrokianum*	10	20	2.22
7	*Cratena* sp.	10	20	2.22
8	*Debregessia longifolia*	10	30	2.61
9	*Desmodium* sp.	10	20	2.22
10	*Draceana* sp.	60	350	22.35
11	*Entada phaseoloides*	10	20	2.22
12	*Ficus urophylla*	10	10	1.82
13	*Glochidion* sp.	20	30	4.04
14	*Glycosmis* sp.	10	30	2.61
15	*Grewia disperma*	80	220	20.09

16	*Jasminium dispermum*	30	30	5.47
17	*Laportea crenulata*	20	30	4.04
18	*Mesea indica*	70	90	13.54
19	*Monerelia cucuboides*	10	20	2.22
20	*Murraya paniculata*	30	50	6.25
21	*Peuraria* sp.	30	30	5.47
22	*Piper mellusa*	80	420	27.96
23	*Rubus ellipticus*	10	10	1.82
24	*Sarcandra glabra*	10	70	4.18
25	*Smilax* sp.	10	10	1.82
26	*Solanum xanthocarpum*	10	20	2.22
27	*Tinospora crispa*	40	70	8.47
28	*Zanthoxylum* sp.	10	10	1.82
	Total		**2540**	**200**

Sl. No.	**Herbs (April)**	**Frequency %**	**Density (No./ha)**	**IVI**
1	*Begonia* sp.	20	5000	7.31
2	*Bidens pilosa*	50	97500	46.86
3	*Cyanotis cappa*	20	8000	8.32
4	*Cyperus* sp.	25	4000	8.39
5	*Elatostemma* sp.	25	36000	19.14
6	*Eupatorium odoratum*	20	20000	12.36
7	*Imperata cylindrica*	15	32000	14.98
8	*Mikania micrantha*	5	2000	2.08
9	*Molineria* sp.	10	4000	4.16
10	*Neprolepis cordifolia*	10	6000	4.83
11	*Ophiopogon intermedius*	10	6000	4.83
12	*Paderia foetida*	35	10000	13.22
13	*Paspalum* sp.	5	6000	3.43
14	*Periploca callosa*	10	1000	3.15
15	*Photos scandens*	5	4000	2.75
16	*Polygonum capitatum*	5	4000	2.75
17	*Polypodium* sp.	10	4000	4.16
18	*Pteris sp.*	10	6000	4.83
19	*Saccharum spontaneum*	25	20000	13.76
20	*Sonchus* sp.	10	4000	4.16
21	*Thysolenea maxima*	15	4000	5.57
22	*Urtica dioca*	15	14000	8.93
	Total		**297500**	**199.97**

Sl. no.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	Begonia sp.	25	6000	6.53
2.	Bidens pilosa	80	117500	45.07
3.	Cyanotis cappa	40	19000	12.75
4.	Cyperus sp.	25	5000	6.28
5.	Elatostemma sp.	50	52500	23.02
6.	Eupatorium odoratum	25	21000	10.22
7.	Imperata cylindrica	30	62000	21.31
8.	Mikania micrantha	10	4000	3.00
9.	Molineria sp.	10	9000	4.23
10.	Neprolepis cordifolia	10	7000	3.74
11.	Ophiopogon sp.	10	3000	2.76
12.	Paderia foetida	35	9000	9.28
13.	Paspalum sp.	5	7500	2.86
14.	Periploca callosa ©	10	1500	2.39
15.	Photos scandens	5	4000	1.99
16.	Polygonum capitatum	10	7000	3.74
17.	Polypodium sp.	10	4000	3.00
18.	Pteris sp.	25	9000	7.26
19.	Saccharum sp.	40	34000	16.44
20.	Sonchus sp.	10	4500	3.13
21.	Thysolenea maxima	15	4500	4.14
22.	Urtica dioca	15	15500	6.84
		495	**406500**	**200.00**

3. Submergence area

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1	*Actinodaphne obovata*	10	20	0.07	4.65
2	*Ailanthus excelsa*	10	10	2.58	6.98
3	*Alangium begoniaefolia*	10	20	0.09	4.68
4	*Albizia chinensis*	30	80	3.03	20.19
5	*Brassiopsis glomerulata*	10	10	0.05	3.46
6	*Dalbergia sisoo*	10	20	0.41	5.12
7	*Dendrocalamus hamiltonii*	10	80	0.56	12.31
8	*Duabanga grandiflora*	10	20	1.94	7.25
9	*Dysoxylon hamiltonii*	10	20	1.26	6.30
10	*Ficus cunia*	10	10	0.16	3.61
11	*Ficus roxburghii*	10	10	0.39	3.93
12	*Ficus* sp.	20	40	15.81	31.11
13	*Gynocardia odorata*	20	20	0.96	8.10
14	*Knema angustifolia*	10	10	0.07	3.48
15	*Kydia calycina*	10	10	0.96	4.73
16	*Leea* sp.	10	10	0.15	3.60

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
17	*Macaranga denticulata*	20	90	3.39	19.64
18	*Macropanax dispermus*	10	10	0.07	3.48
19	*Musa* sp.	20	120	1.15	20.00
20	*Ostodes paniculata*	20	20	0.26	7.14
21	*Pandanas odoratissima*	30	40	0.39	11.85
22	*Pterospermum acerifolium*	50	60	8.84	30.40
23	*Sarcosperma griffithii*	20	30	0.51	8.64
24	*Saurauria nepalensis*	10	10	0.05	3.45
25	*Terminalia myriocarpa*	60	80	25.12	57.63
26	*Toona ciliata*	10	10	3.51	8.27
	Total		**860**		**300**

S. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia penneta*	30	30	4.77
2	*Acacia pruiniscens*	30	40	5.17
3	*Boehmeria longifolia*	50	220	14.72
4	*Boehmeria macrophylla*	30	90	7.16
5	*Budlejja asiatica*	10	10	1.59
6	*Calamus lactospadix*	50	530	27.07
7	*Calamus strictus*	40	380	19.90
8	*Clerodendron coolebrokianum*	20	30	3.58
9	*Cratena* sp.	20	30	3.58
10	*Debregessia longifolia*	30	70	6.36
11	*Desmodium* sp.	20	30	3.58
12	*Entada phaseoloides*	10	30	2.39
13	*Ficus urophylla*	20	20	3.18
14	*Glochidion* sp.	20	30	3.58
15	*Glycosmis* sp.	20	40	3.97
16	*Gnetum* sp.	10	10	1.59
17	*Gnetum spp.*	10	20	1.99
18	*Grewia disperma*	30	30	4.77
19	*Jasminium dispermum*	30	50	5.56
20	*Laportea crenulata*	40	50	6.75
21	*Mesea indica*	70	110	12.72
22	*Monerelia cucuboides*	10	20	1.99
23	*Murraya paniculata*	40	60	7.15
24	*Peuraria* sp.	30	40	5.17
25	*Piper mellusa*	80	360	23.87
26	*Rubus ellipticus*	10	10	1.59
27	*Sarcandra glabra*	20	90	5.97
28	*Smilax* sp.	10	10	1.59
29	*Solanum xanthocarpum*	10	20	1.99
30	*Tinospora crispa*	40	50	6.75
	Total		**2510**	**200.05**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Begonia* sp.	10	2000	3.24
2	*Colocasia* sp.	25	6000	8.44
3	*Commelina* sp.	10	4000	3.89
4	*Cyanotis cappa*	5	4000	2.59
5	*Cyperus* sp.	5	4000	2.59
6	*Elatostemma* sp.	65	88000	45.36
7	*Equisetum* sp.	5	8000	3.89
8	*Forrestica* sp.	10	4000	3.89
9	*Imperata cylindrica*	15	10000	7.13
10	*Lygodium flexuosum*	5	2000	1.95
11	*Mastersia* sp.	10	4000	3.89
12	*Mikania micrantha*	15	6000	5.84
13	*Molininera* sp.	10	4000	3.89
14	*Neprolepis cordifolia*	5	4000	2.59
15	*Ophiopogon intermedius*	15	6000	5.84
16	*Paderia foetida*	5	2000	1.95
17	*Paspalum* sp.	15	6000	5.84
18	*Periploca callosa*	10	1000	2.92
19	*Photos scandens*	10	4000	3.89
20	*Phyrnium pubinerve*	35	32000	19.45
21	*Pilea* sp.	15	36000	15.55
22	*Polypodium* sp.	15	6000	5.84
23	*Pteris* sp.	30	14000	12.32
24	*Saccharum spontaneum*	15	24000	11.66
25	*Senecio cappa*	5	4000	2.59
26	*Sonchus* sp.	5	4000	2.59
27	*Thladanthia* sp.	5	2000	1.95
28	*Thysanolaena maxima*	5	4000	2.59
29	*Urtica dioca*	5	14000	5.83
	Total		**309000**	**199.99**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Begonia* spp.	15	2500	3.64
2.	*Colocasia* sp.	25	6500	6.66
3.	*Commelina* sp.	15	9000	5.29
4.	*Cyanotis cappa*	15	12000	6.06
5.	*Cyperus*	10	4500	3.15
6.	*Elatostemma* sp.	65	92500	36.57
7.	*Equisetum* sp.	10	10500	4.68
8.	*Forrestica* sp.	25	14000	8.57
9.	*Imperata cylindrica*	20	17500	8.46
10.	*Lygodium* sp.	10	3500	2.89

11.	*Mastersia* sp.	10	4000	3.02
12.	*Mikania micrantha*	20	7500	5.91
13.	*Molininera* sp.	10	4000	3.02
14.	*Neprolepis cordifolia*	15	7500	4.91
15.	*Ophiopogon* sp.	25	10500	7.68
16.	*Paderia foetida*	20	4000	5.02
17.	*Paspalum* sp.	20	17000	8.33
18.	*Periploca callosa*	10	1500	2.38
19.	*Pothos scandens*	10	7000	3.78
20.	*Phyrnium pubinerve*	40	39500	18.06
21.	*Pilea* sp.	25	43000	15.96
22.	*Polypodium* sp.	15	6000	4.53
23.	*Pteris* sp.	30	15000	9.82
24.	*Saccharum* sp.	15	25500	9.50
25.	*Senecio cappa*	5	3500	1.89
26.	*Sonchus* sp.	5	4000	2.02
27.	*Thladanthia* sp.	5	1500	1.38
28.	*Thysanolaena maxima*	5	5000	2.27
29.	*Urtica dioca*	5	14000	4.57
		500	**392500**	**200.00**

4. Upstream area

Sl. No.	**Trees**	**Frequency %**	**Density (No./ha)**	**Basal area (m^2/ha)**	**IVI**
1	*Actinodaphne obovata*	10	10	0.13	3.32
2	*Ailanthus excelsa*	30	30	12.27	28.36
3	*Artocarpus chaplasha*	30	30	1.54	7.76
4	*Brassiopsis glomerulata*	30	60	7.85	11.57
5	*Caryota urens*	10	10	0.05	6.80
6	*Chukrassia tubalaris*	10	10	3.51	4.50
7	*Duabanga grandiflora*	30	70	0.80	23.65
8	*Dysoxylon hamiltonii*	40	50	10.95	40.51
9	*Ficus cunia*	40	50	11.42	15.88
10	*Ficus roxburghii*	20	20	0.21	3.70
11	*Gynocardia odorata*	20	20	7.72	11.77
12	*Knema angustifolia*	10	10	0.18	4.72
13	*Kydia calycina*	50	200	1.98	28.96
14	*Leea* sp.	60	90	13.37	3.43
15	*Macropanax disperma*	10	10	0.39	6.89
16	*Musa* sp.	10	10	0.34	37.85
17	*Ostodes paniculata*	10	20	0.15	3.77
18	*Pandanas odoratissima*	30	40	0.40	3.38
19	*Sapindus rarak*	10	10	0.09	7.76
20	*Sarcosperma griffithii*	10	10	0.96	3.49
21	*Terminalia myriocarpa*	10	10	3.51	25.51
22	*Toona ciliata*	20	20	0.28	16.42
	Total		**790**		**300**

S. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1	*Acacia penneta*	20	20	2.97
2	*Acacia pruiniscens*	10	20	1.87
3	*Boehmeria longifolia*	20	120	6.81
4	*Boehmeria macrophylla*	40	70	7.09
5	*Budlejja asiatica*	20	30	3.35
6	*Calamus errectus*	30	90	6.76
7	*Calamus lactospadix*	30	120	7.91
8	*Clerodendron coolebrokianum*	40	90	7.86
9	*Cratena* sp.	10	40	2.64
10	*Debregessia longifolia*	30	40	4.84
11	*Desmodium* sp.	10	10	1.48
12	*Entada phaseoloides*	30	40	4.84
13	*Eupatorium odoratum*	10	80	4.18
14	*Ficus urophylla*	10	10	1.48
15	*Glochidion* sp.	30	30	4.45
16	*Glycosmis* sp.	30	50	5.22
17	*Gnetum* sp.	10	10	1.48
18	*Gnetum* sp.	10	20	1.87
19	*Grewia disperma*	70	110	11.92
20	*Jasminium dispermum*	20	20	2.97
21	*Laportea crenulata*	40	50	6.32
22	*Mesea indica*	70	90	11.15
23	*Monerelia cucuboides*	20	30	3.35
24	*Murraya paniculata*	40	60	6.70
25	*Peuraria* sp.	30	30	4.45
26	*Piper* sp.	70	970	45.00
27	*Plectranthus striatus*	30	160	9.45
28	*Rubus ellipticus*	10	20	1.87
29	*Sarcandra glabra*	10	30	2.25
30	*Smilax* sp.	20	20	2.97
31	*Solanum xanthocarpum*	20	30	3.35
32	*Solanam torvum*	30	40	4.84
33	*Tinospora crispa*	40	50	6.32
	Total		**2600**	**200.01**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1	*Begonia* sp.	10	2000	4.00
2	*Colocasia* sp.	25	6000	10.38
3	*Commelina* sp.	5	4000	3.16
4	*Cyanotis cappa*	5	4000	3.16

5	*Elatostemma sp.*	50	38000	30.80
6	*Equisetum* sp.	5	8000	4.70
7	*Forrestica sp.*	5	4000	3.16
8	*Imperata cylindrica*	5	10000	5.47
9	*Lygodium flexusum*	5	2000	2.39
10	*Mastersia* sp.	5	4000	3.16
11	*Mikania micrantha*	10	6000	5.54
12	*Molineria* sp.	5	4000	3.16
13	*Neprolepis cordifolia*	5	4000	3.16
14	*Ophiopogon intermedius*	15	6000	7.16
15	*Paderia foetida*	5	2000	2.39
16	*Paspalum* sp.	5	6000	3.93
17	*Periploca callosa*	5	1000	2.00
18	*Photos scandens*	5	4000	3.16
19	*Phyrnium pubinerve*	30	32000	22.03
20	*Pilea* sp.	15	36000	18.74
21	*Pogonetum* sp.	10	4000	4.77
22	*Polypodium* sp.	5	6000	3.93
23	*Pteris* sp.	15	14000	10.24
24	*Sacharum spontenum*	30	24000	18.94
25	*Senecio cappa*	5	4000	3.16
26	*Sonchus* sp.	5	4000	3.16
27	*Thladentia* sp.	5	2000	2.39
28	*Thysanolaena maxima*	10	4000	4.77
29	*Urtica dioca*	5	14000	7.02
	Total		**259000**	**200.03**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Begonia* sp.	15	2500	3.64
2.	*Colocasia* sp.	35	7500	8.97
3.	*Commelina* sp.	20	14000	7.85
4.	*Cyanotis cappa*	20	14000	7.85
5.	*Elatostemma* sp.	60	49000	25.51
6.	*Equisetum*	15	17000	7.71
7.	*Forrestica* sp.	20	13500	7.71
8.	*Imperata cylindrica*	15	14500	7.01
9.	*Lygodium* sp.	10	3500	2.94
10.	*Mastersia* sp.	10	4500	3.22
11.	*Mikania micrantha*	25	12000	8.27
12.	*Molineria* sp.	5	2500	1.68
13.	*Neprolepis cordifolia*	15	6000	4.62
14.	*Ophiopogon* sp.	15	5000	4.34
15.	*Paderia foetida*	10	2500	2.66
16.	*Paspalum*	15	12000	6.31

17.	*Pothos scandens*	10	6000	3.64
18.	*Phyrnium pubinerve*	30	34000	15.42
19.	*Pilea* sp.	50	44500	22.29
20.	*Pogonetum* sp.	10	5000	3.36
21.	*Polypodium* sp.	20	12000	7.29
22.	*Pteris* sp.	15	13000	6.59
23.	*Sacharum* sp.	30	29500	14.16
24.	*Senecio cappa*	5	2000	1.54
25.	*Sonchus* sp.	5	3000	1.82
26.	*Thladentia* sp.	5	2000	1.54
27.	*Thysanolaena* sp.	10	7000	3.92
28.	*Urtica dioca*	10	17500	6.87
29.	*Periploca callosa*	5	1000	1.26
			356500	**200.00**

5. Colony area

Sl. No.	Trees	Frequency %	Density (No./ha)	Basal area (m^2/ha)	IVI
1.	*Syzygium* sp.	15	15	0.22	11.11
2.	*Emblica officinalis*	40	100	0.72	43.28
3.	*Albizia chinensis*	50	120	2.67	59.60
4.	*Kydia calycina*	70	170	15.65	128.32
5.	*Bombax cieba*	40	50	7.53	57.69
			455	**26.79**	**300**

Sl. No.	Shrubs	Frequency %	Density (No./ha)	IVI
1.	*Acacia pennata*	5	5	2.62
2.	*Acacia pruinescens*	10	10	5.24
3.	*Artemesia nilagirica*	90	8390	143.43
4.	*Boehmeria longifolia*	5	20	2.80
5.	*Buddleja asiatica*	15	30	8.04
6.	*Clerodendron coolebrokianum*	10	40	5.59
7.	*Debregessia longifolia*	5	5	2.62
8.	*Desmodium laxiflorum*	5	10	2.68
9.	*Grewia disperma*	10	30	5.48
10.	*Jasminium dispermum*	5	15	2.74
11.	*Maesa indica*	10	20	5.36
12.	*Rubus ellipticus*	10	25	5.42
13.	*Solanum xanthocarpum*	5	5	2.62
14.	*Eupatorium odoratum*	10	20	5.36
			8625	**200**

Sl. No.	Herbs (April)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	100	760000	72.84

2.	*Bidens pilosa*	10	100000	8.83
3.	*Borreria articularis*	100	180000	35.42
4.	*Cyanotis vaga*	12.5	60000	6.85
5.	*Imperata cylindrica*	45	120000	18.46
6.	*Lygodium flexuosum*	40	20000	10.81
7.	*Mikania micrantha*	25	60000	9.82
8.	*Paderia foetida*	30	20000	8.43
9.	*Paspalum* sp.	15	80000	8.73
10.	*Polygonum capitatum*	25	80000	11.11
11.	*Thysanolaena maxima*	2.5	40000	3.18
12.	*Urena lobata*	15	30000	5.51
			1550000	**200**

Sl. No.	Herbs (August)	Frequency %	Density (No./ha)	IVI
1.	*Ageratum conyzoides*	100	1350000	44.66
2.	*Bidens pilosa*	15	270000	7.75
3.	*Borreria articularis*	100	1900000	53.26
4.	*Cyanotis vaga*	12.5	650000	13.11
5.	*Imperata cylindrica*	45	1180000	29.05
6.	*Lygodium flexuosum*	40	60000	10.35
7.	*Mikania micrantha*	25	120000	7.76
8.	*Paderia foetida*	30	50000	7.84
9.	*Paspalum* sp.	15	460000	10.73
10.	*Polygonum capitatum*	25	180000	8.70
11.	*Thysanolaena maxima*	2.5	50000	1.37
12.	*Urena lobata*	15	120000	5.41
			6390000	**200**

ANNEXURE-VII
Density of phytoplanktons at various sampling sites

ANNEXURE-VII

Density of phytoplanktons at various sampling sites

APRIL 2009

Class	**Genus**	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Bacillariophyceae	*Anomoeonus sphaerophora*	-	1	-	-	-	-	-	-	-	-
	Frustulia rhomboids	-	1	-	1	-	-	1	-	1	-
	Mastogloia denseii	-	-	1	-	-	-	-	-	-	-
	Neidium affinis	-	-	1	-	-	-	-	-	-	-
Chlorophyceae	*Actinastrum hantzschii*	8	-	1	-	-	7	7	16	3	8
	Closteriopsis longissima	-	-	-	-	1	-	-	-	-	-
	Closterium abruptum	-	5	-	3	-	1	3	4	-	-
	Chlorella vulgaris	8	-	6	-	1	-	8	-	-	12
	Penium simplex	-	-	2	-	-	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	-	-	-	8	-	-	-
	Lyngbya birgei	-	-	1	-	-	-	-	-	-	-
	Microcystis sp.	-	-	-	-	-	-	-	1	-	1
	Oscillatoria acuminata	-	-	-	1	-	-	-	-	-	-
	Unidentified-1	-	-	-	-	-	-	1	-	1	-
Total		**16**	**7**	**12**	**5**	**2**	**8**	**28**	**21**	**5**	**21**

APRIL 2009

Class	Genus	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Bacillariophyceae	*Anomoeonus sphaerophora*	-	1	-	1	-	1	-	1	-	-
	Ceratoneis arcus	-	-	-	-	-	-	-	1	-	-
	Cymbella cistula	-	-	-	-	-	-	1	-	-	-
	Gomphonema geminatum	-	1	-	-	-	-	1	-	-	-
	Mastogloia denseii	-	-	1	-	-	-	-	-	-	-
Chlorophyceae	*Closterium abruptum*	-	3	1	1	1	-	-	-	-	-
	Penium simplex	-	-	-	-	-	-	-	2	-	1
Cyanophyceae	*Microcystis* sp.	4	9	12	11	1	-	14	11	-	1
	Unidentified-1	-	1	1	-	-	4	-	2	2	-
	Synechocystis sp.	-	-	-	-	-	-	-	-	-	1
Total		4	15	15	13	2	5	16	17	2	3

APRIL 2009

Class	Genus	Demwe Upper HEP					Demwe Lower HEP				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Bacillariophyceae	*Anomoeonus sphaerophora*	-	-	-	-	6	-	-	-	-	-
	Ceratoneis arcus	-	-	-	-	-	-	-	-	-	2
	Cymbella cistula	-	-	2	-	43	-	-	-	-	-
	Frustulia rhomboids	-	-	2	-	7	-	-	-	-	-
	Gomphonema geminatum	-	-	1	-	-	-	-	-	-	-
	Mastogloia denseii	-	-	1	-	-	-	-	-	-	-
	Neidium affinis	-	-	-	-	18	-	-	-	-	-
Chlorophyceae	*Actinastrum hantzschii*	-	2	-	-	2	1	1	-	1	1
	Closteriopsis longissima	-	-	-	4	-	-	-	-	-	-
	Closterium abruptum	-	-	-	-	1	-	1	1	1	1
	Chlorella vulgaris	2	3	-	-	7	-	-	-	-	-
	Penium simplex	-	-	-	8	4	-	-	1	-	-
Cyanophyceae	*Gloeothece* sp.	-	-	1	-	-	-	-	-	-	-
	Microcystis sp.	-	-	-	1	-	-	-	-	-	-
	Oscillatoria acuminata	-	-	-	-	-	-	-	-	-	1
	Rivularia bornetiana	-	-	-	-	-	1	-	1	-	-
	Unidentified-1	-	-	-	-	-	-	-	-	-	2
	Synechoccus sp.	-	-	1	-	-	-	-	-	-	-
	Synechocystis sp.	3	-	4	1	-	1	-	1	-	4
Total		5	5	12	14	88	3	2	4	2	11

May 2009

Class	Genus	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Bacillariophyceae	*Cymbella cistula*	1	1	-	-	1	-	1	1	-	1
	Mastogloia denseii	-	-	2	1	-	1	-	-	1	-
Chlorophyceae	*Chlorella vulgaris*	5	6	1	8	1	2	-	1	-	1
	Pediastrum tetras	-	1	-	1	-	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	1	-	-	1	-	1	-	1	-
	Unidentified-1	-	-	-	-	-	-	1	-	-	-
Total		**6**	**9**	**3**	**10**	**3**	**3**	**3**	**2**	**2**	**2**

May 2009

Class	Genus	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Bacillariophyceae	*Cymbella cistula*	-	-	1	-	-	-	1	-	-	-
Chlorophyceae	*Chlorella vulgaris*	3	2	-	-	1	2	-	1	1	1
Cyanophyceae	*Anabaena oscillarioides*	4	-	1	-	1	-	3	2	5	-
	Unidentified-1	-	-	1	1	-	-	1	1	-	1
Total		7	2	3	1	2	2	5	4	6	2

May 2009

Class	Genus	Demwe Upper HEP					Demwe Lower HEP				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Bacillariophyceae	*Cocconeis placentula*	-	-	-	1	-	1	-	1	-	-
	Cymbella cistula	2	1	-	5	-	-	-	-	-	5
	Frustulia rhomboids	6	-	-	-	-	-	-	-	-	1
	Gomphonema geminatum	-	-	-	5	1	-	-	-	-	-
	Mastogloia denseii	7	1	1	5	1	-	1	-	-	-
	Navicula radiosa	-	-	-	-	-	-	3	-	1	-
Chlorophyceae	*Actinastrum hantzschii*	2	-	-	3	2	-	1	-	-	3
	Chlorella vulgaris	5	-	4	2	-	-	-	-	-	8
	Closteriopsis longissima	8	-	1	-	-	-	-	-	-	1
	Pediastrum tetras	-	-	1	-	-	-	1	-	-	1
	Penium simplex	1	-	-	1	-	-	-	-	-	4
	Spirogyra varians	3	-	-	2	-	-	-	-	-	6
	Trochiscia pachyderma	-	-	-	-	-	-	1	-	1	-
Cyanophyceae	*Anabaena oscillarioides*	6	-	1	-	-	-	-	-	-	-
	Hyalotheca bissiliens	2	-	-	1	-	-	-	-	1	2
	Lyngbya birgei	-	-	-	2	-	-	5	-	-	-
	Microcystis sp.	-	-	-	-	-	-	1	-	-	-
	Oscillatoria acuminata	7	-	-	-	-	-	-	-	1	1
	Phormidium ambiguum	-	-	-	1	-	-	-	-	-	-
	Unidentified-1	5	-	-	1	-	-	-	-	-	5
	Spirulina caldaria	-	-	-	-	-	-	3	-	-	-
Total		**54**	**2**	**8**	**29**	**4**	**1**	**16**	**1**	**4**	**37**

June 2009

Class	Genus	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Bacillariophyceae	*Anomoeonus sphaerophora*	-	1	-	-	-	-	-	-	-	-
	Neidium affinis	-	-	1	-	-	-	-	-	-	-
Chlorophyceae	*Actinastrum hantzschii*	2	-	1	-	-	7	7	11	2	2
	Closteriopsis longissima	-	-	-	-	1	-	-	-	-	-
	Closterium abruptum	-	5	-	2	-	1	2	1	-	-
	Chlorella vulgaris	2	-	1	-	1	-	2	-	-	12
	Penium simplex	-	-	2	-	-	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	-	-	-	2	-	-	-
	Lyngbya birgei	-	-	1	-	-	-	-	-	-	-
	Microcystis sp.	-	-	-	-	-	-	-	1	-	1
Total		**4**	**6**	**6**	**2**	**2**	**8**	**13**	**13**	**2**	**15**

June 2009

Class	Genus	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
		S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Bacillariophyceae	*Anomoeonus sphaerophora*	-	1	-	1	-	1	-	1	-	-
	Ceratoneis arcus	-	-	-	-	-	-	-	1	-	-
	Cymbella cistula	-	-	-	-	-	-	1	-	-	-
Chlorophyceae	*Closterium abruptum*	-	2	1	1	1	-	-	-	-	-
	Penium simplex	-	-	-	-	-	-	-	2	-	1
Cyanophyceae	*Microcystis* sp.	1	9	12	11	1	-	11	11	-	1
Total		**1**	**12**	**13**	**13**	**2**	**1**	**12**	**15**	**0**	**2**

June 2009

Class	Genus	Demwe Upper HEP					Demwe Lower HEP				
		S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Bacillariophyceae	*Anomoeonus sphaerophora*	-	-	-	-	1	-	-	-	-	-
	Ceratoneis arcus	-	-	-	-	-	-	-	-	-	2
	Cymbella cistula	-	-	2	-	12	-	-	-	-	-
	Neidium affinis	-	-	-	-	12	-	-	-	-	-
Chlorophyceae	*Actinastrum hantzschii*	-	2	-	-	2	1	1	-	1	1
	Closteriopsis longissima	-	-	-	1	-	-	-	-	-	-
	Closterium abruptum	-	-	-	-	1	-	1	1	1	1
	Chlorella vulgaris	2	2	-	-	7	-	-	-	-	-
	Penium simplex	-	-	-	2	1	-	-	1	-	-
Cyanophyceae	*Gloeothece* sp.	-	-	1	-	-	-	-	-	-	-
	Microcystis sp.	-	-	-	1	-	-	-	-	-	-
Total		2	4	3	4	36	1	2	2	2	4

July 2009

Class	Genus	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Bacillariophyceae	*Frustulia rhomboids*	-	4	-	2	-	-	1	-	1	-
	Mastogloia denseii	-	-	1	-	-	-	-	-	-	-
	Neidium affinis	-	-	1	-	-	-	-	-	-	-
	Tabellaria fenestrata	-	3	-	3	-	-	1	-	1	-
	Atthiya zachariasi	-	-	1	-	-	-	-	-	-	-
	Amphora ovalis	-	-	1	-	-	-	-	-	-	-
Chlorophyceae	*Actinastrum hantzschii*	8	-	1	-	-	7	7	16	3	8
	Closteriopsis longissima	-	-	-	-	5	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	-	-	-	8	-	-	-
	Lyngbya birgei	-	-	1	-	-	-	-	-	-	-
Total		**8**	**7**	**6**	**5**	**5**	**7**	**17**	**17**	**5**	**9**

July 2009

Class	Genus	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Bacillariophyceae	*Cymbella cistula*	-	-	-	-	-	-	1	-	1	-
	Frustulia rhomboids	-	-	-	-	-	4	-	-	-	-
	Gomphonema geminatum	-	1	-	-	-	-	1	-	-	-
	Mastogloia denseii	-	-	1	-	-	2	-	-	2	-
	Melosira ambigua	-	-	-	-	-	-	1	-	-	-
	Unidentified-1	-	1	-	-	-	3	1	-	-	-
	Atthiya zachariasi	-	-	1	-	-	-	-	-	-	-
Chlorophyceae	*Actinastrum hantzschii*	-	-	-	-	-	-	-	-	4	2
Cyanophyceae	*Microcystis* sp.	4	9	12	11	6	-	14	11	-	3
Total		**4**	**11**	**14**	**11**	**6**	**9**	**18**	**11**	**7**	**5**

July 2009

Class	Genus	Demwe Upper HEP					Demwe Lower HEP				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Bacillariophyceae	*Cymbella cistula*	4	-	2	-	4	-	-	-	-	-
	Frustulia rhomboids	-	-	2	-	7	-	-	-	-	2
	Gomphonema geminatum	-	-	1	-	-	-	-	-	3	-
	Mastogloia denseii	-	-	1	-	-	-	-	-	-	-
	Neidium affinis	-	-	-	-	8	-	-	-	-	-
	Melosira ambigua	-	-	2	-	4	-	2	6	-	-
	Tabellaria fenestrata	2	-	2	-	7	2	-	-	2	6
	Unidentified-1	-	-	1	-	-	-	-	-	-	-
	Atthiya zachariasi	-	-	1	-	-	-	-	2	-	-
	Amphora ovalis	1	-	-	-	9	-	-	-	-	-
Chlorophyceae	*Actinastrum hantzschii*	-	2	-	-	2	4	3	-	5	4
	Closteriopsis longissima	-	-	-	4	-	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	-	-	-	-	3	-	-
	Unidentified-2	1	-	1	-	-	-	-	-	-	-
	Microcystis sp.	-	-	-	1	-	-	-	-	-	-
Total		8	2	13	5	41	6	5	11	10	12

August 2009

Class	Genus	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Bacillariophyceae	*Melosira ambigua*	2	4	-	-	2	-	3	6	-	3
	Atthiya zachariasi	-	-	2	3	-	3	-	-	8	2
Chlorophyceae	*Pediastrum tetras*	-	3	-	2	-	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	3	-	-	2	-	2	-	1	-
Total		**2**	**10**	**2**	**5**	**4**	**3**	**5**	**6**	**9**	**5**

August 2009

Class	Genus	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Bacillariophyceae	*Melosira ambigua*	-	-	5	-	-	-	1	-	-	-
	Tabellaria fenestrata	-	2	-	-	-	2	-	-	-	-
	Unidentified-1	-	-	-	3	-	-	-	-	-	-
	Atthiya zachariasi	-	-	-	-	-	-	-	-	-	2
Cyanophyceae	*Anabaena oscillarioides*	4	-	2	-	2	-	3	2	5	-
Total		**4**	**2**	**7**	**3**	**2**	**2**	**4**	**2**	**5**	**2**

August 2009

Class	Genus	Demwe Upper HEP					Demwe Lower HEP				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Bacillariophyceae	*Navicula radiosa*	-	-	-	-	-	-	3	-	1	-
	Pinnularia nobilis	-	-	-	1	-	5	-	6	-	-
	Melosira ambigua	2	1	-	2	-	-	-	-	-	5
	Tabellaria fenestrata	4	-	-	-	-	-	-	-	-	1
	Unidentified-1	-	-	-	2	1	-	-	-	-	-
	Atthiya zachariasi	3	5	1	5	1	-	1	-	-	-
	Amphora ovalis	-	-	-	-	-	-	3	-	2	-
Chlorophyceae	*Actinastrum hantzschii*	2	-	-	3	2	-	1	-	-	3
	Pediastrum tetras	-	-	1	-	-	-	1	-	-	1
Cyanophyceae	*Anabaena oscillarioides*	3	-	1	-	-	-	-	-	-	-
	Unidentifed-2	2	-	-	1	-	-	-	-	1	2
Total		**16**	**6**	**3**	**14**	**4**	**5**	**9**	**6**	**4**	**12**

September 2009

Class	Genus	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Bacillariophyceae	*Anomoeonus sphaerophora*	3	1	-	-	-	-	-	-	-	4
	Ceratoneis arcus	-	-	-	-	-	-	-	1	5	-
	Undentified-1	1	-	-	-	2	4	2	-	-	-
	Atthiya zachariasi	-	-	-	-	-	-	-	-	-	2
	Amphora ovalis	-	-	2	-	-	-	-	-	3	-
Chlorophyceae	*Closteriopsis longissima*	-	-	-	-	3	-	-	-	-	-
	Unidentified-2	-	5	-	2	-	2	2	3	1	1
Total		**4**	**6**	**2**	**2**	**5**	**6**	**4**	**4**	**9**	**7**

September 2009

Class	Genus	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Bacillariophyceae	*Anomoeonus sphaerophora*	5	6	3	5	-	6	-	1	5	4
	Ceratoneis arcus	-	-	-	-	2	-	3	6	3	-
	Amphora ovalis	-	-	-	-	-	-	2	-	-	-
Chlorophyceae	*Closterium abruptum*	-	-	1	1	1	-	-	-	-	-
Cyanophyceae	*Unidentified-3*	-	-	-	-	-	-	6	-	-	-
Total		5	6	4	6	3	6	11	7	8	4

September 2009

Class	Genus	Demwe Upper HEP					Demwe Lower HEP				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Bacillariophyceae	*Anomoeonus sphaerophora*	5	-	-	-	1	-	-	-	-	-
	Ceratoneis arcus	6	2	-	-	-	-	-	2	4	2
	Unidentified-1	-	-	1	-	-	4	1	-	-	-
	Amphora ovalis	-	1	2	-	-	-	-	-	-	-
Chlorophyceae	*Closteriopsis longissima*	-	-	-	1	-	-	-	-	-	-
	Unidentified-2	-	-	-	-	2	-	3	1	1	1
Cyanophyceae	*Unidentified-3*	-	5	3	-	-	-	-	-	-	-
Total		11	8	6	1	3	4	4	3	5	3

ANNEXURE-VIII
Density of zooplanktons at various sampling sites

ANNEXURE-VIII
Density of zooplanktons at various sampling sites

April 2009

Genus	Kalai HEP, Stage-1					Kalai HEP,stage-2				
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Difflugia	6	7	6	9	6	4	2	3	6	5
Keratella	1	2	3	6	3	1	-	-	-	2
Polyarthra	-	-	-	-	-	-	-	-	1	1
Testudinella	-	-	-	-	-	2	-	-	3	-
Ceriodaphnia	-	-	-	-	-	-	1	-	-	-
Cyclops	-	-	-	-	1	-	-	-	1	1
Monostyla	-	-	-	1	1	-	-	-	-	-
Philodina	-	-	-	1	1	-	-	-	-	-
Arcella	1	-	4	3	-	-	-	-	-	-
Colurella	9	7	2	2	1	-	-	-	-	-
Bosminopsis	1	3	5	1	-	-	-	-	7	9
Unidentified-2	4	5	6	3	2	-	-	-	3	2
Trichocerca	-	-	-	-	-	-	-	-	1	1
Total	22	24	26	26	15	7	3	3	22	21
Genus	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Difflugia	-	7	-	-	-	5	1	12	1	-
Polyarthra	-	-	5	-	-	3	-	7	-	-
Ceriodaphnia	-	-	-	-	1	-	-	-	-	1
Cyclops	-	-	-	-	-	1	-	2	-	-
Monostyla	-	-	-	-	-	1	-	-	-	3
Mytillina	-	-	-	-	-	2	-	-	-	-
Philodina	3	2	-	-	5	-	-	1	-	-
Arcella	-	-	-	-	-	1	-	-	-	-
Colurella	-	-	-	-	-	-	-	-	-	1
Unidentified-3	-	-	-	2	-	-	-	1	-	-
Bosmina	-	-	-	-	-	1	-	-	-	-
Bosminopsis	-	3	-	-	-	1	-	-	-	5
Brachionus	-	-	-	-	-	3	-	-	-	-
Unidentified-2	-	-	-	-	5	-	-	-	-	-
Filinia	-	-	-	-	-	-	-	2	-	-
Lecane	-	-	-	-	-	1	-	-	-	-
Total	3	12	5	2	11	19	1	25	1	10

Genus	Demwe Upper HEP					Demwe Lower HEP				
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
Difflugia	2	-	1	1	4	5	3	1	2	5
Keratella	-	-	-	-	2	8	1	7	-	2
Polyarthra	-	-	4	-	5	-	-	-	-	-
Testudinella	1	-	-	-	4	6	4	1	1	-
Ceriodaphnia	-	2	-	-	-	-	-	-	-	-
Monostyla	-	-	-	1	-	-	-	-	-	-
Mytillina	-	5	-	-	-	-	-	1	-	1
Philodina	-	-	-	-	-	9	6	-	-	-

Arcella	-	-	-	-	-	4	-	-	2	1
Unidentified-3	1	-	1	-	-	-	-	-	-	-
Bosminopsis	-	-	-	-	6	-	-	-	-	-
Unidentified-2	-	-	3	-	-	2	-	1	1	1
Lecane	-	-	1	-	-	-	-	-	-	-
Total	4	7	10	2	21	34	14	11	6	10

May 2009

Genus	**Kalai HEP, Stage-1**					**Kalai HEP,stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Difflugia	3	7	6	1	6	4	2	3	6	5
Keratella	1	2	3	6	3	1	-	-	-	2
Polyarthra	-	-	-	-	-	-	-	-	1	1
Testudinella	-	-	-	-	-	2	-	-	3	-
Ceriodaphnia	-	-	-	-	-	-	1	-	-	-
Cyclops	-	-	-	-	1	-	-	-	1	1
Monostyla	-	-	-	1	1	-	-	-	-	-
Bosminopsis	1	3	5	1	-	-	-	-	8	1
Brachionus	-	-	-	-	-	-	-	-	-	-
Unidentified-2	4	5	6	3	2	-	-	-	3	2
Total	9	17	20	12	13	7	3	3	22	12
Genus	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Difflugia	-	7	-	-	-	6	5	3	5	-
Polyarthra	-	-	5	-	-	3	-	7	-	-
Testudinella	5	-	-	-	-	-	-	-	-	-
Ceriodaphnia	-	-	-	2	1	-	-	-	6	1
Cyclops	-	-	-	-	-	1	3	2	-	-
Monostyla	-	-	-	-	-	1	1	-	-	3
Unidentified-3	4	-	-	3	-	-	-	1	-	-
Bosmina	-	-	-	-	-	1	-	-	-	-
Bosminopsis	-	3	-	-	-	1	-	-	-	5
Brachionus	-	-	-	-	-	3	-	-	-	-
Unidentified-2	-	-	-	-	5	-	-	-	-	-
Total	9	10	5	5	6	16	9	13	11	9
Genus	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Difflugia	2	-	1	1	4	5	3	1	2	5
Keratella	-	-	-	-	2	9	1	7	-	2
Polyarthra	-	-	4	-	5	-	-	-	-	-
Testudinella	1	-	-	-	4	6	4	1	1	-
Ceriodaphnia	-	2	-	-	-	-	-	-	-	-
Monostyla	-	-	-	1	-	-	-	-	-	-
Unidentified-3	1	-	1	-	-	-	-	-	-	-
Bosminopsis	-	-	-	-	6	-	-	-	-	-
Unidentified-2	-	-	3	-	-	2	-	1	1	1
Total	4	2	9	2	21	22	8	10	4	8

June2009

Genus	Kalai HEP, Stage-1					Kalai HEP,stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Keratella	1	2	3	6	3	1	-	-	-	2
Polyarthra	-	-	-	-	-	-	-	5	2	5
Testudinella	-	-	-	-	-	2	-	-	3	-
Ceriodaphnia	-	-	-	-	-	-	5	2	-	-
Unidentified-2	13	5	6	3	2	-	-	-	3	2
Filinia	-	-	-	-	-	-	3	2	-	-
Trichocerca	-	-	-	-	-	-	-	-	3	1
Total	14	7	9	9	5	3	8	9	11	10

Genus	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Keratella	-	4	-	-	-	-	-	-	3	5
Polyarthra	-	-	7	-	-	3	6	7	-	-
Testudinella	6	2	-	-	-	-	-	-	-	-
Ceriodaphnia	-	-	-	-	1	-	-	-	-	4
Unidentified-3	2	1	2	2	-	-	2	6	2	-
Unidentified-2	-	-	-	-	5	-	-	-	-	-
Filinia	-	-	-	-	-	-	-	2	1	1
Lecane	1	1	1	-	-	5	1	-	-	-
Total	9	8	10	2	6	8	9	15	6	10

Genus	Demwe Upper HEP					Demwe Lower HEP				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Keratella	-	-	-	-	2	8	5	7	-	3
Polyarthra	-	-	4	5	5	-	-	-	-	-
Testudinella	5	-	-	-	4	6	4	6	2	-
Ceriodaphnia	-	5	-	-	-	-	-	-	-	-
Unidentified-3	2	-	3	2	-	-	-	-	-	-
Unidentified-2	-	-	3	2	-	2	-	2	2	6
Lecane	-	1	1	1	-	-	-	-	-	-
Trichocerca	-	1	-	-	-	-	-	-	-	1
Total	7	7	11	10	11	16	9	15	4	10

July 2009

Genus	Kalai HEP, Stage-1					Kalai HEP,stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Difflugia	2	2	3	4	3	4	2	3	4	5
Keratella	1	1	3	3	3	1	-	-	-	2
Polyarthra	-	-	-	-	-	-	-	-	1	1
Testudinella	-	-	-	-	-	2	-	-	3	-
Ceriodaphnia	-	-	-	-	-	-	1	-	-	-
Cyclops	-	-	-	-	1	-	-	-	1	1
Colurella	2	4	2	2	1	-	-	-	-	-
Epistylis	2	1	1	1	2	-	-	-	2	2
Unidentified-a	-	-	-	-	-	-	-	-	1	1
Total	7	8	9	10	10	7	3	3	12	12
Genus	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Difflugia	-	7	-	-	-	5	3	2	1	-
Keratella	-	-	-	-	-	-	-	-	-	-
Polyarthra	-	-	5	-	-	3	-	7	-	-
Testudinella	4	-	-	-	-	-	-	-	-	-
Ceriodaphnia	-	-	-	2	1	-	-	-	-	1
Cyclops	-	-	-	-	-	1	1	2	-	-
Colurella	2	-	-	-	-	-	-	-	-	1
Epistylis	-	-	-	3	5	-	-	-	-	-
Filinia	-	-	-	-	-	-	-	2	-	-
Unidentified-b	-	-	-	-	-	1	-	-	-	-
Total	6	7	5	5	6	10	4	13	1	2
Genus	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Difflugia	2	-	1	1	4	5	3	1	2	5
Keratella	-	-	-	-	2	8	1	7	-	2
Polyarthra	-	-	4	-	5	-	-	-	-	-
Testudinella	1	-	-	-	4	6	4	1	1	-
Ceriodaphnia	-	2	-	-	-	-	-	-	-	-
Epistylis	-	-	3	-	-	2	-	1	1	1
Unidentified-b	-	-	1	-	-	-	-	-	-	-
Total	3	2	9	1	15	21	8	10	4	8

August 2009

Genus	Kalai HEP, Stage-1					Kalai HEP,stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Difflugia	1	2	1	1	2	4	2	3	2	5
Keratella	1	2	3	3	3	1	-	-	-	2
Polyarthra	-	-	-	-	-	-	-	-	1	1
Testudinella	-	-	-	-	-	2	-	-	3	-
Monostyla	-	-	-	1	1	-	-	-	-	-
Bosminopsis	1	3	1	1	-	-	-	-	2	1
Brachionus	-	-	-	-	-	-	-	-	-	-
Epistylis	4	2	2	3	2	-	-	-	3	2
Total	7	9	7	9	8	7	2	3	11	11
Genus	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Difflugia	-	2	-	2	-	4	5	3	5	-
Keratella	-	-	-	-	-	-	-	-	-	-
Polyarthra	-	-	5	-	-	3	-	7	-	-
Testudinella	5	1	-	-	-	-	-	-	-	-
Monostyla	-	-	-	4	-	1	1	-	-	3
Bosminopsis	-	3	-	-	-	1	-	-	-	5
Brachionus	3	-	-	-	-	3	-	-	-	-
Epistylis	-	-	-	1	5	-	-	-	-	-
Total	8	6	5	7	5	12	6	10	5	8
Genus	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Difflugia	2	-	1	1	2	5	3	1	2	5
Keratella	-	4	-	-	2	2	1	7	-	2
Polyarthra	-	-	4	-	5	-	-	-	-	-
Testudinella	1	-	-	-	4	3	4	1	1	-
Monostyla	-	-	-	1	-	-	-	-	-	-
Bosminopsis	-	2	-	-	3	-	-	-	-	-
Brachionus	-	-	-	-	-	-	-	-	-	-
Epistylis	-	-	3	-	-	2	-	1	1	1
Total	3	6	8	2	16	12	8	10	4	8

September 2009

Genus	Kalai HEP, Stage-1					Kalai HEP,stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Keratella	2	2	2	3	3	1	-	-	-	2
Polyarthra	-	-	-	-	-	-	-	5	2	5
Filinia	-	-	-	-	-	-	3	2	-	-
Unidentified-a	1	-	-	1	-	-	-	-	-	-
Unidentified-b	-	-	1	-	-	-	-	-	3	1
Total	3	2	3	4	3	1	3	7	5	8
Genus	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Keratella	-	4	-	-	-	-	-	-	3	5
Polyarthra	-	-	7	2	-	3	6	7	-	-
Filinia	-	-	-	-	2	-	-	2	1	1
Unidentified-b	1	1	1	1	-	5	1	-	-	-
Total	1	5	8	3	2	8	7	9	4	6
Genus	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Keratella	3	-	-	-	2	8	5	7	4	3
Polyarthra	-	-	4	5	5	-	-	-	-	-
Filinia	2	-	-	-	-	-	-	-	2	-
Unidentified-b	1	1	1	1	-	-	-	-	-	-
Unidentified-c	-	1	-	-	-	-	-	-	1	1
Total	6	2	5	6	7	8	5	7	7	4

ANNEXURE-IX

Density of zooplanktons at various sampling sites

ANNEXURE-IX

Density of zooplanktons at various sampling sites

April 2009

Class	**Genus**	**Kalai HEP Stage-1**					**Kalai HEP, Stage-2**				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Nitzschiaceae	*Nitzchia bacata*	50	20	30	60	30	10	-	-	-	20
Bacillariophyceae	*Cymbella cistula*	-	-	-	-	-	-	-	-	10	10
Chlorophyceae	*Hormidium* sp.	-	-	-	-	-	20	0	0	30	0
Chlorophyceae	*Cosmerium* sp.	-	-	-	-	-	-	10	-	-	-
Chlorophyceae	*Spirotaena* sp.	-	-	-	-	10	-	-	-	10	10
Chlorophyceae	*Spirogyra varians*	20	70	60	10	60	40	20	30	60	50
Chlorophyceae	*Chlorella vulgaris*	-	-	-	10	10	-	-	-	-	-
	Total	70	90	90	80	110	70	30	30	110	90
Class	**Genus**	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S7**	**S18**	**S19**	**S20**
Nitzschiaceae	*Nitzchia bacata*	50	20	-	10	50	-	-	-	-	-
Bacillariophyceae	*Cymbella cistula*	20	-	50	10	0	30	30	70	50	-
Chlorophyceae	*Hormidium* sp.	-	10	-	30	20	-	30	-	60	30
Chlorophyceae	*Cosmerium* sp.	-	10	20	-	10	-	20	-	-	10
Chlorophyceae	*Spirotaena* sp.	10	-	20	-	0	10	-	20	-	-
Chlorophyceae	*Spirogyra varians*	10	70	-	10	20	1050	10	1020	10	20
Cyanophyceae	*Gloeocapsa* sp.	20	-	-	-	-	-	-	-	-	10
Chlorophyceae	*Chlorella vulgaris*	-	-	-	20	-	10	10	-	-	30
Cyanophyceae	*Nostoc* sp.	-	-	-	-	-	20	-	-	-	-
	Total	110	110	90	80	100	1120	100	1110	120	100
Class	**Genus**	**Demwe Upper HEP**					**Demwe Lower HEP**				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Nitzschiaceae	*Nitzchia bacata*	40	-	10	10	20	1080	10	70	-	20
Bacillariophyceae	*Cymbella cistula*	-	50	40	-	50	-	-	-	-	-
Chlorophyceae	*Hormidium* sp.	20	-	-	20	40	60	40	10	10	-
Chlorophyceae	*Cosmerium* sp.	-	30	20	-	-	-	-	-	-	-
Chlorophyceae	*Spirogyra varians*	30	-	30	10	40	50	30	10	20	50
Chlorophyceae	*Chlorella vulgaris*	10	-	50	10	-	-	-	-	-	-
Cyanophyceae	*Nostoc* sp.	20	50	-	-	-	-	-	10	-	10
	Total	120	130	150	50	150	1190	80	100	30	80

May 2009

Class	Genus	Kalai HEP Stage-1					Kalai HEP, Stage-2				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Nitzschiaceae	*Nitzchia bacata*	50	20	30	60	30	10	20	30	-	20
Bacillariophyceae	*Cymbella cistula*	10	10	-	-	-	-	-	-	10	10
Chlorophyceae	*Hormidium* sp.	10	-	10	20	20	20	-	20	30	-
Chlorophyceae	*Cosmerium* sp.	-	10	-	20	-	-	10	20	20	30
Cyanophyceae	*Gloeocapsa* sp.	20	-	20	-	50	30	10	10	10	-
	Total	90	40	60	100	100	60	40	80	70	60
Class	Genus	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S7**	**S18**	**S19**	**S20**
Nitzschiaceae	*Nitzchia bacata*	40	10	-	10	30	-	50	10	50	60
Bacillariophyceae	*Cymbella cistula*	-	-	50	-	-	30	-	70	-	20
Chlorophyceae	*Hormidium* sp.	60	50	-	20	30	-	60	-	20	-
Chlorophyceae	*Cosmerium* sp.	0	20	30	-	10	20	-	30	10	10
Cyanophyceae	*Gloeocapsa* sp.	10	-	-	50	-	-	10	-	10	-
	Total	110	80	80	80	70	50	120	110	90	90
Class	Genus	**Demwe Upper HEP**					**Demwe Lower HEP**				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Nitzschiaceae	*Nitzchia bacata*	30	20	20	50	20	108	10	70	30	20
Bacillariophyceae	*Cymbella cistula*	-	20	40	-	50	-	-	-	-	-
	Hormidium sp.	10	10	-	20	40	60	40	10	10	50
	Cosmerium sp.	-	20	10	20	-	10	10	10	10	20
Cyanophyceae	*Gloeocapsa* sp.	50	-	10	10	10	10	10	10	10	10
	Total	90	70	80	100	120	188	70	100	60	100

ANNEXURE-X

Density of benthic invertebrates at various sampling sites

June 2009

Class	**Genus**	**Kalai HEP Stage-1**					**Kalai HEP, Stage-2**				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Nitzschiaceae	*Nitzchia bacata*	50	20	30	60	30	30	-	40	-	20
Bacillariophyceae	*Cymbella cistula*	-	-	-	-	-	-	20	-	30	30
Cyanophyceae	*Gloeocapsa* sp.	20	-	-	-	-	-	-	-	-	-
Chlorophyceae	*Chlorella vulgaris*	-	60	-	30	30	-	10	20	-	-
Cyanophyceae	*Nostoc* sp.	-	-	-	-	-	-	-	-	-	-
	Total	70	80	30	90	60	30	30	60	30	50
Class	Genus	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S7**	**S18**	**S19**	**S20**
Nitzschiaceae	*Nitzchia bacata*	30	10	-	30	20	-	30	-	10	-
Bacillariophyceae	*Cymbella cistula*	-	-	50	-	-	30	-	70	-	-
Cyanophyceae	*Gloeocapsa* sp.	50	10	-	60	10	-	20	-	20	-
Chlorophyceae	*Chlorella vulgaris*	-	-	-	-	-	30	10	-	40	30
Cyanophyceae	*Nostoc* sp.	-	20	-	-	10	20	-	-	-	-
	Total	80	40	50	90	40	80	60	70	70	30
Class	Genus	**Demwe Upper HEP**					**Demwe Lower HEP**				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Nitzschiaceae	*Nitzchia bacata*	20	-	-	-	20	20	30	20	50	20
Bacillariophyceae	*Cymbella cistula*	-	-	40	-	50	-	-	-	-	-
Cyanophyceae	*Gloeocapsa* sp.	30	-	-	-	-	10	-	20	70	-
Chlorophyceae	*Chlorella vulgaris*	-	-	-	30	-	10	-	-	-	-
Cyanophyceae	*Nostoc* sp.	-	50	-	-	-	-	-	10	10	30
	Total	50	50	40	30	70	40	30	50	130	50

ANNEXURE-X

Density of benthic invertebrates at various sampling sites

April 2009

Order	**Family**	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Ephemeroptera	Baetidae	12	7	6	10	6	4	2	3	6	5
	Ecdyonuridae	1	2	3	6	3	1	-	-	-	2
	Heptageniidae	-	-	-	-	-	-	-	-	1	1
	Leptophlebiidae	-	-	-	-	-	2	-	-	3	-
Plecoptera	Nemouridae	-	-	-	-	-	-	1	-	-	-
	Perlidae	-	-	-	-	1	-	-	-	1	1
Trichoptera	Glossosomatidae	-	-	-	1	1	-	-	-	-	-
	Molannidae	-	-	-	1	1	-	-	-	-	-
	Philopotamidae	1	-	4	3	-	-	-	-	-	-
	Psychomyiidae	9	7	2	2	1	-	-	-	-	-
Diptera	Chironomidae	1	3	5	1	-	-	-	-	17	1-
	Simulidae	13	5	6	3	2	-	-	-	3	2
Coleoptera	Elmidae	-	-	-	-	-	-	-	-	1	1
Total		37	24	26	27	15	7	3	3	32	22
Order	Family	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Ephemeroptera	Baetidae	-	7	-	-	-	15	1	12	1	-
	Heptageniidae	-	-	5	-	-	3	-	7	-	-
Plecoptera	Nemouridae	-	-	-	-	1	-	-	-	-	1
	Perlidae	-	-	-	-	-	1	-	2	-	-
Trichoptera	Glossosomatidae	-	-	-	-	-	1	-	-	-	3
	Leptoceridae	-	-	-	-	-	2	-	-	-	-
	Molannidae	3	2	-	-	5	-	-	1	-	-
	Philopotamidae	-	-	-	-	-	1	-	-	-	-
	Psychomyiidae	-	-	-	-	-	-	-	-	-	1
Odonata	Gomphidae	-	-	-	2	-	-	-	1	-	-
Hemiptera	Mesovelidae	-	-	-	-	-	1	-	-	-	-
Diptera	Chironomidae	-	3	-	-	-	1	-	-	-	5
	Rhagionidae	-	-	-	-	-	3	-	-	-	-
	Simulidae	-	-	-	-	5	-	-	-	-	-
	Tabaenidae	-	-	-	-	-	-	-	2	-	-
	Tipulidae	-	-	-	-	-	1	-	-	-	-
Megaloptera	Corydalidae	1	-	-	1	-	-	-	-	-	1
Total		4	12	5	3	11	29	1	25	1	11
Order	Family	**Demwe Upper HEP**					**Demwe Lower HEP**				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Ephemeroptera	Baetidae	2	-	1	1	4	5	3	1	2	5
	Ecdyonuridae	-	-	-	-	2	18	1	7	-	2
	Heptageniidae	-	-	4	-	5	-	-	-	-	-
	Leptophlebiidae	1	-	-	-	4	6	4	1	1	-
Plecoptera	Nemouridae	-	2	-	-	-	-	-	-	-	-

Trichoptera	Glossosomatidae	-	-	-	1	-	-	-	-	-	-
	Leptoceridae	-	5	-	-	-	-	-	1	-	1
	Molannidae	-	-	-	-	-	11	6	-	-	-
	Philopotamidae	-	-	-	-	-	4	-	-	2	1
Odonata	Gomphidae	1	-	1	-	-	-	-	-	-	-
Diptera	Chironomidae	-	-	-	-	6	-	-	-	-	-
	Simulidae	-	-	3	-	-	2	-	1	1	1
	Tipulidae	-	-	1	-	-	-	-	-	-	-
Megaloptera	Corydalidae	-	-	1	-	-	-	-	-	-	-
Total		4	7	11	2	21	46	14	11	6	10

May 2009

Order	**Family**	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Ephemeroptera	Baetidae	14	12	6	7	3	6	5	-	8	9
	Ecdyonuridae	2	1	-	1	2	2	-	3	2	-
	Ephemerellidae	5	-	4	1	-	-	-	-	-	-
	Heptageniidae	14	-	1-	-	19	7	6	6	8	2
Plecoptera	Nemouridae	-	-	-	-	-	-	-	-	-	-
	Perlidae	4	-	-	3	-	4	1	-	1	-
Odonata	Cordulegastridae	-	-	-	-	-	1	3	-	5	-
Diptera	Chironomidae	-	-	-	-	-	2	-	5	2	1
Total		39	13	20	12	24	22	15	14	26	12
Order	Family	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Ephemeroptera	Baetidae	-	-	-	-	-	-	-	1	-	1
	Ecdyonuridae	1	2	2	6	1	-	-	-	1	-
	Heptageniidae	-	-	1	-	-	-	-	-	-	-
Plecoptera	Nemouridae	-	-	-	-	-	2	1	-	-	1
	Perlodideae	5	4	3	3	1	-	-	-	-	-
Trichoptera	Polycentropidae	-	-	1	-	-	-	-	-	-	-
Odonata	Cordulegastridae	5	2	-	1	1	-	-	-	-	-
Diptera	Chironomidae	-	-	-	-	-	-	-	1	-	-
Megaloptera	Corydalidae	-	-	-	-	-	-	-	1	-	-
Total		11	8	7	10	3	2	1	3	1	2
Order	Family	**Demwe Upper HEP**					**Demwe Lower HEP**				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Ephemeroptera	Baetidae	2	1	1	4	3	1	1	1	-	1
Plecoptera	Perlodideae	1	2	1	-	-	1	-	1	1	-
Trichoptera	Polycentropidae	-	-	1	-	-	-	-	-	-	-
Coleoptera	Dytiscidae	1	-	1	1	-	-	-	1	-	-
	Elmidae	1	-	1	-	1	1	-	1	-	-
Total		5	3	5	5	4	3	1	4	1	1

June 2009

Order	**Family**	**Kalai HEP, Stage-1**					**Kalai HEP, Stage-2**				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Ephemeroptera	Baetidae	2	-	1	1	1	1	5	12	-	-
	Ecdyonuridae	-	-	2	-	-	-	-	7	-	1
	Heptageniidae	-	1	1	-	1	-	-	-	-	-
	Leptophlebiidae	1	-	2	-	-	-	-	-	1	-
Plecoptera	Perlidae	1	-	3	1	1	1	-	2	1	-
Coleoptera	Gyrinidae	1	-	-	1	-	1	-	-	-	1
Total		5	1	9	3	3	3	5	21	2	2
Order	Family	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Ephemeroptera	Baetidae	1	1	6	-	1	-	-	-	-	-
	Ecdyonuridae	-	-	6	-	3	2	1	9	3	2
	Heptageniidae	-	-	-	-	-	-	-	5	-	1
Plecoptera	Peltoperlidae	-	1	2	1	-	-	-	-	-	-
	Perlidae	1	-	8	-	-	1	-	2	-	1
Diptera	Chironomidae	-	-	-	-	-	1	-	-	-	-
Total		2	2	22	1	4	4	1	16	3	4
Order	Family	**Demwe Upper HEP**					**Demwe Lower HEP**				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Ephemeroptera	Ecdyonuridae	1	-	-	-	-	1	-	-	-	-
	Heptageniidae	-	-	-	-	-	-	1	1	-	-
	Leptophlebiidae	-	1	1	1	-	-	-	-	-	-
Plecoptera	Perlodideae	1	-	1	-	1	-	-	-	1	1
Total		2	1	2	1	1	1	1	1	1	1

July 2009

Order	Family	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Ephemeroptera	Ecdyonuridae	1	2	3	6	3	5	-	-	-	2
Plecoptera	Nemouridae	-	-	-	-	-	-	6	-	-	-
	Taeniopterygidae	-	-	-	-	-	-	-	2	-	-
Trichoptera	Glossosomatidae	-	-	-	1	1	-	-	-	-	-
	Leptoceridae	-	-	-	-	-	2	-	-	-	-
	Molannidae	-	-	-	1	1	-	-	1	-	-
Hemiptera	Mesovelidae	-	-	-	-	-	-	-	-	-	-
Diptera	Chironomidae	1	3	5	1	-	-	3	-	17	1-
Megaloptera	Corydalidae	-	-	-	-	-	-	-	-	-	-
Total		2	5	8	9	5	7	9	3	17	12

Order	Family	Hutong HEP, Stage-1					Hutong HEP, Stage-2				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Ephemeroptera	Ecdyonuridae	-	-	1	-	-	-	2	-	1	-
Plecoptera	Nemouridae	-	-	-	-	1	-	-	3	-	1
	Taeniopterygidae	-	-	3	-	-	-	5	-	1	-
Trichoptera	Glossosomatidae	-	-	-	-	-	1	-	-	-	3
	Leptoceridae	-	-	1	-	-	2	-	-	-	-
	Molannidae	3	2	-	-	5	-	3	5	3	-
Hemiptera	Mesovelidae	-	-	-	-	-	1	-	-	-	-
Diptera	Chironomidae	-	3	-	-	-	1	-	-	-	5
Megaloptera	Corydalidae	1	-	-	1	-	-	-	-	-	1
Total		4	5	5	1	6	5	10	8	5	10

Order	Family	Demwe Upper HEP					Demwe Lower HEP				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Ephemeroptera	Ecdyonuridae	5	-	-	-	2	18	1	7	2	2
Plecoptera	Nemouridae	-	2	-	-	-	-	-	-	-	-
	Taeniopterygidae	-	-	2	-	-	-	-	-	3	-
Trichoptera	Glossosomatidae	4	-	-	3	-	-	-	-	-	-
	Leptoceridae	-	5	-	-	-	-	-	1	-	1
	Molannidae	-	-	-	-	-	11	6	-	1	-
Hemiptera	Mesovelidae	1	-	-	2	-	-	-	-	-	-
Diptera	Chironomidae	-	-	-	-	6	-	-	-	-	-
Megaloptera	Corydalidae	-	-	6	2	-	-	-	-	-	-
Total		10	7	8	7	8	29	7	8	6	3

August 2009

Order	Family	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Ephemeroptera	Ecdyonuridae	2	1	2	1	2	2	-	3	2	-
Plecoptera	Nemouridae	-	-	3	-	-	-	-	-	-	4
	Perlidae	4	-	-	3	-	4	1	-	1	2
Trichoptera	Hydropsychidae	-	-	-	-	-	-	-	-	-	-
Megaloptera	Corydalidae	-	-	-	-	-	-	-	-	-	-
Total		6	1	5	4	2	6	1	3	3	6
Order	Family	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Ephemeroptera	Ecdyonuridae	3	2	2	6	4	-	-	-	3	-
Plecoptera	Nemouridae	-	-	-	-	-	2	2	-	4	1
	Perlidae	-	-	-	-	-	-	-	3	-	-
Trichoptera	Hydropsychidae	-	-	-	-	-	-	1	-	-	-
Megaloptera	Corydalidae	-	-	-	-	-	-	-	2	-	-
Total		3	2	2	6	4	2	3	5	7	1
Order	Family	**Demwe Upper HEP**					**Demwe Lower HEP**				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Ephemeroptera	Ecdyonuridae	5	-	1	2	3	2	1	2	2	1
Plecoptera	Nemouridae	-	2	-	-	-	-	-	-	-	-
	Perlidae	-	3	-	2	1	2	-	-	2	1
Trichoptera	Hydropsychidae	-	-	1	-	-	-	1	2	2	-
Megaloptera	Corydalidae	1	-	-	1	1	-	-	-	-	-
Total		6	5	2	5	5	4	2	4	6	2

September 2009

Order	Family	Kalai HEP, Stage-1					Kalai HEP, Stage-2				
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Ephemeroptera	Ecdyonuridae	-	1	2	-	-	-	-	5	-	2
Plecoptera	Peltoperlidae	-	-	-	-	-	1	-	-	-	-
	Perlidae	3	-	3	3	2	-	-	2	3	-
Hemiptera	Corixidae	-	1	-	-	-	-	2	-	-	-
Diptera	Tabanidae	-	-	-	-	-	-	-	-	-	-
Total		3	2	5	3	2	1	2	7	3	2
Order	Family	**Hutong HEP, Stage-1**					**Hutong HEP, Stage-2**				
		S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Ephemeroptera	Ecdyonuridae	-	-	6	-	2	2	4	9	3	2
Plecoptera	Peltoperlidae	-	2	2	3	-	-	-	-	-	-
	Perlidae	3	1	8	-	-	1	-	2	-	1
Hemiptera	Corixidae	-	-	-	1	2	-	-	-	-	-
Diptera	Tabanidae	-	-	-	-	-	-	-	-	-	-
Total		3	3	16	4	4	3	4	11	3	3
Order	Family	**Demwe Upper HEP**					**Demwe Lower HEP**				
		S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Ephemeroptera	Ecdyonuridae	2	2	1	3	1	3	4	3	1	2
Plecoptera	Peltoperlidae	-	-	-	-	1	-	-	-	-	-
	Perlidae	-	-	-	2	-	2	-	2	1	-
Hemiptera	Corixidae	-	2	1	-	-	-	2	-	-	3
Diptera	Tabanidae	-	-	-	-	2	-	-	1	-	-
Total		2	4	2	5	4	5	6	6	2	5

ANNEXURE-XI

Primary Productivity at various sampling sites

ANNEXURE-XI

Primary Productivity at various sampling sites

April 2009

Productivity	**Kalai HEP Stage-1**					**Kalai HEP Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Gross Primary Productivity ($mgC/m^3/day$)	18.7	37.5	28.1	28.1	37.5	37.5	37.5	37.5	37.5	28.1
Net Primary Productivity ($mgC/m^3/day$)	12.5	37.5	25.0	25.0	25.0	25.0	37.5	25.0	25.0	25.0
Productivity	**Hutong HEP Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Gross Primary Productivity ($mgC/m^3/day$)	18.7	28.1	28.1	18.7	28.1	37.5	37.5	37.5	28.1	37.5
Net Primary Productivity ($mgC/m^3/day$)	12.5	12.5	25.0	12.5	12.5	25.0	25.0	37.5	12.5	25.0
Productivity	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Gross Primary Productivity ($mgC/m^3/day$)	37.5	46.9	56.3	28.1	18.8	37.5	28.1	28.1	18.7	28.1
Net Primary Productivity ($mgC/m^3/day$)	25.0	37.5	50.0	12.5	12.5	12.5	12.5	25.0	12.5	12.5

May 2009

Productivity	**Kalai HEP Stage-1**					**Kalai HEP Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Gross Primary Productivity ($mgC/m^3/day$)	31.2	46.8	46.8	62.5	93.7	46.8	78.1	62.5	78.1	78.1
Net Primary Productivity ($mgC/m^3/day$)	15.6	15.6	31.2	31.2	46.8	31.2	46.8	31.2	31.2	62.5
Productivity	**Hutong HEP Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Gross Primary Productivity ($mgC/m^3/day$)	46.8	62.5	62.5	46.8	62.5	78.1	62.5	78.1	31.2	31.2
Net Primary Productivity ($mgC/m^3/day$)	15.6	31.2	31.2	15.6	23.4	31.2	15.6	46.8	15.6	15.6
Productivity	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Gross Primary Productivity ($mgC/m^3/day$)	62.5	46.8	46.8	31.2	31.2	46.8	62.5	62.5	78.1	78.1
Net Primary Productivity ($mgC/m^3/day$)	31.2	31.2	15.6	15.6	15.6	15.6	15.6	31.2	31.25	31.2

June 2009

Productivity	**Kalai HEP Stage-1**					**Kalai HEP Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Gross Primary Productivity ($mgC/m^3/day$)	78.1	78.1	93.8	46.9	78.1	93.7	46.9	78.1	62.5	78.1
Net Primary Productivity ($mgC/m^3/day$)	31.3	23.4	23.4	15.6	46.9	46.9	15.6	31.2	46.9	46.9
Productivity	**Hutong HEP Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Gross Primary Productivity ($mgC/m^3/day$)	46.9	46.9	62.5	62.5	31.2	46.9	78.1	62.5	62.5	62.5
Net Primary Productivity ($mgC/m^3/day$)	15.6	15.6	54.7	15.6	23.4	31.3	54.7	23.4	15.6	31.3
Productivity	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Gross Primary Productivity ($mgC/m^3/day$)	62.5	62.5	54.7	46.9	46.9	78.1	62.5	46.9	93.7	46.9
Net Primary Productivity ($mgC/m^3/day$)	15.6	15.6	31.3	15.6	15.6	46.9	15.6	15.6	62.5	31.2

July 2009

Productivity	**Kalai HEP Stage-1**					**Kalai HEP Stage-2**				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Gross Primary Productivity ($mgC/m^3/day$)	18.7	17.5	18.1	18.1	17.5	17.5	17.5	17.6	17.5	18.1
Net Primary Productivity ($mgC/m^3/day$)	11.5	13.5	12.0	12.5	13.0	12.0	13.5	12.3	25.0	12.2
Productivity	**Hutong HEP Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Gross Primary Productivity ($mgC/m^3/day$)	18.7	18.1	18.1	18.7	18.1	17.5	17.5	17.5	18.1	17.5
Net Primary Productivity ($mgC/m^3/day$)	12.5	12.5	12.0	12.5	12.5	11.5	12.4	13.5	12.5	12.0
Productivity	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Gross Primary Productivity ($mgC/m^3/day$)	17.5	16.9	16.3	18.1	18.8	17.5	18.1	18.1	18.7	18.1
Net Primary Productivity ($mgC/m^3/day$)	14.0	13.5	12.0	12.5	12.5	12.5	12.5	25.0	12.5	12.5

August 2009

Productivity	Kalai HEP Stage-1					Kalai HEP Stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Gross Primary Productivity (mgC/m^3/day)	18.2	18.8	17.8	18.5	19.7	16.8	18.1	18.5	18.1	18.1
Net Primary Productivity (mgC/m^3/day)	12.6	13.6	11.2	12.2	14.8	11.2	12.8	12.2	12.2	12.5
Productivity	**Hutong HEP Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Gross Primary Productivity (mgC/m^3/day)	16.8	16.5	16.5	16.8	16.5	18.1	16.5	17.1	17.2	17.2
Net Primary Productivity (mgC/m^3/day)	11.6	10.2	12.2	11.6	12.4	13.2	11.6	10.8	11.6	12.6
Productivity	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Gross Primary Productivity (mgC/m^3/day)	16.5	16.8	16.8	17.2	16.2	16.8	16.5	16.5	17.1	17.1
Net Primary Productivity (mgC/m^3/day)	11.2	11.4	11.6	12.6	11.6	11.6	12.6	11.2	12.25	11.2

September 2009

Productivity	Kalai HEP Stage-1					Kalai HEP Stage-2				
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Gross Primary Productivity (mgC/m^3/day)	78.1	78.1	93.8	46.9	78.1	93.7	46.9	78.1	62.5	78.1
Net Primary Productivity (mgC/m^3/day)	31.3	23.4	23.4	15.6	46.9	46.9	15.6	31.2	46.9	46.9
Productivity	**Hutong HEP Stage-1**					**Hutong HEP Stage-2**				
	S11	**S12**	**S13**	**S14**	**S15**	**S16**	**S17**	**S18**	**S19**	**S20**
Gross Primary Productivity (mgC/m^3/day)	46.9	46.9	62.5	62.5	31.2	46.9	78.1	62.5	62.5	62.5
Net Primary Productivity (mgC/m^3/day)	15.6	15.6	54.7	15.6	23.4	31.3	54.7	23.4	15.6	31.3
Productivity	**Demwe Upper HEP**					**Demwe Lower HEP**				
	S21	**S22**	**S23**	**S24**	**S25**	**S26**	**S27**	**S28**	**S29**	**S30**
Gross Primary Productivity (mgC/m^3/day)	62.5	62.5	54.7	46.9	46.9	78.1	62.5	46.9	93.7	46.9
Net Primary Productivity (mgC/m^3/day)	15.6	15.6	31.3	15.6	15.6	46.9	15.6	15.6	62.5	31.2

ANNEXURE-XII

Assessment of Impact of Peaking Power Operations of Dibang, Siang Lower and Demwe Lower HEPs on Dibru Saikhowa National Park

ANNEXURE-XII

ASSESSMENT OF IMPACT OF PEAKING POWER OPERATIONS OF DIBANG, SIANG LOWER AND DAMWE LOWER HEPs ON DIBRU SAIKHOWA NATIONAL PARK

1. INTRODUCTION

The Dibru-Saikhowa National Park is situated on the Left Bank of the river Brahmaputra in the extreme east of Assam and falls between the following geographical coordinates: Latitudes: 27° 30' – 27° 45'N, Longitudes: 95°10' – 95° 45'E. Brahmaputra River is mainly formed by confluence of three rivers namely Siang River, Dibang River and Lohit River. Series of hydropower projects are proposed on these three tributaries of Brahmaputra River upstream of confluence point out of which the three large projects located closest to it are, Demwe Lower HEP (1750 MW) on Lohit River, Dibang Multipurpose HEP (3000 MW) on Dibang River and Lower Siang HEP (2700 MW) on Siang River.

During the lean season months, i.e. from November to February, when the river discharges have considerably reduced, these projects operate at their installed capacities during peaking hours of the day (which may vary from duration of 3 hours to 6.5 hours depending upon the water availability). This essentially means that these projects will release only environmental flows during the non-peaking hours (non-peaking hours could varies from 17.5 to 21 hours every day) and in turn conserve the river discharges in its reservoir so as to supply peaking power by generating at their installed capacities during the remaining 3 hours to 6.5 hours in a day. It is thus apprehended by many that during peaking hours of the day, water flow below the downstream of each of these dams will vary on a daily basis and this will cause artificial floods during those 3 hours when these plants are in the peaking mode.

A model study was conducted by DHI to assess the impacts on seasonal flows to peaking power operations. The study has been done using MIKE 11 model.

The purpose of this model study is to simulate this situation and based on available data for these 3 projects simulate the hydraulic conditions to quantify the flows and stage during the lean months. The effect on the hydraulic conditions is to be studied particularly at one site on the Brahamputra river near the Dibru-Saikhowa National park which is a place of importance from the point of view of natural habitat of many species. Dibru-Saikhowa is actually a riverine island having rich bio-diversity.

2. OBJECTIVES AND ASSUMPTIONS FOR THE STUDY

The objectives of the study were:

1. For studying the effect of variation due to peaking power generation on Dibru-Saikhowa National Park the worst case of 3 hours peaking and 21 hours of non-peaking is to be considered during the January-February months.
2. Effect of the three individual projects to be considered in addition to cumulative effect of all the 3 projects peaking at the same time.

The following assumptions are made:

- It is to be assumed that in the worst case scenario all the 3 projects are peaking for 3 hours in a day (24 hours) and their peaking time is same from 8 AM to 11 AM and all these 3 projects will continue generating at their installed capacities during this duration. For the remaining 21 hours of the day, they will release the mandatory environmental flow.
- Three River cross sections at Dibru-Saikowa have been considered to study the impact of the flow variations.

3. SCOPE OF THE STUDY

Existing MIKE 11 models of the three rivers were re-established and applied to simulate the following cases:

1. Propagation of a flood wave from Demwe Lower HE project and resulting water level variation at the confluence
2. Propagation of a flood wave from Dibang HE project and resulting water level variation at the confluence
3. Propagation of a flood wave from Lower Siang HE project and resulting water level variation at the confluence
4. Combined effect of release of water from all three projects at the same time, and simulation of the resulting water level variation at the confluence
5. Without Project conditions (normal flow time series as provided by the Client)

Two scenarios were simulated:

- The river network before 1998
- The river network after 2003 (present case) following change of course of Lohit River

4. DATA

4.1 River channel alignments and cross-sections

Before the year 1998, the flow scenario of Lohit, Dibang and Siang was different as compared to present day. Before year 1998, Lohit River used to meet with Dibang River and then the combined flow of Lohit and Dibang River used to meet with Siang River before Dibru Saikhowa National Park. But from the year 1998 to 2003, the transition of flow path has occurred in Lohit River and as consequence to this the flow path of Lohit has changed. From the year 2003 Dibang river directly meets with Siang River on the northern boundary and before DibruSaikhowa National Park while Lohit River flows along the Southern boundary of DibruSaikhowa National Park and then after passing along the southern boundary of DibruSaikhowa National Park, flow of Lohit River meets with the combined flow of Siang and Dibang River i.e. Brahmaputra River. The two scenarios i.e. Flow scenario before 1998 and after 2003 are given in Figures-1 and 2 respectively.

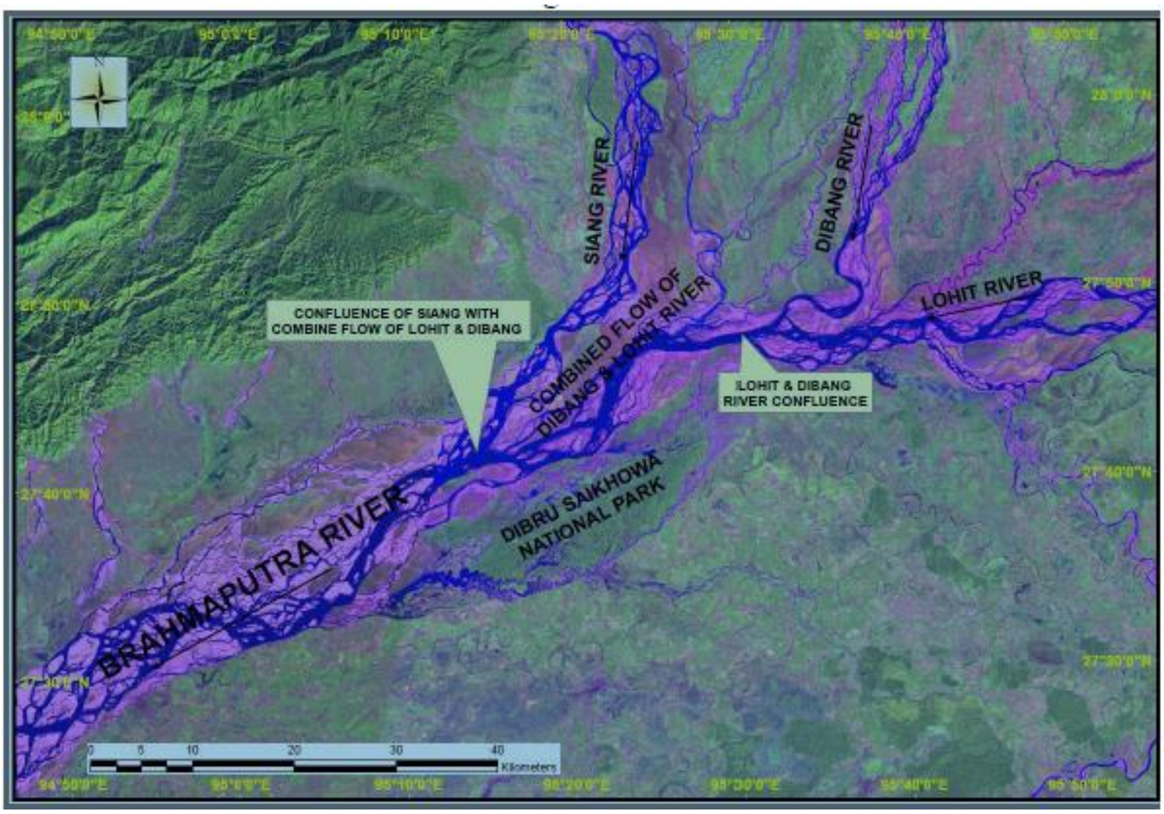


Figure -1 Flow scenario on Brahmaputra River before 1998

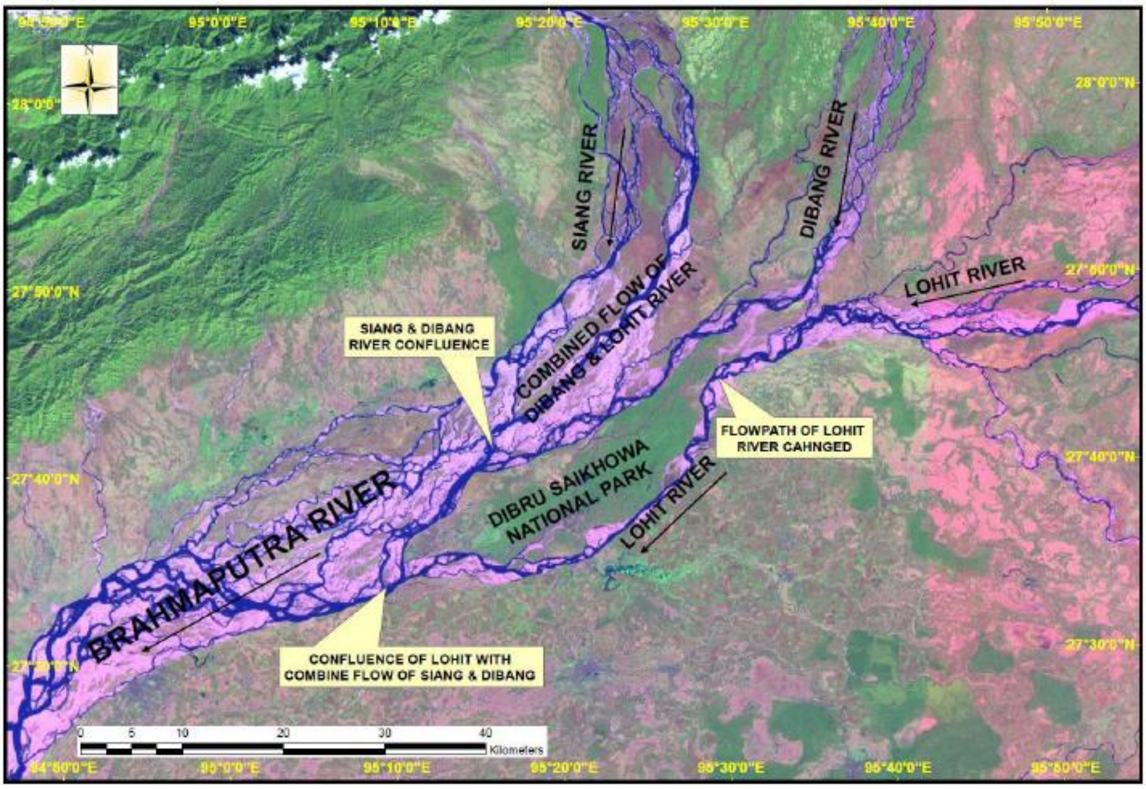


Figure-2 Flow scenario on Brahmaputra River after 2003

4.2 Flow data

The river discharge data in the lean season is controlled by the reservoirs with environmental flow outside the power production period and maximum capacity flow during the power production.

4.3 Scenarios

A MIKE11 model is set up for two different scenarios. The model is combined of all three rivers (Dibang, Lohit and Siang). For each scenario five different cases are simulated and the same are listed as below:

- When only Demwe Lower is constructed and is doing peaking for 3 hours in a day while Dibang and Siang are flowing in their natural regimes.
- When only Lower Siang is constructed and is doing peaking for 3 hours in a day while Lohit and Dibang are flowing in their natural regimes.
- When only Dibang is constructed and is doing peaking for 3 hours in a day while Lohit and Siang are flowing in their natural regimes.
- All three projects are constructed and are peaking for 3 hours.
- No Project scenario.

5. SCENARIO I - RIVER ALIGNMENT AS PER PRESENT DAY

5.1 Network

MIKE11 model is set up for three rivers Siang, Dibang and Lohit (Figure-3). Dibang meets with Siang at chainage of 60 km downstream from Dam site of Siang Lower HEP on Siang River and 82 km downstream of dam site of Dibang Multi-purpose project on

Dibang River. Likewise, Lohit flows along the southern bank of Dibru-Saikowa Park and meets Siang at chainage of 75.53 km on Siang River and 114.3 km on Lohit River downstream of dam site of Demwe Lower HEP. The MIKE 11 river setup is depicted in Figure-3.

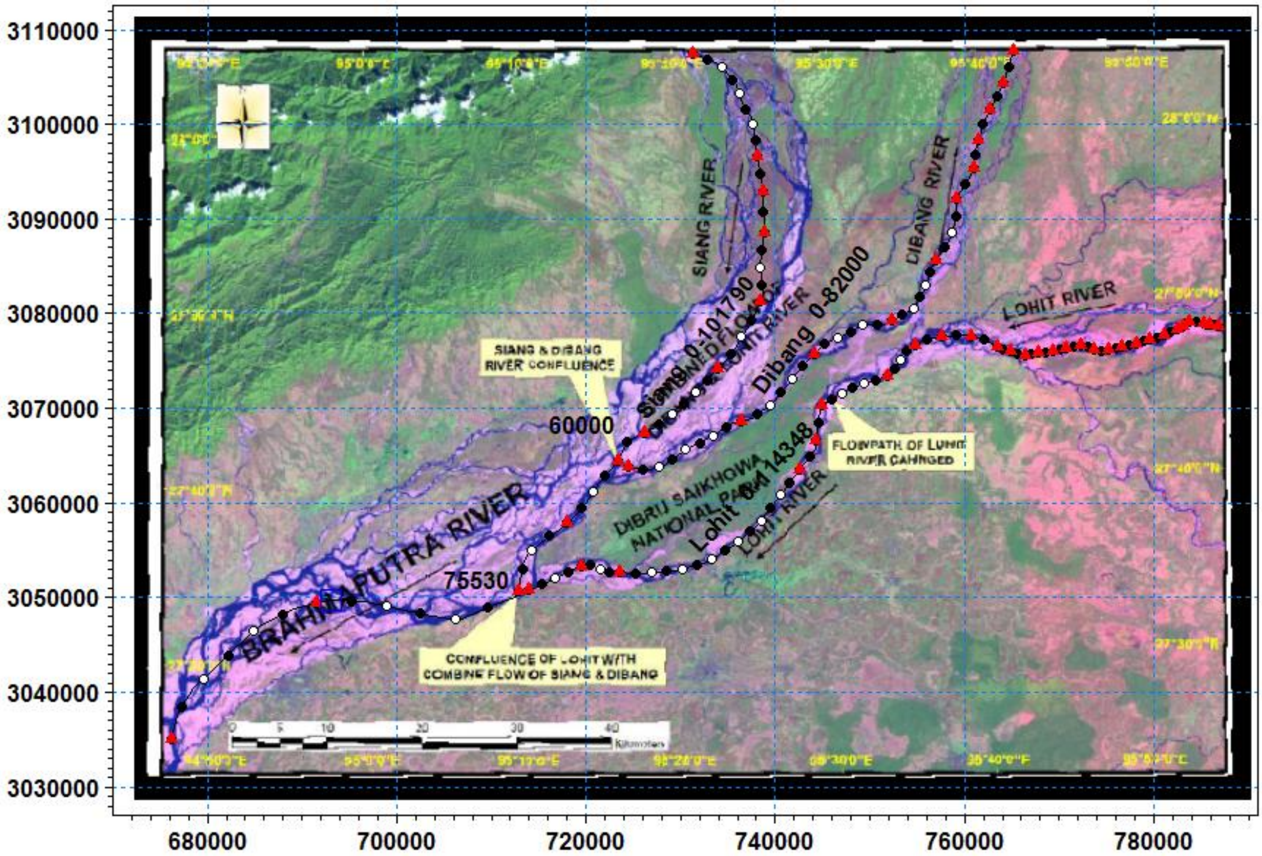


Figure -3: MIKE 11 Network for present scenario (White and black circles are h and q computational points, red triangles are x-sections)

5.2 Cross-section

Cross-sections supplied by client is used in the model. The data was checked and modified to represent the river correctly. The river network with cross-sections in plain view is shown in Figure-4. The quality check reveals that cross-sections are covering both rivers which is not a correct representation of the river. Subsequently, it was decided to correct the cross-sections by dividing them into two each with the correct width. Figures-5 and 6 show the cross-section before and after correction.

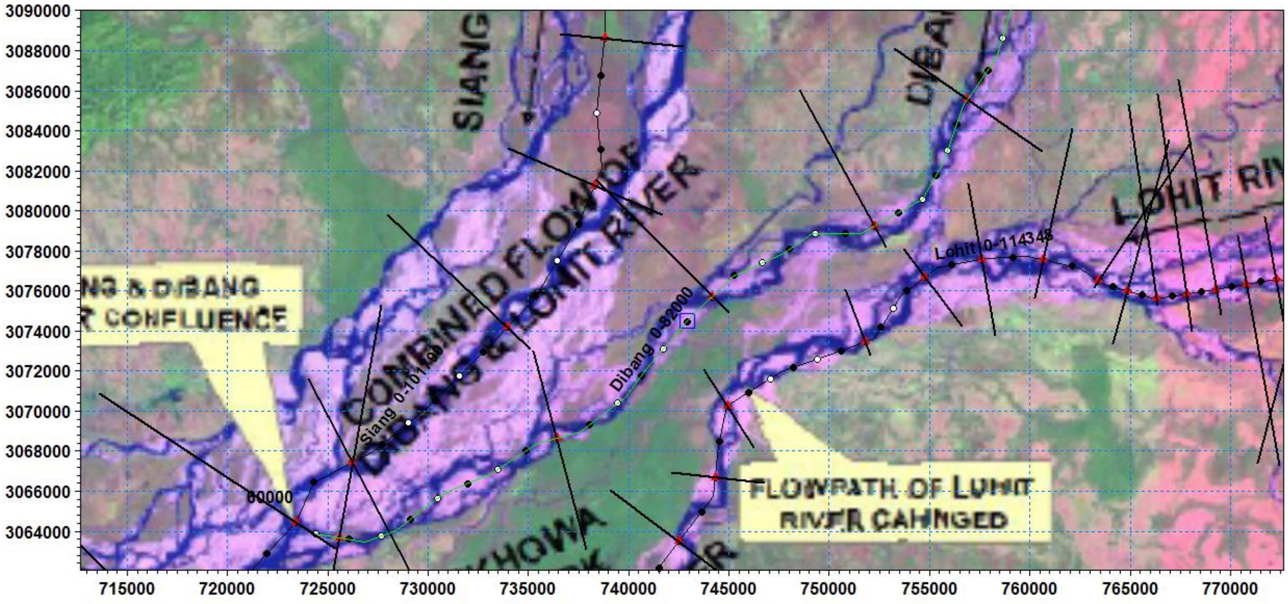


Figure-4 Plain view showing network with x-section

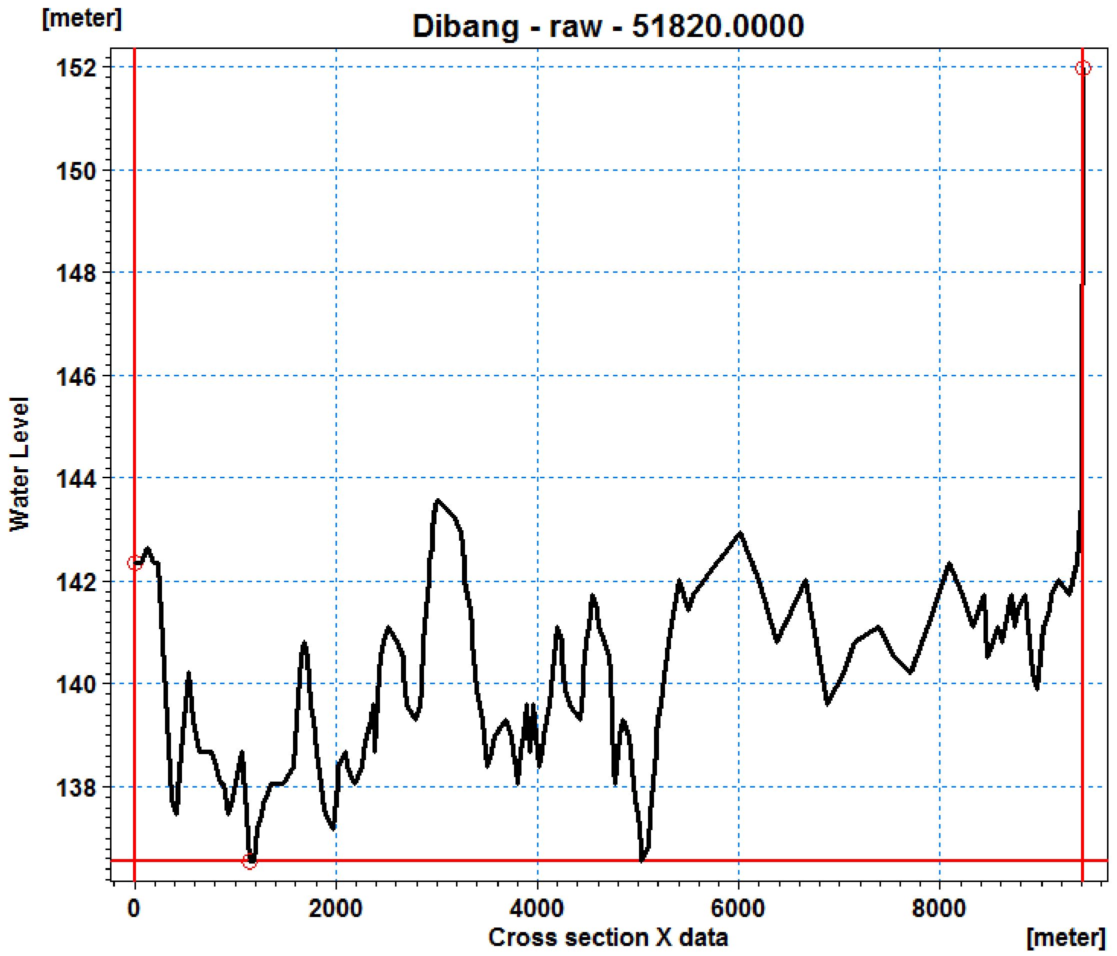


Figure-5: Cross-section before correction (left and right side vertical line represents left and right bank, red horizontal line represents lowest bed level)

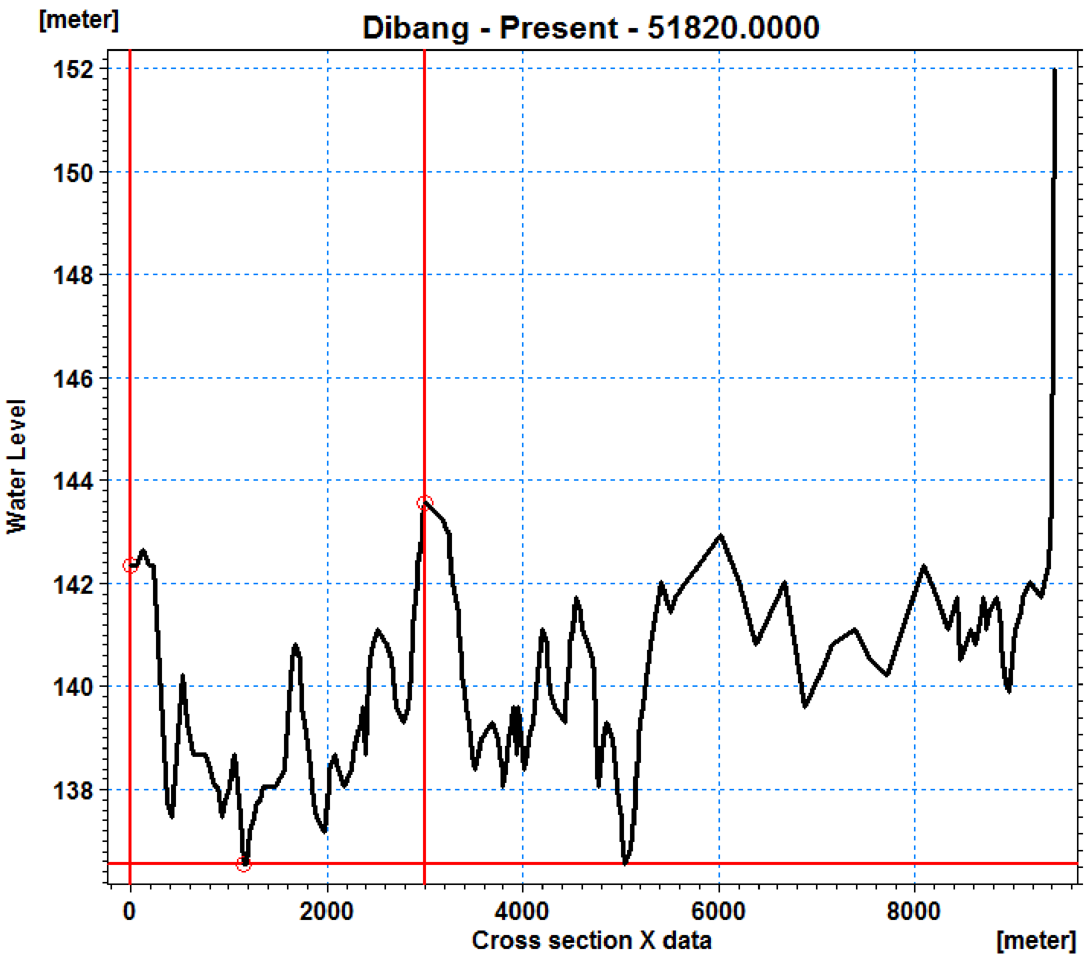


Figure-6 Cross-section after correction (left and right side vertical line represents left and right bank, red horizontal line represents lowest bed level)

The spacing between cross-sections is 5km or more. The maximum grid spacing (max dx) for the model is chosen as 5 km, and it is automatic to interpolate cross-section.

5.3 Boundary condition

Discharge is used as upstream boundary. For normal flow condition constant discharge as listed in Table-1 was used.

The monthly River flows for the average year for each of the three projects at their respective dam sites are as tabulated below. As the time period of concern is the non-monsoon period, the discharge corresponding to January is used.

Table-1: Monthly averaged normal flow for the three projects

S. No.	Month	Discharge (cumec) of Siang River at Lower Siang dam site	Discharge (cumec) of Lohit River at Demwe Lower dam site	Discharge (cumec) of Dibang River at Dibang dam site
1	June	3408.37	831.00	1548.6
2	July	6327.50	1536.33	603.2
3	Aug	8870.13	1519.33	1111.5
4	Sep	7473.13	756.00	484.1
5	Oct	6769.60	709.33	799.6
6	Nov	4064.73	551.67	462.7
7	Dec	1936.30	439.67	310.4

S. No.	Month	Discharge (cumec) of Siang River at Lower Siang dam site	Discharge (cumec) of Lohit River at Demwe Lower dam site	Discharge (cumec) of Dibang River at Dibang dam site
8	Jan	1285.17	384.00	352
9	Feb	1020.80	358.00	384.5
10	Mar	1004.13	330.67	502.4
11	Apr	1283.93	445.00	817.2
12	May	2039.70	830.00	838.5

To represent the release from each dam after construction of each project and considering 3 hours of flow peaking, a hydrograph is impinged at the upstream boundary. The time series for reference from three dams is shown in Figure-7 and Time series for peaking at three dams is shown in Figure-8. The figures shows hydrograph for release of water for all three projects.

The design discharge (flow release) during full power production at the three dams is given in Table-2.

Table-2: Design discharge (release flow) for the three projects

Dam	Discharge (cumec) of Siang River at Lower Siang dam site	Discharge (cumec) of Lohit River at Demwe Lower dam site	Discharge (cumec) of Dibang River at Dibang dam site
Design discharge	5440	1729	1431.61

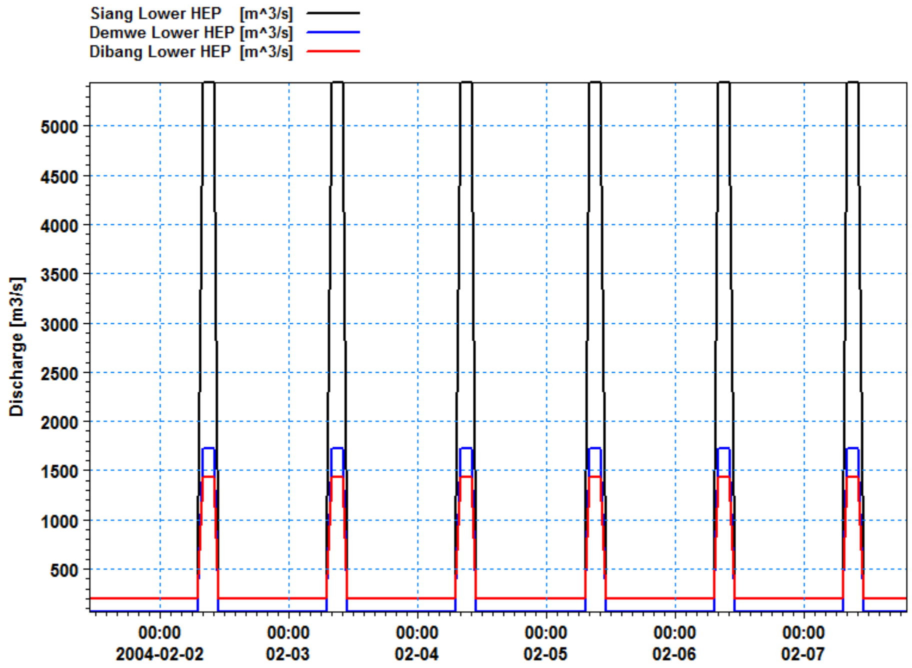


Figure-7 Time series for release from three Dams

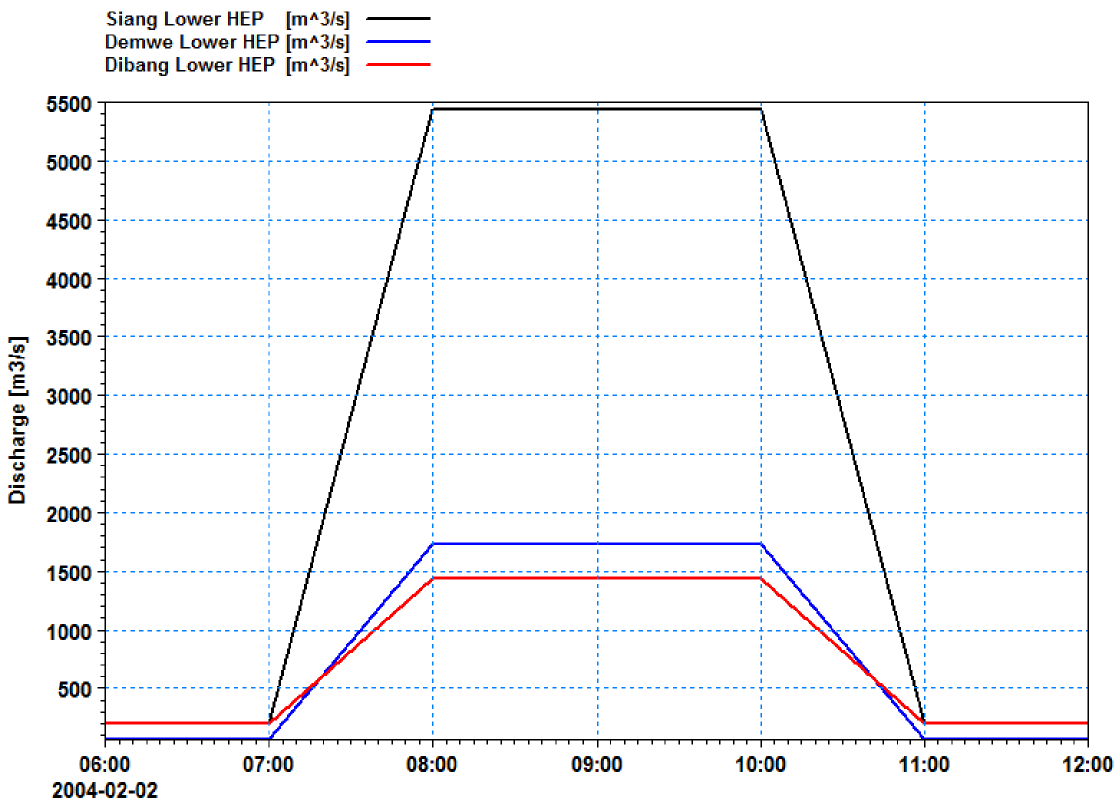


Figure-8: Time series at peaking from three Dams

Runoff coming from intermediate catchment between dam sites to confluence of Brahmaputra with Lohit River is used as distributed source. The Catchment area of Rivers at various locations is given in Table-3.

Table-3: Catchment areas for the three rivers

River	Lohit River		Siang River		Dibang River	
Location	At Demwe Lower dam site	At Confluence of Lohit with Brahamputra	At Siang Lower dam site	At Confluence of Lohit with Brahamputra	At Dibang dam site	At Confluence of Lohit with Brahamputra
Catchment Area (Sq km)	20,174	28,094	2,50,594	2,51,719	11,276	13,351

Runoff for each intermediate catchment is calculated as ratio between catchment up to dam and catchment up to confluence multiply with monthly discharge given in Table-4 shows the monthly River flows for the average year for each intermediate catchment.

Table-4: Lateral inflow (runoff from intermediate catchment areas) for the three rivers (Unit: Cumec)

S. No.	Month	Discharge for intermediate catchment of Lower Siang	Discharge for intermediate catchment of Dibang	Discharge for intermediate catchment of Lohit
1	June	29.31	204.33	887.48
2	July	32.07	542.32	1038.05
3	August	35.17	239.81	771.73
4	September	31.92	161.16	526.01
5	October	20.16	133.93	424.52
6	November	10.73	63.38	314.74
7	December	6.91	57.98	265.88
8	January	4.62	60.87	118.90
9	February	4.66	120.05	122.27
10	March	5.89	72.74	289.92
11	April	8.19	70.88	294.25
12	May	12.59	299.84	683.55

At downstream a constant water level of 106.2 m is used. This corresponds to the natural depth for the natural flow. It is obviously less accurate during the peaking hours of flow release. For that reason, it has been thoroughly tested, that the downstream boundary is sufficiently downstream not to have any influence on the water level results (next section) in the area of concern.

5.4 Results and Discussions

The model is run for five different cases. It is simulated for six days. There is no data to calibrate the model. Thus, sensitivity analysis is done with different manning's n. Three River cross sections at Dibru-Saikowa have been considered to study the impact of the flow variations. These sections are named Dibru-saikowa cross section -I, Dibrusaikowa cross section -II and Dibru-Saikowacross section -III. These cross-sections are of Brahamputra River and Lohit River. From the cross sections of Brahamputra at Dibru-Saikowa it is seen that the riverine islands are fairly stable and the lowest elevations of the Dibru-Saikowa Park at these 3 sections are at the following elevations are given in Table-5.

Table-5: Minimum elevations at three sites

Name of Section	Dibru -Saikowa Cross section no -I	Dibru -Saikowa Cross section no -II	Dibru -Saikowa Cross section no -III
Lowest Brahamputra River Elevation (rnasl)	112.09	108.00	107.89
Lowest Lohit River Elevation (masl)	116.13	114.00	111.25
Lowest Bank elevation; Lowest Elevation of the Park (masl)	125.70	117.30	115.50

Figure-9 shows the position of cross-section I, cross-section II and Cross-section III on Brahmaputra River and Lohit River respectively.

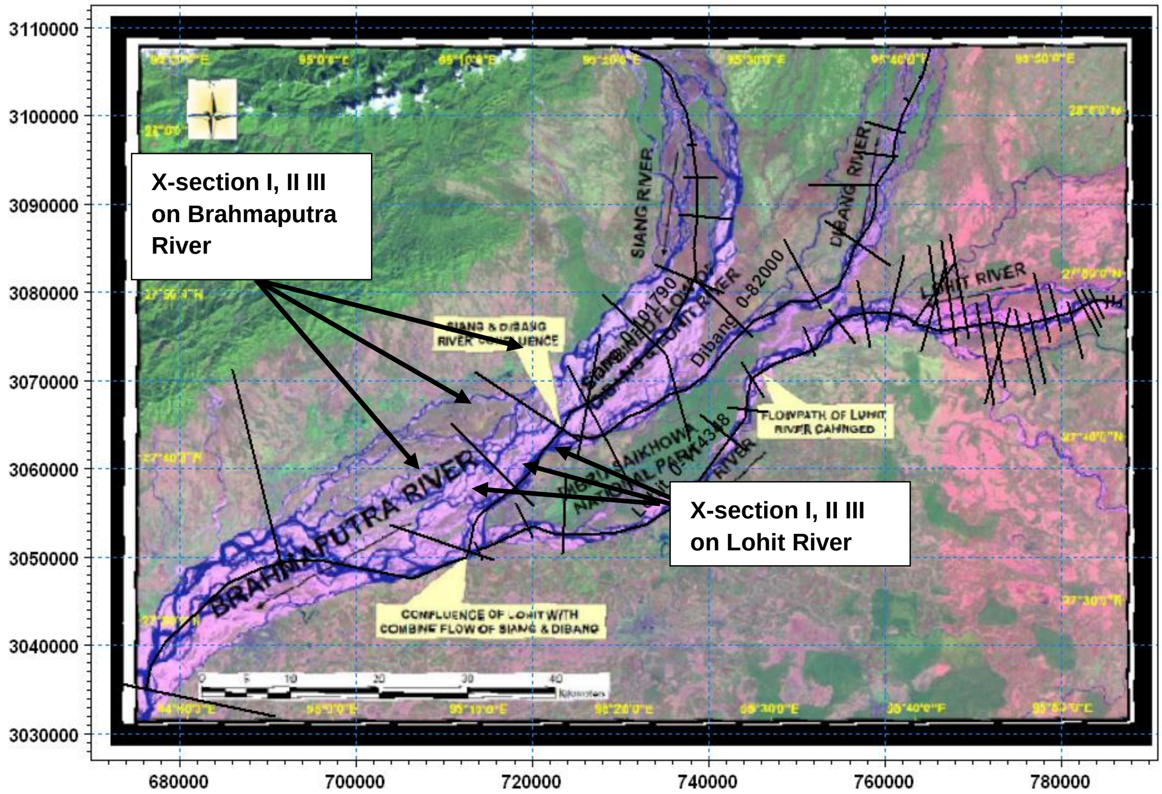


Figure-9: Plan view showing position of Cross-section I, II and III on Brahmaputra and Lohit River

5.4.1 Case1 Demwe Lower Project Only

The model set up as described above is used. In the case with the present river channel alignment, Lohit River is flowing freely without any interference from Dibang River and Siang River at Dibru-Saikhowa national park. Three cross sections at Dibru-Saikhowa National park (on southern boundary) have been considered. The design discharge of 1729 m^3/s is released in the river for 3 hours after 21 hours of non-peak (when only mandatory environmental flow is released downstream of the dam).

It is seen when comparing flow hydrograph at the dam site and Dibru Saikhowa National Park, that the flow hydrograph at various cross sections of Dibru-Saikowa is attenuated significantly due to the long travel distance (105 km) from the dam as well as storage volumes along the river. Figure-10 shows the hydrograph at three different cross-sections on Lohit River. From the hydro graph it may be seen that the maximum flow in the Lohit River near dam site (1729 m^3/s) is attenuated to 464.3 m^3/s at the DibruSaikowa Cross section no –I.

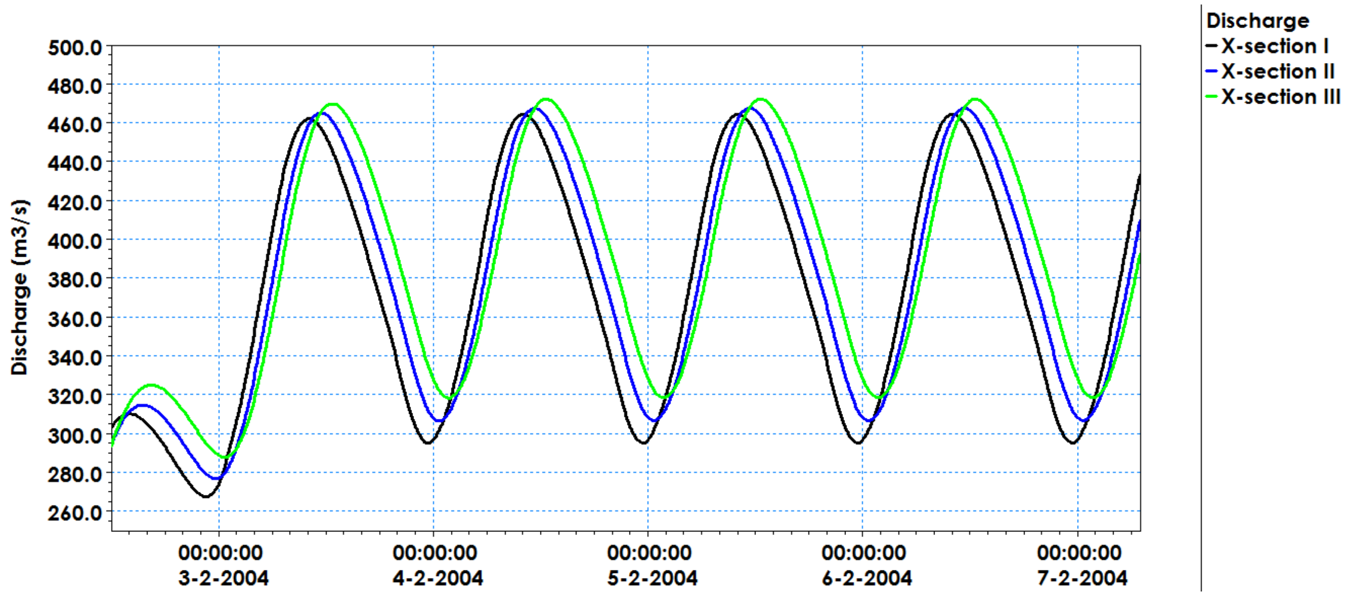


Figure-10 Discharge hydrograph at Cross-section I, II and III on Lohit River

5.4.2 Case2: Lower Siang Project Only

The same set up as described in case 1 is used. Here a design discharge of 5440 m^3/s is released at upstream of Siang for 3 hours after 21 hours of non-peak (when only mandatory environmental flow is released downstream of the dam). Constant discharge is used at the upstream of Dibang and Lohit. Figure-11 shows the discharge at three different cross-sections on Brahmaputra. It shows the peak is attenuated to 2220 m^3/s.

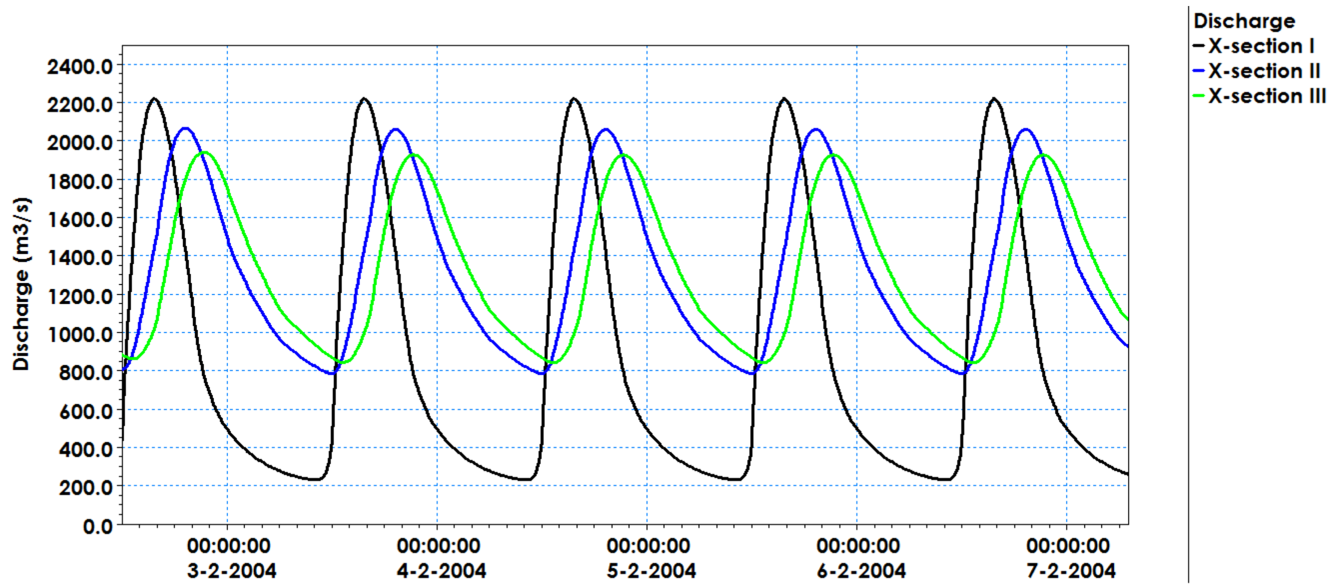


Figure-11 Discharge hydrograph at Cross-section I, II and III on Brahmaputra River

5.4.3 Case 3: Dibang Project Only

The model set up remains the same as described above. A design discharge of 1431.61 m^3/s is released at upstream of Dibang for 3 hours after 21 hours of non-peak (when only mandatory environmental flow is released downstream of the dam). Constant discharge is used at upstream of Siang and Lohit. Figure-12 shows the discharge at three different cross-sections on Brahmaputra. It shows peak is attenuated to 600 m^3/s on Dibang River.

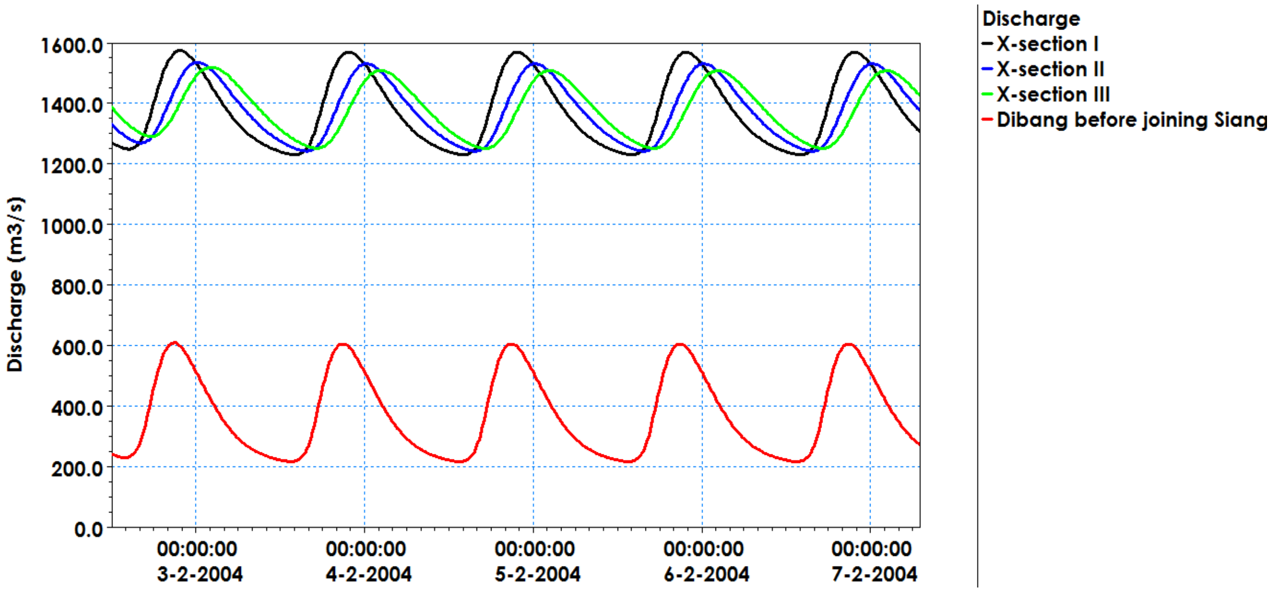


Figure-12 Discharge hydrograph at Cross-section I, II and III on Brahmaputra River and on Dibang River

5.4.4 Case 4: All Three Projects Combined

Design discharge at upstream of all three rivers are used. Figures-13 and 14 shows discharge hydrograph at three different cross-sections on Brahmaputra and Lohit River respectively. It shows attenuated discharge is 2233 m^3/s.

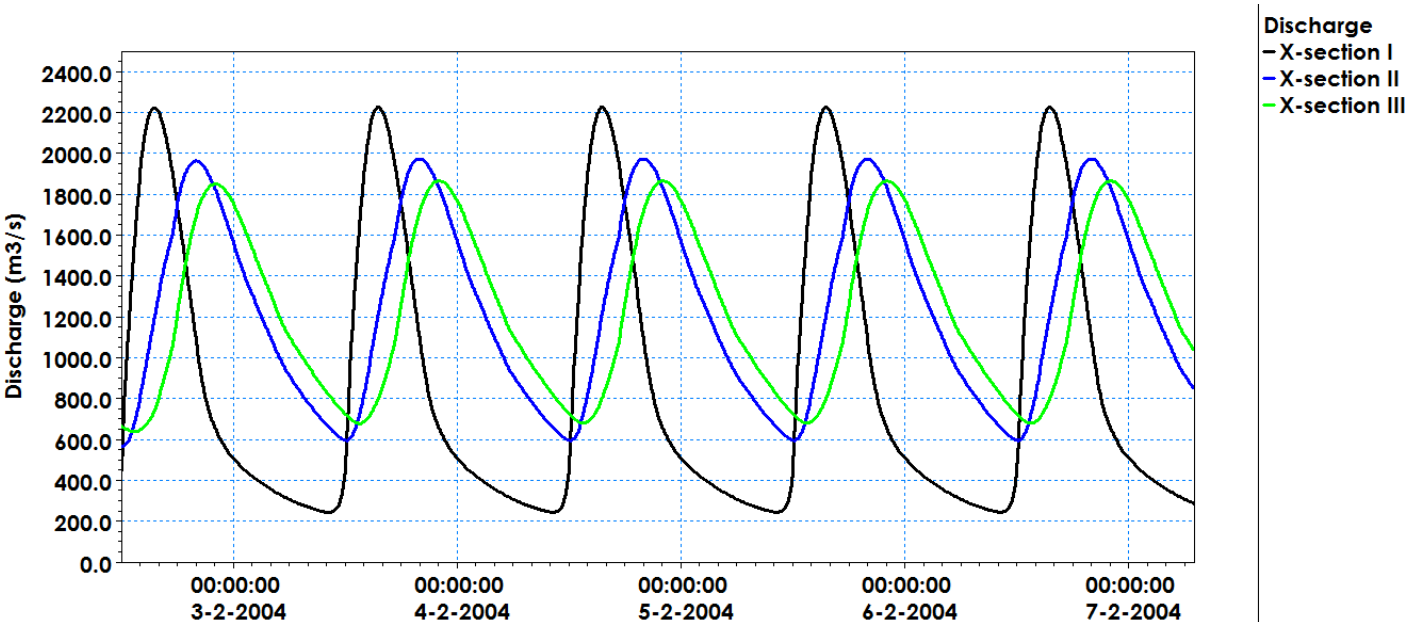


Figure-13 Discharge hydrograph at Cross-section I, II and III on Brahmaputra River

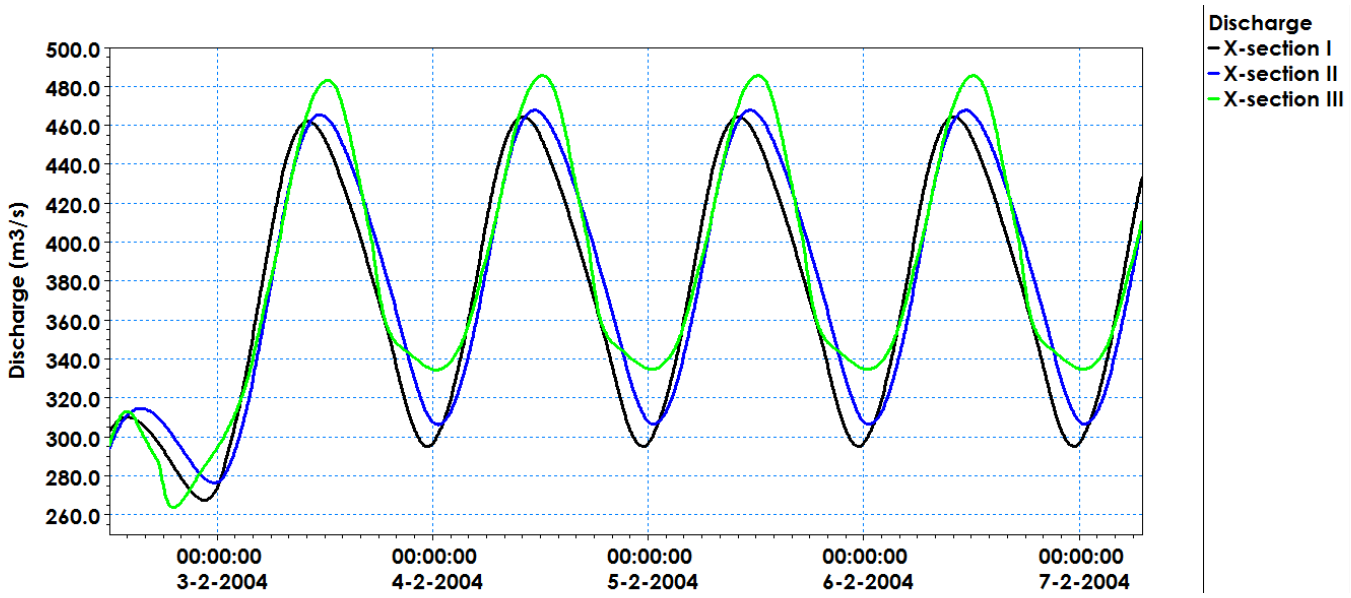


Figure-14 Discharge hydrograph at Cross-section I, II and III on Lohit River

5.4.5 Case 5: No Projects Implemented

When no project is developed all the rivers i.e. Lohit River, Siang River and Dibang River are flowing in their natural regimes. Constant discharge is impinged at upstream of each river.

5.4.6 Sensitivity test with different Manning's n

Model is also run with different manning's n. Figures-15 to 17 shows a comparison of water level for different manning's n at cross-section I and II on Brahmaputra River and at Cross-section I on Lohit River respectively for Case 4 (when all project is constructed). Three different manning's value (0.033, 0.04, 0.05) is used. It shows that the variation is within 0.3 to 0.5 m. A temporal variation of 5-6 hours is observed on Brahmaputra River whereas 9 hours temporal variation is observed on Lohit River.

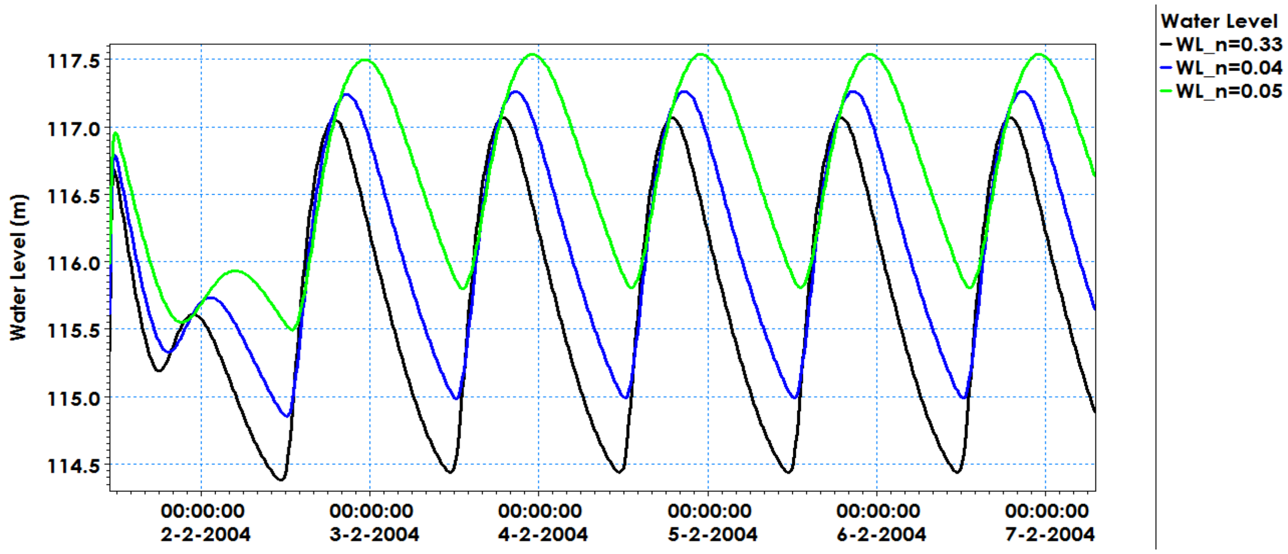


Figure-15: Water Level hydrograph at Cross-section I on Brahmaputra River (with different manning's n)

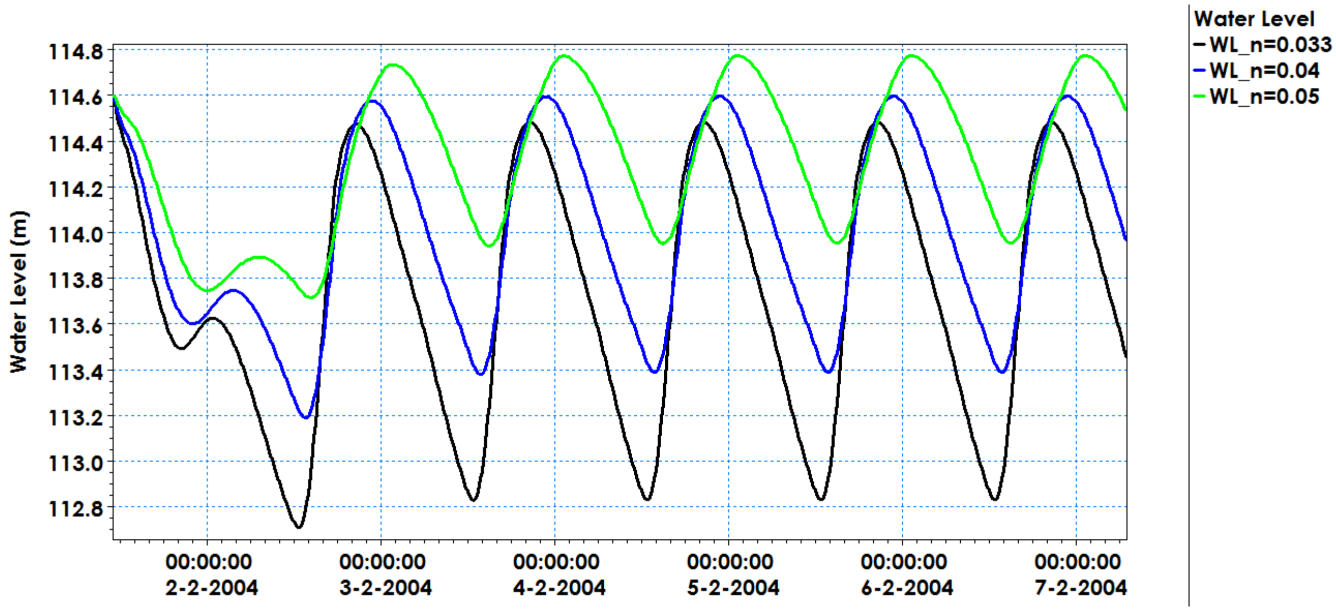


Figure-16 : Water Level hydrograph at Cross-section II on Brahmaputra River (with different manning's n)

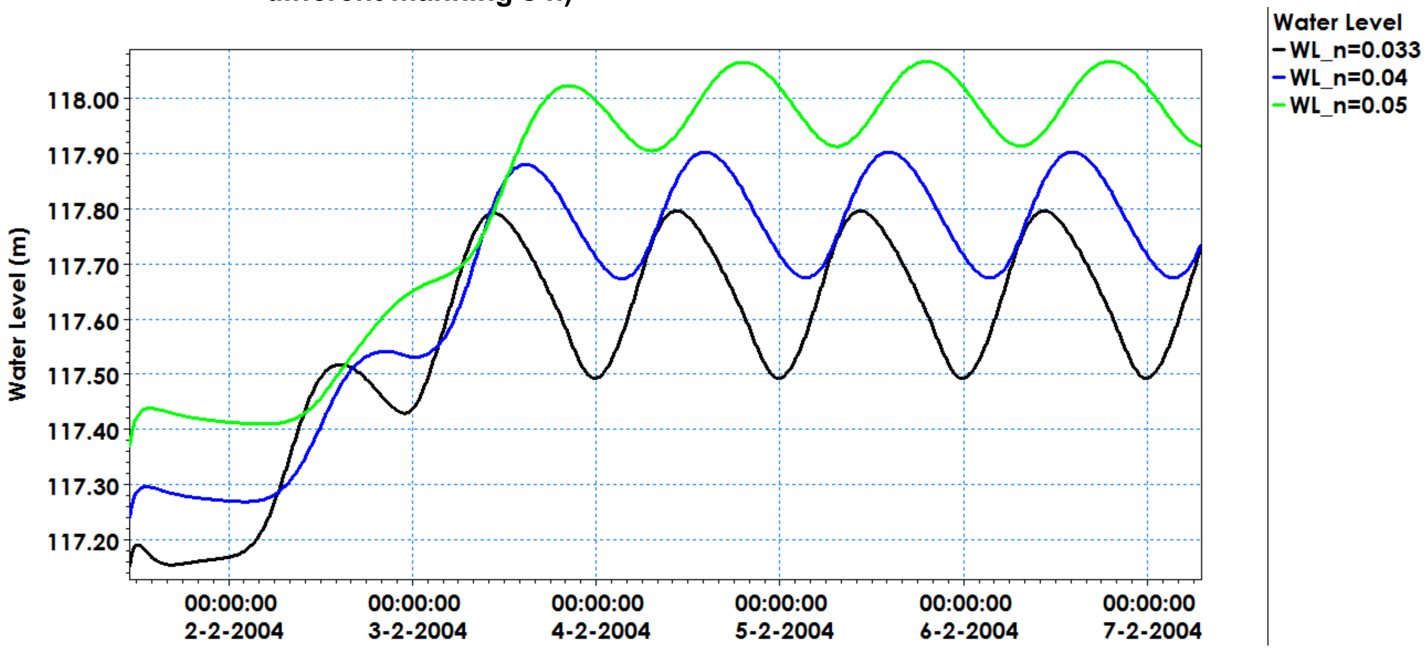


Figure-17: Water Level hydrograph at Cross-section I on Lohit River (with different manning's n)

5.4.7 Summary for the Present Case scenario

Water level and discharge for all five cases with different Manning's n is presented in Table-6.

Table-6: Simulated water levels and discharges at the three sites assuming river alignment based on the present case

Present											
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**			**Lohit**		
						X-I	**X-II**	**X-III**	**X-I**	**X-II**	**X-III**
					Min Bed Level, m	112.09	108.00	107.89	116.13	114.00	111.25
Case-1: Only Damwe is constructed	0.033	Siang =	1004.13	4.66	Max WL, m	116.27	114.11	112.49	117.8	116.068	112.491
					Min WL, m	116.27	114.11	112.41	117.49	115.715	112.41
					Max Discharge, m^3/s	1459.62	1459.15	1925.14	462.03	467.35	472.08
					Min Discharge, m^3/s	1459.62	1459.15	1782.30	295.14	306.5	318.46
	0.04	Dibang =	330.67	120.05	Max WL, m	116.70	114.35	112.67	117.904	116.194	112.7
					Min WL, m	116.70	114.35	112.64	117.675	115.95	112.643
					Max Discharge, m^3/s	1459.66	1459.35	1901.30	427.38	441.4	446.8
					Min Discharge, m^3/s	1459.66	1459.35	1810.30	326.56	336.12	347.35
	0.05	Lohit =	Max - 1729, Min- 66.2	122.27	Max WL, m	117.29	114.68	112.97	118.067	116.365	112.964
					Min WL, m	117.29	114.68	112.93	117.913	116.226	112.934
					Max Discharge, m^3/s	1459.62	1459.15	1879.00	413.407	417.335	423.6
					Min Discharge, m^3/s	1459.62	1459.15	1833.75	350.97	360.6	371.6
Case-2: Only Siang is constructed	0.033	Siang =	Max - 5440, Min- 197	4.66	Max WL, m	117.19	114.54	112.76	117.849	116.133	112.756
					Min WL, m	114.92	113.20	112.14	117.849	116.133	112.14
					Max Discharge, m^3/s	2242.94	2059.82	2419.28	500.75	493.67	532.82

Present											
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**			**Lohit**		
						X-I	**X-II**	**X-III**	**X-I**	**X-II**	**X-III**
					Min Discharge, m^3/s	721.20	784.71	1355.20	500.75	493.67	458.19
	0.04	Dibang =	330.67	120.05	Max WL, m	117.43	114.68	112.90	118.022	116.32	112.9
					Min WL, m	115.40	113.65	112.36	118.022	116.32	112.359
					Max Discharge, m^3/s	2021.80	1886.79	2257.68	500.63	493.67	531.3
					Min Discharge, m^3/s	770.90	836.72	1407.47	500.63	493.67	467.65
	0.05	Lohit =	384.5	122.27	Max WL, m	117.69	114.90	113.10	118.264	116.55	113.1
					Min WL, m	116.06	114.09	112.70	118.264	116.55	112.7
					Max Discharge, m^3/s	1838.41	1752.73	2160.00	500.4	493.65	527.11
					Min Discharge, m^3/s	837.93	923.23	1510.00	500.4	493.65	478.59
Case-3: Only Dibang is constructed	0.033	Siang =	1004.13	4.66	Max WL, m	116.40	114.12	112.54	117.849	116.136	112.544
					Min WL, m	115.89	113.83	112.39	117.849	116.136	112.394
					Max Discharge, m^3/s	1569.93	1530.54	2013.40	493.69	500.38	514.6
					Min Discharge, m^3/s	1229.50	1242.00	1759.31	493.69	500.38	498.83
	0.04	Dibang =	Max - 1431.61, Min- 75.5	120.05	Max WL, m	116.77	114.38	112.74	118.023	116.317	112.744
					Min WL, m	116.35	114.17	112.63	118.023	116.317	112.627
					Max Discharge, m^3/s	1522.37	1492.21	1977.46	493.39	500.18	513.81

Present											
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**			**Lohit**		
						X-I	**X-II**	**X-III**	**X-I**	**X-II**	**X-III**
					Min Discharge, m^3/s	1249.14	1263.76	1786.14	493.39	500.18	500.83
	0.05	Lohit =	384.5	122.27	Max WL, m	117.28	114.66	113.005	118.27	116.56	113.005
					Min WL, m	116.96	114.53	112.928	118.27	116.56	112.926
					Max Discharge, m^3/s	1522.30	1491.14	2013.41	493.85	500.4	513.83
					Min Discharge, m^3/s	1249.17	1263.84	1761.40	493.85	500.4	500.8
Case-4: All project is constructed	0.033	Siang =	Max - 5440, Min- 197	4.66	Max WL, m	117.07	114.48	112.64	117.796	116.058	112.637
					Min WL, m	114.44	112.83	112.01	117.492	115.721	112.007
					Max Discharge, m^3/s	2140.73	1969.66	2203.32	464.52	467.37	485.27
					Min Discharge, m^3/s	496.78	596.92	1151.86	294.81	306.61	334.69
	0.04	Dibang =	Max - 1431.61, Min- 75.5	120.05	Max WL, m	117.26	114.59	112.78	117.902	116.179	112.775
					Min WL, m	114.99	113.39	112.23	117.675	115.951	112.226
					Max Discharge, m^3/s	1892.41	1767.64	2040.99	438.03	441.83	450.32
					Min Discharge, m^3/s	588.29	706.15	1235.90	325.55	335.29	365.9
	0.05	Lohit =	Max - 1729, Min- 66.2	122.27	Max WL, m	117.54	114.77	112.97	118.066	116.354	112.973
					Min WL, m	115.80	113.95	112.55	117.913	116.226	112.549
					Max Discharge, m^3/s	1674.42	1588.40	1888.07	412.93	416.81	411.31

Present											
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**			**Lohit**		
						X-I	**X-II**	**X-III**	**X-I**	**X-II**	**X-III**
					Min Discharge, m^3/s	714.69	838.56	1321.74	351.01	360.69	386.96
Case-5: No project is constructed	0.033	Siang =	1004.13	4.66	WL, m	116.266	115.02	112.518	117.849	116.136	112.519
					Discharge, m^3/s	1459.11	1459.66	1967.4	493.61	500.32	508.8
	0.04	Dibang =	330.67	120.05	WL, m	116.69	114.35	112.74	118.022	116.318	112.74
					Discharge, m^3/s	1459.11	1459.66	1967.4	493.61	500.32	508.8
	0.05	Lohit =	384.5	122.27	WL, m	117.289	114.68	113.02	118.25	116.54	113.03
					Discharge, m^3/s	1459.11	1459.66	1967.4	493.61	500.32	508.8

6 SCENARIO II - RIVER ALIGNMENT AS PER BEFORE 1998

6.1 Network

The MIKE11 model is set up for three rivers Siang, Dibang and Lohit (Figure-18). Dibang meets with Lohit River at chainage of 88 km on Lohit River and 70 km on Dibang River. Combine flow of Lohit and Diabang meets with Siang River at chainage of 60 km on Siang River and 100 km on Lohit River. The above distances are from respective dam sites.

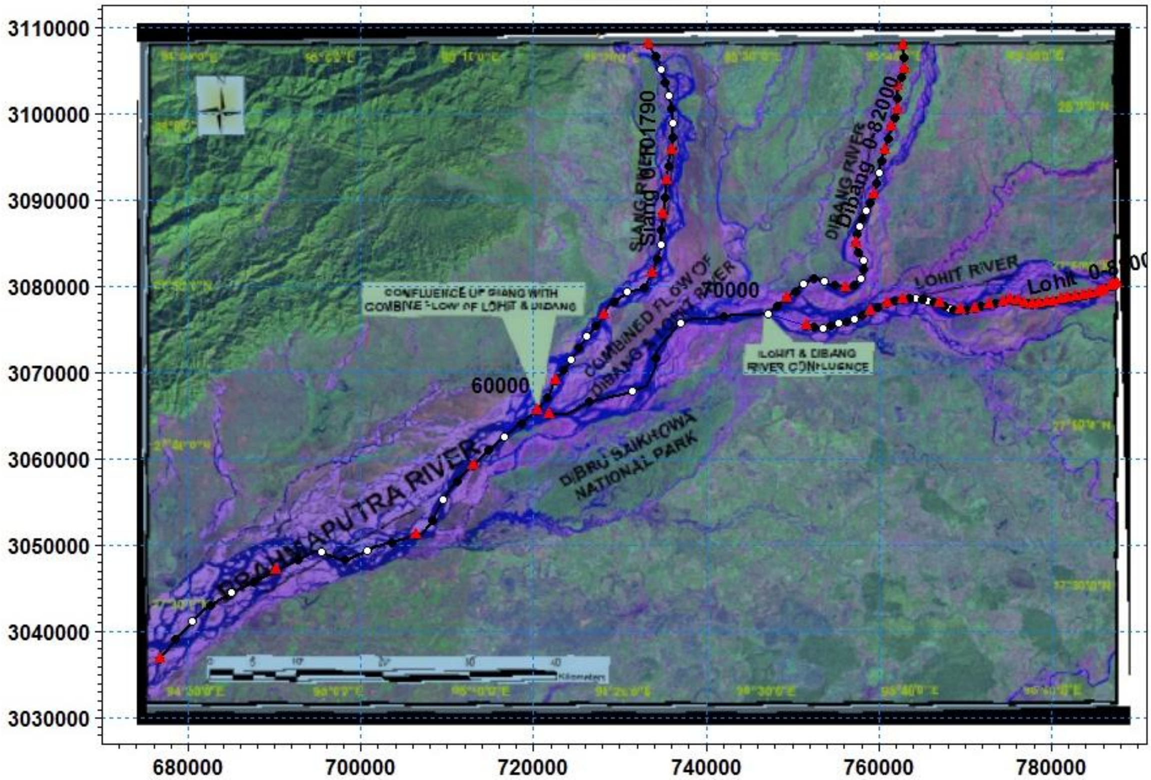


Figure-18 Network for present scenario (White and black circles are h and q computational points, red triangles are x-sections)

6.2 Cross-section

Cross-sections supplied by client are used. Cross-sections are rectified as described in Section- 5.2.

6.3 Boundary condition

A discharge is defined as the upstream boundary. Water level is used as downstream boundary. The same boundary condition as described in Section 5.3 is used.

6.4 Results and Discussions

The model is run for five different cases. It is simulated for six days. Three River cross sections at Dibru-Saikhowa have been considered to study the impact of the flow variations. These sections are named Dibru-saikhowa cross section -I, Dibru-saikhowa cross section-II and Dibru-Saikowa cross section-III. These cross sections are of

Brahamputra River. The minimum elevations at the three cross-sections are given in Table-7.

Figure-7: Minimum elevations at three sites

Name of Section	Dibru -Saikowa cross section no -I	Dibru -Saikowa cross section no -II	Dibru -Saikowa cross section no -III
Lowest Brahamputra River Elevation (rnasl)	112.09	108.00	107.89
Lowest Bank elevation; Lowest Elevation of the Park (masl)	125.70	117.30	115.50

Figure-19 shows the position of cross-section I, cross-section II and Cross-section III on Brahmaputra River.

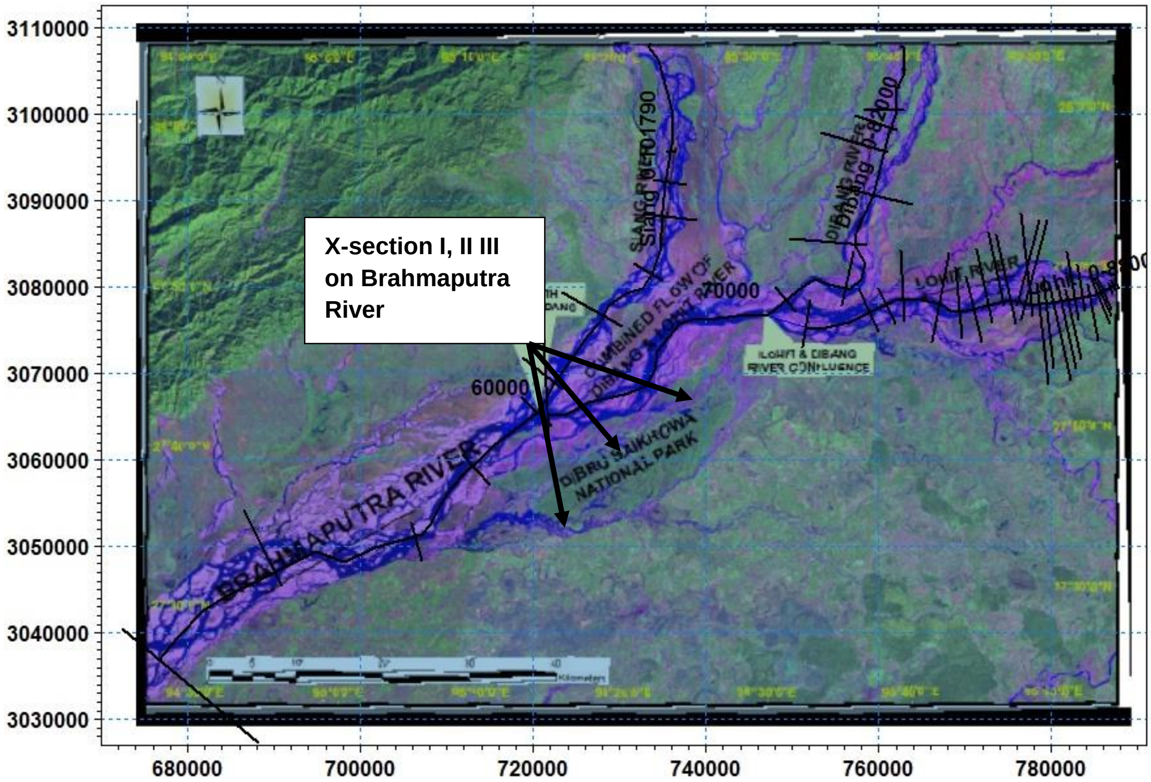


Figure-19: Plan view showing position of Cross-section I, II and III on Brahmaputra and Lohit River

6.5 Case1 Demwe Lower Project Only

The model set up as described above is used. In the present case, Lohit River is flowing freely without any interference from Dibang River and Siang River at Dibru-Saikhowa national park. Three cross sections at Dibru-Saikhowa National park (on southern boundary) have been considered. The design discharge of 1729 m^3/s is released in the river for 3 hours after 21 hours of non-peak (when only mandatory environmental flow is released downstream of the dam). Constant discharge of 1004.13 m^3/s and 330.67 m^3/s

is impinged at Siang and Dibang River upstream. Figure-20 shows hydrograph at three different cross-sections on Brahmaputra River. From the hydro graph it may be seen that the maximum flow at the DibruSaikowa Cross section no –I is around 1878.4 m^3/s.

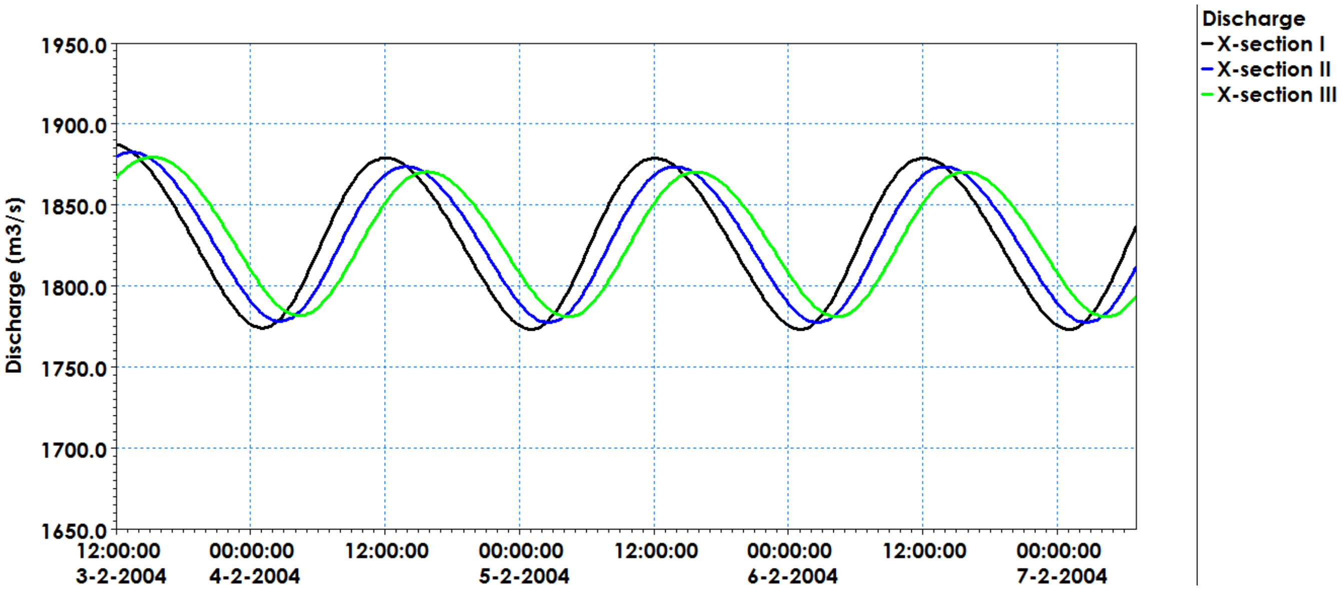


Figure-20: Discharge hydrograph at Cross-section I, II and III on Lohit River

6.5.1 Case2: Lower Siang Project Only

Same set up as described in case 1 is used. Here the design discharge of 5440 m^3/s is re-leased at the upstream end of Siang for 3 hours after 21 hours of non-peak (when only mandatory environmental flow is released downstream of the dam). Constant discharge is used at upstream of Dibang and Lohit. Figure-21 shows discharge at three different cross-sections on Brahmaputra. It shows peak is around 2965 m^3/s at Cross-section I.

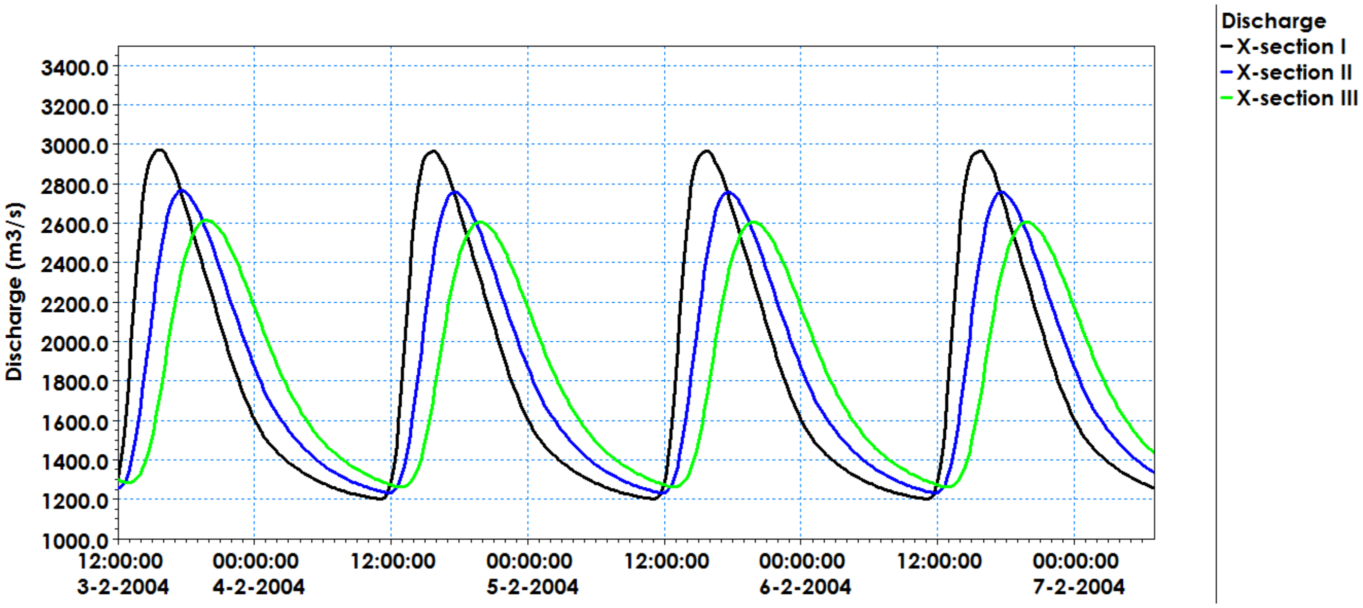


Figure-21: Discharge hydrograph at Cross-section I, II and III on Brahmaputra River

6.5.2 Case 3: Dibang Project Only

Model set up remains the same as described above. Design discharge of 1431.61 m^3/s is re-leased at upstream of Dibang for 3 hours after 21 hours of non-peak (when only mandatory environmental flow is released downstream of the dam). Constant discharge is used at the upstream end of Siang and Lohit. Figure-22 shows discharge at three different cross-sections on Brahmaputra. It shows peak is coming to 2054.71 m^3/s on Dibang River.

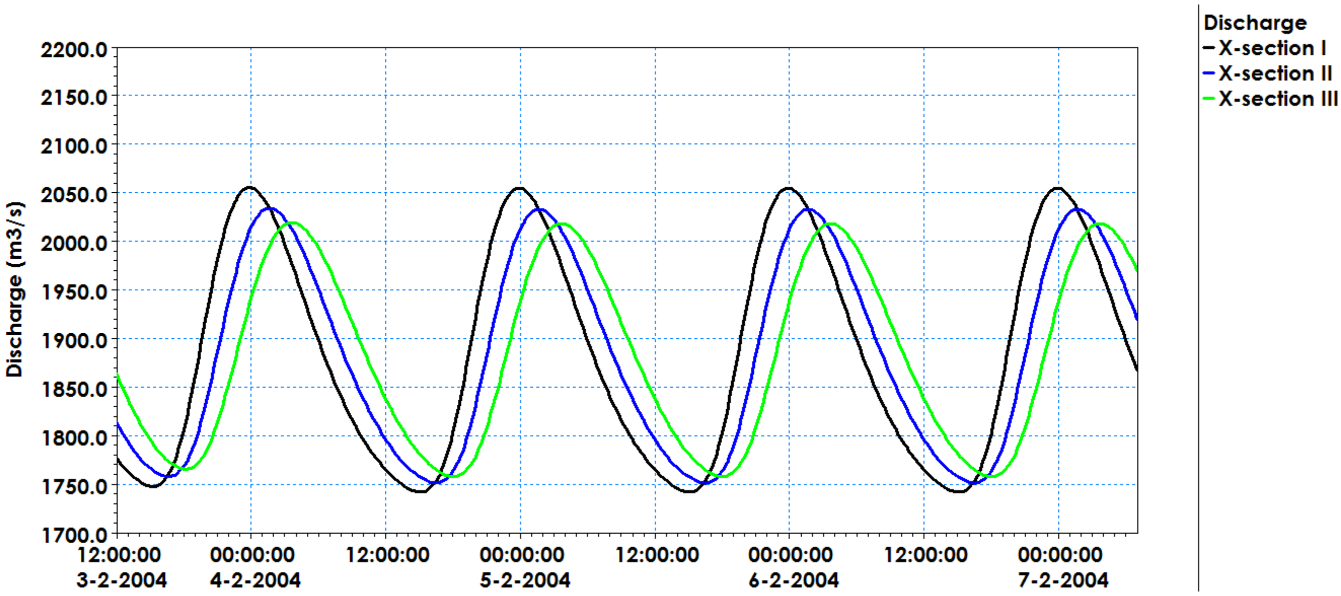


Figure-22 Discharge hydrograph at Cross-section I, II and III on Brahmaputra River and on Dibang River

6.5.3 Case 4: All Three Projects Combined

Design discharge at upstream of all three rivers are used. Figure-23 shows discharge hydrograph at three different cross-sections on Brahmaputra River. It shows that the attenuated discharge is around 2694 m^3/s at Cross-section I.

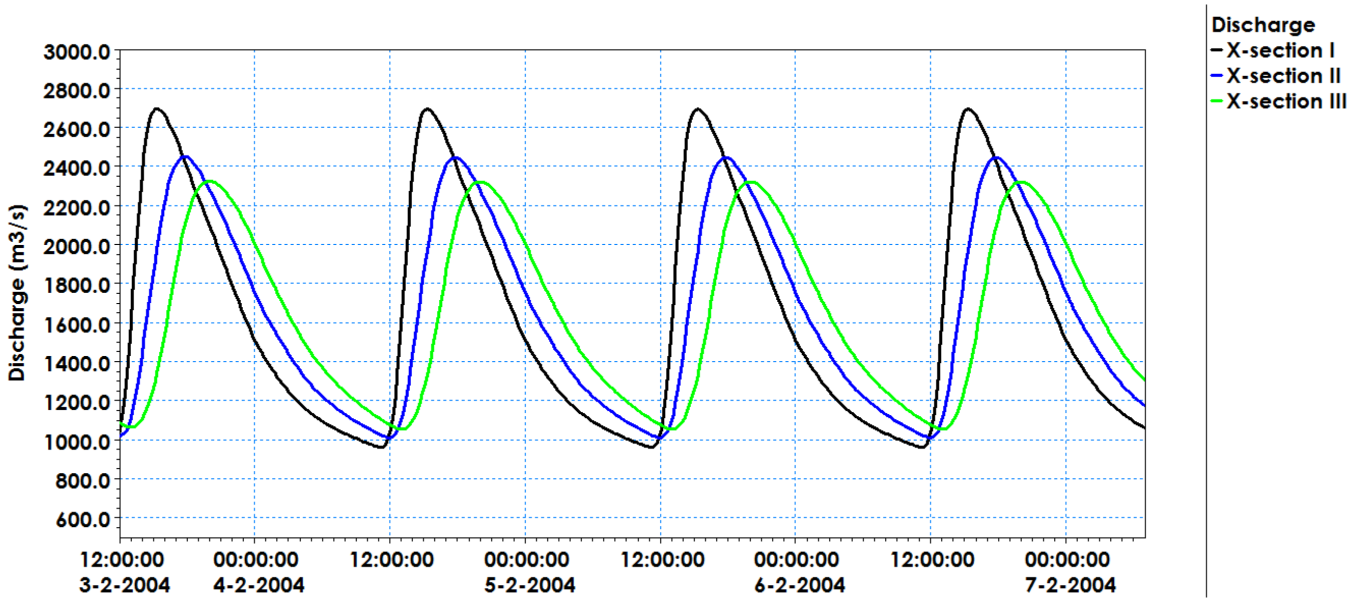


Figure-23 Discharge hydrograph at Cross-section I, II and III on Brahmaputra River

6.5.4 Case 5: No Projects Implemented

When no project is developed, all the rivers i.e. Lohit River, Siang River and Dibang River are flowing in their natural regimes. Constant discharge is impinged at upstream of each river. Water level is coming around 116.88 m at Cross-section I and discharge is 1966.38 m^3/s.

6.5.5 Summary for the 1998 river alignment scenario

Water level and discharge for all five cases with different Manning's n is presented in Table-8.

Table-8: Simulated water levels and discharges at the three sites assuming river alignment based on the before 1998

1998								
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**		
						X-I	**X-II**	**X-III**
					Min Bed Level, m	112.09	108.00	107.89
Case-1: Only Damwe is constructed	0.033	Siang =	1030.17	4.62	Max WL, m	116.77	114.94	112.64
					Min WL, m	116.59	114.83	112.57
					Max Discharge, m^3/s	1892.30	1886.01	1881.84
					Min Discharge, m^3/s	1755.78	1763.24	1767.55
	0.04	Dibang =	330.8	60.87	Max WL, m	117.24	115.24	112.84
					Min WL, m	117.12	115.17	112.80
					Max Discharge, m^3/s	1865.99	1861.05	1857.24
					Min Discharge, m^3/s	1783.74	1788.64	1793.14

1998								
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**		
						X-I	**X-II**	**X-III**
	0.05	Lohit =	Max - 1729, Min- 70	118.9	Max WL, m	117.85	115.611	113.101
					Min WL, m	117.79	115.58	113.08
					Max Discharge, m^3/s	1845.56	1842.79	1841.06
					Min Discharge, m^3/s	1806.83	1809.09	1809.78
Case-2: Only Siang is constructed	0.033	Siang =	Max - 5462, Min- 328	4.62	Max WL, m	117.92	115.58	113.03
					Min WL, m	115.60	114.13	112.18
					Max Discharge, m^3/s	2984.41	2775.08	2619.48
					Min Discharge, m^3/s	1179.32	1204.84	1229.50
	0.04	Dibang =	330.8	60.87	Max WL, m	118.22	115.78	113.17
					Min WL, m	116.11	114.53	112.43
					Max Discharge, m^3/s	2734.27	2597.93	2458.65
					Min Discharge, m^3/s	1203.11	1239.56	1269.41
	0.05	Lohit =	302.87	118.9	Max WL, m	118.57	116.05	113.35
					Min WL, m	116.82	115.03	112.75
					Max Discharge, m^3/s	2538.95	2405.37	2290.03
					Min Discharge, m^3/s	1245.42	1299.38	1359.01
Case-3: Only Dibang is constructed	0.033	Siang =	1030.17	4.62	Max WL, m	116.78	114.95	112.63
					Min WL, m	116.34	114.67	112.48
					Max Discharge, m^3/s	1915.41	1892.00	1877.40
					Min Discharge, m^3/s	1604.52	1615.21	1622.08
	0.04	Dibang =	Max - 1426.8, Min- 50	50.0	Max WL, m	117.21	115.22	112.82
					Min WL, m	116.87	115.02	112.70
					Max Discharge, m^3/s	1862.88	1845.33	1832.11
					Min Discharge, m^3/s	1626.22	1637.73	1648.11
	0.05	Lohit =	302.87	118.9	Max WL, m	117.78	115.57	113.07
					Min WL, m	117.56	115.46	113.00
					Max Discharge, m^3/s	1811.39	1801.53	1794.56
					Min Discharge, m^3/s	1665.84	1676.15	1686.13
Case-4: All project is constructed	0.033	Siang =	Max - 5462, Min- 328	4.62	Max WL, m	117.64	115.42	112.91
					Min WL, m	115.30	113.90	112.06
					Max Discharge, m^3/s	2777.17	2536.54	2396.73

1998								
Cases	**Manning's n**	**Inflow at boundary**		**Inflow from intermediate catchment**		**Brahmaputra**		
						X-I	**X-II**	**X-III**
					Min Discharge, m^3/s	1015.87	1059.07	1096.93
	0.04	Dibang =	Max - 1426.8, Min- 50	60.87	Max WL, m	117.96	115.61	113.05
					Min WL, m	115.83	114.35	112.33
					Max Discharge, m^3/s	2522.49	2343.88	2224.65
					Min Discharge, m^3/s	1059.21	1113.23	1158.34
	0.05	Lohit =	Max - 1729, Min- 70	118.9	Max WL, m	118.35	115.88	113.24
					Min WL, m	116.59	114.89	112.66
					Max Discharge, m^3/s	2322.40	2203.66	2093.78
					Min Discharge, m^3/s	1127.00	1192.91	1259.64
Case-5: No project is constructed	0.033	Siang =	1030.17	4.62	WL, m	116.71	114.91	112.62
					Discharge, m^3/s	1848.00		
	0.04	Dibang =	330.8	60.87	WL, m	117.21	115.23	112.84
					Discharge, m^3/s	1848.00		
	0.05	Lohit =	302.87	118.9	WL, m	117.86	115.61	113.10
					Discharge, m^3/s	1848.00		

7 CONCLUSIONS

To assess the impact of the projects it is required to check the change in water level due to peaking. A comparison is done between sce-narios before construction of the projects and after construction of the projects. Maximum water level variations for the two scenarios are tabulated in Table-9 (present river alignment) and Table-10 (pre-1998 river alignment) respectively. The top width and velocity for the present river alignment is given in Table-11.

It is clear from Tables 9 and 10 that the variation is within 1 m when all projects will be working simultaneously. Water level is well below the minimum elevation of Dibru-Saikowa Park for all cases.

Table-9: Present Scenario Post 2003 – When Lohit has changed to Southern Boundary of Dibru-Saikowa

			Manning's n = 0.033			Manning's n = 0.04			Manning's n = 0.05		
	Cross section No.	**Min Elevation of Dibru-Saikowa Park (m)**	**Max Water Level due to Non monsoon peaking (m)**	**Max Water Level at no project condition (m)**	**Max variation in water level (m)**	**Max Water Level due to Non monsoon peaking (m)**	**Max Water Level at no project condition (m)**	**Max variation in water level (m)**	**Max Water Level due to Non monsoon peaking (m)**	**Max Water Level at no project condition (m)**	**Max variation in water level (m)**
All 3 Projects, Demwe Lower, Dibang and Lower Siang	I	125.700	117.070	116.266	0.804	117.26	116.690	0.570	117.54	117.289	0.251
	II	117.300	114.480	114.11	0.370	114.59	114.350	0.240	114.77	114.68	0.090
	III	115.500	112.637	112.518	0.119	112.78	112.74	0.035	112.97	113.02	-0.047
Only Damwe Lower	I	121.920	117.8	117.849	-0.049	117.904	118.022	-0.118	118.067	118.25	-0.183
	II	120.700	116.068	116.136	-0.068	116.194	116.318	-0.124	116.365	116.54	-0.175
	III	121.070	112.491	112.519	-0.028	112.7	112.74	-0.040	112.964	113.03	-0.066

Table-10: Pre 1998 scenario – When Lohit was flowing along the Northern Boundary of Dibru-Saikowa Park

			Manning's n = 0.033			Manning's n = 0.04			Manning's n = 0.05		
	Cross section No.	**Min Elevation of Dibru-Saikowa Park (m)**	**Max Water Level due to Non monsoon peaking (m)**	**Max Water Level at no project condition (m)**	**Max variation in water level (m)**	**Max Water Level due to Non monsoon peaking (m)**	**Max Water Level at no project condition (m)**	**Max variation in water level (m)**	**Max Water Level due to Non monsoon peaking (m)**	**Max Water Level at no project condition (m)**	**Max variation in water level (m)**
All 3 Projects, Demwe Lower, Dibang and Lower Siang	I	125.700	117.538	116.880	0.658	117.857	117.388	0.469	118.259	118.020	0.239
	II	117.300	115.364	115.015	0.349	115.552	115.341	0.211	115.819	115.714	0.105
	III	115.500	112.873	112.689	0.184	113.015	112.920	0.095	113.196	113.169	0.027
Only Damwe Lower	I	121.920	116.750	116.880	-0.130	117.223	117.388	-0.165	117.844	118.020	-0.176
	II	120.700	114.932	115.015	-0.083	115.236	115.341	-0.105	115.603	115.714	-0.111
	III	121.070	112.631	112.689	-0.058	112.838	112.920	-0.082	113.096	113.169	-0.073

Table-11: Depth and Velocity for the Present Scenario Post 2003 – When Lohit has changed to Southern Boundary of Dibru-Saikowa

Cases	Manning's n	Inflow at boundary		Inflow from intermediate catchment		Brahmaputra			Lohit		
						X-I	X-II	X-III	X-I	X-II	X-III
Case-1: Only Damwe is constructed	0.033	Siang =	1004.13	4.66	Max Velocity (m/s)	1.000	0.960	0.818	0.742	0.852	0.844
					Top width (m)	881.000	881.000	1753.000	500.000	370.000	535.000
	0.04	Dibang =	330.67	120.05	Max Velocity (m/s)	0.872	0.852	0.697	0.644	0.742	0.669
					Top width (m)	973.000	1145.000	1898.000	509.000	375.000	546.000
	0.05	Lohit =	Max - 1729, Min- 66.2	122.27	Max Velocity (m/s)	0.773	0.686	0.586	0.540	0.630	0.522
					Top width (m)	1094.000	1511.000	2085.000	523.000	383.000	561.000
Case-2: Only Siang is constructed	0.033	Siang =	Max - 5440, Min- 197	4.66	Max Velocity (m/s)	1.287	1.107	0.889	0.754	0.879	1.350
					Top width (m)	1079.000	1360.000	1940.000	504.000	373.000	550.000
	0.04	Dibang =	330.67	120.05	Max Velocity (m/s)	1.080	0.927	0.741	0.663	0.780	1.040
					Top width (m)	121.000	1515.000	2038.000	520.000	380.000	557.000
	0.05	Lohit =	384.5	122.27	Max Velocity (m/s)	0.890	0.743	0.618	0.568	0.680	0.766
					Top width (m)	1228.000	1849.000	2200.000	540.000	391.000	569.000
Case-3: Only Dibang is constructed	0.033	Siang =	1004.13	4.66	Max Velocity (m/s)	1.016	1.025	0.828	0.754	0.871	0.997
					Top width (m)	912.000	939.000	1796.000	505.000	374.000	537.000
	0.04	Dibang =	Max - 1431.61, Min- 75.5	120.05	Max Velocity (m/s)	0.903	0.866	0.705	0.663	0.776	0.805
					Top width (m)	985.000	1174.000	1931.000	520.000	380.000	550.000
	0.05	Lohit =	384.5	122.27	Max Velocity (m/s)	0.784	0.691	0.593	0.569	0.680	0.646
					Top width (m)	1092.000	1496.000	2110.000	540.000	391.000	562.000
Case-4: All project is constructed	0.033	Siang =	Max - 5440, Min- 197	4.66	Max Velocity (m/s)	1.260	1.090	0.889	0.850	0.740	1.530
					Top width (m)	1051.000	1297.000	1860.000	500.000	369.000	544.000

Cases	Manning's n	Inflow at boundary		Inflow from intermediate catchment		Brahmaputra			Lohit		
						X-I	X-II	X-III	X-I	X-II	X-III
	0.04	Dibang =	Max - 1431.61, Min- 75.5	120.05	Max Velocity (m/s)	1.054	0.919	0.735	0.645	0.748	1.060
					Top width (m)	1091.000	1416.000	1952.000	509.000	376.000	551.000
	0.05	Lohit =	Max - 1729, Min- 66.2	122.27	Max Velocity (m/s)	0.859	0.733	0.600	0.540	0.634	0.696
					Top width (m)	1167.00	1647.00	2092.00	523	383	563
Case-5: No project is constructed	0.033	Siang =	1004.13	4.66	Max Velocity (m/s)	1.01	0.97	0.82	0.755	0.871	0.883
					Top width (m)	883	883	1780	503	373	536
	0.04	Dibang =	330.67	120.05	Max Velocity (m/s)	0.871	0.85	0.7	0.663	0.775	0.735
					Top width (m)	970	1149	1931	520	380	550
	0.05	Lohit =	384.5	122.27	Max Velocity (m/s)	0.773	0.684	0.591	0.569	0.679	0.601
					Top width (m)	1094	1517	2165	539	391	565

WAPCOS LIMITED

(A Government of India Undertaking)

76 C, Sector 18, Gurgaon - 122015, Haryana, INDIA

Tel. 0124-2397396, Fax. 0124-2397392

Email: environment@wapcos.co.in

AUGUST 2016