DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Umngot HEP (210 MW)

East Khasi Hills & Jaintia Hills Districts

Meghalaya

Sector 1 (c) (i), Category A

JANUARY, 2021

Project Proponent:

M/s. Meghalaya Power Generation Corporation Ltd.
Lumjingshai, Short Round Road
SHLLONG-793001

Submitted By:

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QCI/NABET /ENV/ACO/20/1513, Valid up to 27.1.2021

Name of Lab: J.P. Test & Research Centre, Sahibabad, U.P.
Monitoring Period: Post-Monsoon, 2017, Pre-Monsoon & Monsoon 2018

UID: EQMS/EIA/UHEP/1(c)A/PR535/012021

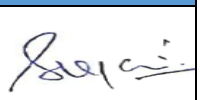
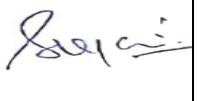
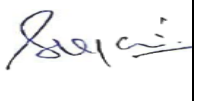
Declaration of Experts Contributing in EIA

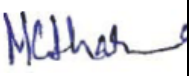
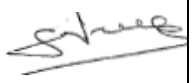
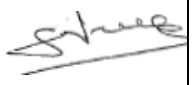
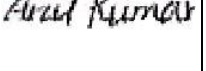
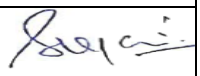
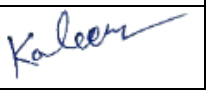
Declaration by Experts contributing to the EIA: Umngot Hydro-electric Project (210 MW), East Khasi Hills District, Meghalaya.

I, S.K. Jain, hereby certify that I was a part of the EIA team in the following capacity that developed the above EIA.

EIA coordinator	
Name:	Yamesh Sharma
Signature	
Period of Involvement:	November 2018 to till date
Contact Information:	Yamesh70@gmail.com

Functional area experts

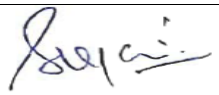
S.N.	Functional Areas	Name of experts	Involvement (period and task)	Signature and date
1	AP	S K Jain	November 2018 to till date Air pollution monitoring. Identification & assessment of quantum of emission and its mitigation measures.	
2	WP	S K Jain	November 2018 to till date Water Quality monitoring network designing. sampling of water samples. Monitoring of water quality. Identification & assessment of quantum of water pollution and its mitigation measures.	
3	SHW	S K Jain	November 2018 to till date Identification of hazardous and non-hazardous wastes. Reuse and recycling of solid wastes	
4	SE	Anil Kumar	November 2018 to till date Baseline socio economic survey. Evaluation of socio-economic development status of the area. impact identification and mitigation measures.	
5	EB	Ratnesh Kotiyal	November 2018 to till date Conducted Ecological survey & preparation of ecology report. Identification & assessment of ecological impact due to proposed project and its mitigation measures.	
6	HG	Yamesh Sharma	November 2018 to till date Surface hydrology and Hydro geological inputs in respect of project and impacts due to dam construction on river and hydrology and ecological flows	
7	GEO	Hardik Patel	November 2018 to till date Regional and project geology aspects/inputs	

8	SC	Manoj Sharma	November 2018 to August 2020 Site Visit, soil sampling plan, identification of impact and mitigation measures including preparation of FAE report.	
9	AQ	Sanjeev Sharma	October 2017 to August 2019 Meteorological parameter measurement. Air Quality modelling to determine GLC due to project construction and suggest mitigation measures.	
10	NV	Sanjeev Sharma	November 2018 to August 2019 Monitoring of noise levels of the project site and surrounding area. Assessment of noise level and vibration potential due to proposed project and its mitigation measures.	
11	LU	Anil Kumar	November 2018 to till date Development of land use maps of study area using GIS / related tools, site visit for ground truth survey, finalization of land use maps	
12	RH	S K Jain	October 2017 to till date	
Functional Area Associates				
1	SE	Kaleem Qureshi	November 2018 to till date As support for socio-economic report and R&R	

Declaration of association in the EIA

Declaration by the Head of the accredited consultant organization/ authorized person

I, S.K. Jain hereby, confirm that the above-mentioned experts prepared the 'EIA/EMP Report of Umngot HEP (210 MW) in East Khasi Hills District, Meghalaya'. I also confirm that the consultant organization shall be fully accountable for any mis-leading information mentioned in this statement.

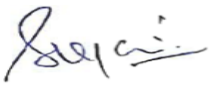
Signature:	
Name:	S.K. Jain
Designation:	Director, Technical
Name of the EIA Consultant organization	EQMS India Pvt. Ltd.
NABET Certificate No.	NABET/EIA/SA-225
Issue Date:	11th May, 2018

CERTIFICATE OF PLAGIARISM CHECK

Title of EIA Report:	Umngot HEP (210MW), District East Khasi Hills, Meghalaya
Name of Accredited Organization:	EQMS India Pvt. Ltd.
Unique Identification Number:	UID: EQMS/EIA/UHEP/1(c)A/PR535/012020
Name of EIA Co-ordinator (EC):	Mr. Yamesh Sharma
Name of the Software:	Aermod View, Ver. 9.8.1 - Air Dispersion Modelling Software dhwani PRO Version 3.6 - Noise propagation modelling BOSS DAMBRK Model- Dam break Analysis ArcGIS for Land use mapping
Date of Check:	10/05/2020

Declaration by the Accredited Consultant Organization /Authorized Person

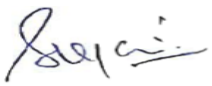
I hereby certify that this EIA Report has been evaluated using online /in-House software viz., Aermod View, Ver. 6.2- air dispersion modelling, dhwani PRO Version 3.6**-** noise propagation modelling software, BOSS DAMRK for dam break analysis and ArcGIS - for land use mapping. The report produced has been analysed by the system and based on it, I certify that the EIA report produced in accordance with good scientific practice.



Date and sign. of EIA Coordinator: 10/05/2020

Name: Yamesh Sharma

Designation: Principal Consultant



Date and sign. of Head of Accredited Organization: 10/05/2020

Name: S. K. Jain

Designation: Director Technical

Name of the EIA consultant organization: EQMS India Private Ltd.

NABET Certificate No. & Issue Date: NABET/1619/SA 070, dated July 17, 2018

Table of Contents

List of Tables

List of Figures

List of Annexure

Chapter 1. INTRODUCTION

1.1. Background

In the past few years, India has turned into a vibrant economy. With the growth of the Industrial sector and an improved quality of life, the demand for electric power is increasing day by day. Quality power is required to maintain the sustained growth of agricultural and industrial sectors, to accomplish a higher GDP and sustainable development. The electrical energy may be generated from fossil fuels, thermal power, nuclear energy, and hydropower or from renewable sources like solar or wind energy. Deriving electrical energy from fossil fuels like coal is becoming increasingly unmanageable because of environmental implications.

Considering the vast and untapped potential and availability, of the hydro resources in India, the development of hydropower projects is required to be explored fully. Power generation from such projects is also comparatively less damaging for the environment. Though power production from hydro resources does have its environmental concerns such as large inundations, disposal of muck and rehabilitation and resettlement (R&R) problems, they can be suitably handled with appropriate plans. e.g., the problem of muck disposal is always resolvable if the restoration of disposal areas is carried out in a scientific way. It would also be appropriate to state here that the problems related to large inundations and R&R may be tackled by going in for run-of-the-river schemes in place of large reservoir schemes as the quantum of inundation and displacement will be much less in run-of-the-river scheme projects.

1.2. Hydro-Power Potential of India

Geo-morphologically, India offers great sources of hydropower with well-defined regions, which are topographically favourable for the run-off river hydro development. The generation from hydel is assumed at plant load factor of 40% for the period 1999-2019. Like the Green Revolution of the past, which concentrated on Punjab and Haryana, the new “Power Revolution” is focusing on power producing states like Chhattisgarh, Himachal Pradesh and Uttarakhand, which have a potential to produce nearly 50000 MW of power because of their rich natural resources. India currently generates about 83% of its electricity from conventional thermal power plants and about 15% from hydroelectric plants (mainly located in J & K State, Himachal Pradesh, Uttarakhand, and the North East). Accordingly, GOI has launched a 50,000-megawatt (MW) hydroelectric initiative. Hydropower is a renewable source of energy and much cheaper as compared to thermal power

As per the assessment of CEA the country is endowed with hydro potential of 84000 MW at 60% load factor or an installed capacity of around 1,50,000 MW. The region wise hydro potential is shown in **Table 1.1**.

Table 1.1 : Region wise Breakup of Hydropower Potential in the Country

Region	Potential at 60% load factor, MW	Feasible Installed Capacity, MW	Potential in billion, KWH/year	Pumped Storage Feasible Installed Capacity, MW	Small Hydro (up to 15 MW Potential), MW
Northern	30155	53405	225	13065	3180
Western	5697	8928	31.4	39684	661
Southern	10768	16446	61.8	17750	801

Eastern	5590	10965	42.5	9125	530
N.E.	31857	58956	239.3	16900	1610
Total	**84044**	**148700**	**600**	**95524**	**6782**

1.3. Installed Capacity from All Sources

As per CEA, the total installed capacity from all sources in India as on 31.10.2018, stands at 3,46,048 MW of which the installed capacity of Hydropower stands at 45,487MW (13.1%) as is apparent from **Table 1.2**. This implies that so far only 30.6% of the feasible hydro potential of 148700 MW could be harnessed. Of total installed capacity 3,46,048 MW, the share of State, Centre and Private is 83,992MW (24.3%), 1,03,030 MW (24.3%) and 1,59,096MW (45.0%) respectively.

Table 1.2 : Region wise Breakup of Hydropower Potential in the Country

S.N.	Source (Fuel)	Installed Capacity (MW)	% of Total
1	Thermal		
(i)	Coal	1,95,993	56.6
(ii)	Gas	24,937	7.2
(iii)	Oil	838	0.2
Sub Total Thermal		2,21,768	64.1
2	Hydro	45487	13.1
3	Nuclear	6780	2.0
4	Renewable Energy Source (RES)	72,013	20.8
Total		**3,46,048**	**100.0**

1.4. Anticipated Power Supply Position in Northern Eastern Region During 2018-19

The annual power supply position in terms of energy requirement (371934 MU) vis-à-vis energy availability (365723 MU) of various States/ Systems during the year 2017-18 as assessed by CEA reveals that there was a deficit of 1.7% energy in the northern region. As per study conducted by CEA, the anticipated power supply position from all sources in the northern states of country. during 2018-19, is shown in **Table 1.3**. It is revealed that though there shall be overall 22.9 % surplus power in the North Eastern region. Meghalaya met the demand almost in full. Arunachal Pradesh, Mizoram, Nagaland and Tripura (including export to Bangladesh) faced energy shortages in the range of 1.3—2.5%. The maximum energy shortage in North-Eastern Region was in Assam and Manipur at 3.5% and 5.2%, respectively. The shortages witnessed were partly on account of constraints in transmission, sub-transmission and distribution system.

Table 1.3 : Region wise Breakup of Hydropower Potential in the Country

State	Energy				Peak			
	Req.	Availability	Surplus (+) Deficit (-)		Req.	Availability	Surplus (+), Deficit (-)	
	(MU)	(MU)	(MU)	%	(MU)	(MU)	(MU)	%
Arunachal Pradesh	860	852	-8	-9	148	166	18	12.5
Assam	9,526	9,900	373	3.9	1841	1520	-320	-17.4
Manipur	876	1,170	294	33.5	196	201	5	2.7

Meghalaya	1,932	2,726	794	41.1	406	478	72	17.8
Mizoram	567	676	109	19.3	114	111	-3	-2.6
Nagaland	873	897	24	2.8	157	155	-2	-1.2
Tripura	1,281	3,330	2050	160.10	359	470	110	30.6
N. E. Region	**15,914**	**19,550**	**3,636**	**22.9**	**2,708**	**3,049**	**342**	**12.6**

Source: CEA -LGBR for 2018-19

1.5. Total Installed Power Generation Capacity

As of April 2018, the state had total installed power generation capacity of 558.29 MW. Hydro power and renewable sources contributed 418.28 MW to the total installed power generation capacity of the state, followed by thermal power with a contribution of 140.09 MW and other sources of power generation. Of the total installed power generation capacity, state utilities accounted for the largest share of 353.03 MW, followed by 345.37 MW under central utilities and the private sector accounted for meagre 0.06 MW. As on 31 May, 2018, the installed capacity of hydropower stations in State/Private/Central sectors in the state was estimated as 558.28 MW as elucidated in **Table 1.4.**

Table 1.4 : Installed capacity of hydropower Stations in Meghalaya (31.5.2018)

S.N.	Sector	State (MW)	Private (MW)	Centre (MW)	Total (MW)
1	Thermal				
(i)	Coal	0.00	0.00	30.40	30.40
(ii)	Gas	0.00	0.00	109.69	109.69
(iii)	Oil	0.00	0.00	0.00	0.00
Sub Total Thermal		0.00	0.00	140.09	140.09
2	Hydro	322	0.00	65.19	387.19
3	Nuclear	0.00	0.00	0.00	0.00
4	Renewable Energy Source	31.03	0.06	0.00	31.09
Total		**353.03**	**0.06**	**345.37**	**558.28**

Source: CEA

1.6. Purpose of the Report

The purpose of environmental impact assessment of the proposed Hydro-electric project is to identify and evaluate the nature, magnitude and significance of the potential adverse environmental impacts arising during construction and operation of the project and formulation of site specific Environmental Management Plan (EMP) shall for avoiding, mitigating, checking the adverse impacts envisaged during EIA studies on various environmental components during construction and operational phase of the project.

1.7. Identification of Project and Project Proponent

Umngot Hydro-Electric Project, conceived as storage scheme across Umngot in East Khasi Hills and Jaintia Hills District of Meghalaya, envisages utilisation of gross head of about 808.60 m for annual power generation of 708.98 MU in a 90 % dependable year. The proposed dam site on river Umngot at Saida near village Siangkhnai. A Surface Power House (3X70 MW,) on the right bank of river Umngot near village Syntung has been proposed.

M/s. Meghalaya Power Generation Corporation Ltd., Lumjingshai, Short Round Road, Shillong-793001, are the project proponent.

1.7.1. *EIA Consultant*

The task of preparation of EIA/EMP report of project has been awarded to M/s EQMS India Pvt. Ltd., 304-305, 3rd floor, Rishabh Corporate Tower, Community Centre, Karkardooma, Delhi-110092. The organization is accredited with NABET/ Quality Control of India to conduct the Environment Impact Assessment Studies for river valley projects among others (NABET/EIA//1619/SA **(Annexure-I).**

1.8. Brief Description of Nature, Size, Location and Importance

1.8.1. *Brief Description of Nature of Project*

The proposed Hydro Electric Project shall comprise the following structures:

- 362m long and 111 metres high concrete dam across river Umngot to impound 71.31 MCM. of water.
- 3.40m diameter head race tunnel of length 5.646 Km
- A restricted orifice surge shaft of 12m diameter and 68.1m height at the junction of HRT and pressure shaft opens into the atmosphere at the top.
- 2.50m diameter steel lined pressure shaft of length 2.209 Km
- Surface Power House of length 107.5m and width 22m for generation of 210 MW of peak power.
- Three tail race channels of cross-sectional dimension 4.40mx2.80 m each
- Tail Race channel of 41 m length and 3.78 m diameter.

1.8.2. *Sector Classification*

As regards the hydroelectric power generation, the project activities are covered under river valley project S.N.I(c)(i)

1.8.3. *Size of Project*

As regards the hydroelectric power generation, the project activities are covered under river valley project S.N.I(c)(i) and projects with threshold limit >25 MW and < 50 MW hydroelectric power generation fall under category “B” and all projects with threshold limit >50 MW hydroelectric power generation are categorized as ‘A”. In so far as hydroelectric power generation from the project shall be 210 MW, it falls under project category “A”.

In terms of IS 11223-1985 the barrage /dam comes under the category of ‘Large Dams’ because its height is more than 30 m and gross capacity 71.31 MCM, which is more than 60MCM.

1.8.4. *Location*

From Shillong, the project is accessible by road on the left bank through the NH-44 E which runs through the neighbouring Jaintia Hills District of Meghalaya to Tamabil, a dry port on the Bangladesh border. On the right bank the Project is also accessible from N.H-44 via a District/village road in East Khasi Hills District where most of the hydraulic structures will be located.

1.8.5. *Importance of Project to the country /Region*

The most important source of power development in the North Eastern region is hydroelectric power located in Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram and Tripura.

The need for Umngot HEP in Umngot Basin, has therefore been considered in context of power shortage in the country as whole. The project has been conceptualized as storage scheme. Umngot

H.E.P. (3 x 70MW) alone would be able to supplement 210 MW of peaking power to the requirements of the state and provide an annual design energy (90% dependability) of 708.98 GWh

1.9. Site Description

1.9.1. *History*

It is a green field project and shall be developed as intervention on Umngot for harnessing unutilised hydro power potential of the river.

1.9.2. *Topography*

The Study area is a plateau interspersed with high hills and deep valleys. The site where the Umngot HEP is located is marked by deep gorges, spurs and abrupt slopes. Umngot Hydroelectric Project is located within a typical plateau land of Meghalaya characterized by flat undulatory table top land and deep gorges.

1.9.3. *Geological Set up and Seismicity*

In the project area, the rock units exposed consist of granite gneisses and quartzite. The bedrock is massive, hard, moderately jointed, and medium to coarse grained. Prominent and persistent joints are observed in small out crops. The overburden consists of mainly clays and sand. The project area falls within Zone V.

1.9.4. *Archaeological/Religious/Historical Monuments*

No archaeological monument of national importance either lies in the project area or in its submergence area. There is also no structure of national heritage in the area.

1.9.5. *Sensitive Area*

No National Park, Sanctuary, Defence Establishments, Notified Eco-sensitive areas or protected area under Wildlife (Protection) Act exists within the project area or within 15 km distance from it

1.10. Policy, Legal and Administrative Framework

The emerging environmental scenario calls for requisite attention on conservation and proper use of natural resources and development without destruction. The environmental consideration in any development process has become a necessity for achieving sustainable development. To achieve these goals, the Ministry of Environment & Forests, Govt. of India, has enacted various acts, legislations, guidelines and standards from time to time. The principal environmental regulatory agency in India is the Ministry of Environment & Forests, New Delhi. MoEF formulates environmental policies and accords environmental clearances for different projects. The important environmental legislations in India are given in **Table 1.5.**

Table 1.5 : Key Environmental Legislations

Name	Scope and Objective	Key Areas	Operational Agencies/Key Player
Water (Prevention and Control of Pollution) Act, 1974, 1988	To provide for the prevention and control of water pollution and	Control sewage and industrial effluent discharges	Central and State Pollution Control Boards

Name	Scope and Objective	Key Areas	Operational Agencies/Key Player
	enhancing the quality of water		
Air (Prevention and Control of Pollution) Act, 1981, 1987	To provide for the prevention and control of air pollution	Controls emission of air pollutants	Central and State Pollution Control Board
Noise Pollution (Regulation & Control) Rule 2000	Noise pollution control	Control of noise pollution in residential, commercial, industrial and silent zones	Central and State Pollution Control Board
Forest (Conservation) Act, 1980, 1988	To consolidate acquisition of common property such as forest, halt India's rapid deforestation and resulting environmental degradation	Regulates access to natural resources, state has a monopoly right over land, categories forests, restriction on de-reservation and using forest for non-forest purpose	State Government and Central Government
Wildlife (Protection) Act, 1972, 1993	To protect wildlife	Creates protected areas (national parks / sanctuaries) categories of wildlife which are protected	Wildlife Advisory Boards, Central Zoo Authorities
Ancient Monuments and Archaeological sites & Remain Act, 1958	To protect ancient monuments of national heritage / importance	Conservation of cultural and historical remains found in India	Archaeological Survey of India
Solid Wastes Management Rules, 2016	To provide rules for collection, storage, segregation, transportation, processing and disposal of municipal solid wastes	Assessment of generation of solid waste materials & management technique.	Central and State Pollution Control Board
Hazardous& other Wastes (Management &Transboundary	Health and safety	Assessment of hazardous materials and management	Central and State Pollution Control Board

Name	Scope and Objective	Key Areas	Operational Agencies/Key Player
Movement) Rules, 2016.			
Biomedical Waste (Management & Handling) Rules ,2016	Health and safety	Assessment of biomedical waste materials and management	Central and State Pollution Control Board
Biological Diversity Act, 2002	Biodiversity conservation	Disclosure of species survey or collection activities to the National Biodiversity Authority	MoEF, New Delhi and State Forest Departments
International Environmental (regulation in which India is a signatory)	Control and reduction of greenhouse gases	International environmental issues such as emission of greenhouse gases	Govt. of India
Environment (Protection) Act, 1986	To provide for the protection and improvement of environment	An umbrella legislation, supplements pollution laws	Central government nodal agency, MoEF can delegate to state departments of environment
Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	The new legislation will guide all land acquisitions of central and state governments, bringing in stricter norms and increasing landowners' compensation significantly.	Fair compensation to the assets acquired and proper rehabilitation and resettlement of PAFs with improvement in post-acquisition social and economic status	Central and State Government
EIA Notification 14th Sep 2006 and its amendments	Environment Impact Assessment	Environmental Protection	Project Development, State and Central Government

1.11. Scoping of the Project

The Expert Appraisal Committee examined the project in great depth and vide letter no. J-12011/1/2016-IA-I dated 12-04-2016 accorded clearance for pre-construction activities in the proposed site along with determination of "Terms of Reference" (TOR) for preparation of EIA/EMP report for project with installed capacity 210 MW. The Ministry also desired that the EIA should be

prepared for three seasons study, covering pre-monsoon, monsoon and post-monsoon and public consultation and submitted for appraisal.

1.12. Compliance of ToR

The EIA/EMP report has been prepared in conformity with all issues brought out in detailed TOR issued by MoEFCC, New Delhi, vide letter no. J-12011/1/2016-IA-I dated 12-04-2016. The brief issues involved, and their reference of compliance have been provided in **Table 1.6.**

Table 1.6 : Compliance of ToR

Point No.	Comment	Reference of compliance
A	**Physical and Chemical Environment**	
1	**Geological and Geophysical Aspects and Seismo-Tectonics:**	
	• Physical Geography, Topography, Regional Geological aspects and structure of the catchment.	Section 3.4.1 through 3.4.4
	• Tectonics, Seismicity and History of past earthquakes in the area. A site-specific study of earthquake parameters will be done. The results of the site-specific earthquake design shall be sent for approval of the NCSDP (National Committee of Seismic design parameters, Central Water Commission, New Delhi for large dams.	Section 3.4.5
	• Landslide zone or area prone to landslide existing in the study area should be examined.	Section 3.4.9
	• Presence of important economic mineral deposit, if any.	Section 3.4.12
	• Justification for location & execution of the project in relation to structural components (dam height).	Section 5.4.3
	•Impact of project on geological environment.	Section 4.2.4
2	**Meteorology, Air and Noise**	
	• Meteorology (viz., Temperature, Relative Humidity, wind speed/direction etc.) to be collected from nearest IMD station.	Section 3.5.1 through section 3.5.6
	• Ambient Air Quality with parameters viz., Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM) i.e., suspended particulate materials <10-microns, Sulphur Dioxide (SO_2), Oxides of Nitrogen (NOx), in the study area at 6 locations.	Section 3.5.7
	• Existing noise levels and traffic density in the study area at 6 locations.	Section3.5.8 and 3.5.9
3	**Soil Characteristics**	

Point No.	Comment	Reference of compliance
	Soil classification, physical parameters (viz., texture, porosity, bulk density and water holding capacity) and chemical parameters (pH, electrical conductivity, Magnesium, calcium, total alkalinity, chlorides, sodium, potassium, organic carbon, available potassium, available phosphorus, SAR, nitrogen and salinity, etc.,) (at 6 locations).	Section 3.6
4	**Remote sensing and GIS Studies**	
	Generation of thematic maps viz., slope map, drainage map, soil map, land use and land cover map, etc. Based on these, thematic maps, an erosion intensity map should be prepared. New Configuration map to be given in EIA report	Figure10.1through10. 5
5	**Water Quality**	
	• History of the ground water table fluctuation in the study area. • Water quality for both surface water and ground water for (i)Physical parameters'(pH, temperature, electrical conductivity, TSS); (ii)Chemical parameters (Alkalinity, Hardness, BOD, COD, NO2, PO4, CI, SO4, Na, K, Ca Mg, Silica, Oil & Grease, phenolic compounds, residual sodium carbonate); (iii) Bacteriological parameters (MPN, Total coliforms) and (iv) Heavy Metals (Pb, As, Hg, cd, cr-6, total Cr, Cu, Zn, Fe) at minimum 6 locations. • Delineation of sub and micro-watersheds, their locations and extent based on the All-India Soil and Land Use Survey of India (AISLUS), Department of Agriculture, Government of India. Erosion levels in each micro-watershed and prioritization of micro-watershed through silt yield index (SYI) method of AISLUS.	Section 3.8.10 Section 3.7 Section10. 1.3 and 10.1.8
B	**Water Environment & Hydrology**	

Point No.	Comment	Reference of compliance
	•Hydro-Meteorology of the project viz. precipitation (snowfall, rainfall), temperature, relative humidity, etc. Hydro-meteorological studies in the catchment area should be established along-with real time telemetry and data acquisition system for inflows monitoring.	Section 3.8.1.3 of EIA
	•Run-off, discharge, water availability for the project, sedimentation rate, etc.	Section 3.8.4 of EIA
	•Basin characteristic's	Section 3.8.1 of EIA
	•Catastrophic events like cloud bursts and flash floods, if any, should be documented.	Section 3.8.14 of EIA
	•For estimation of Sedimentation Rate, direct sampling of river flow is to be done during the EIA study. The study should be conducted for minimum one year. Actual silt flow rate to be expressed in ha-m km^2 year-I.	Section 3.8.15 of EIA
	•Set-up a G&D monitoring station and a few rain gauges stations in the catchment area for collecting data during the investigation.	
	•Flow series, 10 daily with 90%, 75% and 50% dependable years discharges.	Section 3.8.5 of EIA
	• Environmental flow release should be 20% of the average of 4 lean months of 90% dependable year during the lean season and, 30% of monsoon flow during monsoon season. For remaining months, the flow shall be decided by the committee based on the hydrology and available discharge. A site-specific study on minimum environmental flow should be carried out.	Section 3.8.5 and 3.8.6 of EIA Section 3.8.16
C	**Biological Environment**	
	Flora: • Characterization of forest types (as per Champion and Seth method) in the study area and extent of each forest type as per the Forest Working Plan. • Documentation of all plant species i.e. Angiosperm, Gymnosperm, Pteridophytes, Bryophytes (all groups).	Section 3.9 of EIA

Point No.	Comment	Reference of compliance
	• General vegetation profile and floral diversity covering all groups of flora including lichens and orchids. A species wise list may be provided. • Assessment of plant species with respect to dominance, density, frequency, abundance, diversity index, similarity index, importance value index (IVD, Shannon Weiner index etc. of the species to be provided. Methodology used for calculating various diversity indices along with details of locations of quadrates, size of quadrates etc. to be reported within the study area in different ecosystems. • Existence of National park, Sanctuary, Biosphere Reserve etc. in the study area, if, any, should be detailed. • Economically important species like medicinal plants, timber, fuel wood etc. • Details of endemic species found in the project area. • Flora under RET categories should be documented using International Union for the Conservation of Nature and Natural Resources (IUCN) criteria and Botanical Survey of India's Red Data list along-with economic significance. Species diversity curve for RET species should be given. **Fauna**: Fauna study and inventorisation should be carried out for all groups of animals in the study area. Their present status along with Schedule of the species. • Documentation of fauna plankton (Phyto and zooplankton), periphyton, benthos and fish should be done and analyzed. • Information (authenticated) on Avi-fauna and wildlife in the study area. • Status of avifauna their resident/ migratory/ passage migrants etc. Documentation of butterflies, if any, found in the area. • Details of endemic species found in the project area. • RET species-voucher specimens should be collected along-with GPS readings to facilitate rehabilitation. RET faunal species to be	Section 3.9

Point No.	Comment	Reference of compliance
	classified as per IUCN Red Data list and as per different schedule of Indian Wildlife (Protection) Act, 1972. • Existence of barriers and corridors, if any, for wild animals. • Compensatory afforestation to compensate the green belt area that will be removed, if any, as part of the proposed project development and loss of biodiversity. • Collection of primary data on agricultural activity, crop and their productivity and irrigation facilities components. • For categorization of sub-catchment into various erosion classes and for the consequent CAT plan, the entire catchment (Indian Portion) is to be considered and not only the directly the draining catchment.	
D	**Aquatic Ecology**	
	• Documentation of aquatic fauna like macro-invertebrates, zooplankton, Phyto-planktons, benthos etc. • Fish and fisheries, their migration and breeding grounds. • Fish diversity composition and maximum length & weight of the measured populations to be studied for estimation of environmental flow. • Conservation status of aquatic fauna. • Sampling for aquatic ecology and fisheries and fisheries must be conducted during three Seasons-Pre-monsoon (summer), monsoon and winter. Sizes (length & weight) of important fish species need to be collected and breeding and feeding grounds should also be identified along the project site or in vicinity.	Section 3.9
E	**Socio-economic**	
	• Collection of baseline data on human settlements, health status of the community and existing infrastructure facilities for social welfare including sources of livelihood, job opportunities and safety and security of workers and surroundings population.	Section 3.10 of EIA

Point No.	Comment	Reference of compliance
	• Collection of information with respect to social awareness about the developmental activity in the area and social welfare measures existing and proposed by project Proponent. • Collection of information on sensitive habitat of historical, cultural and religious and ecological importance. • The socio-economic survey/ profile within 10 km of the study area for demographic profile; Economic Structure; Developmental Profile; Agricultural Practices; Infrastructure, education facilities; health and sanitation facilities; available communication network etc. • Documentation of demographic, Ethnographic, Economic Structure and development profile of the area. • Information on Agricultural Practices, Cultural and aesthetic sites, Infrastructure facilities etc. • Information on the dependence of the local people on minor forest produce and their cattle grazing rights in the forest land. • List of all the Project Affected Families with their names, education, land holdings, other properties, occupation, source of income, land and other properties to be acquired, etc. •In addition to socio-economic aspects of the study area, a separate chapter on socio-culture aspects based upon study on Anthography of the area should be provided.	
7	**Impact Prediction and Mitigation Measures** The adverse impact due to the proposed project should be assessed and effective mitigation steps to abate these impacts should be described.	
	Air Environment	
	• Changes in ambient and ground level concentrations due to total emissions from point, line and area sources. • Effect on soil, material, vegetation and human health. • Impact of emissions from DG set used for power during the construction, if any, on air environment. • Pollution due to fuel combustion in equipment and vehicles	Section 4.5.1 Section 4.5.2 Section 4.5.3 Section 4.5.4

Point No.	Comment	Reference of compliance
	• Fugitive emissions from various sources • Impact on micro climate	Section 4.5.5 Section 4.5.6
	Water Environment	
	• Changes in surface and ground water quality. • Steps to develop pisci-culture and recreational facilities • Changes in hydraulic regime and downstream flow. • Water pollution due to disposal of sewage • water pollution from labor colonies/ camps and washing equipment.	• Section 4.4.1 • Section 4.4.2 • Section 4.4.3 • Section 4.4.4 • Section 4.4.5
	Land Environment	
	• Adverse impact on land stability, catchment of soil erosion, reservoir sedimentation and spring flow (if any) (a) due to considerable road construction/widening activity (b) interference of reservoir with the inflowing stream (c) blasting for commissioning of HRT, TRT and some other structures. • Changes in land use / land cover and drainage pattern • Immigration of labour population • Quarrying operation and muck disposal • Changes in land quality including effects of waste disposal. • River bank and their stability • Impact due to submergence.	Section 4.3.1 Section 4.3.2 of EIA Section 4.3.3 of EIA Section 4.3.4 of EIA Section 4.3.5 of EIA Section 4.3.6 of EIA
	Biological Environment:	
	• Impact on forests, flora, fauna including wildlife, migratory avi-fauna rare and endangered species, medicinal plants etc. • Pressure on existing natural resources. •Deforestation and disturbance to wildlife, habitat fragmentation and wild animal's migratory corridors.	Section 4.8. of EIA

Point No.	Comment	Reference of compliance
	•Compensatory afforestation-identification of suitable native tree species for compensatory afforestation and green belt. •Impact on fish migration and habitat degradation due to decreased flow of water. •Impact on breeding and nesting grounds of animals and fish.	
	Socio-economic Aspects:	
	• Impact on local community including demographic profile. •Impact on socio-economic status. •Impact on economic status. • Impact on human health due to water / water borne disease • Impact on increase traffic. •Impact on Holy Places and Tourism. •Impacts of blasting activity during project construction which generally destabilize the land mass and leads to landslides, damage to properties and drying-up of natural springs and cause noise pollution will be studied. Proper record shall be maintained of the baseline information in the post project period. •Positive and negative impacts likely to be accrued due to the project are listed.	Section 4.9.1 of EIA Section 4.9.2 of EIA Section 4.9.2 of EIA Section 4.9.3 of EIA Section 4.9.4 of EIA Section 4.9.5 of EIA Section 4.7.6 of EIA Section 4.7.8 of EIA
8	**Environmental Management Plans**	
i)	Catchment Area Treatment (CAT) Plan should be prepared micro-watershed wise. Identification of free draining/ directly draining catchment based upon Remote Sensing and Geographical Information System (GIS) methodology and Sediment Yield Index (SYI) Method of AISLUS, Dept. of Agriculture, Govt. of India coupled with ground survey. Areas or watersheds falling under 'very severe' and 'severe' erosion categories should be provided and required to be treated. Both biological as well as engineering measures should be proposed in consultation with State Forest Department for areas requiring treatment. Year-wise schedule of work and monetary allocation should be provided. Mitigation measures to check shifting cultivation in the catchment area with provision for alternative and better agricultural practices should be included.	Section 10.1

Point No.	Comment	Reference of compliance
ii)	Compensatory Afforestation in lieu of the forest land required for the project needs to be proposed. Choice of plants should be made in consultation with State Forest Department including native and RET species, if any.	Section 10.2
iii)	Biodiversity and Wild Life Conservation & Management Plan for conservation and preservation of endemic, rare and endangered species of flora and fauna to be prepared in consultation with State Forest Department	Section 10.3
iv)	Fisheries Conservation & Management Plan-Fish fauna inhabiting the affected stretch of river, a specific fisheries management plan should be prepared for river and reservoir.	Section 10.4
v)	Resettlement and Rehabilitation (R&R) Plan need to be prepared with due consultation with Project Affected Families (PAFs). The provision of the d R&R plan should be according to the National Resettlement and Rehabilitation Policy (NRRP-2007) as well as State Resettlement and Rehabilitation Policy. Detailed budgetary estimates are to be provided. Resettlements sites should be identified.	Section 10.5
vi)	Plan for Green Belt Development along the periphery of reservoir, colonies, approach road, canals etc. to be prepared in consultation with the State Forest Department. Local plant species suitable for greenbelt development should be selected	Section 10.6
vii)	Reservoir Rim Treatment Plan for stabilization of land slide/land slip zones if any, around the reservoir periphery to be prepared. Suitable engineering and biological measures for treatment of the identified slip zones to be provided with physical and financial schedule.	Section 10.7
viii)	Muck Disposal Plan- suitable sites for dumping of excavated material should be identified in consultation with the State Pollution Control Board and Forest Department. All Muck disposal sites should be minimum 30 m away from the HFL of river. Plan for rehabilitation of muck disposal sites should also be given. The L- section/ cross section of muck disposal sites and approach roads to be given. Financial out lay for this may be given separately	Section 10.8
ix)	Plan for Restoration of quarry sites and landscaping of colony areas, working areas, roads, etc.	Section 10.9
x)	Study of Design Earthquake Parameters: A site specific study of earthquake parameters should be done. Results of the site-specific	Section 10.10

Point No.	Comment	Reference of compliance
	earthquake design parameters should be approved by National Committee of Seismic Design Parameters, Central Water Commission (NCSDP) New Delhi.	
xi)	Dam Break Analysis and Disaster Management Plan: The outputs of Dam Break Model should be illustrated with appropriate graphs and maps clearly bringing out the impact of Dam break scenario. Provision for early warning systems should be provided	Section 10.11
xii)	Water, Air and Noise Management Plans to be implemented during construction and post construction periods.	Section 10.12
xiii)	Public Health Delivery Plan including the provisions of drinking water supply for local community	Section 10.13
xiv)	Labour Management Plan for their Health and Safety.	Section 10.14
xv)	Sanitation and Solid-waste management plan for domestic waste from colonies and labour camps etc.	Section 10.15
xvi)	Local Area Development Plan to be formulated in consultation with the Revenue Officials and Village Panchayats. Local skill development schemes should be given. Details of various activities to be undertaken along with its financial out lay should be provided.	Section 10.16
xvii)	Environmental Safeguards during construction activities including Road Construction.	Section 10.17
xviii)	Energy Conservation Measures	Section 10.18
xix	Environmental Monitoring Programme with physical & financial details covering all the aspects of EMP. A summary of cost estimate for all the plans, cost for implementing all Environmental Management Plans including the cost for implementing environmental monitoring programme should be given. Provision for an Environmental Management Cell should be made	Chapter-6
xx)	A Summary of Cost Estimates for all the plans, cost for implementing all the Environmental Management Plans.	Section 10.19

Chapter 2. : PROJECT DESCRIPTION

2.1. Introduction

Umngot Hydro-Electric Project, conceived as storage scheme across Umngot in East Khasi Hills and Jaintia Hills District of Meghalaya, envisages utilisation of gross head of about 808.60 m for annual power generation of 708.98 MU in a 90 % dependable year. The proposed dam site on river Umngot at Saida near village Siangkhnai. A Surface Power House (3X70 MW,) on the right bank of river Umngot near village Syntung has been proposed. The index map of the project is depicted in **Figure 2.1** and vicinity map of the project is shown in **Figure 2.2.**

2.2. Project Location

From Shillong, the project is accessible by road on the left bank through the NH-44 E which runs through the neighbouring Jaintia Hills District of Meghalaya to Tamabil, a dry port on the Bangladesh border. On the right bank the Project is also accessible from N.H-44 via a District/village road in East Khasi Hills District where most of the hydraulic structures will be located. The satellite view of the project is shown in **Figure 2.3.**

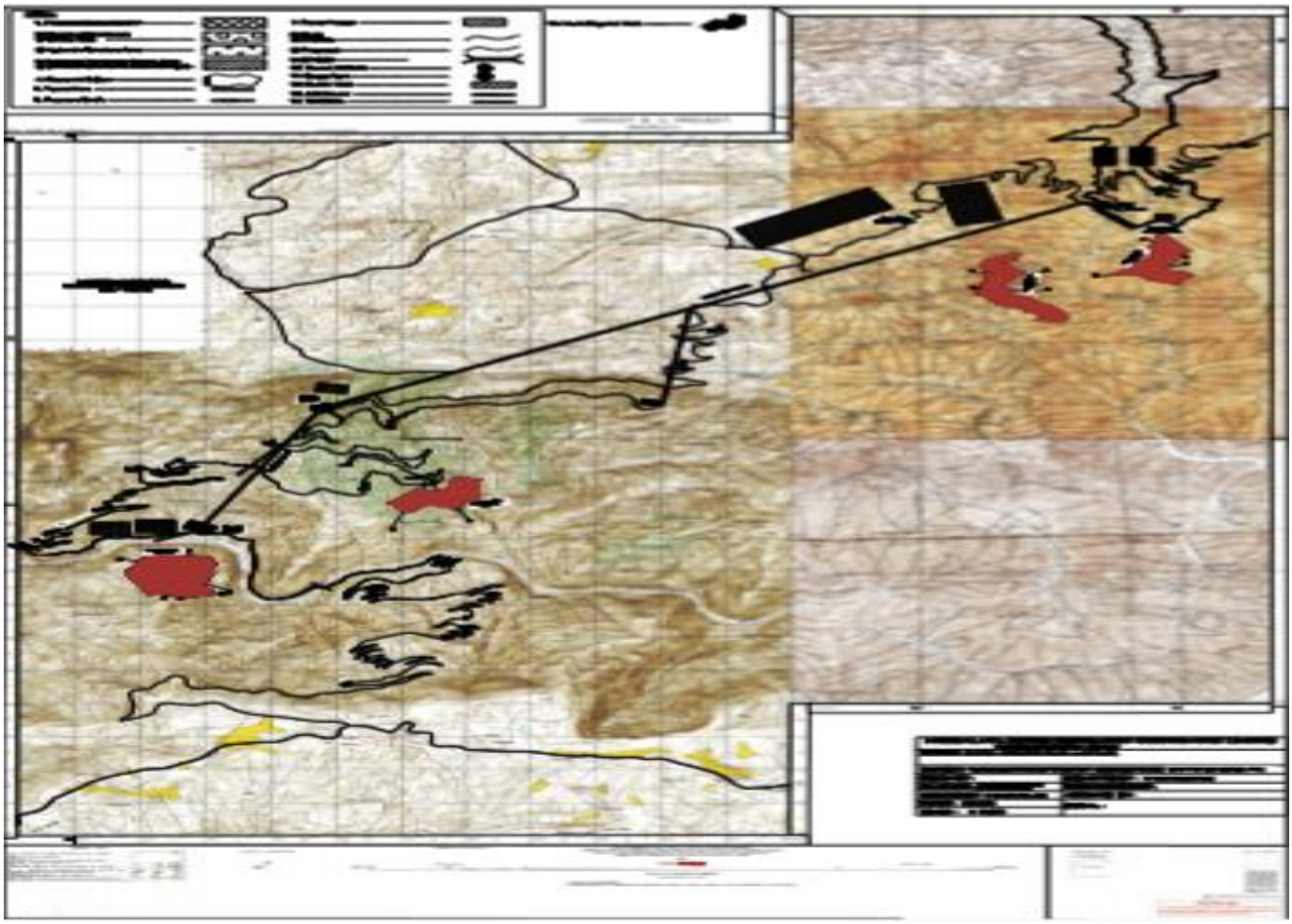


Figure 2.1 : Index Map of Project

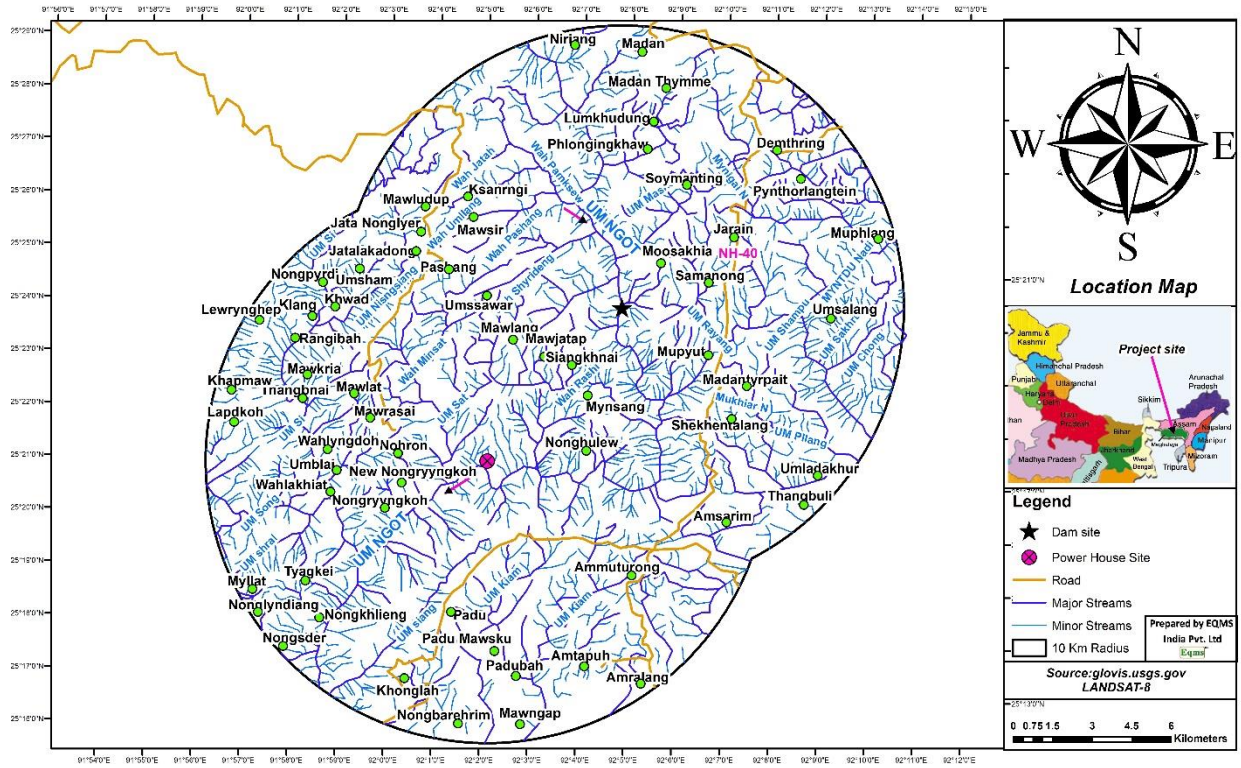


Figure 2.2 : Vicinity Map of Project

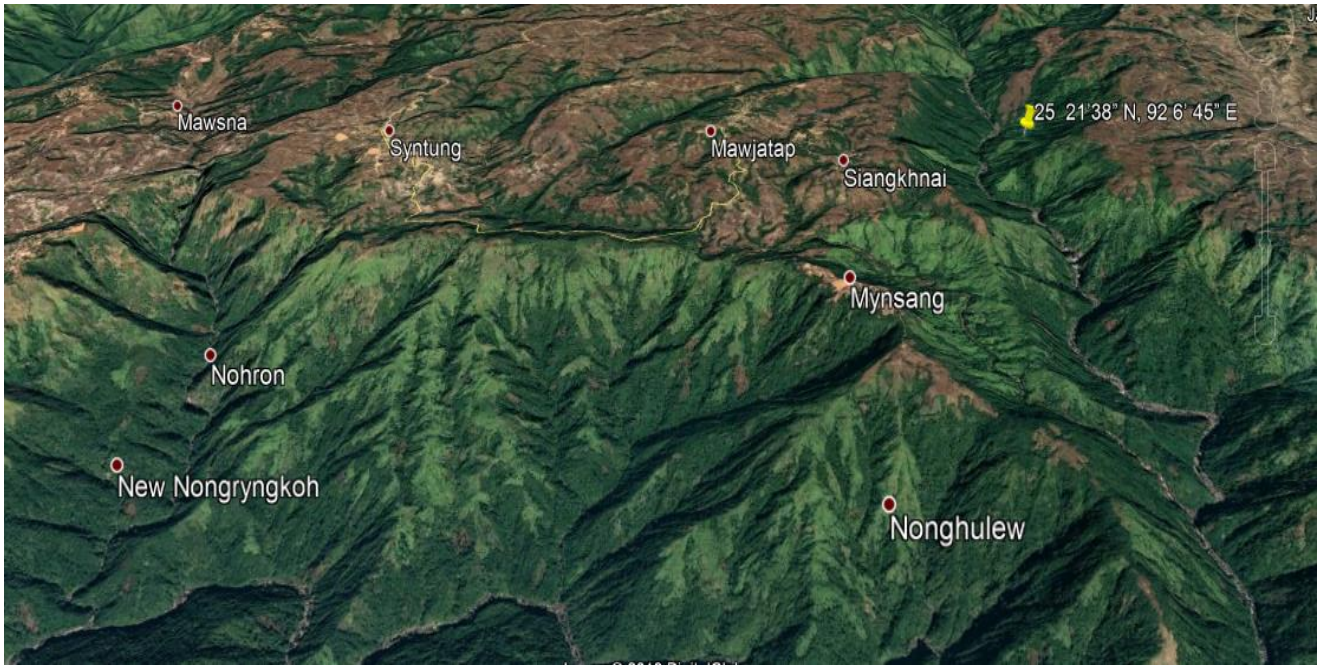


Figure 2.3 : Satellite Map of Project

2.3. Salient Features

The salient features of the project are depicted in **Table 2.1.**

Table 2.1 : Salient Features of Umngot Hydro Electric Project

LOCATION	
State	Meghalaya
District	East Khasi & Jaintia Hills Dist.
River	Umngot
Location of Dam	Saida near village Siangkhnai
Coordinates of Dam Site	25 ^{0} 21'38" N, 92^0 6' 45" E
Location of Power house	Near village Syntung
Coordinates of Power house Site	25 ^{0} 21'10" N, 92^0 3' 20" E
HYDROLOGY	
Catchments area at Dam Site	304 Sq. km
Average Annual Rainfall	3904.08mm
Average Annual Inflow	2580.09
90% Dependable Year Inflow	519 MCM (Year1990 -91)
90% Dependable Year Inflow	784 MCM (Year1989 -90)
PMF for structural design	9760 cumecs
Diversion Flood (Lean Season)	392 cumecs
RESERVOIR	
FRL/ MWL	EL. 1040.00 m
MDDL	EL. 1010.00 m
Gross Storage at FRL/ MWL	71.31 MCM
Dead Storage	22.41 MCM
Live Storage at FRL/ MWL	48.90 MCM
New Zero Elevation (75-year sedimentation)	El. 995.80 m
Submergence Area	253.75 ha
DAM	
Type	Concrete Gravity
Length	362m
Length of Non-overflow Section	275.8 m
Length of Overflow Section	86.2 m
Deepest Foundation Level	EL. 931.00 m
Deepest river bed level at axis	EL. 933.00 m
Max Height Above Foundation Level	111.00 m
Crest level	EL. 994.55 m
Top Level of Dam	EL. 1042.00 m
SPILLWAY	
Type	High Ogee Overflow with Breast Wall
Spillway Bays and Size	6No., 8.50m X 12.70m
Spillway Sill Level	EL. 994.55 ma
Radial Gates	6Nos (7.50 m x 11.78 m)
Spillway Capacity	9779.00 Cumecs
INTAKE STRUCTURE	
Type	Semi-Circular with trash rack

Trash Rack Bays	5 Nos.
Panel Size	2.5 m x4.43 m
Regulating gates	2 Nos fixed wheel type (3.40 m x 3.40 m)
Invert Level at Intake	EL. 997.80 m
Design discharge	30.16 cumec
HEAD RACE TUNNEL	
Diameter	3.40 m
Profile	Modified Horse Shoe
Lining	300 mm
Gradient / Max velocity	1 in 425/3.53 m/s
Length	5646.00 m
Maximum discharge	33.20 cumec
SURGE SHAFT	
Type	Restricted Orifice
Diameter	12.0 m
Height	68.10 m
Diameter of Orifice	1.80m
Surge shaft Top/ Bottom level	EL. 1057.00 m / EL. 988.90 m
Gate	1 No. (4.0 m x 4.00 m)
PRESSURE SHAFT	
Type	Steel lined with concrete backfill
Number	1(one) No. with trifurcation
Length	2209.00 m
Internal Diameter	2.50 m trifurcating to 1.61m dia.
Max/Min Thickness of steel liner	36mm /10 mm
POWER HOUSE	
Type	Surface
Installed capacity	210 MW (3 x 70MW)
Size of Power house	107.5 m (L) x 22 m (W)
Maximum / Minimum Net Head	804.22 m /734.70 m
Rated Design Head	762.50 m
Machine Hall Floor/Service Bay Level	EL. 244.00 m
TAIL RACE CHANNEL	
Size of TRC for Three Individual Units	3 TRT of 41 m length and 3.78m dia.
Size of Main TRC /Length	6.6 mx2.8m/110m
Bed Slope/Max. Velocity	1:200/ 4 m/s
Side Slope	1.5(H):1(V)
TURBINES	
No & Type	3 nos., Jet Pelton (Vert. Shaft)
Maximum Gross head	808.60 m
Annual Units Generated (90% dependability)	708.98 MU
ESTIMATED COST	

ESTIMATED COST	2567.80 crores
Levelized sale price	Rs. 3.45 per KWh
Construction Period	6 years

2.4. Catchment Area

The catchment area is 304sq. km with no intercepted catchment up to dam site. The catchment area is located in the southern part of this plateau which is marked by deep gorges, spurs and abrupt slopes. Through the deep-cut valleys and escarps, the river Umngot rush down swiftly towards the southern plains leaving in its wake numerous cataracts and waterfalls which are very amenable for development of hydro-power. The Umngot HEP is located in the southern part of this plateau. The plateau extends east –west with altitudes ranging from 150 masl to 1965 masl. The entire plateau is mountainous but the eastern and western extensions are relatively lower. Shillong peak is the highest point on the plateau where the origin of the river Umngot is very near its vicinity.

2.5. River Morphology

The river has torrent water flow with frequent rapids and cascade habitats, and few riffle pools and runs in some places. The river banks show pocket pools, riffles and shallow water sites. The substratum of river is dominated with small to large boulders and rocks impregnated with fine sand. Cobbles and gravels were observed in substantial amount. The side banks and flood prone area were predominated with large boulders impregnated in sand with sparse vegetation. The river banks and hill slopes show a fair amount of vegetation dominated with trees, herbs and shrubs.

Morphology of the streams is different due to first order of drainage receiving precipitation. Streams show very high gradient or slope >10% with large boulders and rocky substratum. Cascades and falls form dominant habitat leading to formation of scour and step pools. The stream bed and banks are predominated with rocks and boulders impregnated in sand and shingles. Fairly dense vegetation is observed on the slopes and the valley is 'U' shaped. The biggest fall is Padem fall (overall fall 60m) with a series stepped fall with two steps having drop of more than 10m.The location of morphological features governing the hydraulics of the river in a stretch about 5km u/s of reservoir to 2.5km d/s of dam axis is given in **Table 2.2** and shown in **Figure 2.4.**

Table 2.2 : Location of Rapid, Pools etc., of River

S.N.	Features	Coordinates
Rapids		
1	Rapids	25°26'39.42"N 92° 6'10.35"E
2	Rapids	25°23'52.67"N 92° 6'6.34"E
Fall		
1	Fall	25°20'49.42" N 92° 6'44.32"E
Pools		
1	Pools	25°29'53.43"N 92° 3'22.48"E
2	Pools	25°29'43.63"N 92° 3'49.84"E
3	Pools	25°29'37.17"N 92° 4'54.51"E
4	Pools	25°29'36.95"N 92° 5'25.14"E
5	Pools	25°26'51.29"N 92° 5'48.08"E
6	Pools	25°26'36.92"N 92° 6'10.80"E

7	Pools	25°26'23.41"N 92° 6'11.48"E
8	Pools	25°25'49.40"N 92° 6'14.29"E
9	Pools	25°23'49.98"N 92° 6'8.40"E
10	Pools	25°22'28.86"N 92° 6'42.05"E
11	Pools	25°21'49.08"N 92° 6'41.40"E
12	Pools	25°20'44.43"N 92° 6'47.15"E
13	Pools	25°20'31.92"N 92° 6'48.52"E
Shoal Deposit		
1	Shoal Deposit	25°29'35.10"N 92° 5'9.75"E
2	Shoal Deposit	25°29'39.66"N 92° 5'36.53"E
3	Shoal Deposit	25°29'30.49"N 92° 5'39.98"E
4	Shoal Deposit	25°29'21.58"N 92° 5'42.10"E
5	Shoal Deposit	25°29'9.40"N 92° 5'57.20"E
6	Shoal Deposit	25°28'52.66"N 92° 6'23.08"E
7	Shoal Deposit	25°28'33.19"N 92° 6'24.29"E
8	Shoal Deposit	25°28'25.11"N 92° 6'30.97"E
9	Shoal Deposit	25°27'28.94"N 92° 6'1.02"E
10	Shoal Deposit	25°27'26.27"N 92° 5'55.25"E
11	Shoal Deposit	25°27'10.44"N 92° 5'43.06"E
12	Shoal Deposit	25°26'55.82"N 92° 5'48.44"E
13	Shoal Deposit	25°26'49.30"N 92° 5'53.14"E
14	Shoal Deposit	25°26'30.40"N 92° 6'10.85"E
15	Shoal Deposit	25°26'16.42"N 92° 6'10.43"E
16	Shoal Deposit	25°22'15.08"N 92° 6'37.78"E
17	Shoal Deposit	25°22'7.41"N 92° 6'37.37"E
18	Shoal Deposit	25°21'53.15"N 92° 6'39.08"E
19	Shoal Deposit	25°21'28.19"N 92° 6'27.57"E
20	Shoal Deposit	25°21'28.33"N 92° 6'29.28"E
21	Shoal Deposit	25°21'16.27"N 92° 6'24.00"E
Fish Breeding Ground		
1	Fish Breeding Ground	25°29'46.71"N 92° 3'32.53"E
2	Fish Breeding Ground	25°29'41.66"N 92° 4'31.73"E
Point of Confluence with tributaries		
1	Confluence with tributaries	25°28'18.85"N 92° 6'34.57"E
2	Confluence with tributaries	25°28'8.09"N 92° 6'31.24"E
3	Confluence with tributaries	25°27'43.08"N 92° 6'17.92"E
4	Confluence with tributaries	25°27'28.07"N 92° 5'56.74"E
5	Confluence with tributaries	25°25'45.96"N 92° 6'14.01"E
6	Confluence with tributaries	25°25'38.31"N 92° 6'27.85"E
7	Confluence with tributaries	25°24'33.93"N 92° 6'47.30"E
8	Confluence with tributaries	25°23'59.09"N 92° 6'5.90"E

9	Confluence with tributaries	25°23'20.56"N 92° 6'24.12"E
10	Confluence with tributaries	25°22'45.10"N 92° 6'41.17"E
11	Confluence with tributaries	25°22'23.06"N 92° 6'40.34"E
12	Confluence with tributaries	25°21'51.11"N 92° 6'39.80"E
13	Confluence with tributaries	25°19'54.57"N 92° 7'8.39"E
14	Confluence with tributaries	25°19'24.16"N 92° 6'51.09"E

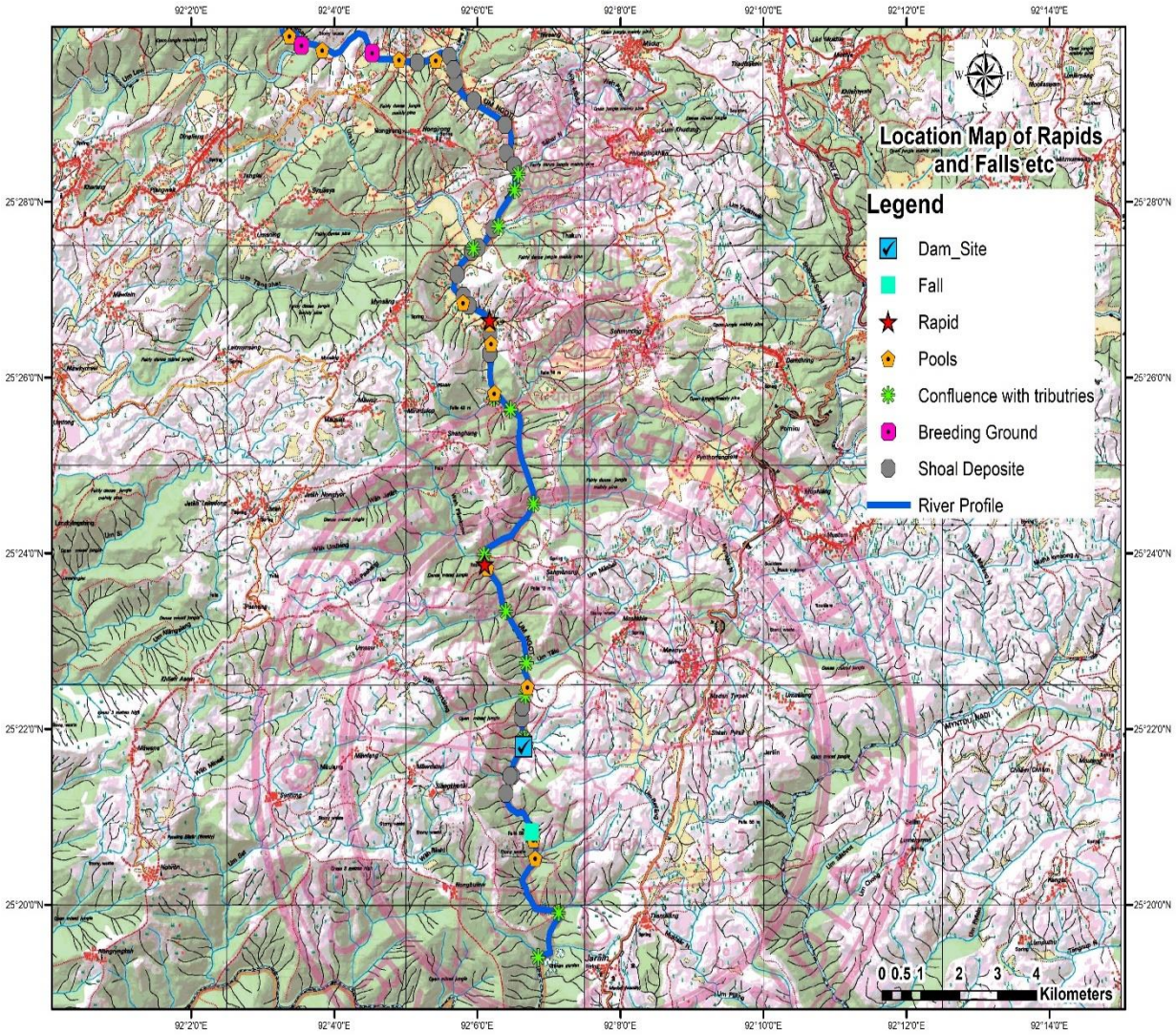


Figure 2.4 : Location of Morphological Features

2.6. Construction Material Requirement

Construction materials like cement, steel, etc will have to be available in sufficient quantities in the market. The cement factories located in Jaintia Hills District will be able to cater to the needs of the Project. Steel can be purchased directly from reputed manufacturers like SAIL, TISCON, etc ex-Guwahati, about 170 Km from Project site. Coarse aggregates can be obtained by crushing of boulders from stone quarries identified in and around the Project area. River sand is available within a radius of 55km from Umiew river near Mylliem and from the Myntdu river at Kharkhana. The requirement

of construction material for the project has been worked out after incorporating the consumptive use of excavated material. Estimated requirement of various materials and the source has been mentioned in **Table 2.3.**

Table 2.3 : Quantity of Various Materials (Lakh cum)

S. No	Material	Estimated Quantity (lakh cum)	Quantity retrieved from excavated muck	Balance quantity to be obtained from quarries	Quarry/ Mining Sites
1	Coarse aggregate	15.34	2.78	12.56	Rock-in-situ quarry sites at left/right bank of Umngot river.
2	Fine aggregate	7.08	0.0	7.08	River bed shoal deposit from Myntdu river at Kharkhana and also from Umiew river, near Mylliem.
3	Stone/Boulder	0.47	0.47	0.00	From excavated muck
	Total	**22.89**	**3.25**	**19.64**	

2.7. Land Requirement for the Project

For execution of the project 390.50 ha land shall be required of which the apportionment between, Forest land and private land shall be 93.53 ha and 296.97 ha respectively.

2.8. Manpower Requirement for the Project

About 1000 workers (labour and staff) would be engaged temporarily during peak construction period. It is expected that 80% of the total work force shall be locally available from adjacent areas. After completion of the project about 100 staff shall be permanently required for regulation of the dam and power house.

2.9. Water Requirement for the Project

The quantity of water required during construction is estimated as 400 kld which shall be drawn from the river water can be pumped and stored in a tank at higher elevation. The treated drinking water shall be supplied to project and labour colony

2.10. Construction Power Requirement for the Project

The total requirement of construction power will be about 8 MW which shall be required at different consumption points. The construction power shall be tapped from 132/33 KV Mustem Sub-station which is about 26-28 Km from the left bank of the dam site and shall have a line length of about 35 – 45 Km to the different work fronts

In emergent situation resulting due to grid failure or load shedding diesel generator sets DG sets of capacity 250-500 KVA will be installed at all the major construction sites to ensure smooth progress of major works during power failure.

(4x 500KVA) shall be deployed for captive power generation.

2.11. Construction Schedule

The project has been planned to be completed in six years' time frame from the date of start including the period required for testing and commissioning of the power plant equipment. Project is planned to be executed in a total period of 72 months after all the statutory clearances have been received and includes Tender Engineering and Award of Work and for Mobilization. Accordingly, the sequence of execution of various Project components has to be carried out as per schedule so that disruption or delay of subsequent activities is avoided. The number of working days available in a calendar year is taken as 240.

The works shall be carried on contractual basis with one or separate packages for dam and appurtenant works, Intake and HRT and Power house and Hydro-mechanical works. There will be two Contract packages. Package – I will include Civil works and Package – II will be for Hydro mechanical works. The construction schedule for broad activities is as under: -

2.11.1. *Excavation*

Excavation and foundation preparation work for the Dam and energy dissipating arrangements, etc will commence by the end of the 11th month and will continue for other blocks up to the 31st month after zero date. Temporary diversion works will be done during excavation till the diversion structures are completed. Excavation works will be mechanized and excavators, loaders, dumpers and other machineries will be used.

2.11.2. *River Diversion*

The construction of upstream and downstream coffer dams is expected to commence by the 9th month after the road cutting has reached to the dam site. The diversion tunnel will also commence by the 9th month and is expected to be completed simultaneously with the coffer dams by the 14th month.

2.11.3. *Concreting*

Concreting works will commence by the end of 16th month and are scheduled to be completed by the end of 70th month. Consolidation and curtain grouting including other related works will be carried out together with concreting works. All works will be mechanized and three tower cranes – one on each flank and one in the middle – will be employed to speed up construction works.

2.11.4. *Radial and Stop Log Gates*

Fabrication of radial and stop log gates with their embedded parts will commence by the end of 14th /16th month and will be completed by the end of 44th /46th month. Transportation of embedded parts to site will start by the end 18th /20th month. Transportation of radial and stop log gates will begin by the end of 44th /46th month and all hydro mechanical equipment will reach the work site by the end of 47th/49th month. Thereafter, erection of these gates will commence and shall be completed by the 68th /70th month.

2.11.5. *Head Race Tunnel*

Construction of HRT from intake face (Face-I) will commence by the end of 17th month after zero date by boring of the adit to the Face I/II. Boring of the HRT from Face-II will commence by the end of 20th month after zero date. Boring of the 1200m adit to HRT can start simultaneously by the 17th/18th month when the road works to this face are over. Providing 12 months for this activity, the adit can be completed by the 29th /30th month. Similarly, the 230m adit at the d/s end through the

Valve Chamber and Surge Shaft can be completed by the 21st /22nd month. Thereafter, tunnel boring can start from all the four faces and will take another 24 months before its completion by the 53rd /54th month. Boring from the Face I towards the Intake can start by the 47th/48th month and could be completed in all respects along with the Intake by the 53rd/54th month.

2.11.6. ***Pressure Shaft***

From the top of the Shaft, excavation will be started by the 23rd/24th month with the conventional drilling and blasting method. A power winch will be installed at the top for lowering men and equipment into the shaft and for mucking. Considering a progress of 1.50m per day, about 410m length would be completed from the top in about 280 days i.e., the 37th month. Boring from the middle of the limb will commence by the 24th /25th month after the road and the adit to the inclined limb have been completed. The bottom of the shaft is expected to be reached by the 42nd /43rd month.

Erection of liner can start by the 42nd /43rd month. The construction of the Butterfly Valve can be taken up simultaneously by the 59th month so as to complete by the 67th month with three months being kept for testing, etc. before it is ready by the 70th month.

2.11.7. ***Power House***

Civil works will commence in the 26th /27th month after the road to Power House site from right bank is through. Twelve months are provided for excavation works after which 1st stage concreting works will begin by the 38th /39th month. All embedded parts and E & M components required from the early stages of 1st stage concreting shall be brought to site well in advance. Concreting and all finishing works in Power House will be over by the 70^{th} / 71^{st} month.

2.11.8. ***E& M Works***

Manufacturing of various components including embedded parts will commence by the 22^{nd} /23^{rd} month and 20 months are provided for manufacturing and transportation. Erection works will start by the end of 42nd/43rd month.

2.11.9. ***E& M Works***

Works for the GIS Hall shall commence alongside with the powerhouse i.e., by the 26^{th}/27^{th} month, and shall also be completed by the 70^{th}/71^{st} month. Erection works of electrical components of the switchyard and transformer yard shall commence by the 46th/47th month and completed by the 70^{th}/71^{st} month i.e., (two) months before commissioning of the Project.

2.12. Project Cost

The estimated cost of the project is Rs. 2567.80 Crores. The cost of generation is estimated at Rs. 4.37 per KWh in the first year and the levelized cost of generation is Rs. 3.45 per KWh.

Chapter 3. : DESCRIPTION OF BASELINE ENVIRONMENT

3.1. Introduction

As a precursor for the prediction of various types of environmental impacts likely to arise due to implementation of this project, it is essential to establish the base line environmental status of the physico-chemical, biological and socio-economic parameters in the project area and within the project influence area.

The information on relevant environmental parameters has been collected through primary and secondary sources in order to understand the present environmental setting of the proposed project site. The major purpose of describing the environmental settings of the study area is:

- To understand the project, need and environmental characteristics of the area.
- To assess the existing environmental quality, as well as the environmental impacts of the future developments being studied; and
- To identify environmentally significant factors or geographical areas that could preclude any future development.
- The basic parameter on which data has been collected is as follows:
- Physico-chemical aspects
- Biological aspects
- Socio-economic aspects

The various factors that have been considered towards the formulation of a proper strategy for conducting the baseline studies are described in the next section.

3.2. Study Area

The EIA study includes the study of various baseline parameters of environment viz. land, water, air, noise, flora, fauna and socio-economics. Integration of these parameters gives an overall perception of positive and negative impacts due to construction of a hydroelectric project, if any. For overall prediction of impacts, the Study Area (**Figure 2.1**) shall be considered as 10 km radius covering all consequential project components viz. diversion structure and powerhouse for conducting study in respect of attributes like air, noise, water and soil for studies. Baseline study shall be carried out for pre-monsoon, monsoon and post monsoon season in accordance with the approved ToR.

For EIA study of the proposed project, following study areas have been considered:

- Catchment area up to the dam site.
- Submergence area.
- Project area or the direct impact area within 10 Km of the main project components (dam, canals etc

Study area map comprising direct impact area which includes complete submergence area, catchment area covered under 10 km radius from the dam axis, and the canal system with command area is shown in **Figure 3.1.**

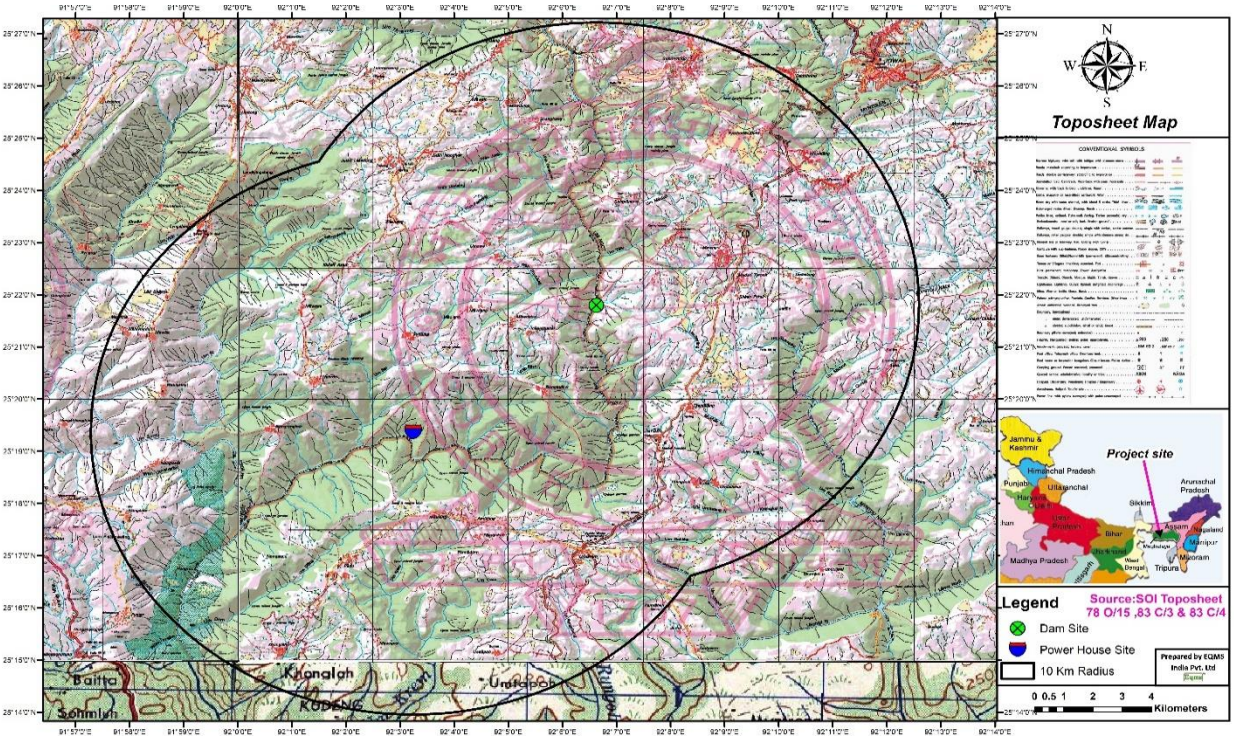


Figure 3.1 : Study Area Map

3.3. Methodology of Conducting Bassline Study

The guiding factors for the present baseline study are the Ministry of Environment, Forests & Climate Change's (MoEF&CC) requirements for the Environmental Impact Assessment (EIA) notification and local regulations and directives. Further, a buffer area extending up to 10 km radius from the site has also been studied, though with a lesser degree of detail. The baseline study and primary data collection has been carried out during post-monsoon, 2017, pre-monsoon 2018 and monsoon ,2018. The studies were conducted by considering the following:

- The various environmental attributes were divided into primary and secondary studies. Primary attributes such as air environment, water, soil, noise, flora and fauna, and Socio-economic were assessed by conducting field studies, on-site monitoring and review of the past studies conducted.
- Baseline data on environmental attributes (Air, Noise, Water and Soil) have been collected for 3 seasons in the study area. The data has been collected by the EIA Consultant by engaging NABL accredited laboratory.
- Secondary attributes such as land use studies, geology, physiological characteristics, and socio-economic environment have been assessed by literature review of previous studies conducted by various government publications.
- An interdisciplinary team through discussions, criteria questions and professional judgement formulated the scoping and the extent of data generation. The baseline studies started with site visits and reconnaissance survey in the study area for fixing the monitoring locations for the primary data. As a secondary data review, various Government agencies were approached for procuring information and relevant data of the area.

3.3.1. *Physical Environment Study*

The study related to physical environment shall be conducted through both site visits and review of the secondary sources like the DPR and other published peer information in respect of the topographical and physiographical features, regional and the local geology of the project area, climatology and seismicity. Soil characteristics shall be establishing through physio-chemical tests of the soil samples revalidated though the published literature while land use and land cover, slope of the study area shall be establishing through remote sensing by using GIS tools.

3.3.1.1 Land use – Landcover Classification

Prior to ground truthing, the satellite data shall be classified using unsupervised classification technique. Further, after collecting ground truth details maximum likelihood classification based on supervised classification method shall be used with remote sensing image data.

After the supervised classification procedure, a land use map shall be prepared and verified in field, and errors or omissions identified.

A reclassification of the land use categories implementing the details and corrections, if any, shall be made. The reclassification output shall be used for the preparation of the final land use classification map. This map after due verification shall be composed and printed, as desired.

3.3.1.2 Slope

Slope is a measure of change in the value of altitudes over distance, which is expressed in degrees or as a percent. The first step in generation of slope map is to create surface using the elevation values stored in the form of contours or points. Surface is a representation of geographic information as a set of continuous data in which the map features are not spatially discrete, i.e., between any two locations, there are no clear or well-defined breaks between possible values of the map features. Models built from regularly or irregularly spaced sample points on the surface can represent the surface.

- Slope map of the study area shall be prepared using the elevation information for the area from contour heights.
- A Digital Elevation Model (DEM) of the area shall be prepare

3.3.1.3 Soil

- The physico-chemical characteristics of the soil samples shall be determined by taking grab samples from locations covering mainly from agricultural and forestland.
- Based on a 3-tier approach (Landform analysis, field survey and laboratory investigation) soil resource map of study area shall be prepared.
- The results shall be superimposed with the soil map of Meghalaya (NBSS Publication 52) prepared by National Bureau of Soil Survey and Land use Planning.
- The taxonomy of soils, as per USDA system of soil classification, shall be adopted.
- The soil map thus prepared shall be used as base map for further analysis.

3.3.2. *Air, Noise and Water Environment Study*

3.3.2.1 Air Quality Assessment

The Ambient air quality monitoring shall be done for two consecutive days for a week in a month. The baseline data of ambient air environment shall be monitored for the parameters given below.

1. Particulate Matter (PM10)

2. Particulate Matter (PM2.5)
3. Sulphur dioxide (SO2)
4. Nitrogen oxide (NOx)

The "Respirable Dust Sampler Envirotech Model APM 460 BL" shall be used for air monitoring. The dust particulate matter is collected on glass micro fibre filter paper (size GF/A20.3x25.4 cm) and dust cup and the gaseous pollutants collected simultaneously by a known volume of air through a number of bubblers of different flow rate through appropriate solution for absorbing different gases. The collected samples are analysed according to standard method for different pollutants. The particulate matters were analysed by Gravimetric method (by weighing the mass of particle). The SO2 was analysed by Colorimetric method by estimating absorbance of SO2 from the exposed absorbing reagent at 540 nm using spectrophotometer. The NOx was analysed by Colorimetric method by reacting the nitrite ions with phosphorous acid sulphanilamide, and NEDA solution by measuring absorbance of NOx from the exposed absorbing reagent at 540 nm using spectrophotometer. For sampling of Carbon Monoxide in Ambient Air and determination of its concentration, non-dispersive infra-red absorption (NDIR) method was used.

Theory of Respirable Dust Sampler (RDS)

The principle involved in Suspended Particulate Matter (SPM) sampling method is that the particles are filtered from known volume of an air sample by a suction apparatus and the particle are deposited on a filter paper. Generally, the gaseous pollutants in air are made to react with liquid absorbing media (0.1N Sodium Tetra-Choloro Mercurate for SO2 and Solution of Sodium Hydroxide and Sodium Arsenite for SO2) at atmospheric temperature and pressure when air is bubbled through the absorbing solution in the impinger. RD sampler measures only the concentration of SPM and Gases in the ambient air.

Calculation

3.3.2.2 For Particulate Matter

i. Average flow rate (initial and final flow rates) in lit/min
= (initial flow rate + final flow rate)/2

ii. Total volume of air sampled (TVA) in m^3
= avg. flow rate (lit/min) * 10^3 (m^3/lit) * sampling time

(hr.) * 60 (min/hr.)

iii. Concentration in ug/m^3
=(w_a-w_a) (mg)/TVA(m^3) *10^6ug/m^3

Where,

Wi and wf in mg are initial and the final weight of the filter paper

For gaseous pollutants

SO_2 (µg/m^3) = (A – A_0) x 1000 x B x D/ V

NO_x (µg/m^3) = (A – A_0) x 1000 x B x D/ 0.82V

Where, A = Sample Absorbance,

A_0 = Reagent blank Absorbance, and

B = Calibration factor (μg/absorbance)

D = Volume of absorbance solution in impinger during monitoring / volume of absorbing solution taken for analysis.

V = Volume of Air Sample in liters.

3.3.2.3 Noise Level Measurement

The noise levels shall be monitored by Envirotech SLM 100 sound level meter (digital Instrument). The instrument consists of the following major section.

1. The Sensor or Microphone

The sensor is a high precision electrode condenser microphone, which must be protected from physical abuse, dirt, oil, water or ingress of any such substance.

2. The Control Panel

The control panel comprises of following: -

1. Recorder for the maximum level of sound and minimum level of sound

2. Range selector

3. Auto and manual rest switches

4. Hold on max and min level

3. The Range Selector

These switches are used for selecting the relevant range of the sound level.

Methodology

The calibrated and charged sound level meter adjusted for slow time response. The noise level shall be measured at different sites for 24 hrs continuously, maximum and minimum level of noise recorded for the particular site, and then average calculated which gives the final readings. The maximum and minimum noise levels for day and night hours recorded.

Sources

The major sources of air pollutants in the project area are vehicular traffic, blasting (during road construction at present), dust arising from local and village road, forest fire and domestic fuel burning.

3.3.2.4 Water Quality Assessment

For assessment of baseline, data of water quality general survey of river upstream and downstream of proposed dam site will be done with following objectives.

- Selection of spots for water sampling and collection of aquatic organisms.
- Distribution and population density of macro-zoo benthos in river.
- Periodical monitoring of physical, chemical and biological characteristics of river.
- Estimation of coliform (MPN) and E. Coli organisms in water of river.

3.3.2.5 Water Quality Analysis

The selection of sites for water sampling shall be done considering the location of different project components, junction of streams and river course, spots of high-water velocity and some of the stagnated pools along with the areas having human interference. The sampling shall be carried out for three seasons. The limnological parameters are recorded mainly following the standard methods described by Welch (1948), CSIR (1974). Mackereth et.al. (1978) and APHA, AWWA, WPCF (1995) as following:

Parameters Instrumentation

Ambient temperature	: Digi thermometer (stainless steel Sensor probe)
Transparency	: Seehi disc method (Weleh 1948)
Water velocity	: EMCON Digi current meter
Turbidity	: Nephelometer
Total Dissolved Solids	: Titration method
pH	: Digi pH meter (HANNA)
Alkalinity, Acidity, Chlorides, Silicates, DO, Free CO2, Zn, Si, Fe and Nutrients (Phosphorus, Sulphates)	: Aquamerck / Aquaquant kits
Total Ca and Mg Hardness – EDTA	: Titrametric methods (Natarajan and Jhingran 1988)
Inorganic phosphates	: Colorimetric Methods
BOD	: Titration
E-Coli and Total Coliform	: MacConkey broth

3.3.2.6 Aquatic Environment

Data on existing aquatic environmental conditions in and around proposed project shall be generated as per following:

- Biological characteristics of river water.
- Inventorization of Phyto benthos and Zoobenthos
- Estimation of coliform organisms.
- Present status of riverine fish fauna: Identification of obligate fish species.
- Their Migratory pattern, diseases, feeding and breeding grounds.

Evaluation of Phyto benthos

Samples of periphyton shall be obtained by scraping off 3 cm2 area of the boulders and preserving it in 1 ml of Lugol's solution. The upper surface of boulders shall be scraped with the help of sharp razor. Three replicates shall be obtained and integrated. Thus, the total area sampled amounts to 9 cm2.

Sedge wick-Rafter cell counts (APHA 1992) shall be made and density recorded as cell mm2. For qualitative studies, the keys of Trivedi and Goel (1984) and Ward and Whipple (1959) are being used for identifying the filamentous and non-filamentous algae.

However, for identifying diatoms, permanent mounts shall be prepared and identified. For computing abundance (as %) 300-400 diatom cells shall be identified in each sample (with BX-40).

Evaluation of Benthic Macro-Invertebrates

Benthic macro-invertebrates shall be collected from the designated sampling sites in study area using surber's square foot sampler (Welch, 1948) adopting random sampling device. All collected specimens shall be preserved in 8% formalin solution and identified up to the generic level with the aid of keys given by Usinger (1950), Ward and Whipple (1959), Needham and Needham (1962), Macan (1979), Tonapi (1980) and Edington and Hildrew (1995). The density of benthic macro invertebrates shall be expressed as unit per meter square (unit/m^2).

Benthic macro-invertebrates shall be sampled from an area of one ft^2. All the stones of the area shall be collected in a bucket with as little disturbance as possible and washed thoroughly. Three replicates shall be obtained and integrated. The samples were sieved and preserved in 70% alcohol for further analysis. The benthic macro-invertebrates could be identified up to order/family/genus level with the help of keys given by Edmondson (1959) and Pennak (1953). Counts of the identified organisms made in each sample and density recorded as individual's m^{-2}. The spatial variations in community structure shall be recorded by computing percentage abundance.

Evaluation of Total Coliform

To assess the quality of water in terms of pathogenic and parasitic organisms, the use of indicator system is the best method. The coliform organisms are considered to be the best indicators of pathogenic organisms. The standard test for the estimation of number of coliform groups is being carried out generally by multiple tube dilution technique which gives most probable number (MPN) of bacteria. A selective medium is used to develop only coliform bacteria. Coliform ferments lactose and produce acid and gas that could be detected by uplifting of Durham's tube by vision. MPN is not an actual enumeration of coliform bacteria but merely an index of the probable.

Culture Media

A. Mac Conkey Broth: For Presumptive Test of Coliform

Peptone 20 g.

Lactose 10 g.

Sodium chloride 5 g.

Bile salt 5 g. (may be replaced by sodium taurocholate

or sodium taurogly – chocolate)

Distilled water 1000 ml.

B. EC Medium: This medium is used for the test of presence of coliform group of fecal origin.

Tryptose or trypton : 20 g.

Lactose	: 5 g.
Bile salt mixture	: 1.5 g.
Bile salt No. 3	
Dipotassium hydrogen phosphate	: 4 g. KH_2PO_4
Potassium dihydrogen phosphate	: 1.5 g. KH_2PO_4
Sodium chloride	: 5 g.
Distilled water	: 1 lit.

C. Buffered Dilution Water: To prepare stock phosphate buffer solution 34 g of potassium dihydrogen phosphate is to be dissolved in 500 ml distilled water at pH 7.2 with 1N NaOH and be diluted in 1 lit with distilled water. 1.25 ml stock phosphate buffer solution will be added to 1-lit distilled water. Dispense in amounts that will provide 9 ml in 150 x 25 mm test tubes sterilized autoclave at 121 °C for 15 min.

Calculation: Coliform density is determined by using a standard MPN Table. It is convenient to express the results of the examination of replicate tubes and dilution in terms of the Most Probable Number (MPN). In usual practice, the results are expressed in terms of MPN index/100 ml of various combinations of +ve and -ve results generally given in most of the microbiological manuals.

Faecal Coliform (MPN) procedure: For separation of coliform organisms of faecal origin from that of non-faecal, elevated temperature tests is used. Gas formation in subculture of the +ve tubes from presumptive tests of coliform in EC medium at 44.5 ±0.2 0C for 24 hrs gives the + ve test of faecal coliform.

Total Count: Total bacterial count is indicative of the presence of chemosynthetic heterotrophic group of bacteria (Exotic) and is often performed in conjunction with total coliform (MPN) in waters. The test is not differential between pathogens and indicator organisms but is considered affirmative to population.

Total count is often performed to assess:

1. Progress of self-purification in rivers, ponds and lakes in time and space.

2. Efficiency of bacterial removal during storage and treatment processes.

3. Ascertaining quality in general.

Culture Media

Nutrient Agar

Beef extract 3 g.

Peptone 5 g.

Agar 15 g.

3.3.3. *Biological Environment*

3.3.3.1 Floral Study

The floristic composition along with frequency, density, abundance, relative values of frequency, density and abundance for each species is calculated by quadrats method. The quadrats are laid out at pre-selected sites to cover different altitudinal zones as also to represent the existing variables within the area.

To study the phyto-sociological attributes of the area, quadrats of 10m x 10m are laid for tree composition, 5m x 5m for shrubs and quadrats of 1m X 1m for herbs. The phyto-sociological parameters of different recorded species shall be calculated using the following formulae (Phillips, 1959; Misra, 1966)

Frequency

It is defined as the chance of finding a species in a particular area in a particular trial sample. Thus, a higher frequency value shows a greater uniformity of its spread or dispersion (Ambasht and Ambasht, 2002).

$$\text{Frequency} = \frac{\text{No. of quadrats in which the species occur}}{\text{Total number of quadrats studied}} \times 100$$

Density

It is, expressed as a numerical strength of a species. However, density is an indicator of the abundance of the species; it does not indicate the distribution of species with regard to space. It helps to identify the dominant and rare species and is also an indicator of the standing biomass and productivity of the region (Ambasht & Ambasht, 2002)

$$\text{Density} = \frac{\text{Total no. of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}}$$

Abundance

It is the number of species occurring in a particular site. It does not give a total picture of the numerical strength of a species in an area because only quadrats of occurrence are taken into consideration (Ambasht & Ambasht, 2002). Abundance is analysed to get an idea of distribution pattern of the species.

$$\text{Abundance} = \frac{\text{No. of individuals of the species in all quadrats}}{\text{Number of quadrats in which the species occur}}$$

Relative values

The relative values of frequency, density and dominance are calculated to understand the ecological importance of the species with in the community (Phillips, 1959; Mishra 1968).

$$\text{Relative Frequency} = \frac{\text{No. of quadrats of occurrence of a species}}{\text{}} \times 100$$

$$\text{Relative Density} = \frac{\text{Number of occurrences of all species}}{\text{No. of individuals of the species in all quadrat's species}} \times 100$$

$$\text{Relative Abundance} = \frac{\text{Total number of quadrats studied}}{\text{Abundance of a species}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Sum of Abundance of all the Species}}{\text{Basal area of a species}} \times 100$$

$$\text{Total basal area of all the species}$$

Importance Value Index (I.V.I)

IVI is a statistical quantity, which gives an overall picture of the importance of the species in the plant community. Since the above relative parameters give clues individually, all the parameters are summed up in order to provide the total picture of sociological structure of a species in the community, and called as Importance Value Index (IVI). It incorporates three important parameters that are measures of diversity and productivity of every species. -The sum of the IVI of all the species in a forest should not exceed 300.

The Importance Value Index (IVI) for different species is sum of relative frequency, relative density and relative basal cover of each species. (Curtis, 1959).

OR

Importance value Index (IVI) = Relative frequency + Relative density + Relative dominance. The vegetational data collected are used to calculate following indices for each site. The importance value index (IVI) is calculated by adding relative frequency (RF), relative density (RD) and relative abundance (RA) of the species (Philips, 1959).

IVI = RF + RD + RA

Where,

RF = (Frequency of a species / sum frequencies of all species) × 100,

RD = (Number of individuals of a species / total number of individuals) × 100.

RA = (Abundance of a species / sum abundances of all species) × 100

For the present study Philips, 1959 method is used

Circumference at breast height (CBH)

Circumference of individual tree species in the quadrat, shall be measured at breast height (1.37m) above ground level. In case of shrub and herb species circumference is measured at root collar height.

Diversity indices

The floral diversity of the study area varies gradually with the altitude. It is a measure of information in a group of species, which have different probabilities of being represented and is based on the assumption that individuals are randomly sampled from an infinitely large population. The species diversity is computed using (Shannon- Weiner, 1963) information index as

Shannon- Wiener diversity index (H')

The index of diversity is computed using Shannon-Wiener information index (Shannon- Wiener, 1963) as:

$$H' = \sum (Ni/N)^2 \log (Ni/N)$$

Where, N is total number of species.

Ni is individuals of a species.

3.3.3.2 Faunal Study

Ground surveys shall be carried out by trekking the impact zone for identification of important animal groups such as butterflies (insects), birds, mammals, reptiles, and some fishes inhabiting the area, along the riverbanks, adjoining forest on the slopes, nallahs, hilltop and agricultural fields.

- For sampling butterflies, the standard 'Pollard Walk' methodology is used by recording all the species encountered while trekking along the foot trails between the two sites, daily. Voucher specimens of species were collected by means of a butterfly net for only those species that could not identified in the field besides photographing them for the same 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) shall be 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 (20m) transect' is 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 shall also be considered.
- 'Reptiles' mainly lizards shall be sampled by 'direct count on open width transects' (n = 4) for 1 hour in each transect.
- Seasonal variation in species diversity of different groups of animals (butterflies and birds), shall be evaluated using Shannon-diversity Index (***H'***) to know the season of peak diversity in the area.

$$H' = -\Sigma N$$

1 Pi In Pi

(From species 1 to n; n= total number of species)

Where, **Pi** is the proportion of the individual species in the total population.

3.3.3.3 Aquatic Fauna

Evaluation of Aquatic Fauna

An extensive survey of Umngot on upstream and downstream of diversion site shall be carried out with the intention to examine aquatic animal species such as fishes, insects, arthropods, amphibians, snakes, water-birds, otters etc.

3.3.4. ***Socio-Economic Study***

The data on socio economic, and dependency aspects shall be collected in two stages. The first stage involves a rapid assessment of the study area in order to obtain an overall perspective of the villages that are located in the project area. The second stage of data collection shall be done in respect of the villages, which are going to be directly affected by acquisition of land for construction of project. A sampling frame for survey area has been devised and as per this, the villages going to be affected due to project construction shall be surveyed. These villages fall in East Khasi Hills and Jaintia Hills. Data collection from secondary sources shall be made to validate some of the information and to supplement the data on demographic aspects.

Secondary information shall be collected from different government and non- government offices. The data proposed to be collected is mainly of secondary nature and involves information regarding access to facilities such as PHC's, schools, bus services, LPG distribution centres, type of roads, livestock information, land utilization, demographic profile of the villages, location and distribution of villages with respect to Project. Public consultation, primarily with stack-holders, shall be conducted.

3.3.4.1 Secondary Sources of Data

Metrological department	: Climatic data
Survey of India	: Topo Sheets 83 C3
National Remote Sensing Agency	: Satellite Data
Forest Survey of India	: Forest cover
Botanical Survey of India	: Floral characteristics
Zoological Survey of India	: Distribution of fauna and identification key.
Revenue Department	: Land data / population statistics.

3.4. Phsico-Chemical Environment

3.4.1. ***Topography***

The Study area is a plateau interspersed with high hills and deep valleys. The site where the Umngot HEP is located is marked by deep gorges, spurs and abrupt slopes. The catchment is situated in the mid- central upland, specially called the Shillong Plateau. The plateau extends east west with altitudes ranging from 150 m to 1965 m above the MSL. The entire plateau is mountainous but the eastern and western extensions are relatively lower. The Satellite image of the study area is shown in **Figure 3.2** and the digital elevation model is shown in **Figure 3.3.**

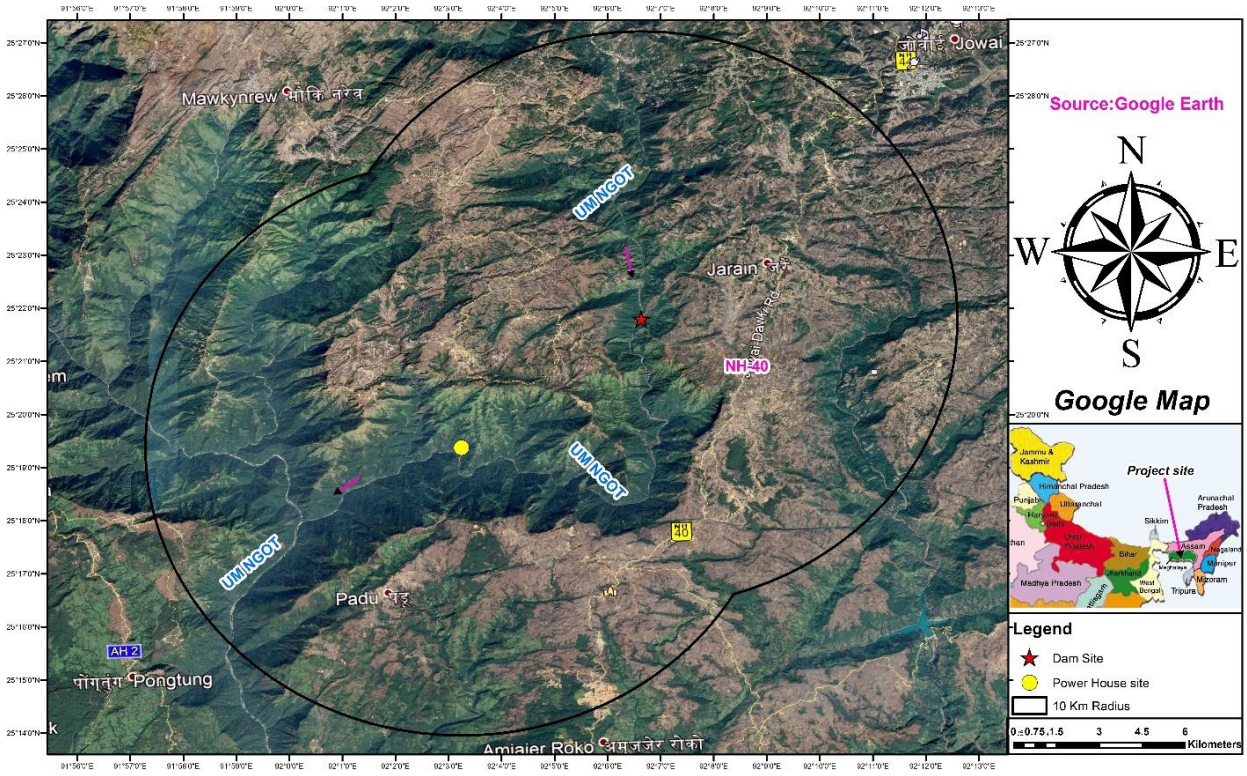


Figure 3.2 : Satellite image of the study area

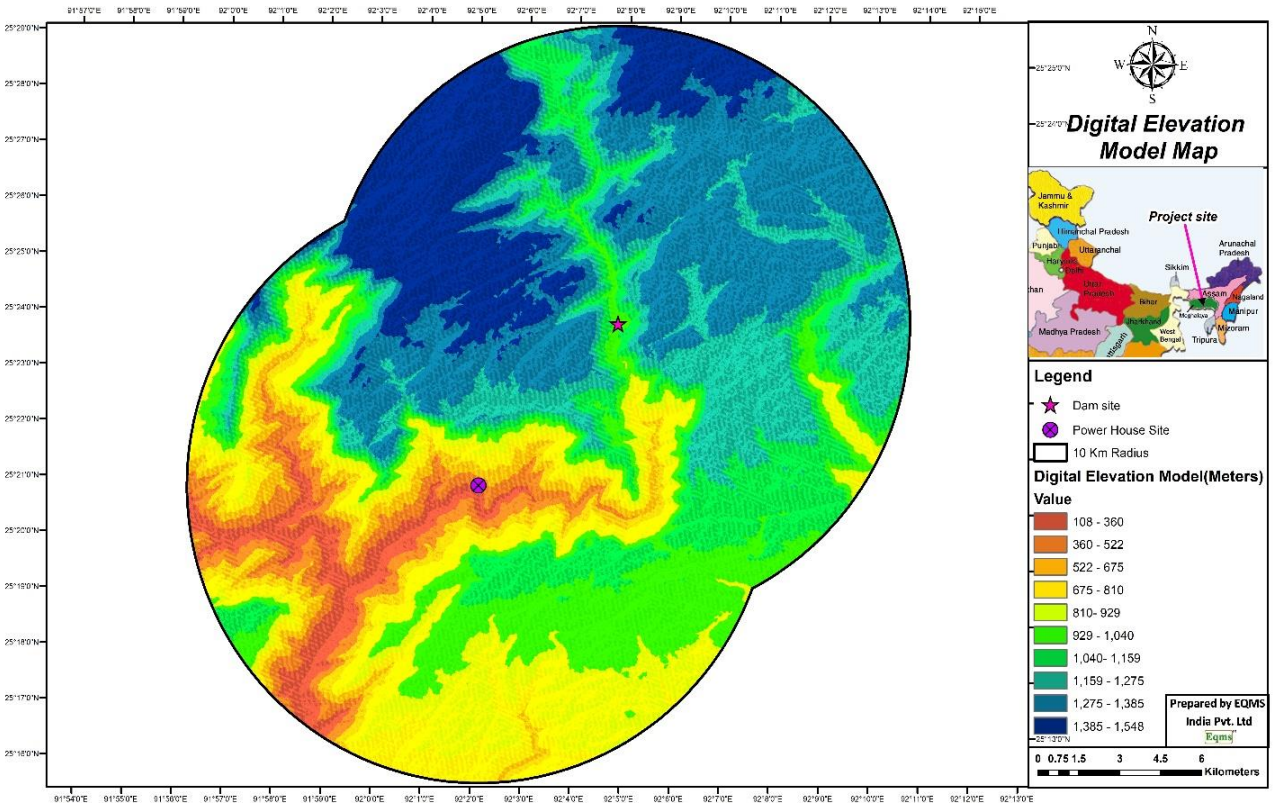


Figure 3.3 : Digital Elevation Model of the study area

3.4.2. *Physiography*

Physiographically, Meghalaya represents a remnant of an ancient plateau of Pre-Cambrian Peninsular shield, block lifted to its present height and is referred as Meghalaya Plateau or as Shillong-Mikir massif. It is the detached northeaster extension of Indian Peninsular shield, part of which lies beneath the alluvium deposited by Ganga Brahmaputra system of rivers. The rivers of the State are rainfed and therefore their discharge dwindles during summer. Important rivers in Garo Hills region are Daring, Sandal, Bugi, Dareng and Simsang. In the central and eastern part of the plateau are Umkhri, Digaru, Umngot and Myntdu rivers.

East Khasi Hills is one of the eleven districts of Meghalaya covering an area of 2748 sq. km. Shillong is the district headquarters of East Khasi Hills which is also the capital of Meghalaya. Shillong is well connected by road with other places in the district as well as with the rest of the Meghalaya and Assam. Shillong is connected by road with all major north eastern states. Two major National Highways pass through East Khasi Hills District -National Highway 40 connects Shillong to Jorabat, Assam in the north and extends southwards to Dauki, at Bangladesh border and National Highway 44 connects Shillong to states of Tripura and Mizoram. The district map is shown in **Figure. 3.4.**

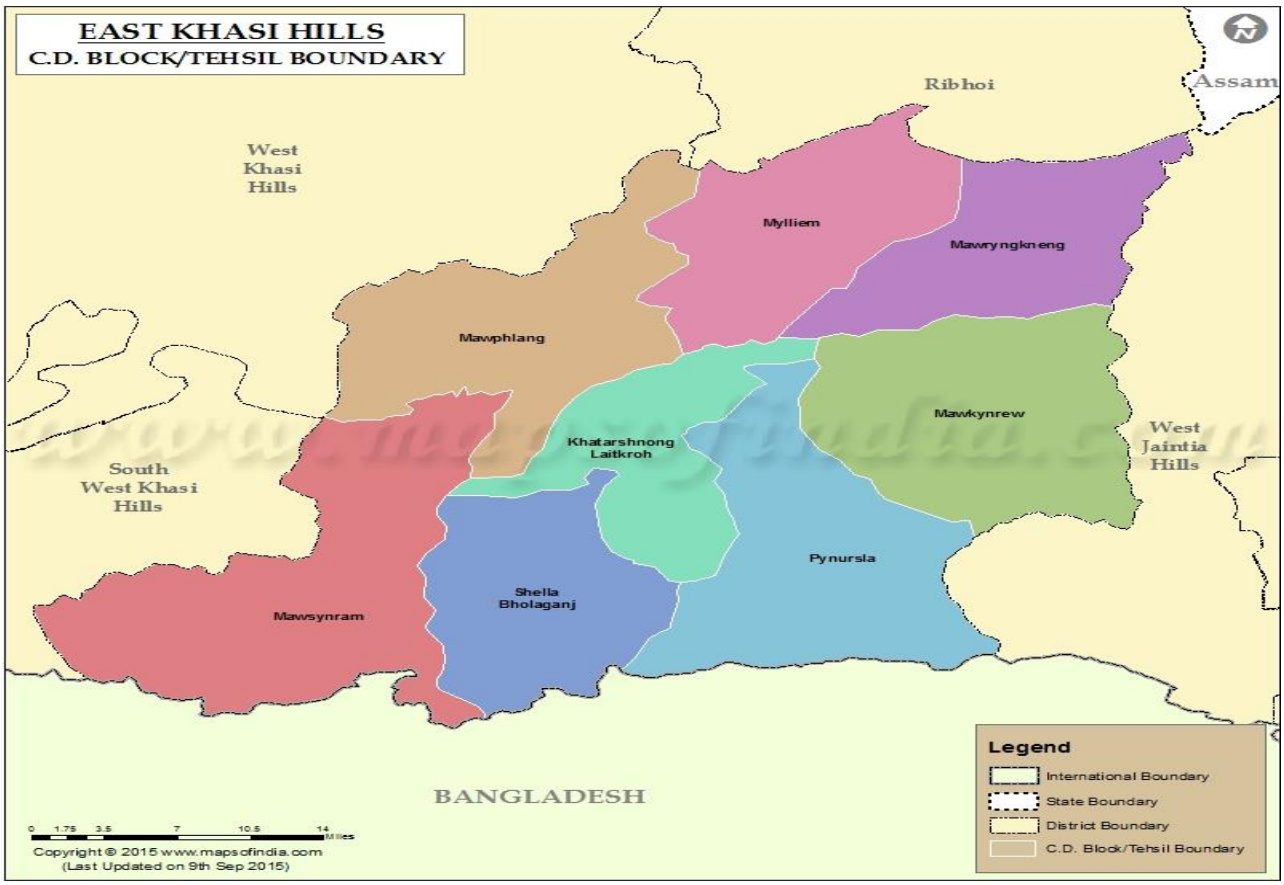


Figure 3.4 : District Map of Est Khasi Hills

3.4.3. *Regional Geology*

Umngot Hydroelectric Project is located within a typical plateau land of Meghalaya characterized by flat undulatory table top land and deep gorges. The plateau top land is occupied by sedimentary sequence of Jaintia Group of Tertiary Age, which are mainly comprised of low dipping to sub horizontally bedded, medium to coarse grained sandstone with intervening minor shale and coal

bands. The sandstones are wavy and also contain medium to large scale through cross stratification and thus, this sedimentary sequence show varying attitudes at places. The Jaintia Group of rocks are unconformably underlain by Crystalline rocks of the Archaean basement complex which are exposed at lower elevations along the valley. The Crystalline comprise granite gneiss, migmatites, granites, biotite-schists, and also intruded at places by basic dykes (dolerite) and pegmatites, quartz veins. Lithologically the Crystalline primarily represent a very complex granitoid association with evidence of deformation at some places. Micro folds (ptygmatic folds), faults (axial planar) have been observed within this rock.

The contact between the sedimentary sequences of Jaintia Group and the Archaean Crystalline is represented by an angular unconformity, which shows a moderate slope towards south. The unconformable contact is observed at around EL. 1210m near the dam site area and near bend point it has been observed at around EL. 1100m indicating a southward inclination of the Tertiary basinal surface. Near bend point and surge shaft ridge area, the sedimentation sequences are found to be much thicker than that of the northern part. All the structural sites of the project are housed within the Crystalline. The prominent foliation within Gneisses trends in N55º-70ºE-S55º-70ºW with dips of 45º-70ºSE with minor variations at some places.

Evidences of macroscopic folding within gneiss are also noticed with different dipping attitudes of the foliation. Aerial photographs on 1:25000 scale of the said project area has been studied and it has been observed that no major lineament in the area is present, barring a few prominent E-W and ENE-WSW trending master joints. The Tertiary drainage, in most of the cases follows these master joints giving rise to rectangular drainage pattern. The primary and secondary drainages normally show the dendritic drainage pattern. Representing typical granitic country. (J.S. Rawat, F.S.2003-2004). In the project area, the rock units exposed consist of granite gneisses and quartzite. The bedrock is massive, hard, moderately jointed, and medium to coarse grained. Prominent and persistent joints are observed in small out crops. The overburden consists of mainly clays and sand.

The general tectono- stratigraphic succession is shown in **Table 3.1.**

Table 3.1 : Litho-stat graphical Succession

Geological Age	Group	Formation	Rock Type
Quaternary			Undifferentiated fluvial sediments (occurring as valley fill deposits)
Unconformity			
Mio- Pliocene		Chengapara	Coarse sandstone, siltstone, clay and marl
Unconformity			
Paleo- Eocene	Jaintia Group	Shella (600m)	Alteration of sandstone and limestone
Cretaceous	Khasi Group	Mahadek (150 m)	Arkosic sandstone (Often Gluconitic & Ureniferous)
Unconformity			
Cretaceous	Sylhet Trap (600 m)		Basalt, Rhyolite, acid tuff
Unconformity			
Neo-Proterozoic – Lower Palaeozoic		Granite Plutons	Porphyritic coarse granite, pegmatite, aplite/quartz vein etc
Intrusive Contact			
Proterozoic (Undiff)	Khasi Basic Ultrabasic intrusive		Epidiorite, dolerite, Amphibolite and pyroxenite dykes and sills

Paleo Mesoproterozoic	Shillong Group	Upper Division Lower Division	Mainly Quartzites intercalated with phyllites Mainly schists with Calc Silicate rocks, carbonaceous phyllite and thin quartzite layers
Unconformity (shared conglomerate)			
Archaean-Proterozoic	Gneissic Complex (Basement Complex		Mainly quartzo feldspathic gneiss with enclaves of granites, amphibolites, schists etc

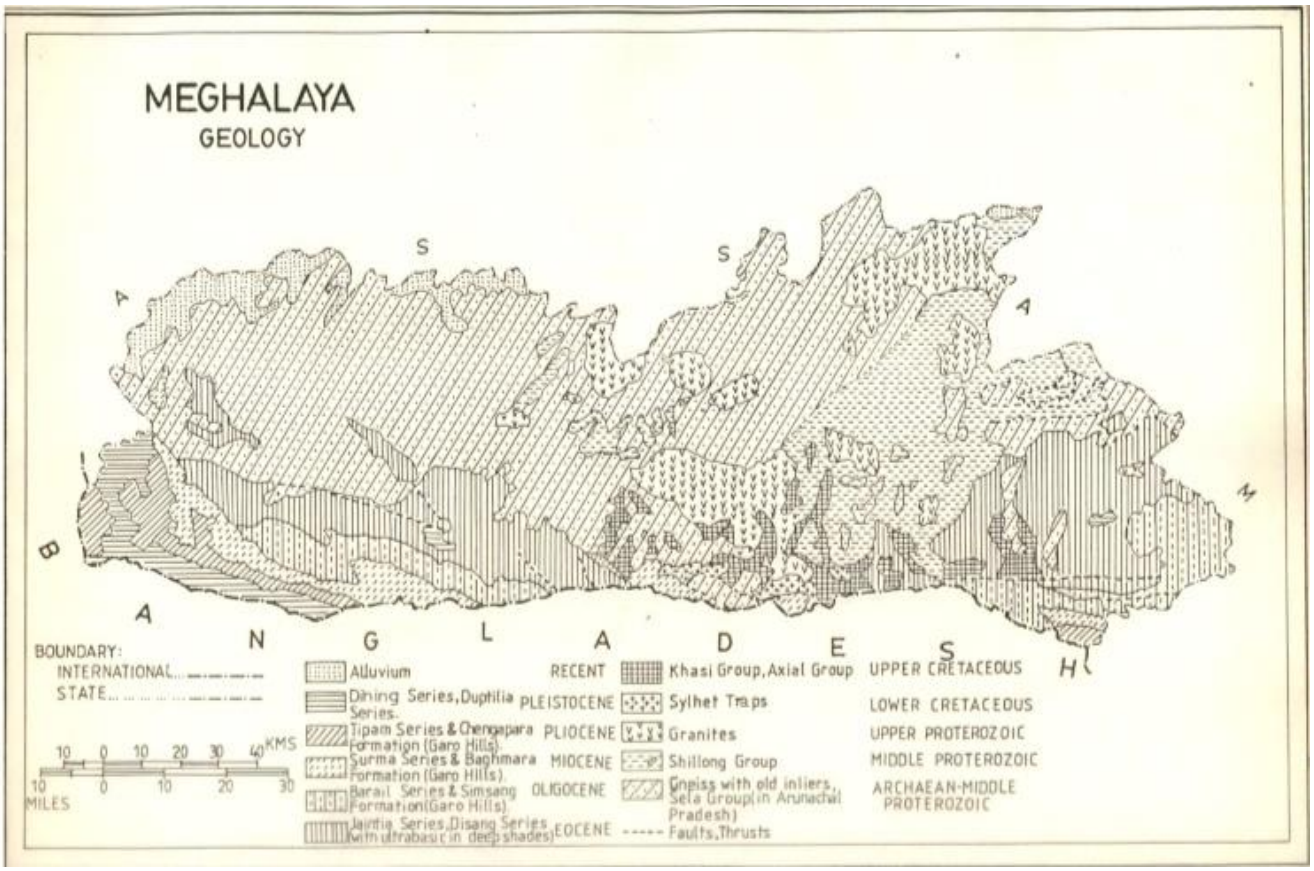


Figure 3.5 : Geological Map of Meghalaya

3.4.4. *Geology of the Project Area*

3.4.4.1 Reservoir Area

In the project area, the rock units exposed consist of granite gneisses and quartzite. The bedrock is massive, hard, moderately jointed, and medium to coarse grained. Prominent and persistent joints are observed in small out crops. The overburden consists of mainly clays and sand.

3.4.4.2 Dam Site

The rocks exposed at the dam site are coarse grained grey to off-white, banded gneisses and migmatites intruded by basic dykes and pegmatites. The general strike of gneissosity / foliation is N60º to 70ºE - S 60º to 70ºW with 45º to 60º dip towards S20º to 30ºE. The gneissosity / foliation show steepness in attitude of dip (70º) in downstream direction towards the bucket portion. In the dam site area, the intrusive basic dykes (dolerite) have been observed on both the abutments varying in thickness from 30cm to 1.30m. In downstream of the dam axis the rock is exposed on both

abutments up to E.L. 950m above which, slopes are covered with thick vegetation. At the dam axis the gneisses are moderately jointed. The geological map of area around dam is shown in **Figure 3.6**.

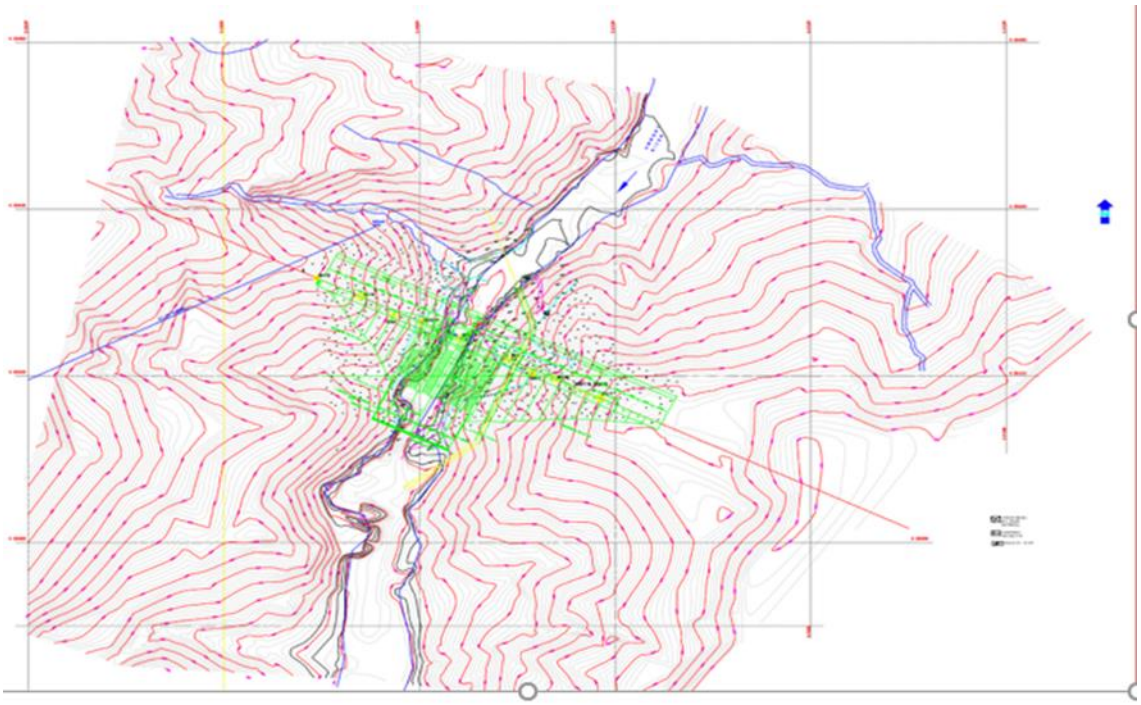


Figure 3.6 : Geological Map of Dam Area

3.4.4.3 Water Conductor System

The HRT alignment in S630W would pass through a tunneling media composed of granite gneiss only. It is found that there is sufficient rock cover above the HRT grade (E.L. 980.40m) i.e., ranging from a minimum of 50m to a maximum of 340m. The river / nala and HRT intersection/crossing zones, where incision is found to be deep, were also studied with a view to decipher the effective rock cover above the HRT grade. Nala crossing the HRT alignment at R.D 200m from intake structure has got a very steep course and is an Ist order stream of the drainage network. Hence, the incision is not much. The bed rock – gneiss is exposed in the nala bed / section. Here, the rock cover above the HRT (RL 997.80m) is about 50m (nala bed level947.80m). In the Wah Rashi River section where the proposed HRT alignment crossing, granite gneiss is exposed whereas the sediment cover overlying unconformably occurs on upslopes of both the banks at about El. 1200m.

On the right bank of the nala section at R.D 5.3 km from the proposed intake structure on HRT alignment, a pulverized rock zone (shear zone) traversing N70º to 80ºE – S70º to 80ºW with 65º to 70º dip towards N10º to 20ºW, has been encountered at the edge of the hill (eastern face). This will cut the proposed HRT alignment around R.D 5.10km from intake. Gneisses in this zone exhibit not only the development of master joint sets in parallelism but also show high frequency of joints, in general. The zone extends in N80ºE direction and traverse on the left bank upslope of the nala. The thickness of rock cover above the HRT is around 200m. The ±600m HRT length will require steel liners besides a cautious and fool proof excavation schedule.

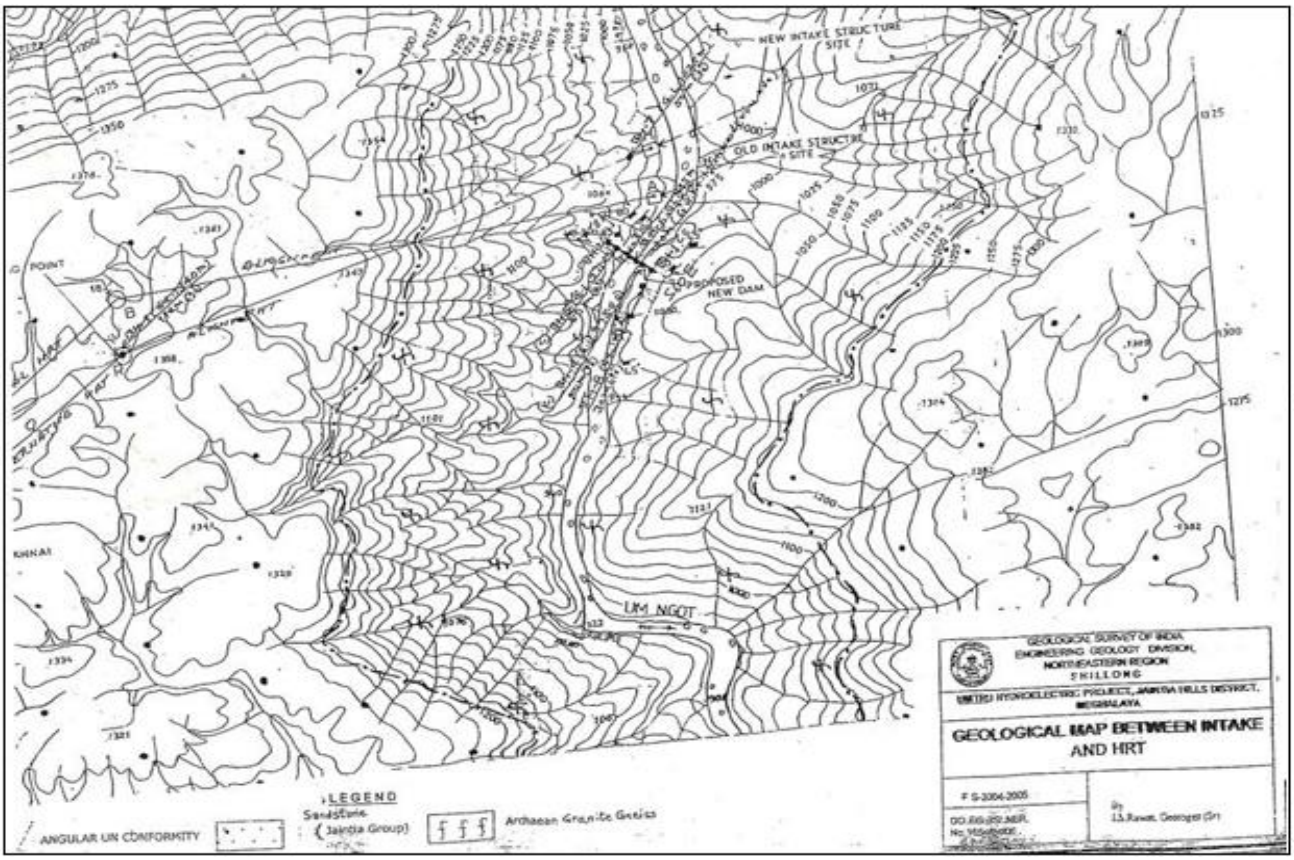


Figure 3.7 : Geological Map of Area between Intake & Powerhouse

3.4.4.4 Power House

The rocks exposed in the area are medium to coarse grained banded gneisses which are covered with thin layer of overburden/hill-wash material **(Figure -3.8).** The general trend of gneissosity is N70ºE – S70ºW with dips ranging from 50º to 65º in N20ºW direction. The area shows scattered exposures of bed rock which is moderately to highly weathered (W2 – W3).

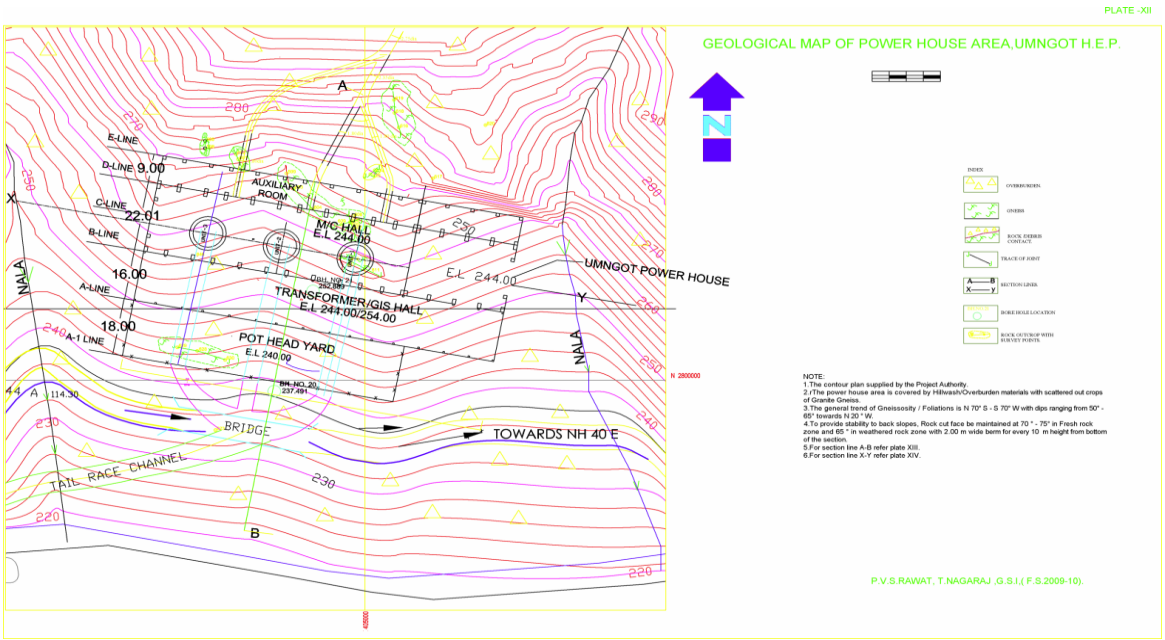


Figure 3.8 : Geological Map of Powerhouse

3.4.5. *Seismicity of The Project Area*

North - East Himalayas are one of the seismically active regions of the world and have experienced earthquakes since times immemorial. The region has also experienced tectonic movements. As per seismic zoning map of India (IS 1893:2002), **Figure 3.9,** the study area falls within **Zone V**. Therefore, site specific design earthquake parameters for Umngot H.E Project" shall have to be considered the maximum probable magnitude for the seismogenic source.

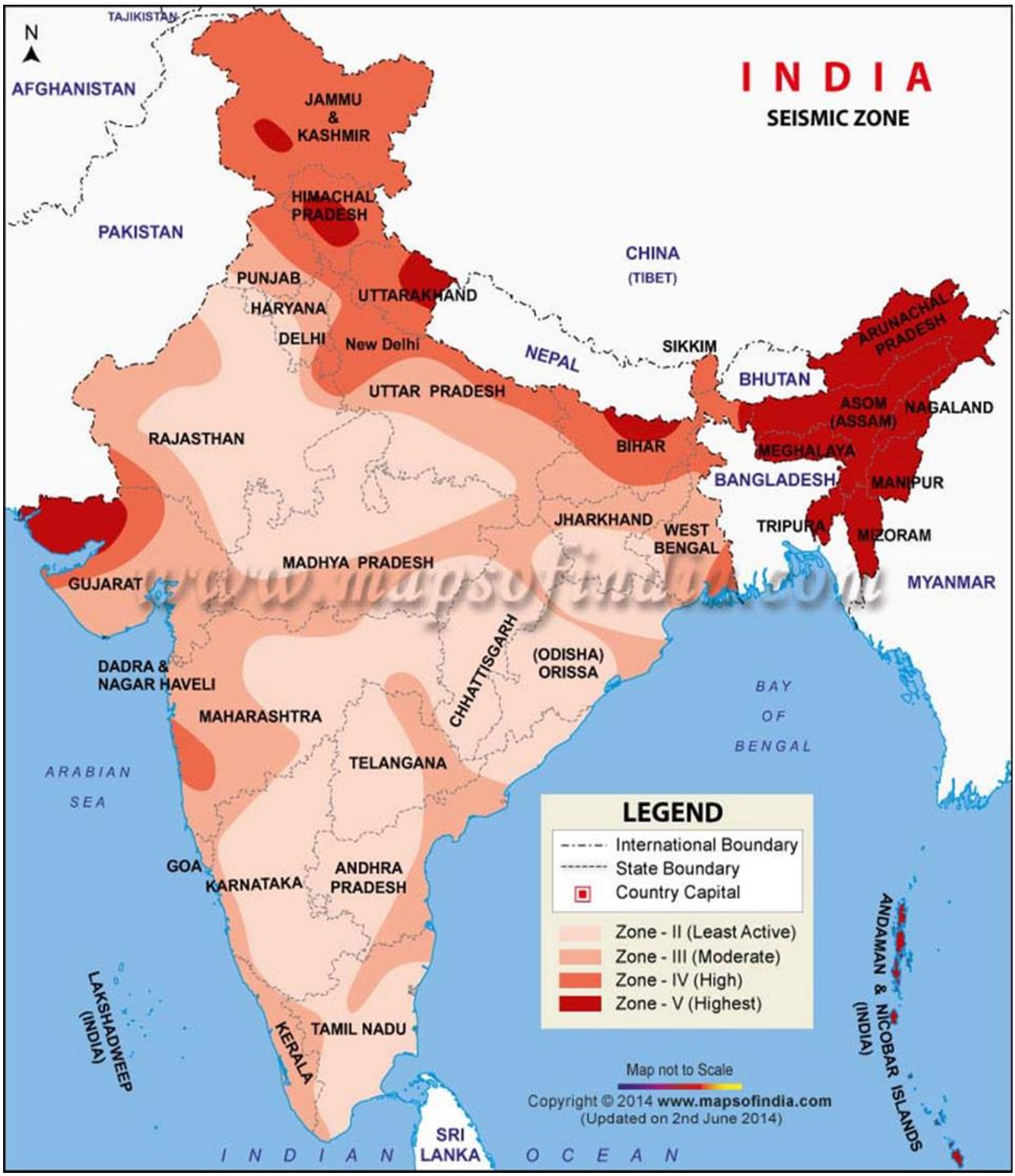


Figure 3.9 : Seismic Zoning Map of India

3.4.5.2 Earthquake Occurrence

The northeast India and its vicinity are known for a very high level of seismicity and two great earthquakes of Richter's Magnitude more than 8.5 have been recorded from this region. The Great Indian Earthquake of magnitude 8.7 was recorded in the year 1897 from the Meghalaya Massif and also the 8.6 Magnitude Earthquake; the Great Assam Earthquake was recorded (1950) from the Mishmi Tectonic Block in the Lohit valley of Arunachal Pradesh. Regional Seismicity Maps have been prepared by a number of research workers, based on various sources (e.g., Santo 1969, Fitch 1970, Chandra1975, Le Dian et al 1984; Mukhopadhyay and Das Gupta, 1988 and Kayal 1989. In the last 100 years as many as eighteen large earthquakes have been recorded from this seismo-tectonic domain, out of which two were the Great Earthquakes- one of 1897 and the other of 1950. List of events of damaging nature is included in **Table 3.2.**

Table 3.2 : History of Earthquake Events

Sl. No	Year	Month	Date	Hour	Min	Sec	Lat	Long	Ms	Mb	Depth Km	Source
1	1897	6	12	11	6	0.0	26.00	91.00	8.7	8.1		CFR
2	1918	7	8	10	22	7.0	24.50	91.00	7.6	7.6	15	ABE
3	1923	9	9	22	3	43.0	25.25	91.00	7.1	7.0		ABE
4	1930	7	3	21	3	42.0	25.50	90.00	7.1	7.0		ABE
5	1932	3	6	0	17	56.0	25.50	92.50	5.6	5.5		GR
6	1932	3	24	16	8	36.0	25.50	90.00	5.6	5.5		GR
7	1932	11	9	18	30	9.0	26.50	92.00	5.6	5.5		GR
8	1932	3	27	8	44	40.0	24.50	92.00	5.6	5.5		GR
9	1933	3	6	13	5	35.0	26.00	90.50	5.6	5.5		GR
10	1938	4	13	1	10	17.0	26.00	91.00	5.7	5.6		ISS
11	1941	1	27	2	30	16.0	26.50	92.50	6.5	6.0	180	GR
12	1941	1	21	12	41	48.0	27.00	92.00	6.7	6.1	100	GR
13	1950	12	29	22	35	20.0	24.00	91.80	6.3	5.9		ISS
14	1954	2	23	6	40	30.0	27.50	91.00	5.6	5.5		CGS
15	1955	11	23	2	33	47.0	26.50	90.00	5.0	5.2		CGS
16	1955	9	20	20	21	13.0	27.50	90.00	5.7	5.6		CGS
17	1956	6	12	3	12	26.0	24.80	90.90	5.2	5.3		ISS
18	1956	3	14	16	39	43.0	25.20	90.80	5.0	5.2		ISS
19	1958	2	13	0	11	37.0	27.62	92.53	5.5	5.5		ISS
20	1958	2	9	9	31	3.0	25.00	90.50	5.0	5.2	36	CGS
21	1960	7	29	10	42	45.0	26.47	90.38	5.5	5.5		ISS
22	1963	6	19	10	47	24.5	24.97	92.06		5.9	44	ISS
23	1963	6	21	15	26	30.5	25.13	92.00		5.7	47	ISS

24	1964	9	1	13	22	37.3	27.12	92.26		5.5	33	ISC
25	1964	4	13	3	19	57.3	27.52	90.17		5.2	52	ISC
26	1964	2	18	3	48	34.4	27.40	91.18		5.6	22	ISC
27	1965	12	9	20	26	1.4	27.43	92.51		5.2	29	ISC
28	1966	9	26	5	10	56.0	27.49	92.61		5.4	20	ISC
29	1967	9	15	10	32	44.2	27.42	91.86		5.8	19	ISC
30	1968	8	18	14	18	58.0	26.42	90.62		5.1	22	ISC
31	1968	6	12	4	29	21.7	24.83	91.94		5.3	39	ISC
32	1968	12	27	14	30	12.0	24.12	91.61		5.1	27	ISC
33	1969	6	30	8	51	54.0	26.93	92.71		5.0	44	ISC
34	1969	11	5	20	25	13.7	27.66	90.24		5.0	13	ISC
35	1973	7	4	16	44	11.4	27.49	92.60		5.2	29	ISC
36	1973	7	6	6	13	32.0	25.88	90.31	4.1	5.0	16	ISC
37	1982	8	31	10	42	45.5	25.38	91.46		5.0	35	ISC
38	1983	2	2	20	44	6.7	26.90	92.87		5.2	45	ISC
39	1984	12	30	23	33	35.0	24.66	92.85		5.5	2	ISC
40	1984	9	22	9	10	29.8	26.49	92.15	4.9	5.2	28	ISC
41	1984	9	30	21	35	25.4	25.44	91.51		5.0	25	ISC
42	1985	10	12	18	22	37.0	27.11	92.52	4.9	5.3	4	ISC
43	1985	1	7	16	13	5.4	27.14	91.96	4.9	5.4	18	ISC
44	1986	2	19	17	34	23.0	25.10	91.13	4.9	5.3	39	ISC
45	1986	9	10	7	50	26.4	25.38	92.14	4.5	5.3	39	ISC
46	1986	12	31	15	49	52.8	26.47	92.91		5.1	46	ISC
47	1987	1	24	10	34	25.9	27.63	92.69		5.0	24	ISC
48	1988	2	6	14	50	45.4	24.67	91.56	5.8	5.8	33	ISC
49	1989	3	8	20	2	6.7	26.93	92.77	4.2	5.1	60	ISC

3.4.5.3 Seismotectonics

Umngot H.E Project lies within the Iso-seismals VIII and IX of this Great earthquake. The source of this event has been related to low angle thrust fault dipping towards north (Oldham, 1899). The location of the epi-center of this quake was 140 km N-W of the project site. It has been interpreted that this event may be related to detachment surface below the Meghalaya Plateau with low angle inclination. The Focus of this event was estimated to be at depth of 15 km. Such a model with source as the detachment surface which dips at low angles towards north and could generate earthquakes of Magnitude 8+ in the project area would give critical motion characteristics.

The project area lies in a highly seismic domain and various sources could be responsible for the diffused contemporaneous activity in Meghalaya Plateau in addition to the Great Earthquake being associated with a low angle northerly dipping detachment surface. For evaluating the ground motion characteristics for a seismic design of structures, near-vicinity as well as remote earthquakes have to be considered which include subduction type events in the Indo – Burmese earthquakes below Meghalaya Plateau. The following thrusts/ faults around the project area have been considered for evaluating the seismic hazard for Umngot H.E Project.

The following significant tectonic features are noticed in the vicinity of project.

i) Kulsi Fault

It is a north –south feature around which seismic activity is recorded. The Maximum Magnitude of some of the seismic events is less than 6. With the strike slip fault mechanism and length of less than 100 km, this fault may not be able to generate earthquakes of magnitude more than 6.5. This fault is located 60 km west of the project site. Similar fault located about 180 km WNW of the site is the Dudnai Fault with similar generating capabilities.

ii) Jamuna Fault

At the western margin of the Meghalaya Plateau, is north –south feature which according to some researchers was the source Fault for the 1930, 7.1 Magnitude Earthquake. The generating capability of this fault is assumed as 7.5 and the site is about 230 km.

Another possible earthquake source is the Barapani Shear Zone, which is located about 60 km NW from the project site. Micro- earthquake activity has been recorded in the vicinity of this feature and the assigned Magnitude for this is 6.5.

iii) Dhansari-Kopili Fault

Located about 60 km north east of the project area could be a source for a 6.5 magnitude event.

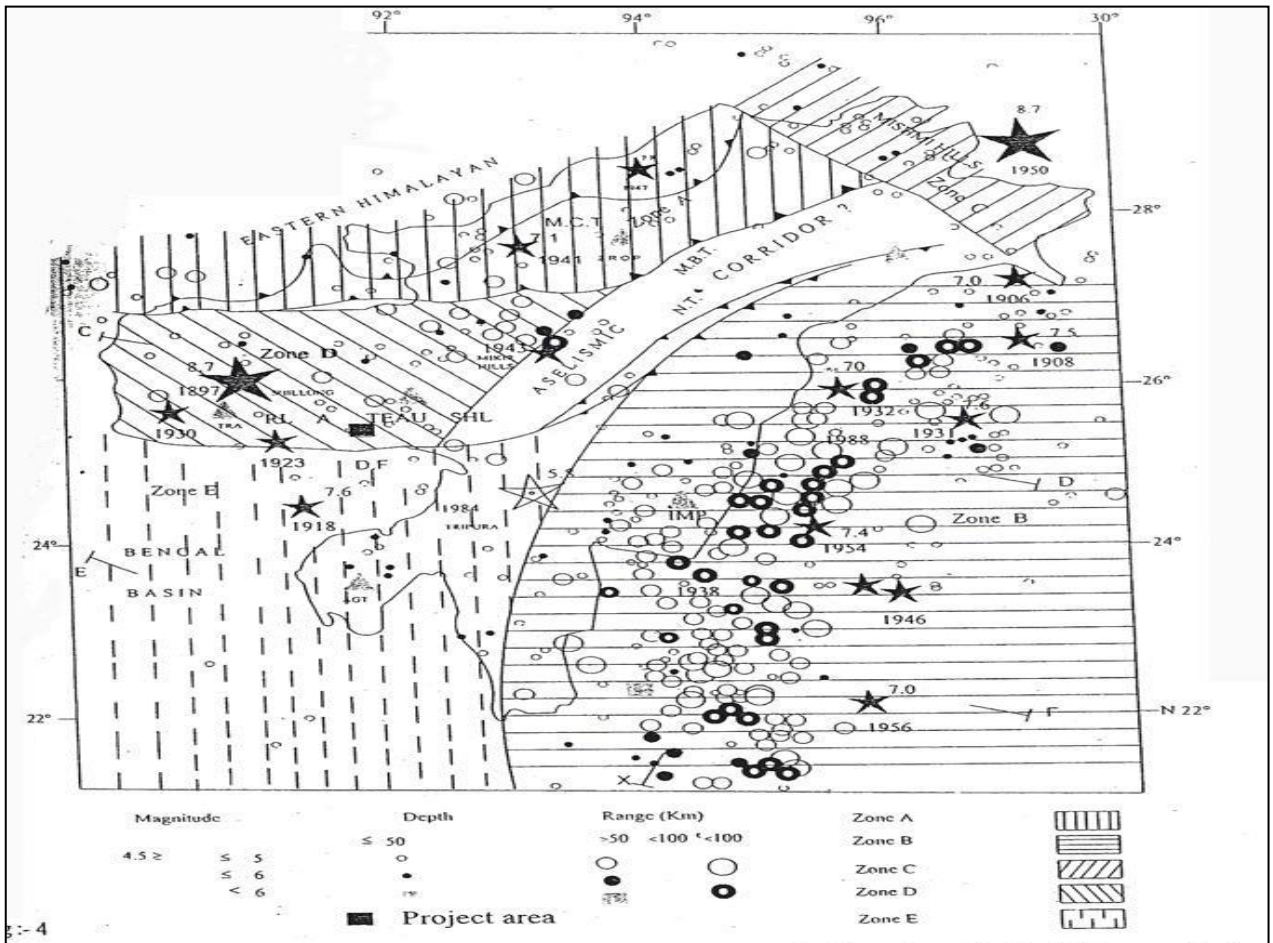
iii) Dawki Fault

It lies 20-25 km south of the project site trending East – west as another possible source of earthquake. The 300 km fault is active, as neotectonics activity along this fault has been recorded

In addition to the above, there are a number of other sources like, the zone between MDF and MCT located more than 100 km from the site with generating capability of 7 to 7.5 Magnitude earthquakes, the Dawki and Sylhet Faults south of the Meghalaya Plateau, The Haflong-Disang thrust and the subduction zone events are considered and provided for in the designs

Based on the seismo- tectonic assessment of the area, a number of seismic sources have been considered along with their earthquake generating capabilities. A number of attenuation relationships have been worked out by many researchers. Most of the attenuation regressions for computation expected of peak Ground Acceleration (PGA) consider the event as point source and these are divided from stations close to major events. Thus, these regressions give different PGA values. ICOLD Bulletin 72 (1989) recommends use of relationships of Cambell (1981) and Joyner and Boore (1981). Indian Institute of Technology (IIT), Roorkee in its report on “Site specific design earthquake parameters for Umngot H.E Project” have considered the maximum probable magnitude

for the seismogenic source as 8.0 for the site which was suggested by NCSDP. The values for Maximum Considered Earthquake (MCE) and Design Based Earthquake (DBE) conditions have accordingly been suggested as 0.36 g and 0.18 g respectively.



cent (1964-96 Seismicty in study region (modified from Kayal) The seismological data are obtaine
m the international seismological Centers (1946-88) and US Geological Survey (1986-1996).
er). Tectonic Zones and major thrusts are indicated. Great and large earthquakes are shown by
lid stars . Two open stars indicate the recent damaging earthquakes in the region. Solid triangle
present the present seismological observatories.

Figure 3.10 : Seismotectonic domain of NE Himalayan Seismic

3.4.6.4 Method of Tunnelling

There are 5 faces in head race tunnel, which is 5.646 km. long. The drilling is proposed by using 2 boom hydraulic drilling jumbo using Jack Hammer (120cfm). The mucking is proposed by using muck cars driven by battery locomotive and rear dumpers and rear end trippers. The loading is proposed by loaders of 2.5 cum. capacity. The drilling and loading equipment have been provided for all 4 working faces. The concrete in tunnel is proposed to be placed by pneumatic concrete pumps of 46 cum. per hour capacity and it will be transported by 4.5 cum transit mixtures. Special gelatin sticks and delay detonators shall be used to suit the type of rock and desired pull.

3.4.6. ***Land Use and Land Cover of Study Area***

The modern technique of satellite remote sensing facilitates such type of studies. The inaccessibility to the region in diverse weather conditions, requirement of synoptic coverage at various locations, and the computer adaptability for land use classification makes the digital image processing and remote sensing an inevitable tool. The dominating classes are dense forest (33.95%), open forest

(24.29%), settlement (5.28%), Open Scrub Land/Rocky area (22.24%), Barren Land/Stony waste area (1.88%), Shifting cultivation (4.64%) and water body (0.30%). The land use pattern of study area is exhibited in **Figure 3.11** and enumerated in **Table 3.3**.

Table 3.3 : Land Use Details of the Study Area

Class Name	Area (sq. km)	% of total area
Agricultural Land	33.87	7.42
Open Scrub Land/Rocky area	101.44	22.24
Water body	1.37	0.30
Dense Forest	154.88	33.95
Open Forest	110.80	24.29
Settlement	24.08	5.28
Barren Land/Stony waste area	8.59	1.88
Shifting Cultivation	21.15	4.64
Total	**456.18**	**100.00**

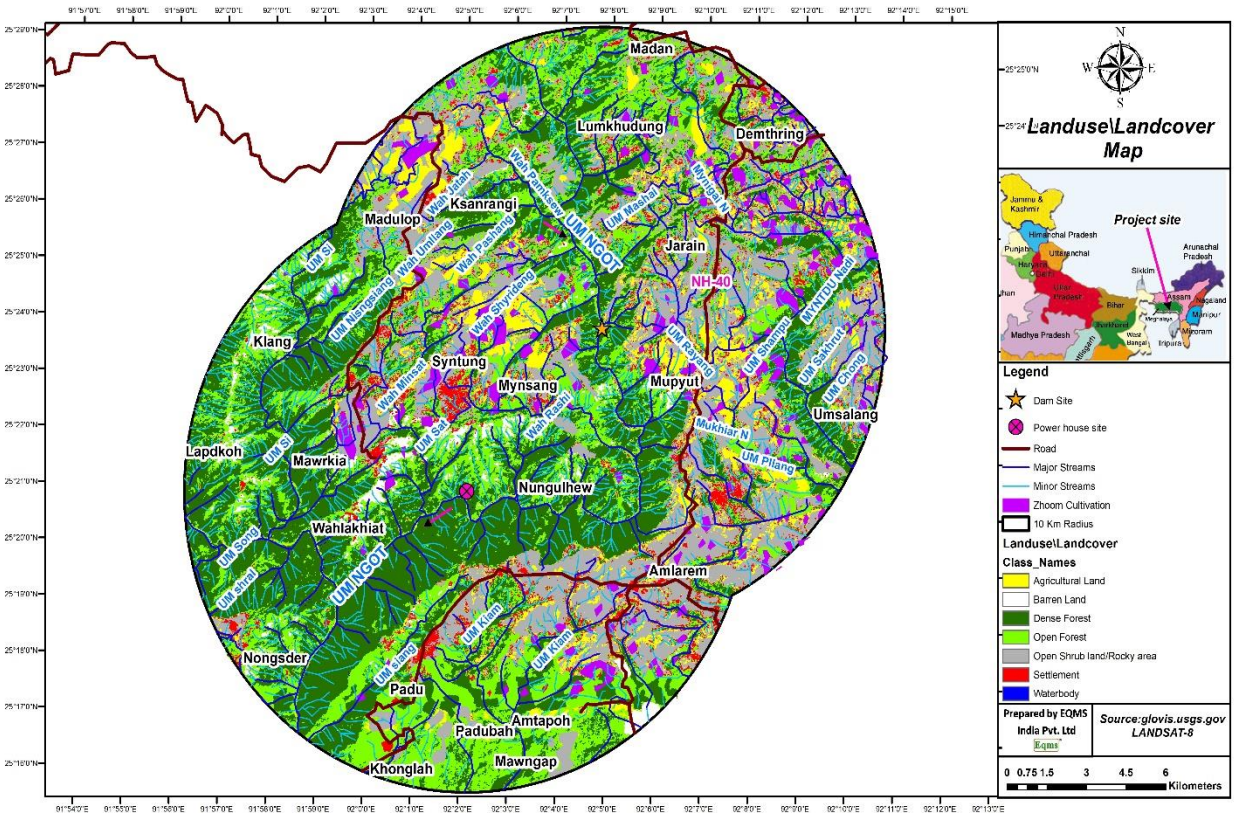


Figure 3.11 : The Land Use Pattern of Study Area

3.4.7. *Slope*

The study area has hilly and plain topography. The general slope of the study area is from south to north and follows the general trend of drainage. The slope map of the study area is shown in **Figure 3.12** and the area under different slope classes is enumerated in **Table 3.4.** About 45.40 % of the area

is covers under very gentle to moderate slope and 54.60 % with moderately steep slope to steep slope.

Table 3.4 : Slope Map of the Study Area

S. No	Slope Range (Degrees)	Slope Description	Area under different class (Sq. km)	Area (%)
1	0-5	Very Gentle Slope	68.34	14.98
2	5-10	Gentle Slope	60.38	13.24
3	10-15	Moderate Slope	78.37	17.18
4	15-35	Moderately Steep Slope	176.20	38.62
5	>35	Steep Slope	72.89	15.98
Total			**456.18**	**100.00**

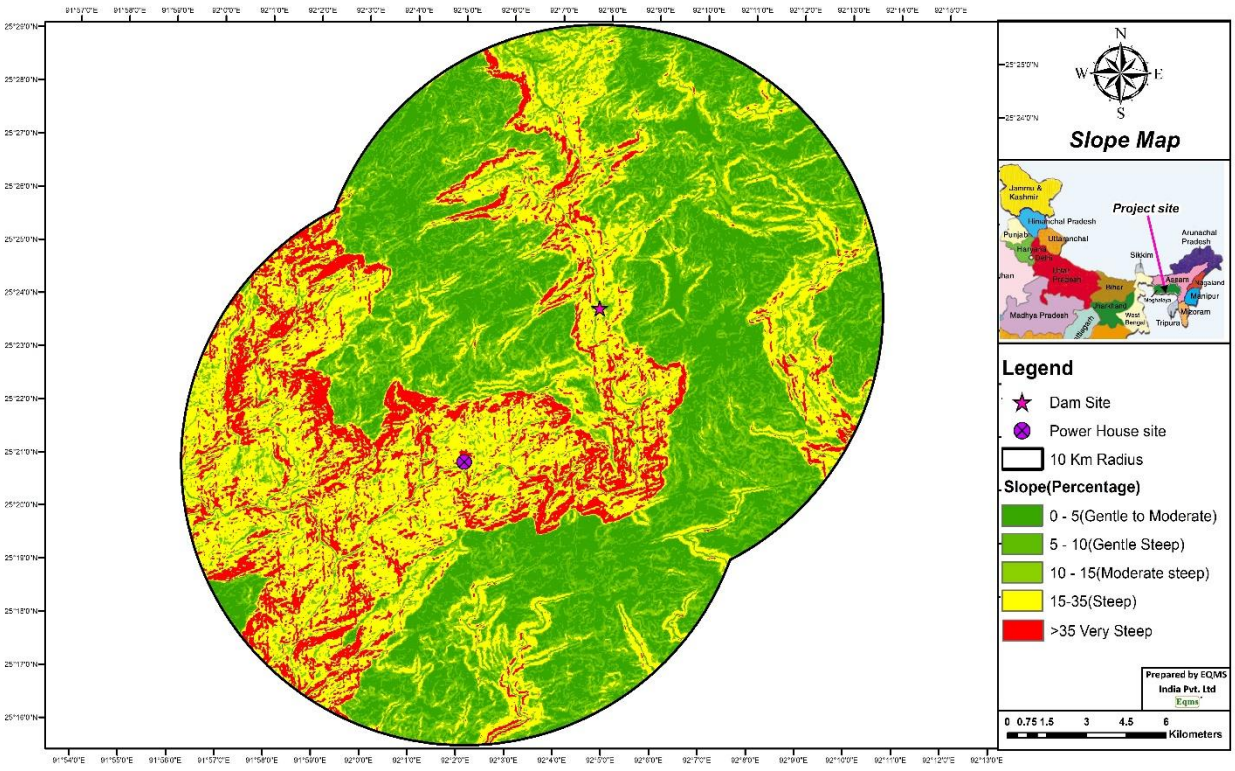


Figure 3.12 : Slope Map of Study Area

3.4.8. *Cropping Pattern of Study Area*

The catchment area has both private or community croplands. Potato, Cabbage, Cauliflower, Carrot, Radish, Tomato, Chilies, Paddy, Millets, Pulses, Jute, Mesta, Ginger, Turmeric, Black Pepper, Sugarcane are the main crop grown during the rainy season. Areca nut, Pineapple and Betel wines are also grown in a limited area. The Eastern slopes of the East Khasi Hills beyond the level of submergence have been denuded and reclaimed for cultivation of Potato, Cabbage, Cauliflower, Carrot, Radish, Tomato, Chilies, Paddy, Millets, Pulses, Broom grass is cultivated mainly in the plateau. Jute, Mesta and Ginger, Black Pepper, Areca nuts and Pineapple are grown in a few localities. Horticulture is not the mainstay of the locals. Orchids from natural sources are collected and sold in Shillong. The common ornamentals grown in gardens are Hibiscus, Hydrangea, Gardenia, Poinsettia, Dahlia, Canna, Gladiolus, Begonia, Tropaeolum, Aster, Poalrgonium, Antirrhinum, Crinum, Celosia,

Holley hock, Kniphofia, Impatiens, Chrysanthemum, Petunia, Pansy, Calendula, Sweet Pea, Salvia, Roses, Bougainvillea, Jasminum etc. A few Orchids like Phais, Dendrobium and Cymbidium varieties are also cultivated.

3.4.9. *Presence of Economically Important Mineral Deposit*

No major occurrence of economic deposit has been found in the reservoir area, except materials like boulder, shingle pebbles, sand which bears no economic mineral importance, save as the construction material.

3.4.10. *Archaeological / Religious / Historical Monuments*

No archaeological monument of national importance either lies in the project area or in its submergence area. There is also no structure of national heritage in the area.

3.4.11. *Sensitive Areas*

No National Park, Sanctuary, Defense Establishments, Archeological Monuments, Notified Eco-sensitive areas or protected area under Wildlife (Protection) Act exists within the project area or within 15 km distance from it.

3.4.12. *Landslide Zones*

Detailed investigations were carried out along the periphery of proposed reservoir along river Umngot, in order to delineate the active as well as potential landslide zones. The study reveals that there are no active or dormant landslide/landslip zone along the periphery of the reservoir extending in river.

3.5. Meteorology, Air and Nose

Meteorological factors have a direct bearing on the dispersion and dilution of pollutants/contaminants, discharged into the atmosphere with consequent impact on air Environment. Micro-meteorological properties of the atmosphere govern the concentration of pollutants and its variations with time and location with respect to their sources. Meteorological information is required to understand the climatic profile of the area as well as for devising the baseline ambient air quality monitoring plans.

3.5.1. *Climate*

The climate in the catchment, as in the whole of Meghalaya, is determined by the altitude of the land surface and the alternating high and low pressure created by the seasonal winds. Warm moist winds come from the south and southwest during summer and cold winds from the north-west during winter. The hills of Meghalaya which run east-west receive most of the rainfall from the South-West Monsoon. The rainy season begins from the end of May and continues till early October. Prior to the arrival of the monsoons, occasional short rainfall or pre-monsoon showers take place over the catchment.

Distribution of rainfall depends upon the topography and relief of the land. The wind ward side records the maximum amount of precipitation whereas the leeward side lies in the rain-shadow region where rainfall diminishes uniformly at the adiabatic rate. Thus, rainfall decreases from south to north.

The four seasons start with spring during March/April where the atmosphere gradually warm up and the temperature heats up by May. The summer season starts as soon as the south-west monsoon winds begin to blow in the last parts of May and lasts till the end of September or early October. Autumn follows and cool temperature prevails up to the end of November. Winter lasts till the end of February.

The principal determinants of weather and climate conditions in the region include.

1. Altitude and its physiographic complexity.
2. Direction of the ridges and location on windward and leeward sides.
3. Degree of slope and aspect.
4. Intensity of forest cover and
5. Proximity to water bodies and glaciers.

3.5.2. *Meteorological Characteristics*

Meteorological factors have a direct bearing on the dispersion and dilution of pollutants/contaminants, discharged into the atmosphere with consequent impact on air Environment. Micro-meteorological properties of the atmosphere govern the concentration of pollutants and its variations with time and location with respect to their sources. Meteorological information is required to understand the climatic profile of the area as well as for devising the baseline ambient air quality monitoring plans. The nearest authoritative IMD meteorological station is Shillong (C.S.O.), latitude 25^{O} 34' and longitude 91^{O} 34', altitude 1596 masl. is located. The climatologically summary for station at Shillong is given in **Table 3.5** and the interpretation of the data is given in sub sections.

Table 3.5 : Climatic Data of IMD Shillong (1980-2010)

Month	Mean max. temp (^{0}C)	Mean min. temp (^{0} C)	Monthly Rainfall (mm)	R.H.at 8:30 (%)	R.H.at 17:30 (%)	Mean wind speed (Km/h)
January	14.9	5.9	13.8	60	87	3.7
February	17.0	7.5	19.3	58	76	5.4
March	21.0	11.1	46.0	54	68	7.8
April	23.2	13.8	129.0	64	72	9.0
May	23.4	15.5	266.6	74	81	6.5
June	24.0	17.4	428.7	84	86	5.2
July	23.9	17.9	496.5	86	87	4.2
August	24.1	17.7	310.5	84	88	3.6
September	23.3	16.7	276.6	83	90	3.4
October	21.8	14.3	211.8	72	90	3.0
November	19.1	10.5	38.8	61	88	3.3
December	16.0	17.2	12.8	60	89	3.4
Average Total	**21.0**	**13.0**	**2250.4**	**70**	**84**	**4.9**

3.5.3. *Temperature*

The mean daily maximum temperature recorded is 21° C while mean daily minimum temperature recorded is 13° C. The highest recorded temperature in the district is 30.2 ° C (04.04.1973) while lowest temperature observed to be -2.4° C (23.02.1973). Monthly variation of daily maximum and minimum temperature is shown in **Figure 3.13.**

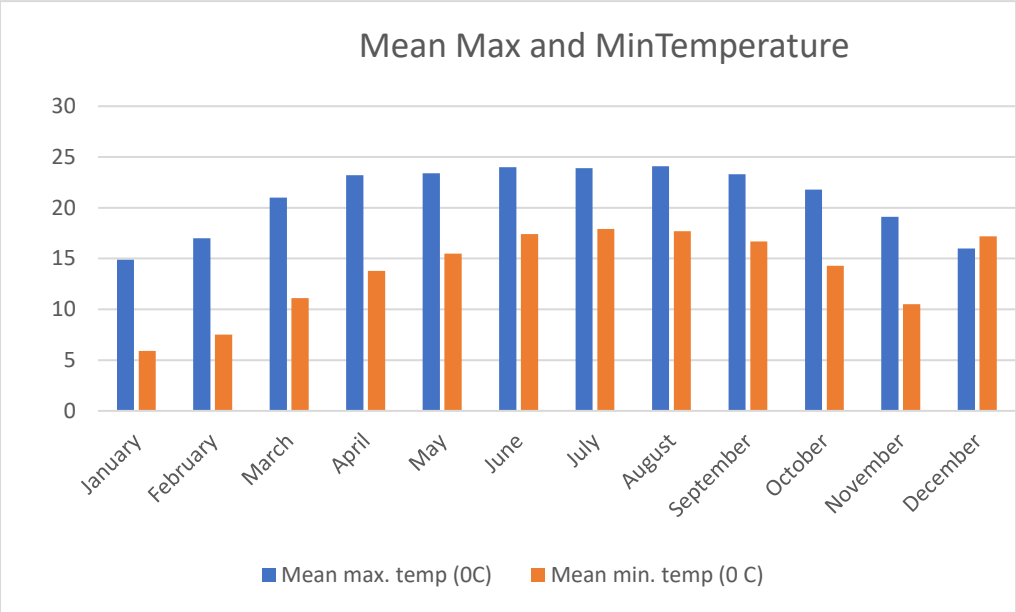


Figure 3.13 : Monthly Variation of daily max and min temperature

3.5.4. *Rainfall*

The south west monsoon during the month of June, July, August and September chiefly contributes the rainfall. The total annual rainfall is 2250.40 mm (1981-2009). The maximum total monthly rainfall is 1080.8 mm, which occurred in August,1974 and minimum monthly rainfall in monsoon is 93.2 mm which occurred in June,1998. There are about 113 rainy days in a year and about 91% of total rainfall occurs during rainy season (June-September). The heaviest fall for 24 hours was 302.2 mm (15.09.1960). The rainfall pattern is given in **Figure 3.14.**

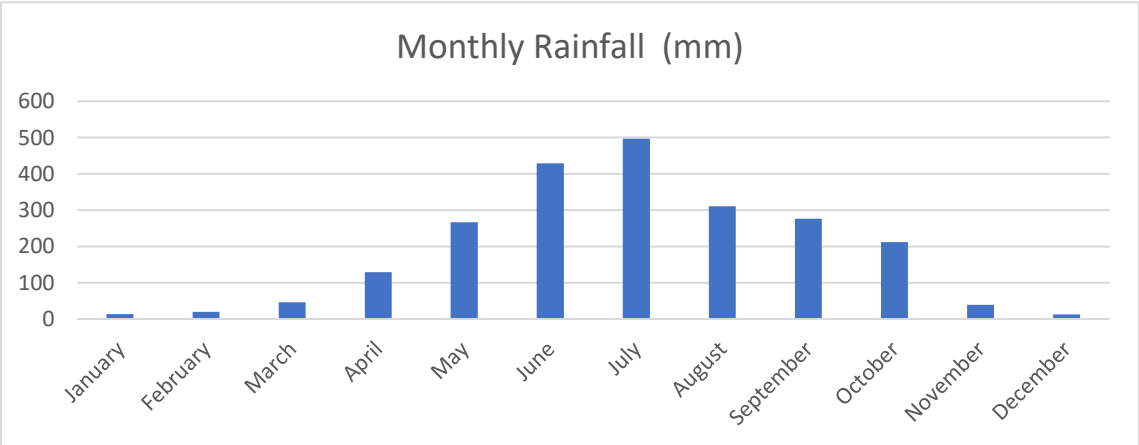


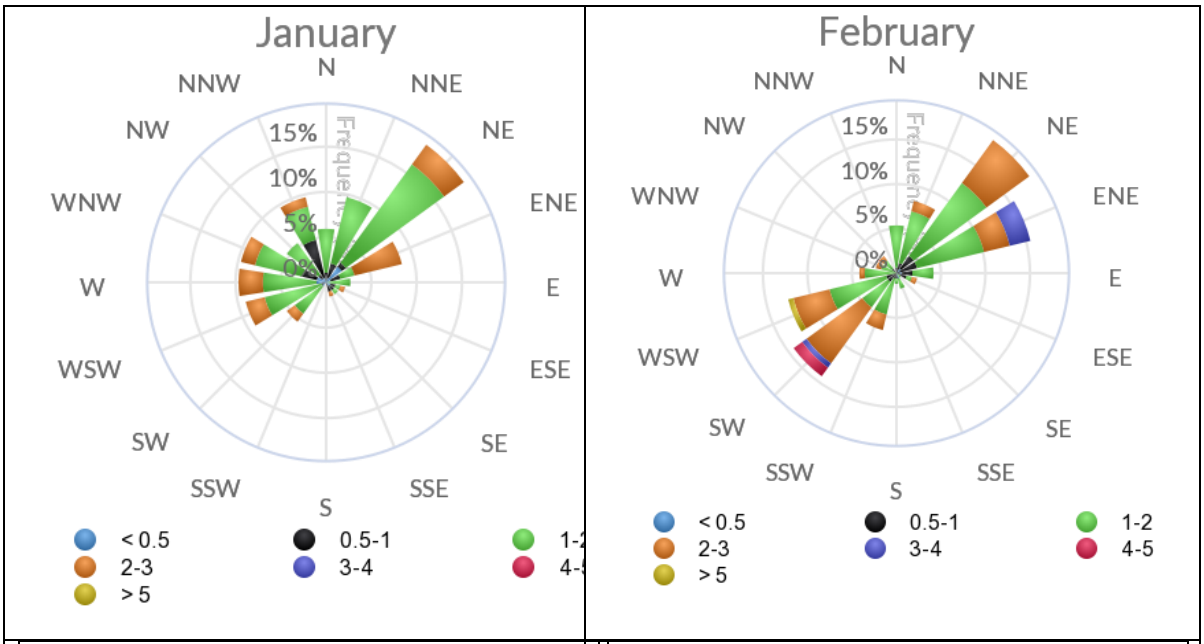
Figure 3.14 : Monthly Variation of Total Rainfall

3.5.5. *Relative Humidity*

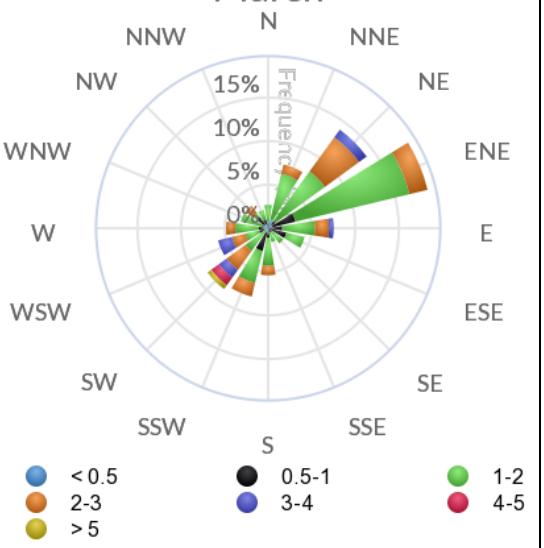
The During the monsoon season, relative humidity generally varies between 83 to 86% in the morning. The air becomes dry after the withdrawal of the north-west monsoon. The driest part of the year is the summer season when in the morning's relative humidity becomes low as 54%.

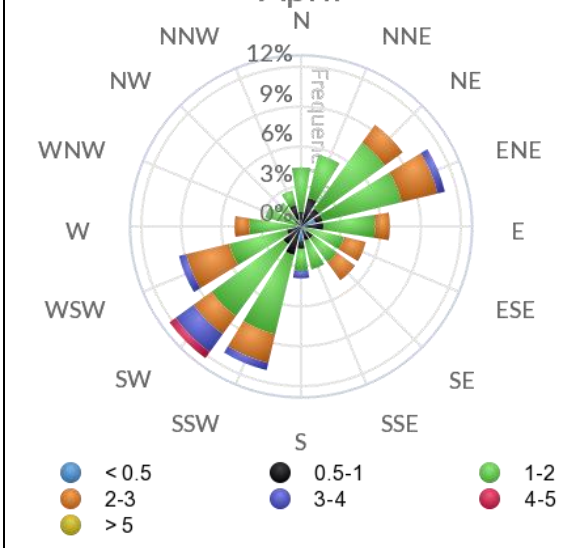
3.5.6. *Wind Speed / Direction*

Predominant wind direction is South-West and West. Winds are particularly calm in post-monsoon and winter season. During the monsoon season, winds blow from SE, SW and S direction. During the winter season, winds blow from NE and W direction. The monthly calm varies between 1.62%(August) to 12.92%(October) The wind-rose diagram as sketched from the IMD Station at Shillong, Meghalaya is shown in **Figure 3.15**.



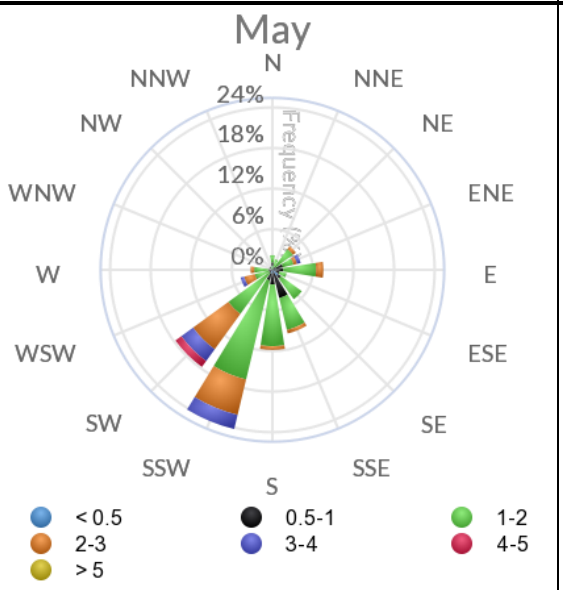
Direction	NE [18.82%]	**Direction**	NE [18.82%]
Speed Range	1-2 m/s	**Speed Range**	1-2 m/s
Average Wind	0.49 m/s	**Average Wind**	0.49 m/s
Calm	8.09%	**Calm**	8.09%

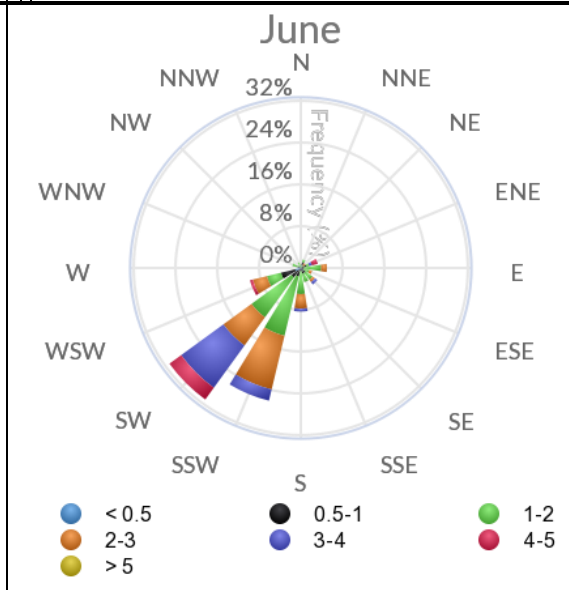




Direction	ENE [18.82%]
Speed Range	1-2 m/s
Average Wind	0.2 m/s
Calm	5.94%

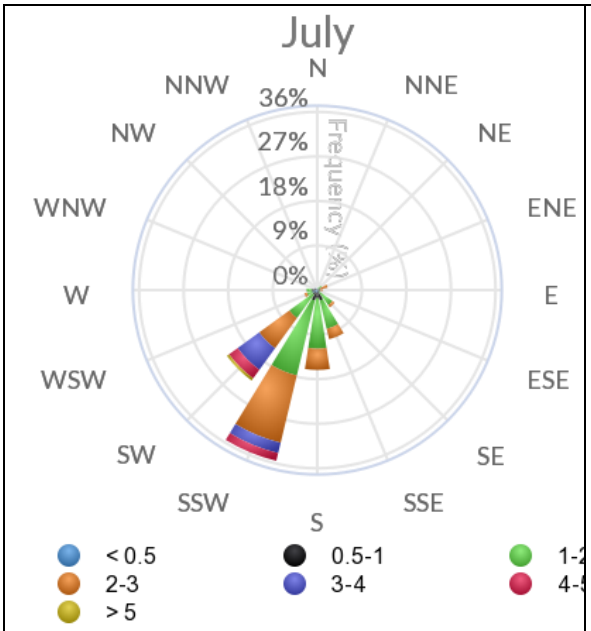
Direction	SW [12.24%]
Speed Range	1-2 m/s
Average Wind	0.25 m/s
Calm	3.9%



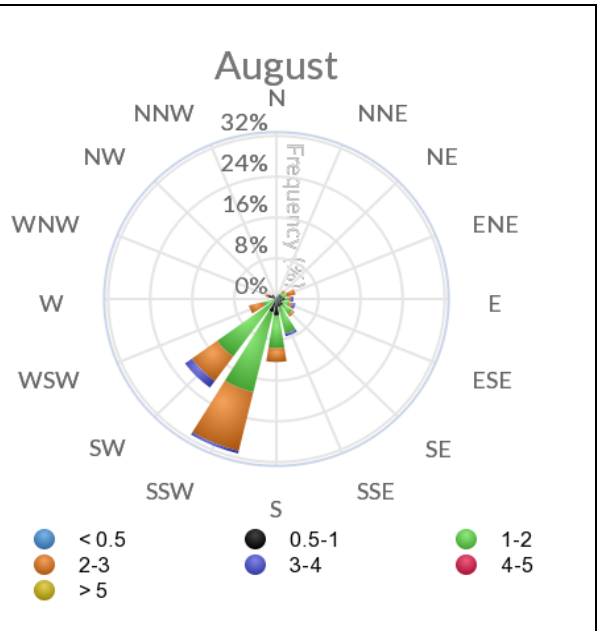


Direction	SSW [24.2%]
Speed Range	1-2 m/s
Average Wind	0.96 m/s
Calm	3.24%

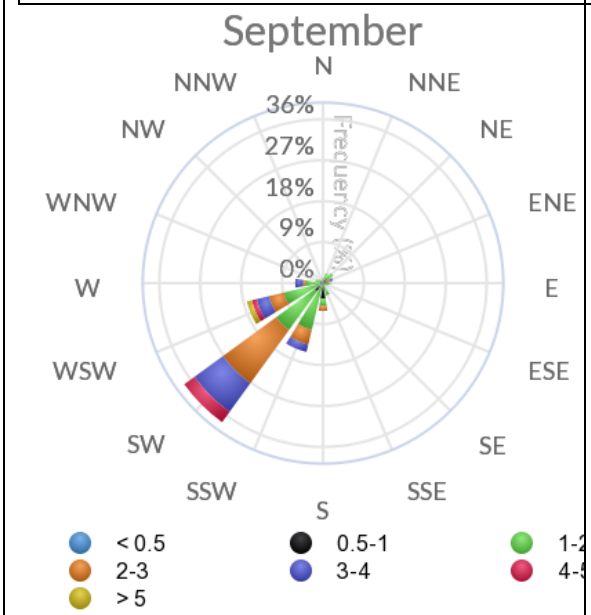
Direction	SW [31.12%]
Speed Range	1-2 m/s
Average Wind	1.46 m/s
Calm	2.79%



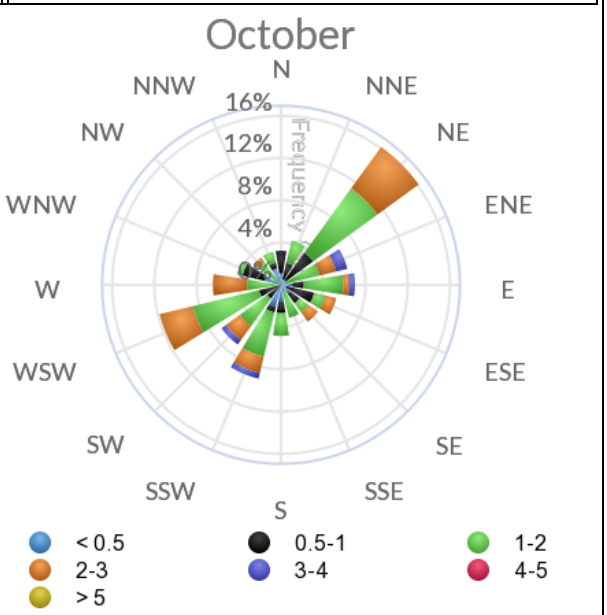
Direction	SSW [35.48%]
Speed Range	1-2 m/s
Average Wind	1.65 m/s
Calm	4.32%



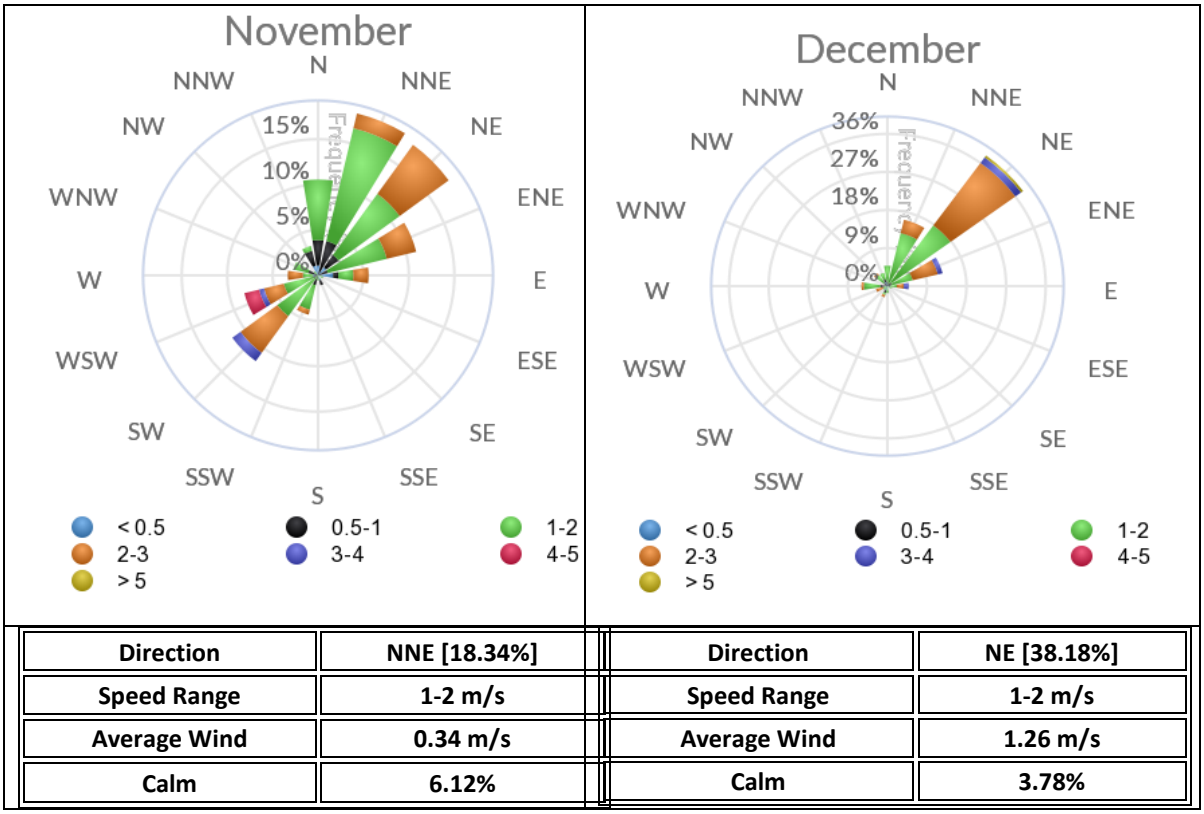
Direction	SSW [31.19%]
Speed Range	1-2 m/s
Average Wind	1.18 m/s
Calm	1.62%



Direction	SW [37.78%]
Speed Range	1-2 m/s
Average Wind	1.65 m/s
Calm	2.79%



Direction	NE [16.14%]
Speed Range	1-2 m/s
Average Wind	0.09 m/s
Calm	12.92%



Direction	NNE [18.34%]	Direction	NE [38.18%]
Speed Range	1-2 m/s	Speed Range	1-2 m/s
Average Wind	0.34 m/s	Average Wind	1.26 m/s
Calm	6.12%	Calm	3.78%

Figure 3.15 : Windrose Diagram

3.5.7. *Air Environment*

Air pollution can cause significant effects on the environment and subsequently on human, animals, vegetation and materials. In most cases, air pollution aggravates pre-existing diseases or degrades health status, making people easily susceptible to other infections and development of chronic respiratory and cardiovascular diseases. Further, environmental impacts from air pollution can include acidic deposition and reduction in visibility. The proposed project is hydro project where no air pollution is envisaged during operation phase. During construction phase, minor air pollution may occur due to quarrying, blasting, drilling, vehicle and D.G set operation.

A site–specific background of air quality monitoring program was conducted for the proposed project site during winter season. Background data was collected for PM_{10}, $PM_{2.5}$, SO_2, NO_x. Since the proposed site has no pollution intensive activities in its vicinity, six sampling stations located within 10.0 km of the site was considered to provide the surrounding baseline air quality. For the selection of the monitoring locations, long-term meteorological trends were taken into consideration to obtain the predominant wind direction during the sampling period. The monitoring was carried out following CPCB standard protocol.

The ambient air quality monitoring locations are detailed in **Table 3.6** and shown in **Figure 3.16.** The ambient air quality monitoring during post-monsoon, 2017; pre-monsoon, 2018 and monsoon, 2018 was conducted by the EIA consultant through ULTRA Research Laboratory (NABL accredited Laboratory). Monitoring was carried out for Particulate Matter (PM_{10} and $PM_{2.5}$), Sulphur dioxide (SO_2), and Oxides of Nitrogen (NOx) as per ToR. Monitoring was carried out on 24 hourly twice a week at six locations.

Table 3.6 : Location of Air Monitoring Stations

S. N.	Station Code	Locations	Approximate Distance (km)
1	AAQ-1	Syntung	7.2 km (S-W)
2	AAQ-2	Dam Site	-
3	AAQ-3	Mawjatap	4 km (N-W)
4	AAQ-4	Nongryngkoh	9.5 km (S-W)
5	AAQ-5	Power House Site	8.0 km (S-W)
6	AAQ-6	Moosakhia	10 km (N-E)

Ambient air quality levels were assessed with respect to National ambient air quality standards prescribed by Central Pollution Control board (CPCB) 2009 Summary results of ambient air quality monitoring data are shown in **Table 3.7** through **Table 3.9.**

The monitoring results of ambient air quality were compared with the National Ambient Air Quality Standards (NAAQS) prescribed by MoEF&CC; GoI Notification dated 16.11. 2009.The maximum concentration of PM_{10}, $PM_{2.5}$ and NOX were 52.0µg/m^3, 25.0µg/m^3,9.8 µg/m^3 and 6.3µg/m^3respectively. Thus, it was found that concentration of pollutants was within the limits of standards prescribed by CPCB.

Table 3.7 : Summary of Ambient Air Quality (µg/m3) During Post- Monsoon, 2017

Location Name	Location Code	Range	Post Monsoon-2017			
			PM2.5 (µg/m^3)	PM10 (µg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)
Syntung	AQ1	Max	25	52	6.3	9.8
		Min	15	32	BDL <5	6.8
		Mean	19	40	5.7	8.2
		98 %tile	25	51	6.3	9.8
Dam Site	AQ2	Max	22	43	BDL <5	7.8
		Min	12	30	BDL <5	6.3
		Mean	17	38	BDL <5	7.0
		98 %tile	22	43	BDL <5	7.8
Mawjatap	AQ3	Max	22	45	BDL <5	8.4
		Min	13	34	BDL <5	6.6
		Mean	17	38	BDL <5	7.5
		98 %tile	22	45	BDL <5	8.4
Nongryngkoh	AQ4	Max	21	40	BDL <5	8.7
		Min	14	27	BDL <5	6.5
		Mean	17	35	BDL <5	7.3
		98 %tile	21	40	BDL <5	8.5
Power House Site	AQ5	Max	21	42	BDL <5	8.2
		Min	13	25	BDL <5	6.4
		Mean	17	34	BDL <5	7.1
		98 %tile	21	42	BDL <5	8.1
Moosakhia	AQ6	Max	21	43	BDL <5	8.8
		Min	13	28	BDL <5	6.2
		Mean	18	36	BDL <5	7.2
		98 %tile	21	43	BDL <5	8.6

NAAQS for 24-Hour Monitoring	60	100	80	80

Table 3.8 : Summary of Ambient Air Quality(µg/m3) During Pre- Monsoon, 2018

Location Name	Location Code	Range	Pre- Monsoon-2018			
			PM2.5 (µg/m³)	PM10 (µg/m³)	SO_2 (µg/m³)	NO_2 (µg/m³)
Syntung	AQ1	Max	20	44	5.8	8.7
		Min	11	26	BDL <5	6.5
		Mean	17	36	5.5	7.6
		98 %tile	20	44	5.8	8.6
Dam Site	AQ2	Max	20	41	BDL <5	7.4
		Min	12	32	BDL <5	6.3
		Mean	16	36	BDL <5	6.9
		98 %tile	20	41	BDL <5	7.4
Mawjatap	AQ3	Max	22	47	BDL <5	8.5
		Min	14	32	BDL <5	6.7
		Mean	18	38	BDL <5	7.3
		98 %tile	22	46	BDL <5	8.4
Nongryngkoh	AQ4	Max	22	42	BDL <5	8.8
		Min	12	29	BDL <5	6.4
		Mean	17	36	BDL <5	7.6
		98 %tile	22	42	BDL <5	8.7
Power House Site	AQ5	Max	19	39	BDL <5	7.5
		Min	10	23	BDL <5	6.4
		Mean	15	31	BDL <5	7.0
		98 %tile	19	38	BDL <5	7.5
Moosakhia	AQ6	Max	21	42	BDL <5	8.0
		Min	12	26	BDL <5	6.4
		Mean	17	34	BDL <5	7.3
		98 %tile	21	41	BDL <5	8.0
NAAQS for 24-Hour Monitoring			60	100	80	80

Table 3.9 : Summary of Ambient Air Quality Data (µg/m3) During Monsoon, 2018

Location Name	Location Code	Range	Monsoon-2018			
			PM2.5 (µg/m³)	PM10 (µg/m³)	SO_2 (µg/m³)	NO_2 (µg/m³)
Syntung	AQ1	Max	21	48	BDL <5	8.5
		Min	13	31	BDL <5	6.3
		Mean	17	39	BDL <5	7.4
		98 %tile	21	47	BDL <5	8.5
Dam Site	AQ2	Max	19	40	BDL <5	7.2
		Min	11	25	BDL <5	6.1
		Mean	16	33	BDL <5	6.7
		98 %tile	19	40	BDL <5	7.2
Mawjatap	AQ3	Max	19	39	BDL <5	8.1
		Min	11	26	BDL <5	6.4
		Mean	15	34	BDL <5	7.1
		98 %tile	19	39	BDL <5	8.0
Nongryngkoh	AQ4	Max	20	41	BDL <5	8.0
		Min	10	23	BDL <5	6.1

		Mean	15	32	BDL <5	7.0
		98 %tile	20	41	BDL <5	7.9
Power House Site	AQ5	Max	18	38	BDL <5	7.5
		Min	9	21	BDL <5	6.2
		Mean	14	30	BDL <5	6.9
		98 %tile	18	38	BDL <5	7.5
Moosakhia	AQ6	Max	19	36	BDL <5	7.8
		Min	11	24	BDL <5	6.4
		Mean	15	32	BDL <5	7.0
		98 %tile	19	36	BDL <5	7.7
NAAQS for 24-Hour Monitoring			**60**	**100**	**80**	**80**

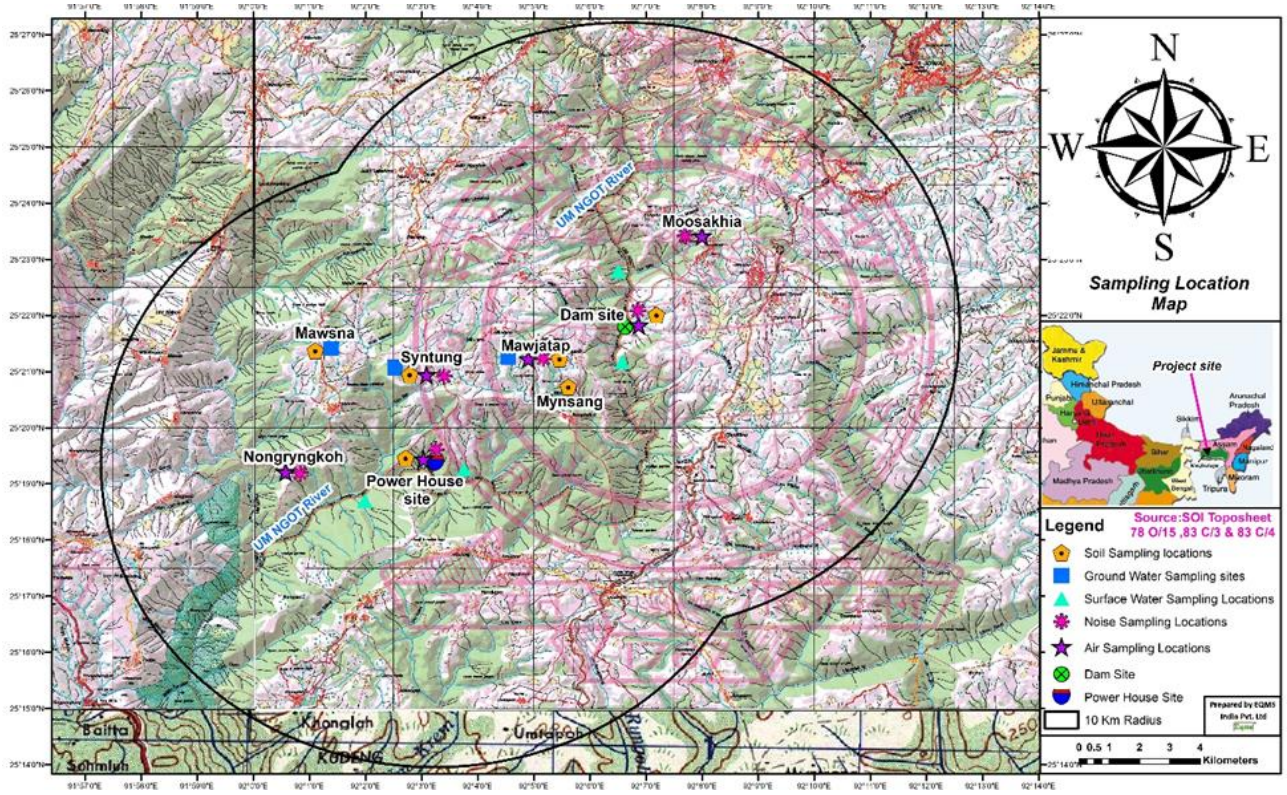


Figure 3.16 : Location of the Ambient Air Monitoring Stations

3.5.8. *Noise Environment*

Noise can be defined as any sound that is undesirable because it interferes with speech and hearing, and is intense enough to damage hearing or is otherwise annoying. Noise impacts can be of concern during construction and operational phases of the project. Factors those are important in determining noise levels include distance from the noise source, natural or manmade barriers between the source and the receptors, whether conditions, etc. In assessing noise, an empirical measure called "dBA" indicates damage to hearing. The higher the dB (A) number, the greater is the risk of damage to hearing. Loud noise may adversely affect people in many ways. For example, noise may interface with sleep, speech, communication and can cause infuriation and other physiological problems. Occupational noise exposure is also the most common cause of Noise-Induced Hearing Loss (NIHL), threatening the hearing of individuals exposed to noise pollution for longer periods of time, at a less intense level. For example, repeated exposure to noise pollution at a construction site can cause NIHL to construction workers, an effect that cannot be reversed.

An assessment of baseline noise quality was undertaken to (a) establish the status of exposure of the major sensitive receptors, and (b) to identify the noise pollution levels in and around the site. The noise monitoring was done following CPCB protocol of Noise Monitoring. Noise monitoring was conducted at six locations. The background monitoring program was carried out in accordance with the requirements of EIA study. Sound pressure level (SPL) measurements were automatically recorded to give the noise level for every hour continuously for 24 hours in a day. Accordingly, one full day (i.e., 24-hourly values) of data was collected at each of the locations for each season. The monitoring locations are provided in **Table 3.10** and shown in **Figure 3.8.** The Noise monitoring results have been detailed in **Table 3.11** through **Table 3.13.** Leq day time (6 am to 10 pm) and Leq night time (10 pm to 6 am) was calculated using the following equation:

$$L_{eq,T} = 10\log\left(1/n\sum_{i=1}^{n}10^{\frac{L_i}{10}}\right)$$

Where, Li = levels observed at an equally spaced times during interval T. Leq day and night (Ldn) was also worked out by using the following equation: Ldn =10 Log10[0.666X10 Ld/10+0.333 X10 (Ln+10)/10.

Table 3.10 : Noise monitoring locations

S. No	Location	Code	Distance	Zone
1	Syntung	N1	4.2 km (u/s)	Residential
2	Dam Site	N2	-	Residential
3	Mawjatap	N3	1 km (d/s)	Residential
4	Nongryngkoh	N4	1.5 km (d/s)	Residential
5	Power House Site	N5	5.0 km (d/s)	Residential
6	Moosakhia	N6	10 km (d/s)	Residential

Table 3.11 : Noise Level of the Study Area (Post-monsoon 2017)

Location	Location Code	Day dB(A)			Night dB(A)			Leq Day & Night, dB(A)
		Max	Min	Leq	Max	Min	Leq	
Syntung	N-1	56.7	44.5	51.0	45.2	38.0	42.4	49.5
Dam Site	N-2	75.7	70.6	73.3	73.0	67.7	71.2	72.7
Mawjatap	N-3	56.7	43.2	51.0	43.4	38.7	41.1	42.6
Nongryngkoh	N-4	55.6	45.0	51.7	44.6	38.0	41.6	44.1
Power House Site	N-5	73.9	69.6	71.8	72.4	68.9	71.1	70.2
Moosakhia	N-6	54.8	44.6	50.6	43.7	38.7	41.4	43.8

Table 3.12 Noise Level of the Study Area (Monsoon 2018)

Location	Location Code	Day dB(A)			Night dB(A)			Leq Day & Night, dB(A)
		Max	Min	Leq	Max	Min	Leq	
Syntung	N-1	56.3	43.0	51.3	44.8	38.5	41.8	49.8

Dam Site	N-2	75.6	70.1	73.0	73.2	68.1	70.5	72.3
Mawjatap	N-3	56.3	43.8	51.4	43.8	39.3	41.8	49.9
Nongryngkoh	N-4	54.4	43.2	50.5	44.0	37.6	41.2	49.0
Power House Site	N-5	75.9	69.5	72.8	71.6	68.5	70.1	72.1
Moosakhia	N-6	52.8	43.2	50.2	42.4	38.1	40.4	51.2

Table 3.13 : Noise Level of the Study Area (Monsoon 2018)

Location	Location Code	Day dB(A)			Night dB(A)			Leq Day & Night, dB(A)
		Max	Min	Leq	Max	Min	Leq	
Syntung	N-1	55.4	42.4	50.8	44.1	39.1	41.9	49.3
Dam Site	N-2	76.0	69.9	72.6	73.2	71.1	72.0	72.4
Mawjatap	N-3	54.2	43.0	50.4	43.7	38.9	40.7	48.9
Nongryngkoh	N-4	54.2	42.3	50.1	43.4	38.1	40.8	48.6
Power House Site	N-5	75.6	70.9	73.3	72.3	69.7	71.3	66.6
Moosakhia	N-6	55.1	43.7	51.0	43.2	39.6	41.1	51.2

The noise monitoring shows that day and night time noise levels are higher at dam site and near power house site due to flow of river. The major source of the noise in the study area is the flow of river and vehicular movement. The ambient air quality standards in respect of noise are 75, 65, 55 and 50 dB (A) Leq in day time and 70, 55, 45 and 40 dB (A) Leq during night time for industrial, commercial, residential and silence zone respectively. The daytime noise level measured during 6:00 a.m. to 10:00 p.m. and nighttime measured from 10:00 p.m. to 6:00 a.m. The noise level is within the prescribed limit in all the monitoring stations except dam and power house site.

3.5.9. *Traffic Density*

The traffic survey is essential to realistically and accurately assess the prevailing traffic volumes and travel characteristics by undertaking classified volume count. The objective of traffic volume count survey is to assess the traffic intensity on the most vulnerable section of the road under question. Two – days, 24 hrs., continuous volume counts were manually undertaken during February 2018 on MDR Mawkynrew , near the point of junction with Siangkhani road for capturing the realistic picture of the current volume and composition of traffic motorized i.e. passenger vehicles (two-wheeler, three-wheeler, bicycle, passenger car); utility vehicles (Jeep, Van, Mini Bus, Standard Bus); Goods vehicles – LCV (Freight), MCV (2 axle rigid chassis), MCV (3 axle rigid chassis), MAV and tractor trailer and non-motorized like animal driven cart. The survey work was conducted by engaging educated people familiar with traffic characteristics. Before the start of survey, the enumerated engaged were briefed and trained by an expert supervisor about the task.

The analysis of traffic counts provides an estimate of average daily traffic (ADT). In order to convert recorded vehicles into a common scale, the passenger car units (PCU) equivalent factor as per IRC:64 -1990 has been adopted. The **Table 3.14** reveals that the total ADT at traffic enumeration point were 656 in terms of number which translates into 689 in terms of PCU.

Table 3.14 : Traffic volume counts on MDR Mawkynrew

S. N.	Nomenclature of Vehicle	PCU factor	No. of Vehicles / day	No. of PCU / day
1	Car / Jeep / Van	1	150	150
2	Two-Wheelers	0.5	300	150
4	Mini- Bus	1.5	20	30
5	Bus	3	50	150
6	Tempo / LCV	1.5	16	24
7	2/3 Axle Truck	3	50	150
10	Tractor	1.5	0	0
11	Cycle	0.5	70	35
Total			**656**	**689**

3.6. Soil

3.6.1. *Soil Type*

The soils of the East Khasi Hills District are light to heavy in texture ranging from acidic soil to soil rich in organic matter though generally poor in phosphorus. Potash content varies from medium to high. Red soils are commonly found in the central and sub-montane regions while black and red loam occurs in the low-lying hills of the border areas. Light and medium soil is suitable for growing of fruit trees and rice. Light soil is also suitable for growing of potato, maize and medium soil for growing of temperate fruit trees. Heavy soil is suitable for growing of rice, pulse and mustard.

The soil of the region can be classified into (1) Laterite soils (2) Red Loamy soils and (3) Red and Yellow soils, Laterite soils occur in the northern part of the region and red and loamy soils, in the central belt. Red and Yellow soils occur in the southern belt. According to NBSS & LUP (ICAR) Nagpur, the region has three types of soil, (1) Ustalfs-Ochrepts-Orthents (2) Udalfs-Ochhrepts and (3) Udalfs Ochrepts-Fluvents-Orthents. Geologically the region is mainly underlain by the Shillong group of rocks.

3.6.2. *Soil Characteristics*

Soil fertility is an important aspect of the soil-plant relationship. Fertility status of the soils is primarily and importantly dependent upon both the macro and micronutrient reserve of the soil. Continued removal of nutrients by crops, with little or no replacement will increase the nutrient stress in plants and ultimately lowers the productivity. The fertility status of soil mainly depends upon the nature of vegetation, climate, topography, texture and decomposition rate of organic matter in the soil. Optimum productivity of any cropping systems depends upon adequate supply of plant nutrients.

The fertility of soil depends on the concentration of N, P, K, organic and inorganic materials and water. Nitrogen is required for growth of plant and is a constituent of chlorophyll, plant protein, and nucleic acids. Phosphorus is most often limiting nutrients remains present in plant cell nuclei and act as energy storage. It helps in transfer of energy. Potassium is found in its mineral form and affect plant cell division, carbohydrate formation, translocation of sugar, various enzyme actions and resistance to certain plant disease, over 60 enzymes are known to require potassium for activation.

It is essential to determine the potential of soil in the area to identify the current impacts of urbanization and industrialization on soil quality and predict impacts, which may arise due to the project operations. Accordingly, a study of assessment of the baseline soil quality has been carried out.

3.6.3. *Soil Monitoring*

The soils on slope and fluvial valleys are good for vegetation. Rocks are weathering due to heavy rainfall. The texture varies from sandy loam to loamy sand. Soil samples from various locations in the study area were collected; the sample locations have been selected to represent the area characteristics based on geology, land use and floristic pattern. The samples have been collected from six locations for soil quality in project area at three different depths from 5 to 15 cm and well mixed. The location of the soil samples is presented in **Table 3.15.** Locations of the soil sampling stations have been shown in **Figure 3.15**. The physical and chemical analysis results of the soil samples collected at site during Post Monsoon, 2017, Pre-monsoon, 2018 and Monsoon 2018 are presented in **Table 3.16** through **Table 3.18**.

Table 3.15 : Location of Soil Quality Monitoring Stations

Station Code	Name	Environmental Setting
S1	Syntung Village	Agriculture Land
S2	Dam Site	Forest Land
S3	Mawjatap	Agriculture Land
S4	Mynsang	Forest Land
S5	Power House Site	Agriculture Land
S6	Mawsna	Agriculture Land

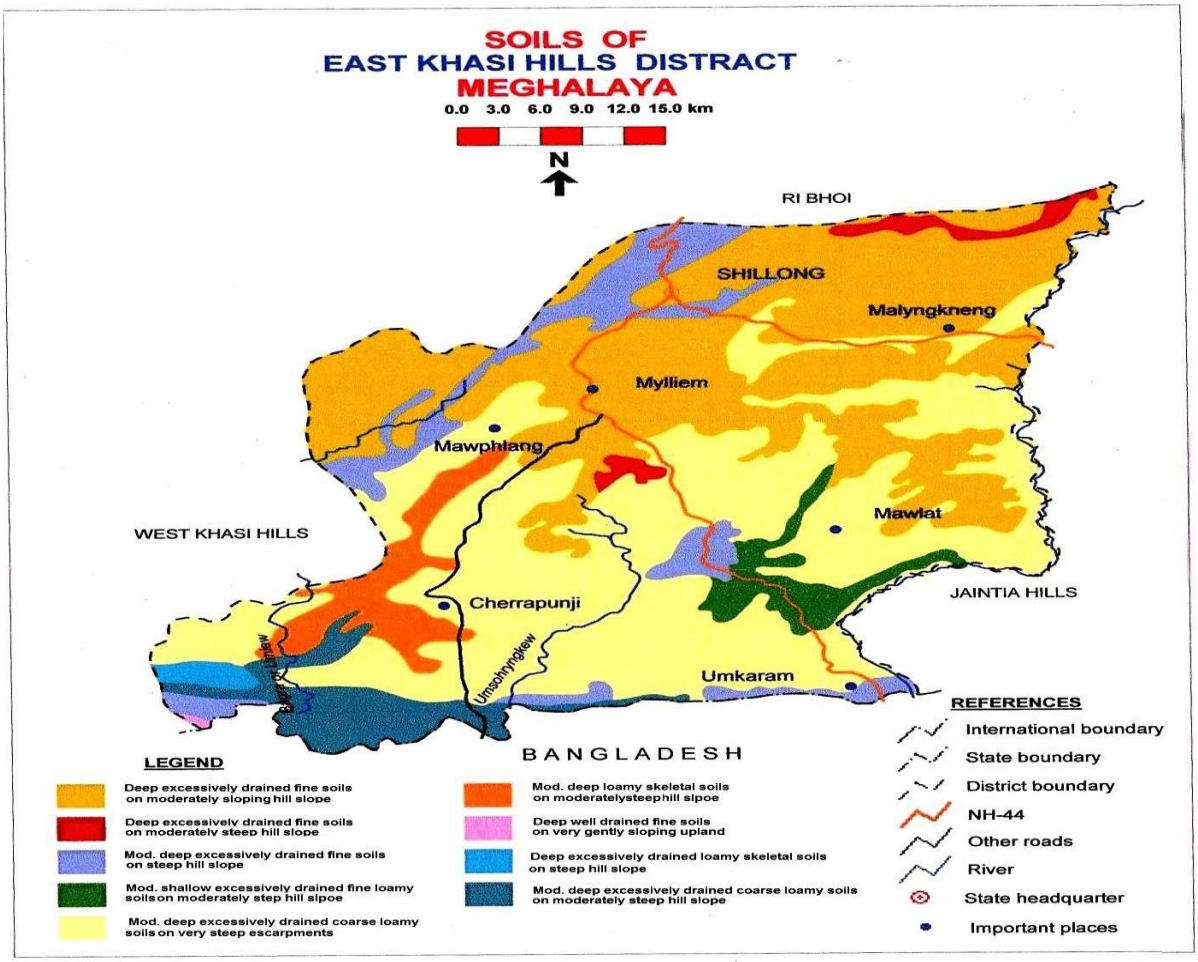


Figure 3.17 : Location of the Soil Sampling Stations

Table 3.16 : Physical & Chemical Characteristics of Soil (Post Monsoon 2017)

S. No.	Parameter	Unit	Post-Monsoon Season, (November 2017)					
			S-1	S-2	S-3	S-4	S-5	S-6
Physical Characteristics								
1.	Texture		Sandy Loam	Sandy	Sandy	Sandy Loam	Sandy Loam	Sandy Loam
2.	Porosity	%	41.9	38.2	40.4	44.9	45.6	43.2
3.	Bulk Density	gm/cc	1.54	1.65	1.58	1.46	1.44	1.51
4.	WHC	%	30.6	28.4	29.9	29.5	29.2	29.8
Chemical Characteristics								
5.	pH (1:2 Suspension)	-	6.95	7.15	7.28	6.94	6.88	6.61
6.	Conductivity (EC)	µmhos/cm	186.5	242.2	126.8	235.4	198.6	218.4
7.	CEC	meq/100gm	12.2	6.5	5.8	12.5	11.6	9.8
8.	Organic Carbon	%	0.64	0.75	0.78	0.68	0.72	0.51
9.	Calcium as Ca	mg/kg	618.5	642.2	708.8	662.5	654.2	722.5
10.	Magnesium as Mg	mg/kg	528.8	615.2	524.5	478.6	546.8	455.4
11.	Chloride as Cl	mg/kg	206.5	215.2	224.6	212.5	218.6	221.4
12.	Total Alkalinity	mg/kg	11.8	14.2	12.5	15.6	10.2	15.5
13.	Sodium as Na	mg/kg	215.5	232.8	244.5	214.2	218.5	225.7
14.	Salinity	mg/kg	118.3	120.5	135.6	136.2	126.5	132.2
15.	**Available Nutrients**							
i).	Nitrogen as N	kg/ha	286.6	275.6	292.4	271.8	288.9	298.5
ii).	Phosphorus as P	kg/ha	7.5	7.8	8.6	10.2	12.6	11.5
iii).	Potassium as K	kg/ha	164.6	172.5	149.6	152.5	168.4	156.2
16.	SAR	-	1.54	1.58	1.66	1.55	1.52	1.61

Table 3.17 : Physical & Chemical Characteristics of Soil (Pre-monsoon-2018)

S. No.	Parameter	Unit	Pre-Monsoon Season, (April 2018)					
			S-1	S-2	S-3	S-4	S-5	S-6
Physical Characteristics								
1.	Texture	USDA System	Sandy Loam	Sandy	Sandy	Sandy Loam	Sandy Loam	Sandy Loam
2.	Porosity	%	44.2	38.9	41.1	45.6	46.4	44.9
3.	Bulk Density	gm/cc	1.48	1.62	1.56	1.44	1.42	1.46
4.	WHC	%	30.8	28.2	29.6	29.1	28.8	29.4
Chemical Characteristics								
5.	pH (1:2 Suspension)	-	6.88	7.15	7.05	6.86	7.02	6.88
6.	Conductivity (EC)	µmhos/cm	196.2	248.6	148.5	225.5	208.4	214.5
7.	CEC	meq/100gm	11.5	5.8	5.6	11.6	11.2	10.4
8.	Organic Carbon	%	0.68	0.78	0.82	0.74	0.75	0.62
9.	Calcium as Ca	mg/kg	615.5	628.2	644.8	610.5	624.2	525.5
10.	Magnesium as Mg	mg/kg	524.5	485.2	515.6	494.2	536.5	469.4
11.	Chloride as Cl	mg/kg	204.2	212.5	226.7	234.5	215.6	242.5
12.	Total Alkalinity	mg/kg	12.5	14.6	12.8	15.4	13.6	14.5
13.	Sodium as Na	mg/kg	198.6	212.8	224.5	215.2	205.5	219.6
14.	Salinity	mg/kg	110.5	118.8	126.4	142.2	132.5	135.8
15.	**Available Nutrients**							
i).	Nitrogen as N	kg/ha	296.4	284.5	288.8	276.2	296.8	302.6

ii).	Phosphorus as P	kg/ha	6.2	7.5	8.4	8.5	11.5	10.8
iii).	Potassium as K	kg/ha	166.4	168.5	155.6	145.8	166.5	154.2
16.	SAR	-	1.41	1.55	1.60	1.56	1.48	1.67

Table 3.18 : Physical & Chemical Characteristics of Soil (Monsoon-2018)

S. No.	Parameter	Unit	Monsoon Season, (July 2018)					
			S-1	S-2	S-3	S-4	S-5	S-6
Physical Characteristics								
1.	Texture	USDA System	Sandy Loam	Sandy	Sandy	Sandy Loam	Sandy Loam	Sandy Loam
2.	Porosity	%	44.5	41.1	38.9	45.7	47.9	46.4
3.	Bulk Density	gm/cc	1.47	1.56	1.62	1.44	1.38	1.42
4.	WHC	%	31.4	29.5	30.1	29.8	29.6	30.1
Chemical Characteristics								
5.	pH (1:2 Suspension)	-	7.02	7.28	7.45	6.96	6.88	6.96
6.	Conductivity (EC)	µmhos/cm	228.5	235.2	214.8	220.4	214.6	228.4
7.	CEC	meq /100-gm	11.2	9.8	8.5	8.2	10.5	9.8
8.	Organic Carbon	%	0.62	0.71	0.66	0.60	0.65	0.59
9.	Calcium as Ca	mg/kg	604.5	623.2	646.5	638.2	642.6	634.4
10.	Magnesium as Mg	mg/kg	516.6	611.4	521.4	485.6	533.5	462.2
11.	Chloride as Cl	mg/kg	214.5	205.2	218.5	225.5	215.6	217.6
12.	Total Alkalinity	mg/kg	11.5	12.8	11.5	14.2	11.4	14.9
13.	Sodium as Na	mg/kg	212.8	229.5	238.2	208.5	216.2	218.6
14.	Salinity	mg/kg	116.6	120.5	131.6	134.2	128.5	131.2
15.	**Available Nutrients**							
i).	Nitrogen as N	kg/ha	294.8	288.6	288.4	276.5	292.2	302.4
ii).	Phosphorus as P	kg/ha	6.5	8.6	8.7	10.6	12.5	11.8
iii).	Potassium as K	kg/ha	156.4	168.2	144.2	145.8	162.5	145.2
16.	SAR	-	1.55	1.56	1.44	1.49	1.52	1.61

3.6.4. *Soil reaction classes and critical limits for Macro and Micro nutrients in soil*

According to Soil Survey Manual (IARI, 1970), the soils are grouped under different soil reaction classes viz. extremely acidic (pH<4.5), very strongly acidic (pH 4.5 – 5.0), strongly acidic (pH 5.1 – 5.5), moderately acidic (pH 5.6-6.0), slightly acidic (pH 6.1-6.5), neutral (pH 6.6- 7.3), slightly alkaline (pH 7.4-7.8), moderately alkaline (pH 7.9-8.4), strongly alkaline (pH 8.5-9.0).The soils are rated as low (below 0.50 %), medium (0.50-0.75 %) and high (above 0.75 %) in case of organic carbon, low (<280 kg ha-1), medium (280 to 560 kg ha-1) and high (>560 kg ha-1) in case of available nitrogen, low (< 10 kg ha-1), medium (10 to 25 kg ha-1) and high (> 25 kg ha-1) for available phosphorus, low (< 108 kg ha-1), medium (108 to 280 kg ha-1) and high (> 280 kg ha-1) for available potassium and low (<10 mg kg-1), medium (10-20 mg kg-1) and high (> 20 mg kg-1) for available sulphur (Singh et. al. 2004, Mehta et. al.1988). Critical limits of Fe, Mn, Zn, Cu and B, which separate deficient from non-deficient soils followed in India are 4.5, 2.0, 0.5, 0.2 and 0.5 mg kg-1 respectively. (Follet and Lindsay, 1970 and Berger and Truog, 1940).

3.6.5. *Interpretation of Soil Characteristics*

3.6.5.1 Physical Properties

Texturally the soils of study area are observed as Sandy Loam and Silty Clay soils. The Bulk Density of the soils was found in the range of 1.38 to 1.65 g/cc. Porosity was observed in the range of 38.2 to 47.9% in the soils of the study area. Water holding capacity of study area soils was observed as 28.2 to 31.4%.

3.6.5.2 Chemical properties

Soil pH ranges from 6.61 to 7.45, thereby indicating the soils are neutral to slightly alkaline in nature. The low EC values indicate low salt content. The organic carbon content of soil varied from 0.51 to 0.82% thereby implying that soils are medium to high in organic content. Available nitrogen content in the surface soils ranges between 271.8 to 302.6 kg/ha, thereby indicating that soils are low to medium in available nitrogen content. Available phosphorus content ranges between 6.2 to 12.6 kg/ha, thereby indicating that soils are low to medium in available phosphorus content. Available potassium content in these soils ranges between 144.2 to 172.5 kg/ha, thereby is indicating that the soils are medium in potassium content.

3.7. Water Quality

The catchment up to the dam site is characterized by many spring fed river / hill torrents. The water is not polluted and bears a lot of dissolved oxygen in it. The natural treatment of water current takes place for a considerable length in upper reaches where the ultraviolet radiation due to sun is quite high. In addition to this the water of the river is not exposed to sewerage in general although some sewerage during monsoon is brought by different streams passing through the inhabitation, during high flood season. The area is free of industrial pollutants as the industrial base is non-existent. In view of the above, the water environment of river up to the project site is benign.

3.7.1. *Water Quality Assessment*

The quality of water is of vital concern for mankind since it is directly linked with human welfare. Water quality characteristics of aquatic environments arise from multitude of physical, chemical and biological interactions. The water bodies are continuously subjected to dynamic state of changes with respect to their geo-chemical characteristics. The dynamic balance in aquatic ecosystem is upset by human activities, resulting in pollution which is obvious by bad taste of drinking water, offensive odour and unchecked growth of aquatic weeds to decrease in number of fish and oil and grease floating on water bodies. These disturb the normal uses of water for public water supply, industry, agriculture etc.

3.7.2. *Reconnaissance Survey*

The information required has been collected through primary surveys and secondary sources. Six groundwater sources and six surface water sources covering 10 km radial distance were examined for physico-chemical, heavy metals and bacteriological parameters in order to assess the effect of existing sources and other activities on water. The samples were collected and analyzed once during each season. Water sampling and analysis has been carried out to determine the existing baseline water quality around the project area. Sampling and analysis have been carried out with following standard guidelines for physical, chemical and bacteriological parameters. Six samples of surface and ground water were collected and examined. The location details of the surface and ground water sampling stations is presented in **Table 3.19.**

Table 3.19 : Water Quality Sampling Stations

Station Code	Station Name	Source
SW1	Umngot River Upstream of Powerhouse site	River
SW2	Umngot River Downstream of Powerhouse site	River
SW3	Umngot River Upstream of dam site	River
SW4	Umngot River Downstream of dam site	River
SW5	Nalla near Powerhouse site	Nalla
SW6	Nalla near Dam site	Nalla
GW1	Syntung Village	Spring
GW2	Mawjatap	Spring
GW3	Mawsna	Spring
GW4	Syntung	Tap water
GW5	Nongryngkoh	Spring
GW6	Moosakhia	Tap water

3.7.3. *Interpretation of Surface Water Quality*

Table 3.19 through **Table 3.21** shows the physico-chemical characteristics of surface water samples collected from upstream and downstream of river/nala, during three season and compared with the drinking water quality standard (IS 10500 :2012) reference values and also in respect of CPCB Water Quality Criteria for designated best use.

The pH values of all analyzed samples ranged between 7.30 – 7.66 and are within the acceptable limit (6.5-8.5). Total hardness levels ranged from 8 to 35.3 mg/l and were well below the acceptable limit of 200 mg/l. The dissolved oxygen values ranged between 6.8-8.0 mg/l and were within the acceptable limit of 6mg/l.Chlorides level in surface water samples ranged from 4 -10 mg/l and were within the acceptable limit of 250 mg/l. The sulphates level ranged from 0.2 to 1.2 mg/l and were within the acceptable limit of 200 mg/l. The nitrate was not detected in an of samples. The concentration of various heavy metals was below the detectable limits, indicating the suitability of water for meeting domestic requirements. The BOD values ranged between 1.0 to 1.6mg/l and were within the CPCB criteria of less than 2mg/l for Class A water. The Total Coliform level were less than 50 MPN/100ml, the limits specified for Class A water under CPCB Water Quality Criteria for designated best use. The water is suitable for meeting drinking water requirements after conventional treatment and disinfection.

Table 3.20 : Surface Water Quality (Post monsoon 2017)

S. No.	Parameters	(SW1)	(SW2)	(SW3)	(SW4)	(SW5)	(SW6)	Method
1	pH Value	7.57	7.62	7.66	7.60	7.37	7.48	IS:3025(Pt-11) 1983 RA2017
2	Temperature ^{0}C	20.1	20.4	20.2	20.1	20.4	20.3	IS:3025(Pt-9)
3	Conductivity, µmhos/cm	59	52	69	72	110	98	IS:3025(Pt-14)
4	Total Suspended Solids mg/l	4	6	5	6	8	7	IS:3025 (Pt-17) :1984 RA 2006
5	Total Hardness as $CaCO_3$ mg/l	14	12	18	20	35.3	26.2	IS:3025(Pt-21)2009RA2014
6	Total Alkalinity mg/l	20	20	26	28	24	27	IS:3025(Pt-23) 1986RA2014
7	Chloride as Cl mg/l	6	5	6	7	6	10	IS:3025(Pt-32) 1988RA2014
8	Sulphates as SO_4 mg/l	0.4	0.3	0.6	0.8	0.9	0.7	IS:3025(Pt-24) 1986RA2014
9	Nitrite as N mg/l	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	IS:3025(Pt-34) 1988RA2014
10	Iron as Fe mg/l	0.08	0.06	0.10	0.12	0.16	0.14	APHA 23rd Ed, 3111
11	Calcium as Ca mg/l	4	3	5	7	12	9	IS:3025(Pt-40) 1991R2014
12	Magnesium as Mg mg/l	1	1.1	1.3	0.6	1.3	0.6	APHA 23rd Ed, 3500 Mg B
13	Sodium as Na mg/l	6	7	7	8	9	8	APHA 23rd Ed, 3500 Na (B)
14	Potassium as K mg/l	1	1	1	1	1.1	0.9	APHA 23rd Ed, 3500 K (B)
15	Phosphate PO_4 mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-31) 1988RA2014
16	Phenolic Compound mg/l	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	IS:3025(Pt-43) 1992RA2014
17	Silica as mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-35) 1988RA2014
18	Zinc as Zn mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
19	Cadmium as Cd mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
20	Copper as Cu mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
21	Lead as Pb mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111

22	Arsenic as As mg/l	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	APHA 23rd Ed, 3114
23	Mercury as Hg mg/l	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	APHA 23rd Ed, 3112
24	Hexavalent Chromium (as Cr^{+6}) mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
25	Total Chromium (as Cr) mg/l	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	APHA 23rd Ed, 3111
26	Oil & Grease mg/l	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	IS: 3025(Pt-39)1991R2014
27	Dissolved Oxygen as DO mg/l	7.8	7.6	8.0	7.8	7.3	6.9	IS: 3025(Pt-38) 1989R2014
28	Chemical Oxygen Demand as COD mg/l	8	6	5	4	6	5	IS: 3025(Pt-58) 2006R2012
29	Bio- Chemical Oxygen Demand as BOD (for 3 Days 27 ˚C) mg/l	1.6	1.4	1.2	1.0	1.4	1.3	IS: 3025(Pt-44) 1993R2014
30	Total Coliform MPN/100ml	15	18	20	23	34	32	IS:1622-2003 RA - 2009

Table 3.21 : Surface Water Quality (Pre-monsoon 2018)

S. No.	Parameters	(SW1)	(SW2)	(SW3)	(SW4)	(SW5)	(SW6)	Method
1	pH Value	7.52	7.57	7.60	7.55	7.34	7.44	IS:3025(Pt-11) 1983 RA2017
2	Temperature ^{0}C	19.8	19.5	19.7	19.4	20.1	19.8	IS:3025(Pt-9)
3	Conductivity, µmhos/cm	53	57	63	71	102	94	IS:3025(Pt-14)
4	Total Suspended Solids mg/l	3	4	4	3	6	5	IS:3025 (Pt-17) :1984 RA 2006
5	Total Hardness as $CaCO_3$ mg/l	12	12	18	18	29.5	28.3	IS:3025(Pt-21)2009RA2014
6	Total Alkalinity mg/l	18	20	22	26	20	23	IS:3025(Pt-23) 1986RA2014
7	Chloride as Cl mg/l	5	6	7	6	7	9	IS:3025(Pt-32) 1988RA2014
8	Sulphates as SO_4 mg/l	0.2	0.3	0.4	0.7	0.8	0.8	IS:3025(Pt-24) 1986RA2014
9	Nitrite as N , mg/l	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	IS:3025(Pt-34) 1988RA2014
10	Iron as Fe mg/l	0.06	0.07	0.08	0.10	0.15	0.14	APHA 23rd Ed, 3111

11	Calcium as Ca mg/l	3	4	6	5	10	10	IS:3025(Pt-40) 1991R2014
12	Magnesium as Mg mg/l	1.1	1.1	0.7	1.3	1.1	0.8	APHA 23rd Ed, 3500 Mg B
13	Sodium as Na mg/l	6	7	6	7	8	7	APHA 23rd Ed, 3500 Na (B)
14	Potassium as K mg/l	1	1	1	1	1	0.8	APHA 23rd Ed, 3500 K (B)
15	Phosphate PO_4 mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-31) 1988RA2014
16	Phenolic Compound mg/l	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	IS:3025(Pt-43) 1992RA2014
17	Silica as mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-35) 1988RA2014
18	Zinc as Zn mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
19	Cadmium as Cd mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
20	Copper as Cu mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
21	Lead as Pb mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
22	Arsenic as As mg/l	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	APHA 23rd Ed, 3114
23	Mercury as Hg mg/l	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	APHA 23rd Ed, 3112
24	Hexavalent Chromium (as Cr^{+6}) mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
25	Total Chromium (as Cr) mg/l	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	APHA 23rd Ed, 3111
26	Oil & Grease mg/l	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	IS: 3025(Pt-39)1991R2014
27	Dissolved Oxygen as DO mg/l	7.4	7.1	7.8	7.2	7.1	6.8	IS: 3025(Pt-38) 1989R2014
28	Chemical Oxygen Demand as COD mg/l	6	8	5	7	7	6	IS: 3025(Pt-58) 2006R2012
29	Bio- Chemical Oxygen Demand as BOD (for 3 Days 27 ˚C) mg/l	1.2	1.6	1.0	1.4	1.5	1.4	IS: 3025(Pt-44) 1993R2014
30	Total Coliform MPN/100ml	18	20	17	21	32	28	IS:1622-2003 RA - 2009

Table 3.22 : Surface Water Quality (Monsoon 2018)

S. No.	Parameters	(SW1)	(SW2)	(SW3)	(SW4)	(SW5)	(SW6)	Method
1	pH Value	7.52	7.59	7.66	7.60	7.30	7.42	IS:3025(Pt-11) 1983 RA2017
2	Temperature ^0C	19.8	20.0	19.6	19.8	19.8	19.6	IS:3025(Pt-9)

3	Conductivity, μmhos/cm	52	47	61	67	99	92	IS:3025(Pt-14)
4	Total Suspended Solids mg/l	13	16	12	10	17	15	IS:3025 (Pt-17) :1984 RA 2006
5	Total Hardness as $CaCO_3$ mg/l	10	8	14	16	31.2	26	IS:3025(Pt-21)2009RA2014
6	Total Alkalinity mg/l	16	14	22	24	22	21	IS:3025(Pt-23) 1986RA2014
7	Chloride as Cl mg/l	5	4	5	6	8	8	IS:3025(Pt-32) 1988RA2014
8	Sulphates as SO_4 mg/l	0.8	0.6	1.0	1.2	0.9	0.8	IS:3025(Pt-24) 1986RA2014
9	Nitrite as N mg/l	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	ND[DL<0.1]	IS:3025(Pt-34) 1988RA2014
10	Iron as Fe mg/l	0.06	0.06	0.08	0.10	0.16	0.15	APHA 23rd Ed, 3111
11	Calcium as Ca mg/l	2	2	5	5	11	9.1	IS:3025(Pt-40) 1991R2014
12	Magnesium as Mg mg/l	0.7	0.7	0.4	0.9	0.9	0.8	APHA 23rd Ed, 3500 Mg B
13	Sodium as Na mg/l	6	5	7	8	9	7	APHA 23rd Ed, 3500 Na (B)
14	Potassium as K mg/l	1	1	1	1	0.9	0.8	APHA 23rd Ed, 3500 K (B)
15	Phosphate PO_4 mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-31) 1988RA2014
16	Phenolic Compound mg/l	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	IS:3025(Pt-43) 1992RA2014
17	Silica as mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-35) 1988RA2014
18	Zinc as Zn mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
19	Cadmium as Cd mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
20	Copper as Cu mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
21	Lead as Pb mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
22	Arsenic as As mg/l	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	APHA 23rd Ed, 3114
23	Mercury as Hg mg/l	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	APHA 23rd Ed, 3112

24	Hexavalent Chromium (as Cr^{+6}) mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111
25	Total Chromium (as Cr) mg/l	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	APHA 23rd Ed, 3111
26	Oil & Grease mg/l	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	IS: 3025(Pt-39)1991R2014
27	Dissolved Oxygen as DO mg/l	7.4	7.2	7.0	7.4	7.4	7.0	IS: 3025(Pt-38) 1989R2014
28	Chemical Oxygen Demand as COD mg/l	7	5	5	6	6.4	6.1	IS: 3025(Pt-58) 2006R2012
29	Bio- Chemical Oxygen Demand as BOD (for 3 Days 27 ˚C) mg/l	1.2	1.0	1.0	1.4	1.4	1.2	IS: 3025(Pt-44) 1993R2014
30	Total Coliform MPN/100ml	22	25	24	29	34	30	IS:1622-2003 RA - 2009

3.7.4. *Interpretation of Ground Water Quality*

Table 3.23 through **Table 3.25** shows the physico - chemical characteristics of ground water samples collected from the selected villages during post-monsoon (2017), pre-monsoon (2018) and monsoon 2018, as compared with the standard (IS 10500: 2012).

The analysis results indicate that the pH ranged between 6.98 to 7.26, which are well within the specified standard of 6.5 to 8.5 limit. Total hardness was recorded to range from 52.8 to 84.8 mg/l, which is within the desirable limit 200 mg/l at all locations. The Total EC concentration recorded ranged between 139-193 μS/cm

Chlorides at all the locations were within the desirable limits (250 mg/l) as it ranged between 10 – 16 mg/l. Sulphates at all the locations were within the desirable limits (200 mg/l) as it ranged between 3.2 – 4.4 mg/l. Nitrates at all the locations were within the desirable limits (45 mg/l) as it ranged between 0.25 – 0.38 mg/l. Iron at all the locations were within the desirable limits (1 mg/l) as it ranged between 0.16 – 0.28 mg/l. Bacteriological studies reveal that no coliform bacterial are present in the samples. The heavy metal contents were observed to be in below detectable limits. All physical and general parameters were observed within the desirable limit as per IS10500:2012 (Second Revision). Thus, it is recommended that water be filtered and disinfected prior to be given to villages for meeting their drinking water requirements.

Table 3.23 : Ground Water Quality During Post-Monsoon, 2017

S. No.	Parameters	(GW1)	(GW2)	(GW3)	(GW4)	(GW5)	(GW6)	Method	Max Requirement as per (IS-10500-2012) Limit	
									Desirable	Permissible
1	pH Value	7.12	7.05	6.98	7.20	7.15	7.06	IS:3025(Pt-11) 1983 RA2017	6.5-8.5	No Relaxation
2	Temperature ^{0}C	24.8	24.5	25.0	24.2	24.0	24.3	IS:3025(Pt-9)	-	-
3	Conductivity, µmhos/cm	159	143	179	182	152	148	IS:3025(Pt-14)	-	-
4	Total Suspended Solids mg/l	<2	<2	<2	<2	<2	<2	IS:3025 (Pt-17) :1984 RA 2006	-	-
5	Total Hardness as $CaCO_3$ mg/l	56	54	72	81.3	57.8	57	IS:3025(Pt-21)2009RA2014	200	600
6	Total Alkalinity mg/l	50	48	60	58	51	50	IS:3025(Pt-23) 1986RA2014	200	600
7	Chloride as Cl mg/l	14	12	16	16	14	12	IS:3025(Pt-32)	250	1000
8	Sulphates as SO_4 mg/l	3.8	3.2	4.2	4.4	3.6	3.6	IS:3025(Pt-24) 1986RA2014	200	400
9	Nitrite as N $_{mg}$/l	0.32	0.26	0.38	0.28	0.30	0.34	IS:3025(Pt-34) 1988RA2014	45	No Relaxation
10	Iron as Fe mg/l	0.22	0.20	0.28	0.26	0.24	0.26	APHA 23rd Ed, 3111	0.3	No Relaxation
11	Calcium as Ca mg/l	19	18	26.8	29.1	20	21	IS:3025(Pt-40) 1991R2014	75	200
12	Magnesium as Mg mg/l	1.6	2.2	1.2	2.1	1.8	1.1	APHA 23rd Ed, 3500 Mg B	30	100
13	Sodium as Na mg/l	7	5	6	7	6	5	APHA 23rd Ed, 3500 Na (B)	-	-
14	Potassium as K mg/l	1	1	1	1.3	0.9	1	APHA 23rd Ed, 3500 K (B)	-	-
15	Phosphate PO_4 mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-31) 1988RA2014	-	-
16	Phenolic Compound mg/l	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	IS:3025(Pt-43) 1992RA2014	0.001	0.002
17	Silica mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-35) 1988RA2014	-	-
18	Zinc as Zn mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	5	15

19	Cadmium as Cd mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.003	No Relaxation
20	Copper as Cu mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.05	1.5
21	Lead as Pb mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.01	No Relaxation
22	Arsenic as As mg/l	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	APHA 23rd Ed, 3114	0.01	0.05
23	Mercury as Hg mg/l	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	APHA 23rd Ed, 3112	0.001	No Relaxation
24	Hexavalent Chromium (as Cr^{+6}) mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.05	No Relaxation
25	Total Chromium (as Cr) mg/l	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	APHA 23rd Ed, 3111	0.05	No Relaxation
26	Oil & Grease mg/l	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	IS: 3025(Pt-39)1991R2014	-	-
27	Total Coliform	ND <2	ND <2	ND <2	ND <2	ND <2	ND <2	IS:1622-2003 RA -	Shall not be detectable	

Table 3.24 : Ground Water Quality During Pre-Monsoon, 2018

S. No.	Parameters	(GW1)	(GW2)	(GW3)	(GW4)	(GW5)	(GW6)	Method	Max Requirement as per (IS-10500-2012) Limit	
									Desirable	Permissible
1	pH Value	7.14	7.12	7.04	7.26	7.20	7.12	IS:3025(Pt-11) 1983 RA2017	6.5-8.5	No Relaxation
2	Temperature ^0C	20.5	20.3	20.1	21.0	20.8	20.7	IS:3025(Pt-9)	-	-
3	Conductivity, µmhos/cm	145	139	168	193	162	150	IS:3025(Pt-14)	-	-
4	Total Suspended Solids mg/l	<2	<2	<2	<2	<2	<2	IS:3025 (Pt-17) :1984 RA 2006	-	-
5	Total Hardness as $CaCO_3$ mg/l	54	52.8	62.1	84	58.6	55.7	IS:3025(Pt-21)2009RA2014	200	600
6	Total Alkalinity mg/l	48	46	56	59	54	52	IS:3025(Pt-23) 1986RA2014	200	600
7	Chloride as Cl mg/l	12	13	15	16	15	14	IS:3025(Pt-32)	250	1000
8	Sulphates as SO_4 mg/l	3.6	3.4	3.7	4.2	3.7	3.4	IS:3025(Pt-24) 1986RA2014	200	400

9	Nitrite as N $_{mg}$/l	0.32	0.29	0.34	0.25	0.29	0.32	IS:3025(Pt-34) 1988RA2014	45	No Relaxation
10	Iron as Fe mg/l	0.20	0.22	0.26	0.28	0.25	0.27	APHA 23rd Ed, 3111	0.3	No Relaxation
11	Calcium as Ca mg/l	18	17.2	22.4	30	22	20	IS:3025(Pt-40) 1991R2014	75	200
12	Magnesium as Mg mg/l	2.2	2.4	1.5	2.2	1.6	1.4	APHA 23rd Ed, 3500 Mg B	30	100
13	Sodium as Na mg/l	7	8	10	8	7	6	APHA 23rd Ed, 3500 Na (B)	-	-
14	Potassium as K mg/l	1	1	1	1.1	0.9	0.9	APHA 23rd Ed, 3500 K (B)	-	-
15	Phosphate PO_4 mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-31) 1988RA2014	-	-
16	Phenolic Compound mg/l	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	IS:3025(Pt-43) 1992RA2014	0.001	0.002
17	Silica mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-35) 1988RA2014	-	-
18	Zinc as Zn mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	5	15
19	Cadmium as Cd mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.003	No Relaxation
20	Copper as Cu mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.05	1.5
21	Lead as Pb mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.01	No Relaxation
22	Arsenic as As mg/l	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	APHA 23rd Ed, 3114	0.01	0.05
23	Mercury as Hg mg/l	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	APHA 23rd Ed, 3112	0.001	No Relaxation
24	Hexavalent Chromium (as Cr^{+6}) mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.05	No Relaxation
25	Total Chromium (as Cr) mg/l	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	APHA 23rd Ed, 3111	0.05	No Relaxation
26	Oil & Grease mg/l	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	IS: 3025(Pt-39)1991R2014	-	-

27	Total Coliform	BDL	BDL	BDL	ND <2	ND <2	ND <2	IS:1622-2003 RA -	Shall not be detectable

Table 3.25 : Ground Water Quality During Monsoon, 2018

S. No.	Parameters	(GW1)	(GW2)	(GW3)	(GW4)	(GW5)	(GW6)	Method	Max Requirement as per (IS-10500-2012) Limit	
									Desirable	Permissible
1	pH Value	7.10	7.06	7.06	7.18	7.22	7.16	IS:3025(Pt-11) 1983 RA2017	6.5-8.5	No Relaxation
2	Temperature ^{0}C	21.4	21.2	21.3	21.1	21.4	21.2	IS:3025(Pt-9)	-	-
3	Conductivity, µmhos/cm	150	142	162	188	156	154	IS:3025(Pt-14)	-	-
4	Total Suspended Solids mg/l	<2	<2	<2	<2	<2	<2	IS:3025 (Pt-17) :1984 RA 2006	-	-
5	Total Hardness as $CaCO_3$ mg/l	54.9	53.2	60.9	84.8	57.6	57	IS:3025(Pt-21)2009RA2014	200	600
6	Total Alkalinity mg/l	50	48	54	60	52	54	IS:3025(Pt-23) 1986RA2014	200	600
7	Chloride as Cl mg/l	10	12	14	14	14	12	IS:3025(Pt-32)	250	1000
8	Sulphates as SO_4 mg/l	3.4	3.3	3.7	3.8	3.8	3.5	IS:3025(Pt-24) 1986RA2014	200	400
9	Nitrite as N $_{mg}$/l	0.33	0.30	0.32	0.26	0.28	0.33	IS:3025(Pt-34) 1988RA2014	45	No Relaxation
10	Iron as Fe mg/l	0.22	0.21	0.26	0.29	0.24	0.26	APHA 23rd Ed, 3111	0.3	No Relaxation
11	Calcium as Ca mg/l	19	18	22.1	31	21.1	21	IS:3025(Pt-40) 1991R2014	75	200
12	Magnesium as Mg mg/l	1.8	2.0	1.4	2.1	1.2	1.1	APHA 23rd Ed, 3500 Mg B	30	100
13	Sodium as Na mg/l	7	7	9	8	7	5	APHA 23rd Ed, 3500 Na (B)	-	-
14	Potassium as K mg/l	1	1	1	1.1	0.9	1	APHA 23rd Ed, 3500 K (B)	-	-
15	Phosphate PO_4 mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-31) 1988RA2014	-	-
16	Phenolic Compound mg/l	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	ND (DL<0.001)	IS:3025(Pt-43) 1992RA2014	0.001	0.002

17	Silica mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	IS:3025(Pt-35) 1988RA2014	-	-
18	Zinc as Zn mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	5	15
19	Cadmium as Cd mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.003	No Relaxation
20	Copper as Cu mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.05	1.5
21	Lead as Pb mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.01	No Relaxation
22	Arsenic as As mg/l	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	BDL [DL<0.025]	APHA 23rd Ed, 3114	0.01	0.05
23	Mercury as Hg mg/l	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	BDL [DL<0.001]	APHA 23rd Ed, 3112	0.001	No Relaxation
24	Hexavalent Chromium (as Cr^{+6}) mg/l	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	BDL [DL<0.01]	APHA 23rd Ed, 3111	0.05	No Relaxation
25	Total Chromium (as Cr) mg/l	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	BDL [DL<0.05]	APHA 23rd Ed, 3111	0.05	No Relaxation
26	Oil & Grease mg/l	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	ND [DL<0.2]	IS: 3025(Pt-39)1991R2014	-	-
27	Total Coliform	BDL	BDL	BDL	ND <2	ND <2	ND <2	IS:1622-2003 RA -	Shall not be detectable	

3.8. Water Environment and Hydrology

In order to conduct EIA studies of Umngot HEP baseline data pertaining to water environment of the project within the study area has been collected. The baseline data was studied for evaluating the basin characteristics, drainage pattern, hydrology, ground water regime and downstream water use. The existing physico-chemical and bacteriological parameters were also analyzed for the river and its tributaries at different sites.

3.8.1. *Basin Characteristics of Drainage Basin*

Umngot hydroelectric project is located in the southern face of the state, which is marked by deep gorges, spurs and abrupt slopes. The catchment area is situated in the mid-control upland, specifically called the Shillong plateau. The entire plateau is mountainous but the eastern and western extensions are relatively lower. The natural vegetation ranges from coniferous trees in the upper region to temperate forests and subtropical forests in the middle and lower hills. Stony waste lands and grass lands occupy most of the drainage basin, the drainage in the Umngot river basin is of Trellis pattern where long tributaries flow down the dip slopes and small tributaries flow down the scarp slopes. These flows towards south in a stretch of about 20km between the proposed dam site and the power house site is encountered by number of falls and rapids to drop from an elevation of 940m to 210m.

3.8.2. *Drainage Pattern*

Drainage is the single most entity, which defines the network antecedent river. The drainage pattern of the study area exhibits Trellis pattern as shown in **Figure 3.18**. Umngot is one of the major southwardly flowing rivers of Meghalaya State with origination at an altitude of 1840M near the junction of Nongkrem road and NH-44 at a distance of 11km from Shillong. It is flowing along the borders of Jaintia hills district of Meghalaya. The drainage is of Trellis pattern where long tributaries flow down the dip slope and small tributaries flow down the escarp slopes. The river length from the place of origin up to dam site is about 51 km with a slope of 1:55. The river flows towards east for a distance of about 22 km through dense shrubs and jungle with gentle gradient till it reaches an elevation 1130 m. From this point river takes a sharp turn towards South along the border of East Khasi Hills and Jaintia hills districts and flows for a further distance of about 5 km through rapids where it is joined by one of the major tributaries. It then takes a mild turn towards east for a distance of about 4 km to join another tributary Umtang nallah from the west at an elevation of 1070 m. From this point the river flows crisscrossing along the due South for a distance of 20 km before reaching near village Jarain, and then it takes a sharp turn towards east with rapids and falls offering good scope for harnessing hydro power potential from the river. This short stretch of about 20 km between dam site and the proposed power house site is encountered by a number of falls and rapids to drop from an elevation of 940m to 210m. The drop between the proposed dam site and power house is about 730 m

3.8.2.1 Gross Trellis

The trellis drainage pattern is normally developed in the hillside slopes and usually aligned along the strike of the rock formation. The softer rocks like phyletic slates exhibit such drainage. The trellis drainage pattern is well developed in the terraces and lower most reaches of the valley. The majority of the area possesses a dendritic to sub-dendritic drainage containing irregular branching of the smaller tributaries. The closeness of these small branches is depending on the permeability of the

underlying rocks and the amount and nature of precipitation. It is the most common drainage pattern of hillside slopes of the study area.

3.8.3. *Hydro- meteorology*

For a hydro-electric project the important hydrological parameters which have a bearing on the project and its design are the water availability, occurrence of storms in and around the basin, the flood estimation and the sediment inflow rate entering into the reservoir. Detailed Hydrological studies have already been conducted in respect of 10-daily water availability series, probable maximum design flood and silt rate at the diversion site.

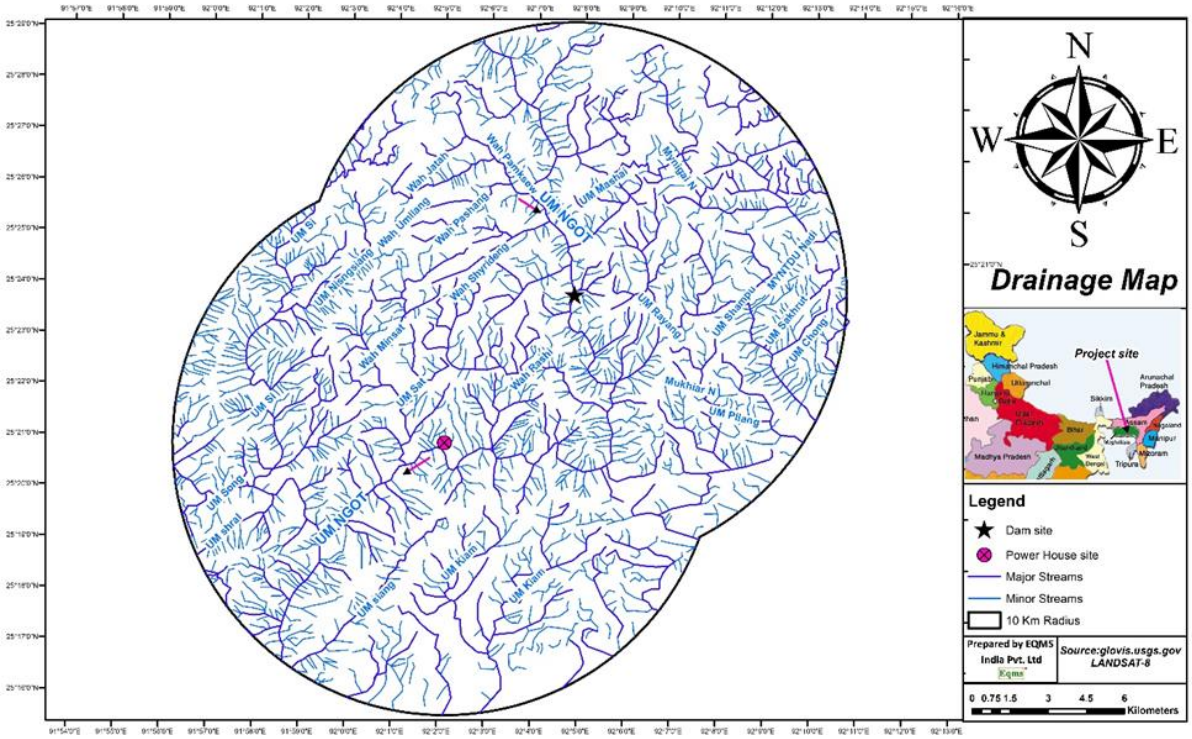


Figure 3.18 Drainage Pattern of Study area

3.8.4. *Data Availability*

Monthly rainfall data is available for 3 stations namely Sohmynting, Dohkharang & Jatah from September 1991 onwards, for two stations namely Umngot and Smit from 1994 and for 3 stations namely Pommura, Puriang & Nongjrong from March 2002 onwards. The year wise rainfall data at these sites is given in **Table 3.26.** Daily Discharge data of Umngot G & D site is available from June 1989 to May 2006.

Table 3.26 : Yearly Rainfall Data at different Stations

Year	Cherra	Jowai	Shillong	Umngot
1977-78	8936.90		4248.80	
1978-79	7846.00		1394.10	
1979-80	12105.20		2050.20	
1980-81	7893.50		2486.30	
1981-82	10566.70		1869.90	
1982-83	9882.70		2185.30	
1983-84	13739.80	2847.40	2310.50	
1984-85	15503.80	6491.20	2534.60	

1985-86	10021.30	5993.70	1892.20	
1986-87	8297.30	6474.50	2003.70	
1987-88	15423.70	9314.10	4422.40	
1988-89	17117.61	6371.45	3409.80	
1989-90	13586.60	5494.45	6518.00	
1990-91	11771.00	4851.35	1559.90	
1991-92	12304.60	6480.40	2596.90	3550.79
1992-93	9022.22	4739.60	2365.50	3759.35
1993-94	10238.90	5925.40	4566.50	4686.10
1994-95		3641.30	1123.10	3566.39
1995-96		7819.46		6022.38
1996-97		3467.60		5099.96
1997-98		4490.50		4493.58
1998-99		3934.30		5334.14
1999-00		3943.80		4733.85
2000-01		3724.30		4383.77
2001-02		3788.60		4470.96
2002-03		3384.20		4172.91
2003-04		4003.90		3776.15
2004-05		5484.40		4700.05
2005-06		3402.70		3483.91

3.8.5. *Water Availability*

The catchment area of Umngot river at dam site is 304 km2. Based on the water availability studies carried out by Central Water Commission, an inflow series for the period 1989 to 2005 has been developed. The flow series has been rearranged in the cycle of hydrological years from June to May (1989-90 to 2004-2005) for the purpose of project planning. The water availability series for Dam site of Umngot HEP adopted for project planning is given in **Table 3.27** and **Table 3.28.**

Table 3.27 : Ten Daily Flow series at Dam Site (Cumec)

YEAR/MONTH	1989-90	1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006
JUNE	40.38	77.47	12.30	2.59	63.45	61.37	21.49	11.85	5.17	19.94	23.90	86.21	30.98	10.76	21.11	12.46	6.06
	65.02	18.97	100.13	45.51	144.60	94.37	402.78	6.42	81.84	48.76	30.33	118.25	51.79	250.40	46.50	20.17	13.33
	32.58	22.23	25.42	104.02	56.61	47.11	59.51	104.04	71.24	41.50	84.04	136.00	33.46	104.43	214.87	70.50	79.18
JULY	155.52	50.49	17.05	76.58	125.16	33.01	142.53	105.82	132.41	57.65	126.51	22.81	38.14	125.64	81.02	328.08	27.23
	36.10	42.35	22.16	85.78	44.80	10.67	53.47	186.57	146.73	165.05	135.42	32.46	28.88	43.69	108.64	328.76	81.28
	74.89	62.76	9.24	32.01	40.51	33.56	31.54	19.85	17.19	56.68	53.13	28.40	144.69	98.25	41.70	39.31	26.32
AUGUST	23.60	16.89	48.47	48.41	102.43	19.43	32.83	26.09	22.15	74.90	35.53	178.06	36.55	22.28	26.57	22.39	50.16
	27.65	11.19	7.82	55.54	32.52	71.28	156.31	30.07	57.17	138.66	43.12	30.54	28.10	53.19	44.17	19.41	29.84
	7.93	23.46	6.43	87.80	52.88	25.70	26.42	29.44	32.61	73.53	73.02	28.20	65.69	29.24	22.06	37.85	171.62
SEPTEMBER	19.74	14.93	98.25	37.57	36.08	10.95	22.29	18.82	35.89	78.09	30.90	44.35	45.36	12.09	26.56	46.38	17.58
	24.56	34.93	8.50	33.96	18.48	22.39	26.79	13.22	38.79	15.67	17.36	36.75	55.91	11.17	15.71	30.65	9.71
	53.77	37.33	27.58	66.78	49.58	10.87	83.65	15.22	34.68	12.74	13.91	20.09	37.06	55.68	11.12	30.52	11.47
OCTOBER	25.28	23.18	3.04	24.33	8.91	49.26	17.51	45.57	15.61	9.35	24.43	15.82	50.86	17.07	48.88	261.28	25.25
	35.58	33.99	33.86	20.93	7.16	17.17	12.76	10.73	9.88	12.89	55.89	21.18	18.32	10.50	22.21	24.81	9.12
	7.79	8.55	1.51	9.45	5.98	7.43	8.69	56.58	7.33	28.65	23.62	33.14	11.48	7.04	12.23	10.48	35.55
NOVEMBER	10.08	8.14	7.10	6.45	7.92	5.70	22.85	19.91	5.70	8.61	10.88	15.32	9.01	5.82	9.43	6.99	8.90
	6.03	5.80	5.02	5.18	6.10	4.43	20.59	9.46	4.67	6.68	7.28	8.49	6.72	25.15	6.50	5.60	6.57
	4.96	4.57	4.15	4.11	4.26	3.73	8.41	7.01	3.97	18.74	5.73	6.09	5.73	8.09	5.67	4.81	5.07

DECEMBER	4.16	3.66	3.40	4.16	4.10	3.14	5.94	5.14	3.54	7.85	5.00	5.20	4.91	6.10	4.86	3.90	4.23
	3.47	3.09	2.74	3.21	3.07	2.64	4.80	4.39	3.34	5.76	4.49	4.78	4.32	5.48	4.52	3.37	3.66
	2.72	2.60	1.98	2.75	2.62	2.37	4.40	3.90	2.70	4.87	4.09	4.22	3.89	4.49	4.18	3.05	3.32
JANUARY	2.11	1.83	2.76	6.18	2.33	2.28	3.95	3.28	2.60	4.30	3.67	3.80	3.60	3.99	3.73	2.65	3.01
	1.80	2.56	2.28	3.41	2.35	2.34	3.37	3.01	2.38	3.93	3.44	3.57	3.67	3.65	3.51	2.39	2.73
	1.58	2.05	1.79	2.63	2.15	2.03	2.83	2.87	2.38	3.36	3.38	3.40	3.75	3.23	3.21	2.50	2.56
FEBUARY	1.44	1.73	2.64	2.36	2.92	1.75	2.45	2.56	2.08	2.99	3.52	3.01	3.08	3.32	2.92	2.16	2.22
	1.48	1.44	2.50	3.95	2.18	1.94	2.20	2.52	1.89	2.68	3.07	2.61	3.00	2.80	2.77	1.96	2.37
	4.89	1.21	2.25	2.53	2.24	2.06	3.59	2.66	1.72	2.48	2.64	3.50	3.48	2.50	2.63	1.81	2.11
MARCH	4.69	1.12	1.85	2.64	11.69	1.46	2.37	2.43	2.18	17.90	2.54	2.98	2.60	2.39	2.29	1.70	1.73
	3.29	1.44	1.69	2.09	5.59	1.18	2.58	2.20	1.82	1.91	3.14	2.69	2.29	2.89	3.01	2.15	1.95
	2.91	1.35	1.69	3.94	7.27	1.27	2.20	2.96	4.06	1.96	2.06	2.64	3.17	4.22	4.47	9.18	1.33
APRIL	34.76	1.31	1.49	1.82	4.87	1.05	1.44	6.14	3.95	2.06	2.08	3.04	5.59	3.08	4.11	5.30	2.25
	21.44	0.90	1.54	4.55	2.25	1.41	4.49	5.01	4.77	3.62	1.89	3.88	6.38	2.73	29.93	3.70	2.01
	51.10	0.95	2.63	8.70	2.25	1.41	2.32	7.53	7.43	2.23	2.37	6.41	15.15	3.27	8.52	11.27	8.36
MAY	8.95	32.93	4.39	23.76	4.09	2.13	9.64	7.14	3.67	22.78	4.13	5.64	12.46	3.14	4.01	103.84	6.44
	33.97	22.81	31.51	26.80	4.27	50.96	8.02	4.56	2.80	8.39	6.01	5.73	31.76	3.04	91.89	50.65	4.53
	37.93	15.40	8.11	10.44	49.72	6.44	13.02	7.52	32.55	65.70	63.91	10.12	17.74	4.07	10.86	156.24	111.18
Total	**874.16**	**595.63**	**515.28**	**862.91**	**923.39**	**616.29**	**1230.04**	**792.48**	**808.91**	**1032.84**	**916.43**	**939.37**	**829.58**	**954.87**	**956.39**	**1668.25**	**780.23**

Table 3.28 : Monthly Flow series at Dam Site (MCM)

S N.	YEAR	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	Annual
1	1989-90	114.73	249.11	50.51	92.04	60.66	18.16	9.11	4.87	6.06	9.60	99.59	69.32	**783.75**
2	1990-91	103.57	135.85	45.49	73.78	57.46	16.03	8.33	5.77	3.59	3.49	3.12	62.12	**518.60**
3	1991-92	119.10	42.66	54.74	116.06	33.31	14.05	7.19	6.06	6.19	4.67	4.89	38.73	**447.66**
4	1992-93	131.43	170.70	173.26	119.51	48.08	13.60	8.98	10.78	7.20	7.83	13.02	53.61	**757.99**
5	1993-94	228.66	185.35	166.85	89.98	19.57	15.79	8.65	6.09	5.95	21.84	8.09	54.47	**811.31**
6	1994-95	175.27	69.64	102.80	38.20	64.46	11.97	7.25	5.92	4.60	3.49	3.34	52.00	**538.92**
7	1995-96	275.99	199.33	188.54	114.67	34.41	44.80	13.46	9.01	6.81	6.37	7.13	27.63	**928.15**
8	1996-97	105.68	271.49	76.51	40.82	102.90	31.43	11.95	8.16	6.22	6.81	16.14	17.26	**695.36**
9	1997-98	136.73	257.52	99.53	94.49	28.75	12.39	8.51	6.57	4.61	7.31	13.96	36.53	**706.89**
10	1998-99	95.21	246.28	254.40	92.01	46.44	29.40	16.55	10.30	6.61	5.40	6.84	89.36	**898.80**
11	1999-00	119.47	276.81	137.35	53.72	91.84	20.64	12.09	9.35	7.75	6.86	5.48	96.71	**838.07**
12	2000-01	294.16	74.75	207.04	87.42	63.47	25.83	12.64	9.60	7.27	7.41	11.16	19.44	**820.18**
13	2001-02	100.43	195.42	118.29	119.52	70.68	18.54	11.57	9.85	7.66	7.23	22.84	55.07	**737.10**
14	2002-03	315.86	239.68	93.00	68.20	30.43	33.75	14.27	9.67	7.02	8.56	7.81	9.21	**837.46**
15	2003-04	244.06	203.50	82.09	46.13	73.05	18.66	12.08	9.31	6.96	8.83	36.77	93.01	**834.46**
16	2004-05	39.10	353.75	72.09	92.92	109.68	15.03	9.18	6.73	4.81	12.05	17.51	26.85	**809.71**

3.8.6. *Determination of 90 %, 75% and 50 % Dependable Flow for Power Study*

The annual yield data observed has been arranged in descending order to arrive at 90% and 50% dependable year on the basis of Weibull's formulae. The computation of dependable year is shown in **Table 3.29.**

Table 3.29 : Computation of 90% and 50% Dependable Year

Hydrological Year	Annual Yield (MCM)	Discharge in descending order	Rank	Dependability
1989-90	783.75	928.15	1	5.88
1990-91	518.6	898.8	2	11.76
1991-92	447.66	838.07	3	17.65
1992-93	757.99	837.46	4	23.53
1993-94	811.31	834.46	5	29.41
1994-95	538.92	820.18	6	35.29
1995-96	928.15	811.31	7	41.18
1996-97	695.36	809.71	8	47.06
1997-98	706.89	783.75	9	52.94
1998-99	898.8	757.99	10	58.82
1999-2000	838.07	737.1	11	64.71
2000-01	820.18	706.89	12	70.59
2001-02	737.1	695.36	13	76.47
2002-03	837.46	538.92	14	82.35
2003-04	834.46	518.6	15	88.24
2004-05	809.71	447.66	16	94.12

On the basis of the above table, it is seen that the year 1990-91 would constitute 90% dependable year, 1989-90 would constitute 50% dependable year.

- Yield at 90% dependability Year (1989-90): 469.64MCM
- Yield at 50% dependability Year (1990-91) :796.73 MCM

3.8.7. *Dependable Flow (50% and 90%)*

The details of 10-daily flow in 50% and 90% dependable year are given in **Table 3.30**. The 10-daily flow pattern in 50% and 90% dependable year at Umngot HEP is shown in **Figure 4.2**.

Table 3.30 : 10-daily Flow in 50% and 90% dependable year (cumec)

Month	Period	50% Dep. Yr. (1989-90)	90% Dep. Yr. (1990-91)
Jun	I	40.38	77.47
	II	65.02	18.97
	III	32.58	22.23
Jul	I	155.52	50.49
	II	36.10	42.35
	III	74.89	62.76

Aug	I	23.60	16.89
	II	27.65	11.19
	III	7.93	23.46
Sep	I	19.74	14.93
	II	24.56	34.93
	III	53.77	37.33
Oct	I	25.28	23.18
	II	35.58	33.99
	III	7.79	8.55
Nov	I	10.08	8.14
	II	6.03	5.80
	III	4.96	4.57
Dec	I	4.16	3.66
	II	3.47	3.09
	III	2.72	2.60
Jan	I	2.11	1.83
	II	1.80	2.56
	III	1.58	2.05
Feb	I	1.44	1.73
	II	1.48	1.44
	III	4.89	1.21
Mar	I	4.69	1.12
	II	3.29	1.44
	III	2.91	1.35
Apr	I	34.76	1.31
	II	21.44	0.90
	III	51.10	0.95
May	I	8.95	32.93
	II	33.97	22.81
	III	37.93	15.40

3.8.8. *Flow Duration Curve*

Based on the 10 daily water availability series adopted for dam site (**Table 3.23), the** ten daily flow pattern is furnished in **Figure 3.19** and curve for the approved series has been presented in **Figure. 3.20.** It is evident from the graph that 90% and 50% discharges are computed as 32.92 cumec, 47.57 cumec and 88.18 cumec respectively.

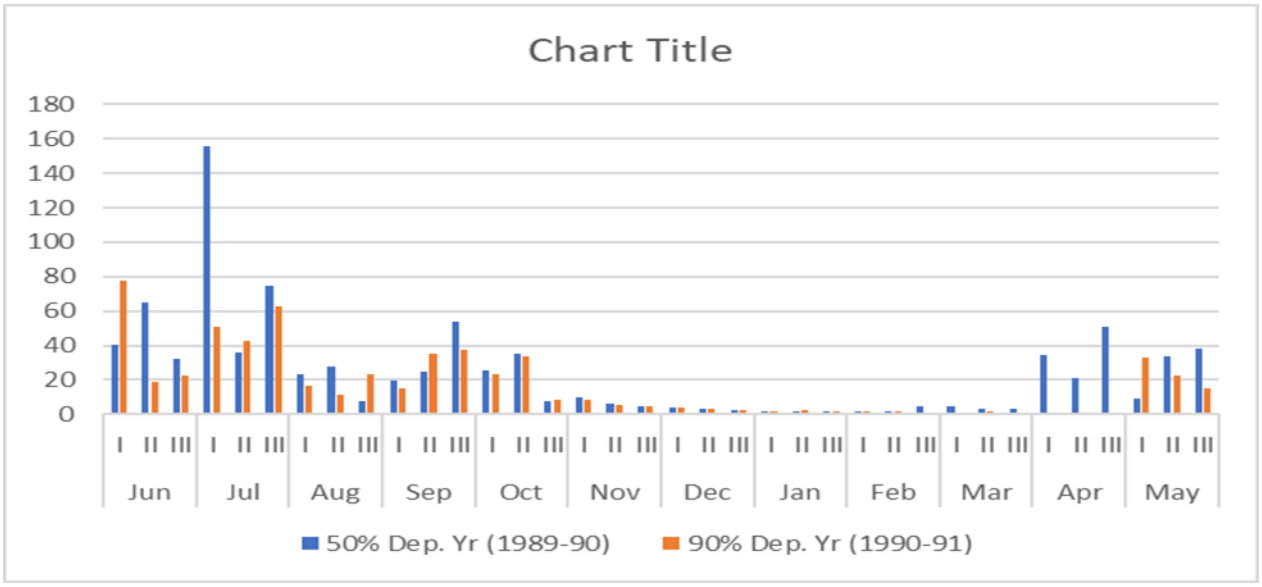


Figure 3.19 : Ten Daily Flow Pattern

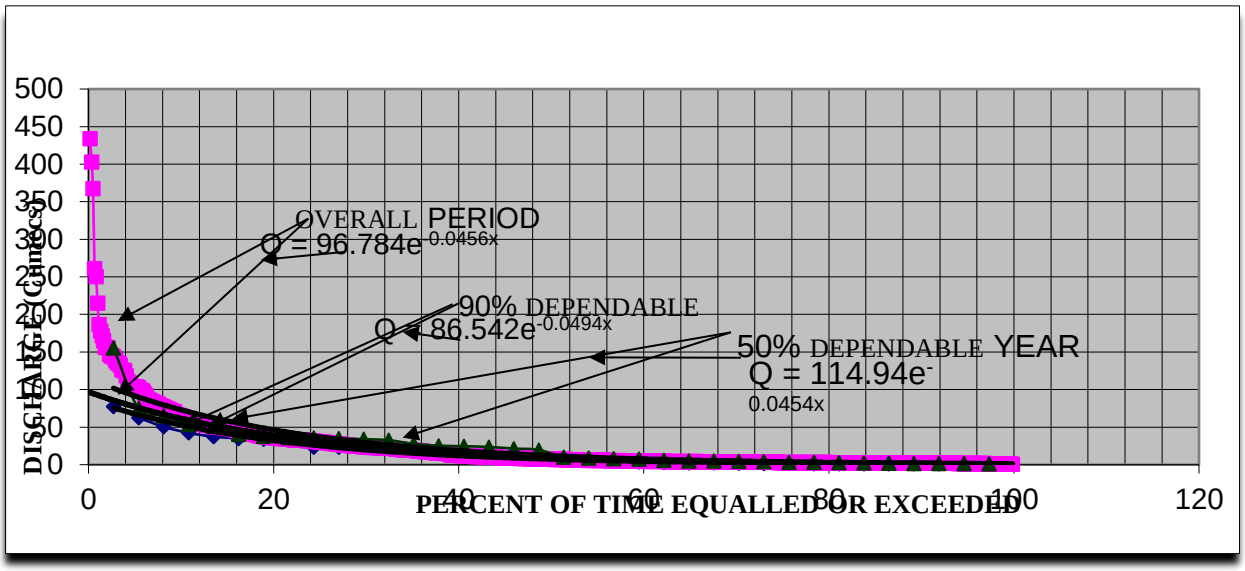


Figure 3.20 : Flow Duration curve at Dam Site

3.8.9. ***Design Flood***

The design flood for the project is adopted as per the criteria laid down in IS 11223-1985. As per the IS code, dam comes under the category of 'Larger Dam' because its height is more than 30m and gross storage (71.316 MCM) is more than 60 MCM. Therefore, its design flood would be Probable Maximum Flood (PMF). The peak value of flood hydrograph is 9760 cumec, which is adopted as the design flood for this project, which is also used to design the spillway for the safety of the dam. The additional catchment area from the proposed Dam site to the proposed Power house site is about 60.00 Skim. and the flood from its own catchment is worked out proportionately to about 1770.00 Cumecs and from where the total Design flood at the Powerhouse site is estimated at 11530.00 Cumecs.

3.8.10. ***Diversion Flood***

The diversion flood estimated for the working period between November to April, without causing any interruption to the works in the project, has been calculated by the Frequency Analysis using the

Gumbel Distribution for 25 years return period. The data considered for the analysis are the maximum discharges during the November-April season for the period under observation from 1989 to 2006. The maximum flood during this period is 392.44 Cumecs which occurred on the 9th April, 1990. This flood is an extreme event for the period under consideration since the most of the maximum flows which have been observed ranges between 10 to 90 Cumecs and has therefore not been considered in Flood Analysis by the Gumbel Distribution Method. The diversion flood as worked out by this method (Table 7.17) using the data of the other 17 years is 392 Cumecs and is considered appropriate to be adopted in the design of the diversion tunnel.

3.8.11. *Water Use*

Umngot HEP is conceived as storage scheme to harness water of Umngot River for non-consumptive of power generation by diverting maximum 33.2 cumec of water from the pond to pass through 3.40m diameter low pressure tunnel 5.646 km long for utilizing 808.60 m gross head of water for generating 708.98 GWH power at 90% dependability.

3.8.12. *Upstream Water Use*

On the upstream of the proposed Umngot HEP in basin, at present no HEP is existent. The hydro-electric schemes are based on non-consumptive use of water. Besides these there is neither any industry nor any lift/flow irrigation or water supply scheme utilizing the direct flow of river in the study area. All flow irrigation schemes (FIS) and water supply schemes on the upstream of the project take-off from the local nalas and spring respectively and thus are not dependent upon the discharge of Umngot river. In the study area, irrigation canal / gules off-take from local nalas to meet the water requirement of crops being raised in nearby villages. The irrigated area is very insignificant as always is the case in the hill and the irrigation water requirement is also very little due to low evapo-transpiration rates and the variety of the crops raised.

3.8.13. *Downstream Water Use*

On the d/s of proposed dam to the point of release of tail race water in about 20 km length of the River, there is no direct consumptive use of water of the river either for industry or for irrigation/ water supply scheme.

3.8.14. *Catastrophic Events Like Cloud Burst and Flash Floods*

As per available records no incidence of flash flood due to cloud burst or incessant rains from worst storm has been witnessed in sub-basin. The study of rainfall data of the rain gauges in the catchment manifest that there has not been any disastrous flood in the river. As per state disaster management plan the study area is not flood prone at all.

3.8.15. *Sedimentation Studies*

Sediment studies of the Umiam Reservoir in a nearby catchment, with the city of Shillong and other places with larger human settlements falling in its catchment, and therefore with much greater developmental activities, have indicated that in 39 years the sediment accumulation is 20.551 M Cum. The average silting rate from a catchment of 220 Sq.Km. worked out to about 23.95 Ham/100 Sq. Km/Yr. which is slightly higher than the average value of rate of siltation of 17.65 Ham/100 Sq. Km/Yr. as worked out by the Central Water Commission for the Himalayan Region.

Based on the observed flows and the various characteristics features of the catchment, as noted earlier, and the sedimentation studies in the Umiam Reservoir, the average rate of siltation of 17.65

Ham/100 Sq. Km/Yr. is thought adequate to be adopted for the calculation of the amount of silt that is likely to be deposited in the Umngot Reservoir.

Based on the sedimentation rate the volume to be accumulated in the reservoir after certain years is shown in **Table 3.31**.

Table 3.31 : Sediment Volume

Sl. No.	After years	Sediments (ham.)
1	25	1117.55
2	50	2200.55
3	75	3231.30
4	100	4201.89

Moody's method to fix L.S.L. (New Zero Elevation) is adopted as laid down in IS -5477 (part 2) – 1994 on "Methods for fixing the capacities of Reservoir – Part II – Dead Storage''. The new zero elevation so worked out at the end of 25 years, 50 years and 75 years shall be El. 966.50m, 981.20 and 995.80 m respectively.

3.8.16. *Environmental Flow Requirement*

Environmental consideration requires that a minimum flow is always guaranteed into the river downstream of the diversion structure to meet the requirement of aquatic life, drinking water, wild life, fisheries, riparian rights and religious rites of people. An important component of the e-flow regime has to be the mimicking of the river flow to keep it very close to the natural flow. In view of the fact that the TRC of the power house of the Project shall discharge full water through tailrace about 20 km d/s of the dam, a minimum release of water during lean/non-monsoon/monsoon season shall have to be released so as to address the environmental flow requirement (EFR). In view of the fact that there is no consumptive use of water in the impacted stretch of the river, the requirement is mainly for meeting ecological flow needed for aquatic life and mainly for the fish life.

The minimum stipulated flow for leanest month January - April) has been worked out on the basis of 20% of average flow in four consecutive leanest months in 90% dependable year which is year 1990-91 for diversion site. The computation of minimum flow requirement works out to 0.30 cumec as presented in **Table 3.32**. During non-leanest and non-monsoon months of October, November, December and May, which includes the breeding period/spawning movement (March - April) has been worked out as 3.43 cumecs and presented in **Table 3.33.** During monsoon months (June-September), it has been worked out as 10.33 cumecs and presented in **Table 3.34**. The minimum ecological flow for all seasons has been based on the current norms of the MoEF.

Table 3.32 : Computation of Minimum Flow Requirement during lean period

Month	Period	90% Dep. 1990-91	% of ecological flow as per MoEF norms	Ecological flow in cumec
January	I	1.83	20	0.37
	II	2.56	20	0.51
	III	2.05	20	0.41
February	I	1.73	20	0.35

	II	1.44	20	0.29
	III	1.21	20	0.24
March	I	1.12	20	0.22
	II	1.44	20	0.29
	III	1.35	20	0.27
April	I	1.31	20	0.26
	II	0.90	20	0.18
	III	0.95	20	0.19
			Total	3.58
			Average	0.30

Table 3.33 : Minimum Flow Requirement during non-monsoon and non - lean period

Month	Period	90% Dep. 1990-91	% of ecological flow	Ecological flow in cumec
October	I	23.18	25	5.80
	II	33.99	25	8.50
	III	8.55	25	2.14
November	I	8.14	25	2.04
	II	5.80	25	1.45
	III	4.57	25	1.14
December	I	3.66	25	0.92
	II	3.09	25	0.77
	III	2.60	25	0.65
May	I	32.93	25	8.23
	II	22.81	25	5.70
	III	15.40	25	3.85
			Total	41.18
			Average	3.43

Table 3.34 : Computation of Ecological Flow Requirement during monsoon

Month	Period	90% Dep. 1990-91	% of ecological flow as per MoEF norms	Ecological flow in cumec
June	I	77.47	30	23.24
	II	18.97	30	5.69
	III	22.23	30	6.67
July	I	50.49	30	15.15
	II	42.35	30	12.71
	III	62.76	30	18.83
August	I	16.89	30	5.07

	II	11.19	30	3.36
	III	23.46	30	7.04
September	I	14.93	30	4.48
	II	34.93	30	10.48
	III	37.33	30	11.20
			Total	123.90
			Average	10.33

3.8.17. ***Hydrogeology***

Meghalaya has geographical area of 21081 sq. km of which the valley area is merely 226 sq. km (1.07% of total state area), while the rest is hilly area. Hydrogeologicaly, the area is grouped into porous and fissured formations based on the nature of openings in the aquifer system. Alluvium and sedimentary formations and fissured consolidated rocks form the main repositories of ground water. The Consolidated Formations form the high land plateau of Meghalaya.

The availability of ground water in hilly region is manifested in the form of springs, seepages, wells and bore well of limited/ nominal yield. Ground water occurs in the area under water table conditions in the top weathered and fractured zone of quartzite. Further below, semi-confined to confined condition exist in the interconnected joints, fractures etc., of the underlying hard quartzite. The weathered quartzites have poor to moderate yields. The depth of this weathered zone varies up to about 30 m below ground level. The underlying second zone is fissured and jointed which is the zone of saturation. The distribution and disposition of these joints and fractures are of complex nature due to the various tectonic and structural disturbances to which country rocks are subjected to. Groundwater occurs under semi-confined condition in this zone. Such zones saturated with water are likely to extend down to 60 to 180 m below ground level.

The study area covering Mawkynrew and Mawryngkneng blocks is a mountainous terrain which is mainly dependent on topography, zone of weathering, fracturing and interstices present in country rocks. Quartzite (Shillong group) forms the main aquifer of the area. The Central Ground Water Board has constructed exploratory well one each in Mawryngkneng and Mawkynrew block. The depth of the exploratory well at Mawryngkneng and Mawkynrew was 59.45m and 153.70 below ground level respectively, with two sets of aquifers within a depth range of 4 to59.45m in case of exploratory well at Mawryngkneng and four sets of aquifers at a depth of 32-39:39-82; 124-127 and 148.6-153.7 mbgl. The yield of the wells varied from 8.08m3/hr. to16m3/hr. Transmissivity (T) is in the order of 8.08 m2 /day at Mawryngkneng.

The hydrogeological map of Greater Shillong is given in **Figure 3.21.**

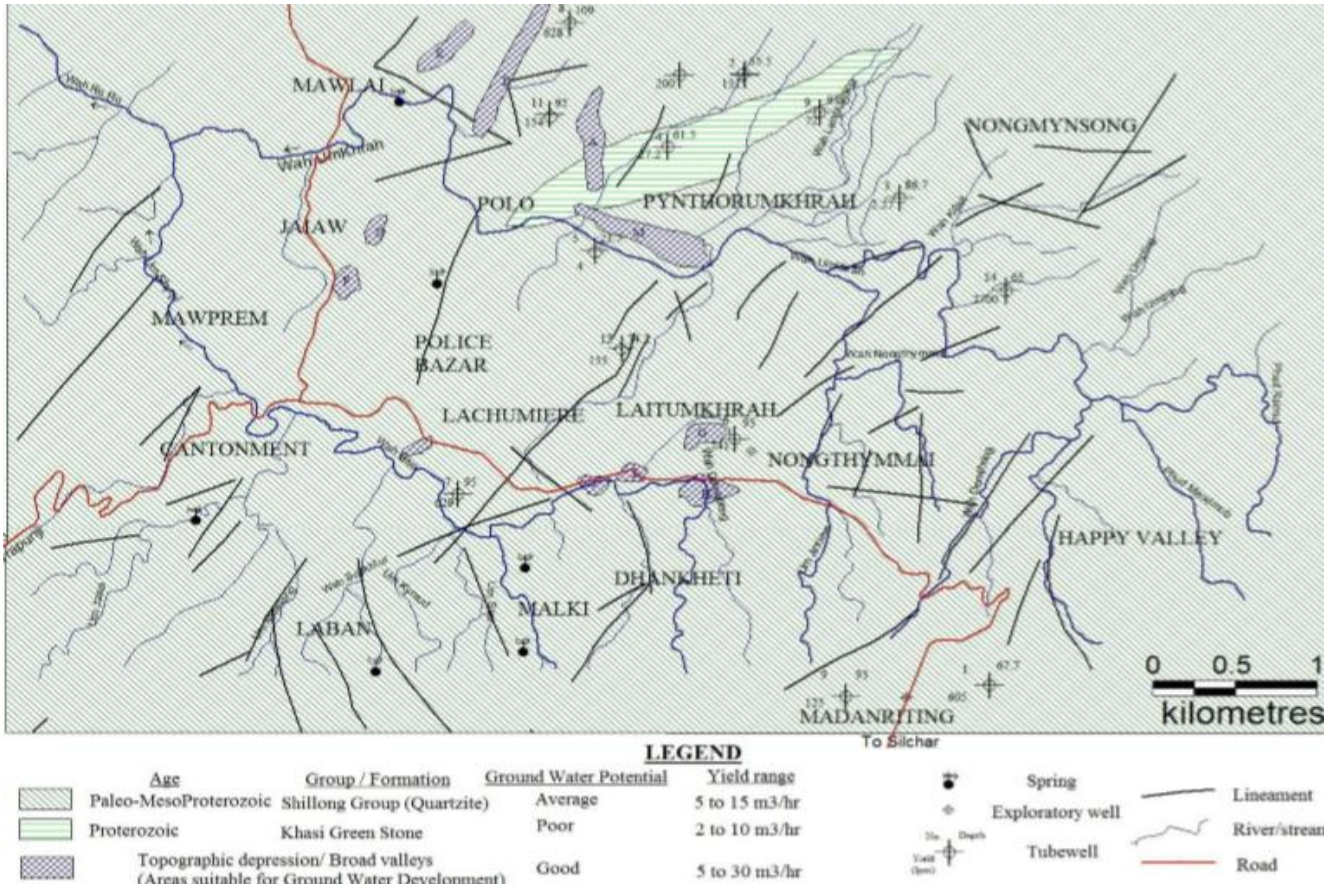


Figure 3.21 : Hydrogeological Map of East Khasi Hills District

3.8.17.2 History of Ground Water Table Fluctuation

The study area is covered under hilly terrain where Central Ground Water Board, North Eastern Region, has not set up Ground Water Monitoring Stations (GWMS) in order to know ground water condition and its variation, in both time and space. However, long-term ground water fluctuation data is available for valley area. As per Ground Water Year Book NER,2015-16, during period March 2008 to March 2015 at Observation location Ballat (Well No78O4B1), Cherrapunji (Well No78O3C1) and Shillong Polo (Well No78O2D1), fall of 0.336m.0.03m and 1.259m respectively had been recorded. During period November 2006 to November 2015 at Observation location Ballat (Well No78O4B1) and Shillong Polo (Well No78O2D1), fall of 0.236m and 0.071m respectively had been recorded, while at Cherrapunji (Well No78O3C1) a rise of 0.003 m was recorded.

3.9. Biological Environment

3.9.1. *Introduction*

The biological environment includes both terrestrial and aquatic ecosystems. A change in the composition and structure of biotic communities are reflected by a change in the distribution pattern, density, diversity, frequency, dominance and abundance of natural species of flora and fauna existing in the ecosystem. Studies on biological aspect of ecosystems are significant under Environmental Impact Assessment for protection of natural flora and fauna from impacted and influenced zones of project. Assessment on the impact of environmental pressure on the biological community structure serves as an inexpensive and efficient early warning system to check the damage to a particular ecosystem. This document reports the Baseline Environmental Data on the Flora and Fauna of the study area of 10 km radial distance around the Project site including submergence and influence

zones. Field survey was conducted for baseline study of existing biological resources in three different seasons and all the data has been gathered by direct inventory as well as through reviewing secondary information. Thus, both participatory and consultative approaches were followed under this study.

3.9.1.1 Broad Objective

The primary objectives of this study were to generate baseline information on existing biodiversity, to understand the ecological status of existing floral and faunal species and evaluate the probable impacts on the biological environment in and around project area during construction and operation of proposed Hydro-electric Project.

3.9.1.2 Study Area

The study area for this study was according to the approved ToR issued by MoEF has been delineated as:
Catchment Area up to the Dam Site

3.9.1.3 Submergence Area

The project area or the Direct Impact Area (DIA) to be acquired for various project appurtenances and area within 10 km from main project components (i.e., Dam, Power House etc.), Area downstream of Dam up to the point where Tail Race Tunnel (TRT) meets the river Downstream up to 10 km from tip of Tail Race Tunnel.

3.9.1.4 Flora (Vegetation)

Vegetation Study has been carried out for following objectives:

- To make an inventory/checklist of plants including angiosperms, Gymnosperms, Pteridophytes, Bryophytes, and significant Micro flora found in the study area
- To analyze the quantitative and qualitative characters (Frequency/Density /Abundance/IVI/Shannon diversity etc.) of existing vegetation at different locations of the study area
- To list out the Economically Important Plant/animal species and RET species (As per IUCN, WPA and BSI) present in the study area
- To assess the Cropping and Horticulture Pattern and Practices in the study area

3.9.2. ***Methodology***

3.9.2.1 Floral Study

The present report on the plants of project area is based on extensive field survey of the area. The seasonal study has been conducted during 2018 for Winter, Monsoon and Pre-Monsoon season. Besides the collection of plant species, information was also collected on the vernacular names and uses of plants made by local inhabitants.

3.9.2.2 Phytosociology

A nested quadrates technique was used for sampling the vegetation. The size and number of quadrates needed were determined using the species area curve (Mishra, 1968) and the running mean method (Kershaw, 1973). Summarization of previously used methods and recommendations led to the use of more than often (10 x10 m) quadrates laid out for sampling the tree stratum and 1x1m quadrates for herbs, grasses and seedlings of tree species less than 1.3 cm dbh (diameter at breast height) at different altitudinal gradients using GPS. However, for examining the shrub species 3x3m sample plots were laid out. The enumeration of the vegetation in each of the quadrate was

done by measuring dbh individually in case of woody vegetation and collar diameter in case of herbs and grasses, with the help of tree caliper and electronic digital caliper. In case of grasses and sedges, each erect shoot is considered to a plant tiller and the enumeration was done by laying 1x1m quadrates at random, further subdivided into 10x10 cm segments.

Four such segments selected at random were analyzed from each quadrate by counting the tillers individually. The method used was that of Singh and Yadava (1974).

The vegetation data collected for phyto-sociological information was quantitatively analyzed for density, frequency and abundance according to Curtis and McIntosh (1950). The relative values of frequency, density and dominance of all the species were summed up to represent Importance Value Index (IVI). The following are the formulae to derive frequency, density, dominance, IVI etc.

$$\text{Frequency} = \frac{\text{Total number of quadrats in which species occurred}}{\text{Total number of quadrats studied}}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of species in all quadrats}}{\text{Total number of quadrats in which species occurred}}$$

$$\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrats studied}}$$

IVI = Relative frequency + Relative dominance (basal area) + Relative density

$$\text{Relative Frequency} = \frac{\text{Frequency of the species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Density of the species}}{\text{Total density of all species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Dominance of the species}}{\text{Total dominance of all species}} \times 100$$

$$\text{Relative Abundance} = \frac{\text{Abundance of the species}}{\text{Total abundance of all species}} \times 100$$

Diversity of The Forest Vegetation

The tree species diversity for each stand in different forest types was determined using Shannon Wiener information function (Shannon and Wiener, 1963), which is:

$$H = - \sum_{i=1}^{s} (Ni/N) \ln (Ni/N)$$

Where, Ni is the total number of individuals of species i and N is the total number of all species in a stand.

3.9.2.3 Faunal Study

Ground surveys were carried out by trekking the impact zone for identification of important animal groups such as butterflies (insects), birds, mammals, reptiles, and some fishes inhabiting the area, along the riverbanks, adjoining forest on the slopes, nallahs, hill top and agricultural fields.
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 (20m) 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 from these areas.
'Reptiles' mainly lizards were sampled by 'direct count on open width transects' (n = 4) for 1 hour in each transect.

3.9.2.4 Aquatic Fauna

Evaluation of Aquatic Fauna

An extensive survey of river Umngot in upstream and downstream of dam and proposed Power house during 2018 for Winter, Monsoon and Pre monsoon season 2018, with the intention to examine aquatic animal species such as Phytoplankton, zooplanktons, fishes and other aquatic species.

3.9.3. *Forest and Forest types in Meghalaya*

Meghalaya is a treasure trove of Nature, with its richly varied and dense endemic, exotic and cultivated flora. Nature, in its generous abundance, had bestowed on Meghalaya a unique array of vegetation, ranging from tropical and sub-tropical to temperate or near temperate. This is due to the diverse topography, varied and abundant rainfall and differential climatic and edaphic conditions of the State, within small regions. Biotic factors have also played an important role, at places decisive.
The State is basically an agricultural State. It has a total geographical area of 22,429 km2. The total estimated forest area of the State is 8,514 km2 of which only 722.36 km2 are directly under the control of the State Forest Department. The remaining areas are managed by the respective District Councils of Khasi Hills, Jaintia Hills and Garo Hills as per provisions of the Sixth Schedule to the Constitution of India. Except the reserved forest areas and protected forests in and around Shillong (being managed by the department in arrangement with the District Councils), the rest of the forest areas are subjected to the primitive agricultural practice of shifting cultivation or slash and burn method especially in Garo Hills. However, there are few pockets of undisturbed natural forests still in

existence, comprising about 1000 km2 being protected by the tribal as 'Sacred Groves'. Essentially, they are located in strategic watersheds and still play an important role.

The forests of Meghalaya can be broadly grouped into tropical, subtropical and temperate types. The Indian Institute of Remote Sensing have classified the vegetation of Meghalaya into tropical evergreen, tropical semi-evergreen, tropical moist deciduous, subtropical broad leaved, subtropical pine and temperate forest types, grasslands and savannas. Detailed description of forest is described in following sections:

Tropical forests: These forests occur up to an elevation of 120 m where average annual rainfall ranges between 100 and 250 Cm. They may be evergreen, semi evergreen, and moist deciduous depending on the annual rainfall. Such type of forests occurs along the banks of the River Umngot.

Tropical evergreen forests: These forests usually occur in high rainfall areas as well as near catchment areas. They seldom form continuous belts due to various exogenous factors. But still, they harbour very rich species diversity, where nature is at its extravaganza forming a closed evergreen canopy. The trees exhibit clear zonation with dense and impenetrable herbaceous undergrowth. Small strips and patches of such type of communities could be seen along the banks of the river and the streams that discharge into the river in the form of narrow strips.

Tropical semi-evergreen forests: This category of forests occupies the north-eastern and northern slopes of the State, typically up to elevations of 600m, where annual rainfall is 150 to 200 Cm with a comparatively cooler winter. The numbers of species here are fewer than the evergreen zone. There are also a few species in these forests which are deciduous in nature, such as *Careya arborea, Dillenia pentagyna and Callicarpa arborea.* Again, there is a clear stratification of the trees in these forests.

Tropical moist and dry deciduous forests: This type of forest occurs where annual rainfall is below 150 Cm and at comparatively low elevations. Deciduous forests are much more extensive in their distribution in the State and include a host of economically important trees like *Shorea robusta, Tectona grandis, Terminalia myriocarpa, Sterculia villosa, Logerstroemia flos-reginae, Logerstroemia parviflora, Morus laevigatus, Artocarpus chaplasha, and Gmelina arborea.*

Grass and Savannas: Grasslands of Meghalaya are also not a climax type but are only the result of removal of original forest cover. The rolling grasslands covering large areas can be seen throughout the Shillong plateau, around Riangdo, Ranikor, Weiloi, Mawphlang, Mawsynram, Cherrapunji, Shillong, Jowai, Jarain, and Sutnga in Khasi Hills and Jaintia Hills districts and major parts of West Garo Hills district.

Temperate Forests: 5.10 The temperate forests occupy the higher elevations of about 1000 m, mostly along the southern slope of Khasi Hills and Jaintia Hills. The rainfall here is very high (200-500 Cm) with severe winter during November to March. Ground frost is also common during December to January.

3.9.3.1 Forest

According to the State of Forest Report (FSI 2001), the actual forest cover of the state is 15,584 sq. km. This accounts for around 69.5% of the state's geographic area. Per capita forest area in the state is 0.64 hectares compared to the national average of 0.11 hectares. However, the total recorded forest area is 9,496 sq. km. The area of reserved and protected forests under the control of the state government is only 1,124 sq. km. The Unclassed Forests, managed by Autonomous District Councils, village durbars and other traditional institutions, and private owners cover an area of 8,372 sq. km. During 1985-87, 73.41% (16,466 sq. km) of the total geographical area of the state was under forest

cover. It decreased to 69.75% (15,645 sq. km) by the year 1987-89 and then increased to 69.48% (15584 sq. km) in 1999-2001 **(Table 3.35).**

Table 3.35 : Forest Land Cover of Meghalaya

Population	Total Geographical Area '000 ha	Total Forest (x103 ha)		Dense Forest '000 ha	Open Forest '000 ha	Per Capita Forest Cover in ha
		Recorded	Cover			
2306069	2243	949.60	1563	592	971	0.64

Source: State of Forest Report (FSI 2001)

3.9.3.2 Forests and Forests types in the study area

The Umngot River runs through a deep valley between the Eastern part of East Khasi Hills and the Western part of Jaintia Hills. There are no reserve forests in the area of submergence where the dam is proposed to build.

Forest type in Submergence Area:

The forests that occur in the area of submergence are typical tropical riverside forests dominated by different species of Ficus, *Shorea robusta, Tectona grandis, Terminalia myriocarpa, Sterculia villosa, Logerstroemia flos-reginae, Logerstroemia parviflora, Morus laevigatus, Artocarpus chaplasha, Gmelina arborea, Schima wallichii, Artocarpus gameziana,Tetrameles nudiflora, Lannea coromandelica, Salmalia malabarica Erythrina stricta, Premna milliflora, Vitex peduncularis, Albizia lebbeck, Terminalia bellirica, Anthocephalus cadamba* and others.

Figure 3.22 Photograph of Submergence area

Figure 3.23 Photograph of Catchment area

The catchment area towards the Jaintia Hills was represented mainly by private or community croplands. Potato, Cabbage, Cauliflower, Carrot, Radish, Tomato, Chilies, Paddy, Millets, Pulses, Jute, Mesta, Ginger, Turmeric, Black Pepper, Sugarcane are the main crops grown during the rainy season. Areca nut, Pineapple and Betel wines are also grown in a limited area. The Eastern slopes of the East Khasi Hills beyond the level of submergence have been denuded and reclaimed for cultivation of Potato, Cabbage, Cauliflower, Carrot, Radish, Tomato, Chilies, Paddy, Millets, Pulses, Jute, Mesta and Ginger. Black Pepper, Areca nuts and Pineapple are grown in a few localities. In upper part of the hills large areas are also under the cultivation of broom grass (*Thysanolaena maxima*) on the plateau regions.

The catchment area of the Umngot River supports all the different types of vegetation types described earlier. There are different types of forests, grasslands and croplands. Based on the ownership of the land, the forests are classified as the reserve forests, unclassified community forests and sacred grooves. The sacred groves of Meghalaya are the best protected pieces of natural vegetation and have been preserved since time immemorial. Therefore, these are treasure trove of unique flora. However, there no sacred groove in the submergence area. A protective hedge of Castanopsis kurzii trees, which do not allow the growth of the Khasi pine within the enclosed area, surrounds these groves. Inside the groves however, the soil is richly laden with humus, accumulated over the centuries and which supports a variety of plant life found nowhere else. As indicated, there are unclassified dense (private forests) and open forests in the catchment and reservoir areas. Land use and Land cover of the catchment and submergence area: The land use and land cover details of the catchment is given in **Table 3.36.** Out of the total forest area, only 4% is a reserve forest and the rest are treated as unclassified community forests.

Table 3.36 : Land use and Land cover of the catchment and submergence area

Sl. no	Land use / Land cover category	Catchment area		Area of submergence	
		Area in Ha	%	Area in Ha	%

1	Shifting/ Zhum cultivation	1611	5.29	-	0
2	Arable land	6245	20.52	56.5	22.3
3	Dense forests	3963	13.02	8.28	3.26
4	Open forests	6475	21.27	51.72	20.38
5	Tree studded scrubland	10058	33.85	8.96	3.53
6	Barren land (mainly along the river banks)	-	-	34.74	13.68
7	Built up land	1216	4	0	0
8	River and other Water bodies	865	2.84	93.55	36.85
Total		**30433**	**100**	**253.85**	**100**

Economically Important Species (Viz. Medicinal, Timber, Fuel Wood etc. Sacred groves): Forest-Groves are known by various names as "Ki Law Kyntang" (sacred forest); "Ki Law Adong" (prohibited forest); "Ki Law Shnong" (village forest) and "Ki Law Kynti" (private forest). These sacred groves are basically nature's own museum, as they have been preserved since time immemorial, and are hence a treasure trove of unique flora. A protective hedge of Castanopsis kurzii trees, which do not allow the growth of the Khasi pine within the enclosed area, surrounds these groves. Inside the groves however, the soil is richly laden with humus, accumulated over the centuries and which supports a variety of plant life found nowhere else. The trees in every grove are loaded with epiphytic growth of pipers, ferns, orchids etc. The size of the sacred groves varies from as small as an acre to hundreds of acres. There is at least one sacred grove for every two villages on an average.
Some of the important tree species, which yield valuable timber for trade, are Khasi Pine, Sal, Teak, Bamboos. In Meghalaya forests the rubber-yielding plant of Ficus elastica belonging to the family of Moraceae is common. Lac and Gum are obtained from forests in the area. Forests offer tremendous scope for sericulture or silk worm rearing industry.

Ornamental Plants: The forests of study area are treasure house of valuable products such a timber, fuel wood, fodder, resin, tannin, gums, shellac, fiber, latex, essential oils, fats, edible fruits, honey and a large number of medicinal plants. Study area is well known for bay leaves and cinnamon. Morus alba, Quercus semiserrata and a number of other tree species play a vital role in the economy of the State, being the host plants for rearing of silk worms for sericulture. The common ornamental trees are: *Cassia fistula, Cassia nodosa, Jacaranda acutifolia, Magnolia griffithii, Lagerstroemia indica, Callistemon viminalis, Rhododendron spp*. The other seasonal ornamental plants are Dahlia, Canna, Gladiolus, Hygrangium, Begonia, Tropaeolum, Aster, Polargonium, Antirrhinum, Crinum, Celosia, Kniphofia, Impatiens, Chrysanthemum, Petunias, Pansy, Calendula, Sweet peas and Salvia. Many climbers like Bougainvillea, Rosa, Jasminum, etc. are quite common. Orchids like *Phaius, Paphiopedilum* and *Cymbidium spp.* are also cultivated. Other ornamentals grown in gardens are Hibiscus, Hydrangea, Gardenia, Poinsettia, Dahlia, Canna, Gladiolus, Begonia, Tropaeolum, Aster, Poalrgonium, Antirrhinum, Crinum, Celosia, Holley hock, Kniphofia, Impatiens, Chrysanthemum, Petunia, Pansy, Calendula, Sweet Pea, Salvia, Roses, Bougainvillea, Jasminum etc. A few Orchids like Phais, Dendrobium and Cymbidium varieties are also cultivated.

Agriculture: The major crop plants of study area are Paddy, Maize, Millets, Pulses, Potato, Jute and Mesta, Ginger, Turmeric, Black Pepper, Sugar Cane, Oil Seeds. Both Areca nut and Betel. The catchment area towards the Jaintia Hills was represented mainly by private or community croplands. Potato, Cabbage, Cauliflower, Carrot, Radish, Tomato, Chilies, Paddy, Millets, Pulses, Jute, Mesta, Ginger, Turmeric, Black Pepper, Sugarcane are the main crop grown during the rainy season. Areca nut, Pineapple and Betel wines are also grown in a limited area. The Eastern slopes of the East Khasi Hills beyond the level of submergence have been denuded and reclaimed for cultivation of Potato, Cabbage, Cauliflower, Carrot, Radish, Tomato, Chilies, Paddy, Millets, Pulses, Broom grass is cultivated mainly in the plateau. Jute, Mesta and Ginger, Black Pepper, Areca nuts and Pineapple are grown in a few localities. Horticulture is not the main stay of the locals. Orchids from natural sources are collected and sold in Shillong.

Medicinal plants: Different parts of many plants growing in study have been put to medicinal use. Among the important and recognized medicinal plants found and cultivated in the study area are Ipecac, *Rauvolfia serpentina*, Cinchona, Abromine, Chaulmoogra oil, Croton oil, Eucalyptus, Castor oil, Chiretta, *Solanum khasianum, Casearia vareca, Zanthoxylum armatum, Hedyotis scandens, Paederia foetida, Salix alba, Anacardium occidentale, Cinnamomum* and *Taxus baccata.* A list of trees including the shrubs, herbs and climber is given in **Table 3.37**.

Table 3.37 : List of Flora in Project Area

S.No.	Plant Species	Family	Local Name
1	*Aglaia perviridis*	Meliaceae	-
2	*Albizia procera*	Mimosaceae	Dieng Sohriew
3	*Altsonia scholaris*	Apocynaceae	-
4	*Artocarpus lacucha*	Moraceae	Dieng Sohsyrtet
5	*Aphanomixis polystachya*	Meliaceae	Dieng-soh-sying
6	*Bauhinia purpurea*	Caesalpiniaceae	Me-gong
7	*Beilschme roxburghiana*	Laraceae	-
8	*Beilschmiedia roxburghiana*	Lauraceae	-
9	*Bombax ceiba*	Bombacaceae	Dieng ruin
10	*Callicarpa arborea*	Verbencaeae	Dieng-lakhoit
11	*Camellia caudata*	Theaceae	
12	*Caryota urens*	Arecaceae	Dieng Lakhar
13	*Casearia vareca*	Flacourtiaceae	-
14	*Castanopsis indica*	Fagaceae	Dieng sohot
15	*Castanopsis purpurella*	Fagaceae	-
16	*Castanopsis tribuloides*	Fagaceae	-
17	*Cinnamomum granduliflerum*	Lauraceae	-
18	*Cinnamomum tamala*	Lauraceae	Dieng Latyrpad
19	*Citrus latipes*	Rutaceae	Dieng sohkynphor
20	*Coffea khasiana*	Rubiaceae	-
21	*Desmos longiflorus*	Schisandraceae	-
22	*Diospyros kaki*	Ebenaceae	Dieng-iong
23	*Dysoxylum gobara*	Meliaceae	Sla-luchai
24	*Engelhardtia spicata*	Juglandaceae	Gandmowa

25	*Erythrina stricta*	Papilionaceae	-
26	*Eurya acuminata*	Theaceae	Dieng shit
27	*Eurya cerasifolia*	Theaceae	-
28	*F. oligodon*	Moraceae	-
29	*Ficus geniculata*	Moraceae	Phrap-agar
30	*Ficus hirta*	Moraceae	Dieng jri
31	*Ficus nerifoloia*	Moraceae	Dieng jri
32	*Garcinia xanthochymus*	Cluciaceae	Jharambi
33	*Glochidion hirsutum*	Euphorbiaceae	-
34	*Gynocadia odorata*	Flacourtiaceae	-
35	*Homalium schlichii*	Flacourtiaceae	-
36	*Hydnocarpus kurzi*	Flacourtiaceae	-
37	*Itea macrophylla*	Itaceae	
38	*L. khasyana*	Lauraceae	-
39	*Lagerstroemia hirsuta*	Lythraceae	Taman
40	*Lannea coromandelica*	Anacardiaceae	Jhingran
41	*Lindera latifolia*	Lauraceae	-
42	*Litsea citrata*	Lauraceae	
43	*Lithocarpus elagans*	Fagaceae	-
44	*Litsea lancifolia*	Lauraceae	-
45	*Macaranga denticulata*	Euphorbiaceae	Dieng Lakhar
46	*Michelia glabra*	Magnoliaceae	-
47	*Miliusa globosa*	Anonaceae	-
48	*Myrica esculanta*	Myricaceae	Dieng sohphie
49	*Oroxylum indicum*	Bignoniaceae	Pharri
50	*Parkia roxburghii*	Mimosaceae	Dieng jariat
51	*Persea odoratissima*	Lauraceae	Kaula
52	*Picresema sp.*	Simaroubiaceae	-
53	*Pithecellobium monadelphum*	Mimosaceae	-
54	*Pinus khasiana*	Pinaceae	Dieng kseh
55	*Podocarpus nerrifolia*	Podocarpaceae	-
56	*Pyrularia edulies*	Santalaceae	-
57	*Quercus griffithii*	Fagaceae	-
58	*Rhus acuminata*	Anacardiaceae	Dieng sohma
59	*Rhus javanica*	Anacardiaceae	-
60	*Samanea saman*	Mimosaceae	--
61	*Sapindus rarak*	Sapindaceae	-
62	*Schefflera bengalensis*	Araliaceae	-
63	*Schefflera hypoleucea*	Araliaceae	-
64	*Schima wallichii*	Theaceae	Dieng ngan
65	*Schima wallichii*	Theaceae	Dieng ngan
66	*Stereospermum chelonoides*	Bignoniaceae	Padal
67	*Styrax serrulatum*	Styraceae	-
68	*Saurauia punduana*	Actinidiaceae	-

69	*Syzygium cuminii*	Myrtaceae	Dieng Jamun
70	*Syzygium tetragomum*	Myrtaceae	Dieng-soh-sarlei
71	*Tetradium fraxinifolium*	Rutaceae	-
72	*Trema aboinensis*	Ulmaceae	-
73	*Vaccinum donianum*	Ericaceae	-
74	*Villebrunea integrifolia*	Urticaceae	-
Shrubs			
1	*Aeschynanthus hookeri*	Gesneriaceae	-
2	*Andrachne cordifolia*	Euphorbiaceae	-
3	*Aralia thomsonii*	Araliaceae	
4	*Artabotrys caudatus*	Annonaceae	-
5	*Aspidopterys roxburghiana*	Malpighiceae	-
6	*B. platyphylla*	Urticaceae	-
7	*Bambusa tulda*	Poaceae	-
8	*Boehmeria macrophylla*	Urticaceae	-
9	*Boehmeria sidaefolia*	Urticaceae	
10	*Breynia retusa*	Euphobiaceae	
11	*Calamus floribundus*	Arecaceae	-
12	*Cassia floribunda*	Fabaceae	
13	*Chromolaena odoratum*	Asteraceae	-
14	*Clerodendrum colebrookianum*	Verbenaceae	-
15	*Corylopsis himalayana*	Hamamelidaceae	
16	*Desmodium triquetrum*	Papilionaceae	-
17	*Embelia subcoriaceae*	Myrsinaceae	
18	*Embelia vestita*	Myrsinaceae	
19	*Erythroxylum kunthianum*	Erythroxylaceae	
20	*Euonymus lowsonii*	Celastraceae	
21	*Eupatorium adenophorum*	Asteraceae	
22	*F. lanceolata*	Moraceae	-
23	*Ficus clavata*	Moraceae	
24	*Ficus scandens*	Moraceae	-
25	*Indigofera heterantha*	Papilionaceae	-
26	*Isodon ternifolius*	Lamiaceae	-
27	*Ixora acuminata*	Rubiaceae	-
28	*Jasminium dispermum*	Oleaceae	
29	*L. crispa*	Leeaceae	-
30	*Lasianthus lucidus*	Rubiaceae	-
31	*Lantana camara*	Verbeniacaeae	-
32	*Lasianthus sikkimensis*	Rubiaceae	-
33	*Leea aequata*	Leeaceae	-
34	*Liculia pinceana*	Rubiaceae	-
35	*Loranthus odoratus*	Loranthaceae	-
36	*Loxostigma griffithii*	Gesneriaceae	-
37	*Measa indica*	Myrsinaceae	

38	*Micromelum integerrimum*	Rutaceae	-
39	*Mimosa rubecaulis*	Mimosaceae	-
40	*Mussaenda roxburghii*	Rubiaceae	-
41	*Melastoma nepalensis*	Myricaceae	-
42	*Osbeckia nepalensis*	Lythraceae	-
43	*Oxyspora paniculata*	Lythraceae	-
44	*Pentapanax fragrans*	Araliaceae	-
45	*Phlogacanthus thyrsiflorus*	Acanthaceae	-
46	*Piper pedicillatum*	Piperaceae	-
47	*Plectranthus striatus*	Lamiaceae	
48	*Polygonum molle*	Polygonaceae	
49	*Prinsepia utilis*	Rosaceae	
50	*Psychortia curviflora*	Rubiaceae	
51	*Psychortia erratica*	Rubiaceae	
52	*Psychotria denticulata*	Rubiaceae	-
53	*R. ellipticus*	Rosaceae	-
54	*R. moluccanus*	Rosaceae	-
55	*R. paniculatus*	Rosaceae	-
56	*R. rosaefolius*	Rosaceae	-
57	*Rhynchotecum vestitum*	Gesneriaceae	
58	*Rubus acuminatus*	Rosaceae	-
59	*Rubus assamensis*	Rosaceae	
60	*Rubus ellipticus*	Rosaceae	
61	*Rubus khasiana*	Rosaceae	
62	*S. surettense*	Solanaceae	-
63	*Senecio cappa*	Myricaceae	
64	*Shutaria vestida*	Rubiaceae	
65	*Solanum aculeatissimum*	Solanaceae	
66	*Solanum ferox*	Solanaceae	-
67	*Strobilanthes auriculata*	Acanthaceae	-
68	*Trevesia palmata*	Araliaceae	-
69	*Viburnum foetidum*	Caprifoliaceae	
70	*Viscum articulatum*	Loranthaceae	-
Herbs			
1	*Sida cordata*	Malvaceae	-
2	*Borreria sp.*	Rubiaceae	-
3	*Cyperus flavidus*	Cyperaceae	-
4	*Impatiens khasiana*	Balsaminaceae	-
5	*Oxalis corniculata*	Oxalidaceae	-
6	*Trigonella foenum-graecum*	Papilionaceae	-
7	*Melilotus indica*	Papilionaceae	
8	*Desmodium triquetrum*	Papilionaceae	
9	*Drymaria cordata*	Caryophyllaceae	
10	*Hedyotis vestita*	Rubiaceae	-

11	*H. scandens*	Rubiaceae	-
12	*Ageratum conyzoides*	Asteraceae	-
13	*Blumea chinensis*	Asteraceae	-
14	*Crepis japonica*	Asteraceae	-
15	*Inula cappa*	Asteraceae	-
16	*Mikania macrantha*	Asteraceae	-
17	*Senecio araneosus*	Asteraceae	-
18	*Lophatherum gracile*	Poaceae	-
19	*Isachne himalaica*	Poaceae	-
20	*Selaginella semicordata*	Selaginallaceae	-
21	*Hedychium ellepticum*	Zingiberaceae	-
22	*Globba clarkia*	Zingiberaceae	-
23	*Begonia palmata*	Begoniaceae	-
24	*Impatiens khasiana*	Balsaminaceae	-
25	*Impatiens banthamii*	Balsaminaceae	-
26	*Commelina paludosca*	Commelinaceae	-
27	*Panicum brevifolium*	Poaceae	-
28	*Murdannia gigantean*	Commelinaceae	-
29	*Aeginetia indica*	Orobanchaceae	-
30	*Carex filicina*	Cyperaceae	-
31	*Crassocephalum crepidioides*	Asteraceae	-
32	*Achyrospermum wallichianum*	Lamiaceae	-
33	*Elatostema dissectum*	Urticaceae	-
34	*Elsholtzia blanda*	Lamiaceae	-
35	*Arisaema tortuosum*	Araceae	-
36	*Dianella ensata*	Liliaceae	-
37	*Cyanotis vaga*	Commelinaceae	-
38	*Balanophora dioica*	Balanophoraceae	-
39	*Murdannia nudiflora*	Commelinaceae	-
40	*Sonerila khasiana*	Melastomaceae	-
Climbers			
1	*Cocculus macrocarpus*	Menispermaceae	-
2	*Stephania glabra*	Menispermaceae	-
3	*Toddalia asiatica*	Rutaceae	-
4	*Celastrus monosperma*	Celastraceae	-
5	*Cayratia mollissima*	Vitaceae	-
6	*Cissus adnata*	Vitaceae	
7	*Tetrastigma discolor*	Vitaceae	-
8	*Mucuna monosperma*	Papilionaceae	-
9	*Entada phaseoloides*	Mimosaceae	-
10	*Hedera nepalensis*	Araliaceae	-
11	*Jasminum dispermum*	Oleaceae	-
12	*Ichnocarpus frutescens*	Apocynaceae	-
13	*Marsdenia tinctoria*	Asclepiadaceae	-

14	*Porana paniculata*	Convolvulaceae	-
15	*Thunbergia grandiflora*	Acanthaceae	-
16	*Aristolochia roxburghiana*	Aristolochiaceae	-
17	*Dioscorea bulbifera*	Dioscoreaceae	-
18	*Smilax aspericaulis*	Smilacaceae	-
19	*Rhaphidophora decursiva*	Araceae	-

Eco-Sensitive areas in Study Area

As stated earlier, there are no National Parks, wildlife Sanctuary, Biosphere Reserves or other protected areas is present within the study area.

Vegetation Structure (Vegetation Sampling Locations)

The vegetation sampling was carried out at five different sampling locations covering the study area described in ToR. Proposed Dam site of Umngot HEP is present in **Table 3.38.**

Table 3.38 : Sampling Location of Floristic Survey

S.No.	Vegetation Type	Name of Location	Latitude	Longitude	District	Type
S-1	Scrub Land	Umsawwar	25°21'59.18"N	92° 4'5.00"E	E.K. Hills	Shrub and tree
S-2	Dense Forest	Syntung	25°21'22.71"N	92° 3'25.15"E	E.K. Hills	Shrub and tree
S-3	Open Forest	Sohmynting	25°24'4.24"N	92° 7'56.26"E	J. Hills	Shrub and tree
S-4	Open Forest	Near Dam Site	25°21'47.89"N	92° 6'58.44"E	J. Hills	Shrub and tree
S-5	Open Forest	Near Power house	25°19'15.02"N	92° 2'44.41"E	E. K. hills	Shrub and tree

3.9.4. ***Community Composition and Structure at different Sampling Locations***

3.9.4.1 S1: Scrub land near Umsawwar

Scrub land near Umsawwar, is located on hill top. Scrub vegetative has been recorded in this area. The elevation of the the site is 1400 amsl. The site is located about 300 m above of the riverbed. A total of 4 tree, 10 shrub, and 13 herb species were recorded during primary survey. Tree flora was dominated with Pinus kesiya followed by *Schima wallichii* and *Rhus accuminata*. *Melastoma nepalensis, Eurya acuminata*. *Melastoma nepalensis* were leading species in shrub's flora whereas herb's flora was predominated with *Paspalum orbiculare,* Isachne himalaica, *Borreria* sp.and *Gnaphalium pensylvanicum*. Tree, shrub and herb density values were recorded as 170 trees ha-1, 2480 shrubs ha-1 and 46800 herbs ha-1 respectively. The Basal cover of tree species recorded as 89.11 m2 ha-1. **(Table 3.39).**

Table 3.39 : Phytosociological Characters of Plant Community

S. No.	Scientific Name	Density (/ha)	Fre (%)	Ab	Basal Cover (Sq. m/ha)	IVI
Tree						

1	*Schima wallichii*	40.00	20.00	2.00	25.61	80.83
2	*Rhus accuminata*	20.00	10.00	2.00	3.35	29.81
3	*Saurauria punduana*	10.00	10.00	1.00	0.71	20.97
4	*Pinus khasia*	100.00	30.00	3.33	59.45	168.39
Total		**170.00**	**70.00**		**89.11**	**300.00**
Shrub						
1	*Eupatorium adenophorum*	240.00	20.00	0.13	0.645	30.72
2	*Eurya acuminata*	360.00	30.00	0.29	0.306	32.70
3	*Sida rhombilolia*	40.00	10.00	0.14	0.016	5.93
4	*Castanopsis indica*	80.00	10.00	0.18	0.039	8.01
5	*Lantana camara*	280.00	30.00	0.23	0.306	29.48
6	*Melastoma nepalensis*	120.00	20.00	0.05	0.963	32.32
7	*Melastoma nepalensis*	480.00	50.00	0.18	1.346	66.56
8	*Eupatorium adenophorum*	200.00	20.00	0.15	0.368	23.51
9	*Senecio cappa*	280.00	30.00	0.21	0.368	30.73
10	*Rubus ellipticus*	400.00	30.00	0.23	0.589	40.04
Total		**2480.00**	**250.00**		**4.945**	**300.00**
Herb						
1	*Borreria sp.*	4800.00	12.00	4.00	0.005	32.448
2	*Ageratum conyzoides*	2000.00	12.00	1.67	0.004	23.462
3	*Isachne himalaica*	3200.00	8.00	4.00	0.009	38.811
4	*Bidens pilosa*	2000.00	8.00	2.50	0.003	17.733
5	*Commelina paludosca*	2800.00	8.00	3.50	0.004	22.046
6	*Cyperus flavidus*	1200.00	8.00	1.50	0.001	12.018
7	*Drymaria cordata*	1200.00	4.00	3.00	0.000	5.889
8	*Eupatorium adenophorum*	4400.00	16.00	2.75	0.001	24.594
9	*Gnaphalium pensylvanicum*	2800.00	8.00	3.50	0.001	13.657
10	*Plantago erosa*	3200.00	8.00	4.00	0.001	14.512
11	*Pratia begonifolia*	4000.00	12.00	3.33	0.001	21.126
12	*Melastoma nepalensis*	4400.00	8.00	5.50	0.001	19.412
13	*Paspalum orbiculare*	10800.00	16.00	6.75	0.007	54.291
Total		**46800.00**	**128.00**		**0.036**	**300.000**

3.9.4.2 S-2: Dense Forest near Syntung

This sampling site is moderately steep to gentle area located at the elevation of 1338 amsl. The natural vegetation of the area is dominated by the Pinus khasia at higher elevations whereas the lower elevations are dominated with *Schima wallichii.* A total of 10 tree, 9 shrubs and 11 herb species were recorded at this location during primary survey. *Pinus kesiya*, *Schima wallichii* and *Saurauria punduana* were the leading tree species recorded during primary study. Tree flora was represented by a density of 180 trees ha-1 and Basal area of 33.29 m2 ha-1. Shrub flora at this site was dominated with *Lantana camara, Eupatorium adenophorum* and *Circium* sp. with a shrub density of 2240 shrubs ha-1 and Basal area of 2.8 m2 ha-1. Herbaceous flora was recorded as 52000 herbs ha-1 with the leading herb species like *Paspalum orbiculare, Plantago erosa* and *Barreria* sp. **(Table 3.40).**

Table 3.40 : Phytosociological Characters of Plant Community

S. No.	Scientific Name	Density (/ha)	Fre (%)	Ab	Basal Cover (Sq. m/ha)	IVI
Tree						
1	*Plangium chinensis*	10.00	10.00	1.00	0.97	16.16
2	*Schima wallichii*	20.00	20.00	1.00	3.35	36.55
3	*Saurauria punduana*	20.00	10.00	2.00	5.63	35.71
4	*Rhus javanica*	10.00	10.00	1.00	0.18	13.80
5	*Rhus acuminata*	10.00	10.00	1.00	0.54	14.86
6	*Macaranga denticulate*	10.00	10.00	1.00	2.41	20.48
7	*Pinus kesiya*	60.00	30.00	2.00	17.66	109.45
8	*Litsea citrata*	10.00	10.00	1.00	0.27	14.05
9	*Lindera caudata*	10.00	10.00	1.00	0.18	13.80
10	*Myrica esculanta*	20.00	10.00	2.00	2.11	25.13
Total		**180.00**	**130.00**		**33.29**	**300.00**
Shrub						
1	*Lantana camara*	440.00	40.00	2.75	1.4	87.36
2	*Eupatorium adenophorum*	640.00	40.00	4.00	0.4	59.70
3	*Itea macrophylla*	120.00	20.00	1.50	0.1	16.58
4	*Melastoma nepalensis*	80.00	20.00	1.00	0.0	13.88
5	*Rubus khasianas*	120.00	20.00	1.50	0.0	15.41
6	*Senecio cappa*	120.00	20.00	1.50	0.4	28.58
7	*Wendlandia wallichii*	200.00	20.00	2.50	0.1	21.67
8	*Circium sp.*	280.00	30.00	2.33	0.2	31.47
9	*Solanum aculeatissimum*	240.00	20.00	3.00	0.2	25.34
Total		**2240.00**	**230.00**		**2.8**	**300.00**
Herb						
1	*Melastoma nepalensis*	6400.00	12.00	5.33	0.004	29.84
2	*Osbeckia capital*	4800.00	12.00	4.00	0.004	26.76
3	*Paspalum orbiculare*	4400.00	12.00	3.67	0.011	41.48
4	*Barreria sp.*	4400.00	12.00	3.67	0.004	25.23
5	*Plantago erosa*	4800.00	8.00	6.00	0.008	31.22
6	*Ageratum conyzoides*	3200.00	8.00	4.00	0.004	20.83
7	*Commelina paludosca*	800.00	4.00	2.00	0.000	4.46
8	*Crossouphalum sp.*	4800.00	16.00	3.00	0.004	28.13
9	*Cyperus flavidus*	4800.00	16.00	3.00	0.003	27.43
10	*Emilia sonchifolia*	4400.00	16.00	2.75	0.001	22.33
11	*Eupatorium denophorum*	9200.00	24.00	3.83	0.004	42.30
Total		**52000.00**	**140.00**		**0.047**	**300.00**

3.9.4.3 S-3: Open Forest near Sohmynting

This sampling site is to moderately steep gentle area located at the elevation of 1325 amsl. The site is located about 305 m above of the river bed. The site is dominated with Camellia caudate and

Castanopsis purpurella. Primary survey revealed a total of 9 tree, 9 shrub and 12 herb species at this sampling site. Tree flora was dominated with Castanopsis purpurella. Tree density was recorded as 310 trees ha-1 while basal cover was recorded as 94.43 m2 ha-1. Melastoma nepalensi, Castanopsis purpurella and Cassia floribunda were found the leading species in shrub flora. Density and basal area for shrub species were recorded as 2280 ha-1 and 3.36 m2 ha-1 respectively. Herbaceous flora was dominated with Paspalum orbiculare, Cyperus flavidus, and Commelina paludosca. Herb density was found as 44400 herbs ha-1**. (Table 3.41).**

Table 3.41：Phytosociological Characters of Plant Community

S. No.	Scientific Name	Density (/ha)	Fre (%)	Ab	Basal Cover (Sq. m/ha)	IVI
Tree						
1	*Castanopsis purpurella*	70.00	40.00	1.75	33.11	79.87
2	*Camellia caudata*	150.00	60.00	2.50	55.43	140.42
3	*Plangium chinensis*	20.00	20.00	1.00	1.69	19.35
4	*Schima wallichii*	20.00	10.00	2.00	2.07	14.20
5	*Saurauria punduana*	10.00	10.00	1.00	0.27	9.06
6	*Rhus javanica*	10.00	10.00	1.00	0.94	9.78
7	*Rhus acuminata*	10.00	10.00	1.00	0.31	9.11
8	*Macaranga denticulate*	10.00	10.00	1.00	0.37	9.17
9	*Syzygium tetragomum*	10.00	10.00	1.00	0.24	9.04
Total		**310.00**	**180.00**		**94.43**	**300.00**
Shrub						
1	*Cassia floribunda*	280.00	30.00	2.33	0.64	43.95
2	*Shutaria vestida*	440.00	40.00	2.75	0.37	46.91
3	*Lantana camara*	120.00	20.00	1.50	0.05	15.20
4	*Eupatorium adenophorum*	40.00	10.00	1.00	0.02	6.38
5	*Itea macrophylla*	480.00	40.00	3.00	0.15	42.30
6	*Melastoma nepalensis*	240.00	30.00	2.00	1.39	64.26
7	*Rubus khasianas*	360.00	30.00	3.00	0.37	39.23
8	*Wendlandia wallichii*	120.00	20.00	1.50	0.05	14.96
9	*Circium sp.*	200.00	20.00	2.50	0.33	26.80
Total		**2280.00**	**240.00**		**3.36**	**300.00**
Herb						
1	*Barreria sp.*	3200.00	8.00	4.00	0.0011	22.27
2	*Plantago erosa*	1600.00	8.00	2.00	0.0003	11.66
3	*Ageratum conyzoides*	1600.00	4.00	4.00	0.0004	9.64
4	*Commelina paludosca*	2400.00	8.00	3.00	0.0018	25.73
5	*Crossouphalum sp.*	2800.00	8.00	3.50	0.0010	19.88
6	*Cyperus flavidus*	5200.00	12.00	4.33	0.0011	29.63
7	*Emilia sonchifolia*	5200.00	16.00	3.25	0.0011	32.49
8	*Paspalum orbiculare*	6000.00	20.00	3.00	0.0011	37.15
9	*Melastoma nepalensis*	2800.00	12.00	2.33	0.0008	21.37
10	*Osbeckia capital*	2800.00	8.00	3.50	0.0005	16.18
11	*Cyperus flavidus*	3200.00	12.00	2.67	0.0011	25.13

12	*Emilia sonchifolia*	7600.00	24.00	3.17	0.0018	48.87
Total		**44400.00**	**140.00**		**0.0123**	**300.00**

3.9.4.4 S-4: Open Forest near Power House Site

The site is located slope of the hill. A total of 3 trees, 8 shrubs and 11 herbs species has been recorded in submergence area. *Schima wallichii* and *Oroxylum indicum* were the tree species recorded from the area with a density of 25 trees ha-1 and a Basal cover of 6.98 m2 ha-1. *Pantapanax fragrans*, *Eurya acuminate,* and *Lantana camara* were the leading species in shrub flora. Shrub's density was recorded as 1280 shrubs ha-1. Herbaceous flora was dominated with *Ageratum conyzoides, Pratia begonifolia and* Bidens pilosa. Herb density was recorded as 24800 herbs ha-1. **(Table 3.42).**

Table 3.42 : Phytosociological Characters of Plant Community

S. No.	Scientific Name	Density (/ha)	Fre (%)	Ab	Basal Cover (Sq. m/ha)	IVI
Tree						
1	*Oroxylum indicum*	5.00	5.00	1.00	1.26	63.07
2	*Ficus sp.*	5.00	5.00	1.00	0.67	54.64
3	*Schima wallichii*	15.00	10.00	1.50	5.05	182.29
	Total	25.00	20.00		6.98	300.00
	Shrub					
1	*Pantapanax fragrans*	200.000	30.000	1.667	0.37	56.58
2	*Eurya acuminata*	80.000	20.000	1.000	0.48	48.68
3	*Sida rhombilolia*	80.000	20.000	1.000	0.08	23.18
4	*Castanopsis indica*	120.000	20.000	1.500	0.10	27.67
5	*Lantana camara*	280.000	20.000	3.500	0.14	42.53
6	*Melastoma nepalensis*	40.000	10.000	1.000	0.07	13.54
7	*Melastoma nepalensis*	240.000	20.000	3.000	0.22	44.14
8	*Mimosa rubicaulis*	240.000	30.000	2.000	0.11	43.68
Total		**1280.000**	**170.000**		**1.58**	**300.00**
Herb						
1	*Isachne himalaica*	800.00	4.00	2.00	0.0004	25.78
2	*Bidens pilosa*	2000.00	4.00	5.00	0.0004	30.62
3	*Commelina paludosca*	800.00	4.00	2.00	0.0004	25.78
4	*Cyperus flavidus*	2000.00	4.00	5.00	0.0001	18.04
5	*Drymaria cordata*	2400.00	4.00	6.00	0.0001	21.85
6	*Eupatorium adenophorum*	2800.00	4.00	7.00	0.0001	23.46
7	*Gnaphalium pensylvanicum*	2800.00	4.00	7.00	0.0001	23.46
8	*Plantago erosa*	2800.00	4.00	7.00	0.0003	29.75
9	*Pratia begonifolia*	2400.00	8.00	3.00	0.0002	31.82
10	*Ageratum conyzoides*	4400.00	12.00	3.67	0.0004	54.58
11	*Melastoma nepalensis*	1600.00	4.00	4.00	0.0000	14.85
Total		**24800.00**	**56.00**		**0.0025**	**300.00**

3.9.4.5 S-5: Open Forest Near Dam site (Submergence Area)

Submergence area has been sampled near Dam site. Submergence area of the Dam is comprised with 7 trees, 11 shrub and 13 herb species. Tree flora recorded with a density of 140 trees ha-1, shrub's density was recorded as 1760 shrubs ha-1 while herb's density has been recorded as 48400 herbs ha-1. Tree basal cover was recorded as 31.64 m2 ha-1. *Schima wallichii, Pantapanax fragrans* and *Ageratum conyzoides* were the dominant plant species in tree, shrub and herb layers respectively **(Table 3.43).**

Table 3.43 : Phytosociological Characters of Plant Community

S. No.	Scientific Name	Density (/ha)	Fre (%)	Ab	Basal Cover (Sq. m/ha)	IVI
Tree						
1	*Ficus sp.*	10.00	10.00	1.00	1.23	22.15
2	*Oroxylum indicum*	20.00	10.00	2.00	1.66	30.63
3	*Bombax ceiba*	20.00	10.00	2.00	2.41	33.01
4	*Erythrina stricta*	10.00	10.00	1.00	0.23	18.98
5	*Schima wallichii*	60.00	30.00	2.00	24.10	152.35
6	*Samanea saman*	10.00	10.00	1.00	0.97	21.32
7	*Vellebrunea integrifolia*	10.00	10.00	1.00	1.04	21.56
Total		**140.00**	**90.00**		**31.64**	**300.00**
Shrub						
1	*Chromolaena odoratum*	160.00	20.00	2.00	0.20	29.63
2	*Pantapanax fragrans*	200.00	20.00	2.50	0.64	57.56
3	*Eurya acuminata*	240.00	40.00	1.50	0.17	41.51
4	*Sida rhombilolia*	280.00	30.00	2.33	0.33	48.31
5	*Castanopsis indica*	160.00	20.00	2.00	0.04	20.40
6	*Lantana camara*	120.00	10.00	3.00	0.01	11.82
7	*Melastoma nepalensis*	80.00	10.00	2.00	0.01	9.55
8	*Melastoma nepalensis*	40.00	10.00	1.00	0.09	12.11
9	*Mimosa rubicaulis*	120.00	20.00	1.50	0.05	18.55
10	*Ixora cuminata*	280.00	30.00	2.33	0.17	39.24
11	*Trevesia palmata*	80.00	10.00	2.00	0.04	11.31
Total		**1760.00**	**220.00**		**1.74**	**300.00**
Herb						
1	Borreria sp.	1600.00	8.00	2.00	0.0023	13.78
2	*Ageratum conyzoides*	6800.00	12.00	5.67	0.0250	69.29
3	*Isachne himalaica*	2400.00	8.00	3.00	0.0018	14.50
4	*Bidens pilosa*	4000.00	16.00	2.50	0.0077	34.82
5	*Commelina paludosca*	4400.00	12.00	3.67	0.0023	22.69
6	*Cyperus flavidus*	4800.00	12.00	4.00	0.0008	20.75
7	*Drymaria cordata*	6000.00	12.00	5.00	0.0016	24.64
8	*Eupatorium adenophorum*	4000.00	8.00	5.00	0.0026	19.25
9	*Gnaphalium pensylvanicum*	2800.00	8.00	3.50	0.0010	13.80
10	*Plantago erosa*	2000.00	8.00	2.50	0.0002	10.75

11	*Pratia begonifolia*	4800.00	8.00	6.00	0.0035	22.62
12	*Melastoma nepalensis*	2000.00	8.00	2.50	0.0023	14.61
13	*Paspalum orbiculare*	2800.00	8.00	3.50	0.0035	18.49
Total		**48400.00**	**128.00**		**0.0544**	**300.00**

3.9.4.6 Diversity and Species Richness

Shannon diversity and Species richness for tree species was recorded highest at sampling station-I (Scrub land near Umsawwar)) and these values were found as 2.06 and 3.11 respectively. Lowest diversity (0.95) for tree species recorded in Power house area while the tree species richness was found least near Dam site. Shrub's diversity and species richness were recorded highest in downstream area whereas the lowest values for shrub's diversity and richness were found near Power house site. As far as the Herb species diversity and richness were concerned, was found highest near Dam site.

3.9.4.7 Seasonal Variation in Species Composition

A total of 37 herbs species were recorded in the study area in all season. Highest number (37) of herb species was recorded during rainy season. (**Table 3.44).**

Table 3.44 : Seasonal variation in Non woody (herbs) species composition

S. N.	Botanical Name	Family	Seasons		
			Winter	Summer	Rainy
1	*Sida cordata*	Malvaceae	P	A	P
2	*Impatiens khasiana*	Balsaminaceae	A	P	P
3	*Oxalis corniculata*	Oxalidaceae	P	A	P
4	*Trigonella foenum-graecum*	Papilionaceae	P	P	P
5	*Melilotus indica*	Papilionaceae	A	P	P
6	*Desmodium triquetrum*	Papilionaceae	P	P	P
7	*Hedyotis vestita*	Rubiaceae	A	P	P
8	*H. scandens*	Rubiaceae	A	P	P
9	*Ageratum conyzoides*	Asteraceae	A	A	P
10	*Blumea chinensis*	Asteraceae	A	P	P
11	*Crepis japonica*	Asteraceae	A	A	P
12	*Inula cappa*	Asteraceae	A	A	P
13	*Mikania macrantha*	Asteraceae	A	P	P
14	*Senecio araneosus*	Asteraceae	A	A	P
15	*Lophatherum gracile*	Poaceae	A	A	P
16	*Isachne himalaica*	Poaceae	A	P	P
17	*Selaginella semicordata*	Selaginallaceae	P	P	P
18	*Hedychium ellepticum*	Zingiberaceae	P	P	P
19	*Globba clarkia*	Zingiberaceae	A	P	P
20	*Begonia palmata*	Begoniaceae	P	P	P
21	*Impatiens khasiana*	Balsaminaceae	A	P	P

22	*Impatiens banthamii*	Balsaminaceae	P	P	P
23	*Commelina paludosca*	Commelinaceae	A	P	P
24	*Panicum brevifolium*	Poaceae	P	P	P
25	*Murdannia gigantean*	Commelinaceae	A	P	P
26	*Aeginetia indica*	Orobanchaceae	A	P	P
27	*Carex filicina*	Cyperaceae	A	P	P
28	*Crassocephalum crepidioides*	Asteraceae	A	P	P
29	*Achyrospermum wallichianum*	Lamiaceae	A	P	P
30	*Elatostema dissectum*	Urticaceae	P	P	P
31	*Elsholtzia blanda*	Lamiaceae	P	P	P
32	*Arisaema tortuosum*	Araceae	A	P	P
33	*Dianella ensata*	Liliaceae	P	P	P
34	*Cyanotis vaga*	Commelinaceae	A	P	P
35	*Balanophora dioica*	Balanophoraceae	A	P	P
36	*Murdannia nudiflora*	Commelinaceae	A	A	P
37	*Sonerila khasiana*	Melastomaceae	A	P	P

(W - winter, S - Summer, M - Monsoon, + - Present)

3.9.4.8 Rare, Endangered, threatened (RET) Species recorded/reported from study area

As per the primary survey no RET species were recorded. However, as per secondary data records 8 RET species have been recorded/reported from Khasi and Jaintia hills area. Detail list of the RET species is presented in **Table 3.45.**

Table 3.45 : List of Orchids reported in Khasi and Jaintia Hills

Family	Name of plant species	Status as per IUCN / BSI
Asclepiadaceae	*Ceropegia angustifolia*	Vulnerable NE Hilly region, Khasi
Cyperaceae	*Fimbristylis stolonifera*	Rare in abandoned jhum of Khasi hills
Elaeocarpaceae	*Elaeocarpus prunifolius*	Rare
Orchidaceae	*Paphiopedilum venustum*	Vulnerable
Orchidaceae	*Vanda coerulea*	Rare
Theaceae	*Cleyera japonica*	Rare
Thelypteridaceae	*Metathelypteris decipiens*	Rare / Endemic
Thelypteridaceae	*Coryphopteris didymochlaenoides*	Rare / Endemic Fern

3.9.5. ***Fauna***

3.9.5.1 Faunal Diversity (Meghalaya State):

More than 110 mammal species are reported from the Meghalaya Forests, but none is endemic to the state. Some of the species of conservation importance include tiger (*Panthera tigris*), clouded leopard (*Pardofelis nebulosa*), Asian elephant (Elephas maximus), wild dog (*Cuon alpinus*), Malayan sun bear (*Ursus malayanus*), sloth bear (*Melursus ursinus*), large Indian civet (*Viverra zibetha*),

Chinese pangolin (*Manis pentadactyla*), Indian pangolin (*Manis crassicaudata),* Assamese macaque (*Macaca assamensis*), bear macaque (*Macaca arctoides*), and capped leaf monkey *(Semnopithecus pileatus*). The tiger, clouded leopard, Asian elephant, Assamese macaque, bear macaque, capped leaf monkey, wild dog, sloth bear, and smooth-coated otter are threatened species (IUCN 2000). There are about 2,000 elephants in the Garo Hills and 500 in Jaintia Hills. The wild Buffaloes are also found in the forests of Meghalaya. Frogs and toads represent amphibians. Three types of reptiles - lizards, tortoises and snakes, are reported from the state. Several species of fishes and crabs are also found.

3.9.5.2 Faunal Study

Faunal survey was carried out for the species of Mammals, Birds, Herpetofauna and Insects and the study of mammals and birds were studied by placing systematic transects at different sampling locations in the study area. This exploration of the species was carried out with respect to the habitat types and altitudes where they occurred. A study and survey of Birds (resident, migratory), land animals including mammals, reptiles and insects and aquatic flora and fauna including fish species was undertaken during the study period by a team of experienced biologists. Fauna of Meghalaya (Volume I and II), published by the Zoological Society of India, Meghalaya Flora and Fauna by the Directorate of information and Public relations, Government of Meghalaya and published Scientific reports have been used as references. As far as the larger vertebrates including Carnivores and reptiles are concerned, the data is based mainly on secondary sources corroborated by local residents. Birds have been watched using binoculars, photographed for identification. But the list of birds is based both on primary and secondary sources. Butterflies are based mainly on primary observations.

3.9.5.3 Mammals

All the sampling for mammalian fauna was carried out in the morning and evening time by using 2-3 km long transects and animal trails. The focus of the sampling was towards the direct sighting of animals but indirect signs like scats, pellets, pugmarks, scraps, vocalizations, horns etc. were also recorded during the survey walk and refereed for the presence of animals. The indirect evidences and information of the animal presence has been also collected through the interviews of local people and available literature. A list of mammals reported from the catchment area is given in **Table 3.46.** The list is mainly based on secondary sources as per the list only Leopard is schedule-I species.

Table 3.46：List of mammalian species recorded (direct or indirect evidences) during the study

S.N.	Scientific Name	Common Name	Family	WPA Schedule
1	*Panthera pardous*	Leopard	Felidae	Sch I (Part I)
2	*Macaca arctoides*	Bear macaque	Cercopithecidae	Sch II (Part I)
3	*Macaca assamensis*	Assam macaque	Cercopithecidae	Sch II (Part I)
4	*Felis chaus*	Jungle Cat	Felidae	Sch II (Part I)
5	*Canis aureus*	Jackal	Canidae	Sch II (Part I)
6	*Viverricula indica*	Small Indian Civet	Viverridae	Sch II (Part I)
7	*Paguma larvata*	Masked Palm Civet	Viverridae	Sch II (Part I)
8	*Antherurus macrourus*	Bush-tailed porcupine	Hystricidae	Sch II (Part I)
9	*Suncus murinus*	House Shrew	Soricidae	Least Concern
10	*Suncus fellowesgordoni*	Pigmy Shrew	Soricidae	Least Concern
11	*Anourosorex squamipes*	Chinese Mole Shrew	Soricidae	Least Concern

12	*Herpestes urva*	Crab Eating mongoose	Herpestidae	Sch II (Part I)
13	*Herpestes edwardsii*	Indian Grey Mongoose	Herpestidae	Sch II (Part I)
14	*Muntiacus muntjak*	Barking deer	Cervidae	Sch III
15	*Rusa unicolor*	Sambar	Cervidae	Sch III
16	*Dremomys lokriah*	Long-nosed Squirrel	Sciuridae	Sch II (Part I)
17	*Ratufa bicolor*	Him. Giant squirrel	Sciuridae	Sch II (Part I)
18	*Petaurista*	Red Giant Flying Squirrel	Sciuridae	Sch II (Part I)
19	*Callosciurus pygerythrus*	Hoary Bellied Squirrel	Sciuridae	Sch II (Part I)
20	*Parascaptor leucura*	Indian Mole	Talpidae	Sch IV
21	*Rattus niviventer*	House Rat	Muridae	Sch IV
22	*Chiropodomys gliroides*	Pencil-tailed Tree Mouse	Muridae	Sch V
23	*Berylmys bowersi*	White-toothed Rat	Murinae	Sch V
24	*Berylmys mackenziei*	Keneth's Rat	Murinae	Sch V
25	*Leopoldamys edwardsi*	Long-tailed giant Mouse	Murinae	Sch V
26	*Rhizomys pruinosus*	Hoary Bamboo rat	Spalacidae	Sch-V
27	*Cannomys badius*	Lesser Bamboo Rat	Spalacidae	Sch-V
28	*Rhinolophus pusillus*	Least Horseshoe bat	Rhinolophidae	Sch IV

3.9.5.4 Reptilian Fauna

The Reptilian fauna were sampled on the same transect marked for mammals/birds. Moreover, the sampling also carried out along the banks of River and adjoining springs/Nallas of submergence and downstream sections of dam site. The reptilian fauna of the Umngot Hydroelectric project is given in **Table 3.47**. None of the species that come under the RET category were spotted during the surveys.

Table 3.47 : List of Reptilian fauna recorded from the study area

S.N.	Common name	Latin name	Distribution	Status	
				ZSI /IUCN	WPA Schedule
1	Lizard	*Cyrtodactylus khasiensis*	Widespread	Common	II (Part II)
2	Lizards	*Cosymbotus platyurus*		Common	II (Part II)
3	Lizards	*Calotes emma*	Widespread	Common	II (Part II)
4	Lizards	*Calotes jerdoni*	Widespread	Common	II (Part II)
5	Lizards	*Calotes versicolor*	Widespread	Common	II (Part II)
6	Lizards	*Gecko*	Widespread	Common	II (Part II)
7	House Gecko	*Hemidactylus brooki*	Widespread	Common	II (Part II)
8	Monitor lizard	*Varanus bengalensis*	Common	Vulnerable	I (Part II)
9	Yellow Monitor	*Varanus flavescens*	Common	Endangered	I (Part II)
10	Water Monitor	*Varanus salvator*	Common	Endangered	I (Part II)
11	Rock Python	*Python molorus*	Scarce	Endangered	I (Part II)
12	Rat snake	*Ptyas korros*	Very common	Common	II (Part I)

13	Black Krait	*Bungarus niger*	Common	Scarce	II (Part II)
14	Banded Krait	*Bungarus fasciatus*	Common	Scarce	II (Part II)
15	Indian Cobra	*Naja*	Scarce	Threatened	II (Part II)
16	Pit Viper	*Trimeresurus albolabris*	Common	common	II (Part II)

3.9.5.5 Avifauna

Bird survey was conducted on the same transects and trails marked for mammal's survey. The whole sampling was carried out in a fixed width trails of 2-3 km wherever the terrain permits and point counts were carried out at a fixed distance at more or less at regular intervals. A prismatic field binocular (10X50) was used for the bird watching during transect walk mostly during morning and evening hours at nearby habitations as well as near to water bodies in the study area. An on-spot identification of birds has been carried out with the help of pictorial guides/literature published by Grimmett et al. (2011). A list of local, resident, migrant and vagrant birds of the catchment area of the Umngot River is given in **Table 3.48.** The list shows none of species belong to the Schedule I category of the WPA,

Table 3.48 : List of Avifauna recorded during the study

Sl. No.	Common name	Latin name	Order	Residential status	WPA Schedule
1	Assam Bamboo Partridge	*Bambusicola fytchii*	Galiformes	Local migrant	IV
2	Assam Black Partridge	*Francolinus*	Galiformes	Local migrant	IV
3	Black winged kite	*Elanus caeruleus*	Falconiformes	Local migrant	IV
4	Brahmy Kite	*Heliaster 122ndus*	Falconiformes	Local migrant	IV
5	Cattle Egret	*Bubulcus ibis*	Ciconiformes	Local migrant	IV
6	Common Pochard	*Aythya ferina*	Ciconiformes	Local migrant	IV
7	Common Teal	*Anas crecca*	Ciconiformes	Local migrant	IV
8	Coot	*Fulica atra*	Gruciformes	Resident	IV
9	Eastern Grey Goose	*Anser*	Ciconiformes	Migratory	IV
10	Eastern Grey Heron	*Ardea cinerea*	Ciconiformes	Local migrant	IV
11	Eastern Purple Heron	*Ardea purpurea*	Ciconiformes	Local migrant	IV
12	Eeastern Steppe Eagle	*Aquila rapax*	Falconiformes	Local migrant	IV
13	Goshawk	*Accipiter gentiles*	Falconiformes	Local migrant	IV
14	Great egret	*Ardea alba*	Ciconiformes	Local migrant	IV
15	Indian Black Vulture	*Sarcogyps calvus*	Falconiformes	Local migrant	IV
16	Indian Moorhen	*Gallinula chloropus*	Gruciformes	Local migrant	IV
17	Indian Red jungle Fowl	*Gallua gallus murghi*	Galiformes	Resident	IV
18	Indian Shikra	*Accipiter badius*	Falconiformes	Local migrant	IV
19	Khalij Pheasant	*Polyplectron biclcaratum*	Galiformes	Local migrant	IV
20	Large cormorant	*Phalacrocorax carbo sinensis*	Felicaniformis	Local migrant	IV

21	Large Indian Kite	*Milvus migrans*	Falconiformes	Local migrant	IV
22	Lesser whistling Teal	*Anas javanica*	Ciconiformes	Local migrant	IV
23	Little Bustard Quail	*Turnix sylvatica*	Gruciformes	Local migrant	IV
24	Little cormorant	*Phalacrocorax niger*	Felicaniformis	Local migrant	IV
25	Little grebe	*Podiceps rufficollis*	Podicipediformis	Migratory	IV
26	Little green Heron	*Ardea striatus*	Ciconiformes	Local migrant	IV
27	Night Heron	*Nycticorax nycticorax*	Ciconiformes	Local migrant	IV
28	Paintail	*Anas acuta*	Ciconiformes	Local migrant	IV
29	Pariah kite	*Milvus migrans*	Falconiformes	Vagrant	IV
30	Peacock Pheasant	*Polyplectron bicalcaratum*	Galiformes	Vulnerable	IV
31	Smaller / median Egret	*Egretta intermedia*	Ciconiformes	Local migrant	IV
32	Pheasant tailed Jacana	*Hydrophasianus chirurgus*	Gruciformes	Resident	IV
33	Red Wattled Lapwing	*Vanellus indicus*	Gruciformes	Resident	IV
34	Eastern golden Plover	*Pluvialis dominica*	Gruciformes	Resident	IV
35	Eastern Little Ringed Plover	*Charadrius dubius curonicus*	Gruciformes	Resident	IV
36	Spotted Sandpiper	*Tringa glareola*	Gruciformes	Resident	IV
37	Common sandpiper	*Tringa hypoleucos*	Gruciformes	Resident	IV
38	Fantail Snipe	*Gallinago gallinago*	Gruciformes	Local migrant	IV
39	Woodcock	*Scolopax rusticola*	Gruciformes	Resident	IV
40	Painted snipe	*Rostratula benghalensis*	Gruciformes	Local migrant	IV
41	Indian River Tern	*Sterna aurantia*	Gruciformes	Local migrant	IV
42	Wedge tailed Pigeon	*Treron spenura*	Columbiformes	Resident	IV
43	Bengal green Pigeon	*Treron phoenocoptera*	Columbiformes	Resident	IV
44	Indian Blue rock Pigeon	*Columba livia*	Columbiformes	Resident	IV
45	Indian Ring Dove	*Streptopelia decaocto*	Columbiformes	Resident	IV
46	Indian spotted dove	*Streptopelia chinensis*	Columbiformes	Resident	IV
47	Northern Ring nosed Parakeet	*Psittacula krameri*	Psittaciformes	Resident	IV
48	Northern blossom headed Parakeet	*Psittacula cyanocephala*	Psittaciformes	Resident	IV
49	Indian Lorikeet	*Loriculus vernalis*	Psittaciformes	Resident	IV
50	Red winged crested Cuckoo	*Clamator coromandus*	Cuculiformes	Local migrant	IV
51	Common Hawk Cuckoo	*Cuculus varius*	Cuculiformes	Local migrant	IV
52	Indian Cuckoo	*Cuculus micropterus*	Cuculiformes	Local migrant	IV
53	Khasi Hills Cuckoo	*Cuculus canorus*	Cuculiformes	Resident	IV
54	Indian Koel	*Eudynamis scolopacea*	Cuculiformes	Local migrant	IV
55	Grass Owl	*Tyto capensis*	Strigiformes	Local migrant	IV
56	Indian great horned Owl	*Bubo bengalensis*	Strigiformes	Local migrant	IV
57	Northern Spotted Owl	*Athene brama indica*	Strigiformes	Local migrant	IV

58	Eastern Palm Swift	*Cypsiurus parvus*	Apordiformes	Local migrant	IV
59	Indian Pied Kingfisher	*Ceryle rudis*	Coraciformes	Local migrant	IV
60	Great Blue Kingfisher	*Alcedo hercules*	Coraciformes	Local migrant	IV
61	Assam Blue - eared Kingfisher	*Alcedo meninting*	Coraciformes	Local migrant	IV
62	Eastern White breasted Kingfisher	*Halcyon smyrnensis*	Coraciformes	Local migrant	IV
63	Burmese Roller	*Coracias bengalensis*	Coraciformes	Local migrant	IV
64	Assam Great Barbet	*Megalaima virens*	Piciformes	Local migrant	IV
65	Blue throated Barbet	*Megalaima asiatica*	Piciformes	Local migrant	IV
67	Eastern Rufus Woodpecker	*Micropternus brachyurus*	Piciformes	Local migrant	IV
68	Black necked green Woodpecker	*Picus canus*	Piciformes	Local migrant	IV
69	Pole headed Woodpecker	*Gecinulus grantia*	Piciformes	Local migrant	IV
70	Assam Great Slaty Woodpecker	*Mulleripicus pulverulentus*	Piciformes	Resident	IV
71	Green breasted Pitta	*Pitta sordida*	Piciformes	Resident	IV
72	Black necked Oriole	*Oriolus xanthornus*	Piciformes	Resident	IV
73	North Indian Black Drongo	*Dicrurus adsimillis*	Piciformes	Local migrant	IV
74	Assam Grey Drongo	*Dicrus leucophaeus*	Piciformes	Resident	IV
75	Grey headed Myna	*Sturnus malabaricus*	Piciformes	Resident	IV
80	Indian Pied Myna	*Sturnus contra*	Piciformes	Resident	IV
81	Hill Myna	*Gracula religiosa*	Piciformes	Resident	IV
82	Indian House Crow	*Corvus splendens*	Piciformes	Resident	V
83	Eastern Jungle Crow	*Corvus macrorhynchos*	Piciformes	Resident	IV
84	Indian wood Shrike	*Tephrodornis pondicerianus*	Piciformes	Local migrant	IV
85	Small Grey	*Coracina*	Piciformes	Local migrant	IV
86	Cuckoo Shrike	*melaschistos*			
87	Finch billed Bulbul	*Spizixos canifrons*	Piciformes	Resident	IV
88	Black headed Bulbul	*Pycnonotus atriceps*	Piciformes	Resident	IV
89	Striated green Bulbul	*Pycnonotus striatus*	Piciformes	Resident	IV
90	White throated Bulbul	*Criniger flaveolus*	Piciformes	Resident	IV
91	Assam brown Babbler	*Pellorneum albiventre*	Piciformes	Resident	IV
92	Long tailed Wren Babbler	*Spelaeornis longicaudatus*	Piciformes	Local migrant	IV
93	Red headed Babbler	*Stachrys chrysaea*	Piciformes	Local migrant	IV
94	Yellow breasted Babbler	*Macronous gularis*	Piciformes	Local migrant	IV
95	Red capped Babbler	*Tamalia pileata*	Piciformes	Local migrant	IV
96	Assam orange Parrot bill	*Paradoxornis nipalensis*	Piciformes	Local migrant	IV
97	Assam red headed Parrot bill	*Paradoxornis ruficeps*	Piciformes	Local migrant	IV

3.9.5.6 Butterfly/Moth

The butterflies are beautiful day flying insects of order Lepidoptera which make excellent subject for natural history observation as they can be reared at home and can be easily observed for various stages of the development of organisms. Earlier butterflies classified into smaller families and India alone had 9 families. However, many of the older families are now merged into the family Nymphalidae and finally only 5 families maintaining across the world and all of which are represented in India. During the primary surveys for three seasons, a total of 14 species of butterfly were encountered from the study area. Blue Pansy, Common Marmon, Indian Cabbage White, Plain Tiger, Long-tailed Blue and Common Emigrant are most frequent species recorded from study area. No moth species has been recorded in primary survey **(Table 3.49).**

Table 3.49 : List of Insects and Butterflies recorded from the study area

S.N.	Scientific name	Family	Common Name	Conservation Status as per IWPA
1	*Princeps polyctor*	Papilionidae	Blue Peacock	-
2	*Priceps helenus*	Papilionidae	Red Helen	-
3	*Princeps castor*	Papilionidae	Common Ravan	-
4	*Graphium sarpedon*	Papilionidae	Common Bluebottle	-
5	*Graphium*	Papilionidae	Tailed Jay	-
6	*Eurema hecabe*	Pieridae	Common Grass Yellow	-
7	*Eurema blanda*	Pieridae	Three Spot Grass Yellow	-
8	*Catopsilia Pomona*	Pieridae	Common Emigrant	-
9	*Catopsilia pyranthe*	Pieridae	Mottled Emigrant	-
10	*Hebomoia glaucippe*	Pieridae	Great Orange Tip	
11	*Appias libythea*	Pieridae	Striped Albatross	IV
12	*Appias lyncida*	Pieridae	Chocolate Albatross	II
13	*Cepora nadina*	Pieridae	Lesser Gull	II
14	*Pieris canidia*	Pieridae	Indian Cabbage White	-
15	*Delias spasithoe*	Pieridae	Red-Base Jezebel	-
16	*Jamides celeno*	Lycaenidae	Common Cerulean	II
17	*Zizeeria karsandra*	Lycaenidae	Dark Grass Blue	-
18	*Pseudozizeeria maha*	Lycaenidae	Pale Grass Blue	-
19	*Zizina otis*	Lycaenidae	Lesser Grass Blue	-
20	*Chilades lajus*	Lycaenidae	Lime Blue	-
21	*Zemeros flegyas*	Lycaenidae	Punchinello	-
22	*Neptis soma*	Nymphalidae	Sullied Sailer	II
23	*Neptis hylas*	Nymphalidae	Common Sailer	-
24	*Euploea aglae*	Nymphalidae	Common Crow	-
25	*Mycalesis mineus*	Nymphalidae	Dark-Brand Bushbrown	-
26	*Ypthima huebner*	Nymphalidae	Common Fourring	-
27	*Pelopidas mathias*	Hesperiidae	Small Branded Swift	-
28	*Junonia almana*	Nymphalidae	Peacock Pansy	-

3.9.6. *Aquatic Ecology*

An in-depth aquatic ecological study was carried out in the project area for three seasons as per the ToR provided by MoEF. Primary data on various components of aquatic biodiversity were collected through intensive field survey of the study area, aquatic sampling and consultation with local communities. Review of secondary data was also made for confirming the primary data. Secondary data review has been carried out by using published research papers/literatures. No commercial fishing is available in the entire stretch of Umngot River.

METHODOLOGY

The Umngot is one of the major southwardly flowing rivers of Meghalaya originating at an altitude of 1840 m from the junction of Nongkrem road and NH-44 which is at a distance of 11 km from Shillong, situated in Khasi Hills district of Meghalaya. The drainage is of Trellis pattern where long tributaries flow down the dip slopes and small tributaries flow down the escarp slope. The Umngot Hydroelectric Project is located within a typical plateau land of Meghalaya characterized by flat adulatory table top and deep gorges. The river Umngot flows along such a deep gorge in almost southerly direction starting near Smit, in the East Khasi Hills District. The mean elevation of the plateau near the project area is around 1350 m and with a smooth and gentle slope toward south. The general elevation difference between plateau top and the river bed at the dam site is about 400 m but near the power house area the elevation difference increases up to 600 m approximately.

Sampling Design: HEP impact terrestrial and aquatic environments variously and most important of them are the flow regimes. Therefore, various sampling designs are needed to assess the biodiversity and suitable environmental flow. In order to assess the biodiversity and understand impacts on it, stations were selected up and down stream of the proposed dam site. A total of three sampling stations were selected to evaluate the aquatic biodiversity and determine the degree of impact on aquatic biodiversity and water quality. Details of the phytoplankton and zooplanktons sampling locations is presented in **Table 3.50.**

Table 3.50 : Phytoplankton's, Zooplanktons and Benthos Sampling Locations

Sl. No.	Location Name	Coordinates
1	Umngot river near Dam site (2 km Upstream)	25°21'58.69" N & 92° 6'33.34"E
2	Umngot river near Dam site (2 km downstream)	25°21'29.28"N & 92° 6'29.47"E
3	Umngot river near Power house site (2 km downstream)	25°19'14.37"N & 92° 2'41.08"E

Sampling Rationale for Aquatic Biodiversity: In order to understand aquatic ecosystem of river line running in project area, biological components which constitute the structure of an ecosystem, the major communities found in the stream; the bottom dwelling benthos were sampled. Since the benthic diatoms (a group of algae with silica walls) are abundant in the mountain streams, they were opted to represent the auto-trophs. In case of the hetero-trophs, the benthic macro-invertebrates with high indicator value were considered suitable. Fish is also an important part of the aquatic ecosystem for the same functions. It is a cheap source of high-quality animal protein and hence as nutritional food for the mountain communities and therefore is an integral part of their daily life. A qualitative study of these indicator groups provides the knowledge of aquatic flora and fauna while quantitative studies help to understand the community features such as taxonomic composition of species, abundances and assemblages which vary with the physical and chemical attributes of the

ecosystem. The sampling was carried out during winter, summer and Monsoon seasons as per ToR provided by the MoEF. A total of 4 biological parameters were studied which are as follows:

Sampling for Plankton Communities (Phytoplankton and Zooplankton): Plankton is sampled by sieving 100 liters of water through plankton net mesh size (25 µ). The sieved sample is preserved in 4% formalin for microscopic study. Density is computed by performing counts in S-R Cell according to Welch (1948). Identifications are performed with the help of standard keys (Edmondson 1959; Prasad & Mishra 1992, Krammer and Lange-Bertalot 1999; 2004; Lange Bertalot 2001, Jaiswal & Tiwari 2003).

Zoobenthos (Benthic Invertebrates): The macro-invertebrate fauna is sampled by carefully lifting small boulders, cobbles and pebbles from the marked area (1 ft2) and washing in a bucket full of water by dipping number of times to dislodge the attached fauna. Soft substratum in the form of clay and silt is sampled with Ekmann dredge. The sediments are sieved to obtain the fauna. Samples are preserved in 5% formalin for laboratory analysis. Macro-invertebrate samples are identified to family and class level with the help of standard keys (Edmondson 1959; Edington & Hildrew 1995).

Nekton (Fish): Fish samples are collected by experimental fishing through cast net and gill net and local markets/shops. The samples are preserved in 10% formalin for species identification with the help of standard keys (Day 1958; Talwar & Jhingran1991; Jayaram 2002). Fish samples are used for determining the food habits and the environmental resource base.

3.9.6.2 Plankton:

In case of phytoplankton, a total 31 taxa were observed in all the three stations. Out of these 31 taxa, 6 taxa belong to class Cyanophyceae, 12 belong to class Chlorophyceae, 2 belongs to Euglenophyceae and 13 from. Class Bacillariophyceae. Class Bacillariophyceae was most abundant group followed by Chlorophyceae and Cyanophyceae. Distribution of Planktons in Umngot river at different location is presented in **Table 3.51**.

Table 3.51：Distribution of Phytoplankton taxa in pond and river habitats

Sl. No.	Taxa	S1	S2	S3
Cyanophyceae- Blue green algae				
1	*Oscillatoria sp.*	+	-	+
2	*Microcystis sp.*	+	+	+
3	*Leptolyngbya sp.*	+	+	-
4	*Anacystis sp.*	+	+	+
5	*Microcystis sp.*	+	+	+
6	*Anabaena spiroides*	+	+	+
Cholorophycae- Green Algae				
7	*Ankistrodesmus falcatus*	+	+	-
8	*Closterium acutum*	+	+	-
9	*Cosmarium spp*	+	-	+
10	*Characium sp*	-	+	+
11	*Hyalotheca sp*	+	+	+
12	*Oedogonium sp.*	+	+	-
13	*Scenedesmus dimorphus*	-	+	+
14	*Cladophora sp.*	+	-	+
15	*Ulothrix sp.*	-	-	+

16	*Zygnema sp.*	+	+	+
17	*Spirogyra sp.*	+	-	+
18	*Chlorella sp.*	+	+	+
Euglenophycae /Flagillates				
19	*Euglena vedinas*	-	+	+
20	*Chlamydomonas sp*	+	+	-
Bacillariophycae-Diatoms				
21	*Achnanthidium spp*	-	-	+
22	*Navicula spp*	+	+	+
23	*Synedra spp*	+	-	+
24	*Fragillaria spp*	+	+	+
25	*Nitzeschia spp*	+	-	+
26	*Cymbella spp*	-	+	+
27	*Gomphonema spp*	+	+	-
28	*Hantzschia amphioxys*	+	+	+
29	*Craticula sp*	-	-	+
30	*Denticula kutzing*	+	+	-
31	*Diatoma vulgare*	+	+	+
Shannon Diversity Index (Monsoon)		1.45	1.40	1.42
Shannon Diversity Index (Winter)		1.45	1.46	1.48
Shannon Diversity Index (Summer)		1.50	1.45	1.53

3.9.6.3 Zooplankton

Rotifers and cladocera larvae were chief component of zooplanktonic communities that serves as fish food. The taxa observed at different sites of Umngot river were Rotaria sp, Brachionus spp, Fillinia sp., Keratella sp. (Rotifers) and Bosmina sp. (Cladocera). In case of zooplankton, a total 25 taxa were observed in all the three stations. Out of these 25 taxa, 5 taxa belong to class Protozoa, 9 belong to class Rotifera, 3 belongs to Copepoda, 6 belongs to Cladocerans and 2 from. Ostracos. Rotifera was most abundant group. Distribution of zooplanktons in Umngot river at different location is presented in **Table 3.52.**

Table 3.52：Distribution of Zooplankton taxa in pond and river habitats

Sl. No.	Taxa	S1	S2	S3
Protozoa				
1	*Arcella discoida*	+	+	+
2	*Ceratium sp.*	+	-	+
3	*Paramecium sp.*	-	-	+
4	*Vorticella sp.*	+	+	-
5	*Didinium sp*	+	+	-
Rotifera				
6	*Asplanchnopus brightwelli*	+	-	+
7	*Brachionus sp.*	+	+	+
8	*B. rubens, B. bidens*	+	-	+

9	*B. caudatus*	-	+	+
10	*Filinia longiseta*	+	+	+
11	*Keratella tropica*	+	+	-
12	*Monostylla bulla*	-	+	+
13	*Trichocera longiseta*	+	-	+
14	*Rotaria sp*	-	-	+
Copepoda				
15	*Cyclops leuckarti*	-	+	+
16	*Diaptomus sp.*	+	+	-
17	*Mesocyclops hyalinus*			
Cladocera				
18	*Daphinia corinata*	+	-	+
19	*Daphinia pulex*	+	+	+
20	*Daphnia circinata*	-	-	+
21	*Moina branchiate*	+	+	-
22	*Alona macrocopa*	+	-	+
23	*Bosmina loniotris*	+	+	+
Ostracods				
24	*Heterocypris sp*	+	+	-
25	*Cypris sp*	+	-	+
Shannon Diversity Index (Monsoon)		1.10	1.04	1.06
Shannon Diversity Index (Winter)		1.32	1.28	1.29
Shannon Diversity Index (Summer)		1.52	1.42	1.48

3.9.6.4 Macro-Invertebrates

In riverine ecology and wetland ecosystem, benthic invertebrate fauna provides a crucial link between the primary producers (aquatic plants and algae) and the higher consumers (fish, birds, amphibians). As a food for higher consumers, they are particularly important as a source of protein. Birds require high protein levels during breeding and moulting, and duckling survival has been shown to increase with invertebrate abundance (Scheffer, 1998). Macro invertebrates are widely used as indicators of short- and long-term environmental changes in both lentic and lotic systems. They provide both a facility for examining temporal changes and integrating the effects of prolonged exposure to intermittent discharges or variable concentrations of pollutants (Hellawell, 1986). Thus, it is promising to characterize the changes occurring in these macro invertebrate communities to assess target ecosystems exposed to environmental disturbance. Macro-invertebrate's fauna comprises of 16 species belonging to order Ephemeroptera, Diptera, Odonata and Hemiptera (**Tables 3.53**). The lower density and diversity of macro-invertebrates can be attributed to the high-water velocity and lesser number of riffle-pool habitats. Species richness, density and species composition of macro-invertebrates are largely used as indicators of the water quality. Though, low richness and density of macro-invertebrate in Umngot river is due to washing out due to monsoonal rains and its naturally happening.

Table 3.53 : Macrobenthos Invertebrate fauna in the Study Area

Sl. No.	Species	S1	S2	S3
Ephemeroptera				
1	*Ephemera nadinac*	+	+	+
2	*Ephemera sp*	+	-	+
3	*Ephemerella indica*	-	-	+
4	*Baetis simplex*	+	+	-
5	*Baetis festivus*	+	+	-
6	*Caenis latipennis*			
7	*Epeorus gilliesi*			
8	*Cinygmula sp.*			
9	*Orthetrum sp*			
10	*Chironomus sp*			
Odonata				
11	*Orthetrum sp*	+	-	+
Diptera				
12	*Chironomus sp*	+	-	+
13	*Simulium sp*	-	+	+
Hemiptera				
14	Aphids, Bugs, Necton & misquotes larvae: Anisops sp, Gyrinus sp	+	+	-
Molluscan				
15	Indian river Crab, keakura	+	-	+
16	Shrimps	-	-	+
Shannon Diversity Index (Monsoon)		0.90	0.86	0.88
Shannon Diversity Index (Winter)		0.95	0.98	0.93
Shannon Diversity Index (Summer)		1.03	0.98	1.04

3.9.6.5 Nektons (Fish community)

A total of 16 fish species from 7 families were reported from Umngot river from all primary as well as secondary sources. Considering the number of fishes in Umngot river and adjacent area, it can be concluded that the area is not rich ichthyol faunal diversity. The low fish diversity in this area can be attributed to the nature of river and land use/ land cover in the catchment and habitat structure including river morphology. It is observed that 50% of the fish species collected belonged to the family Cyprinidae. This perhaps may be due to the fact that fishes which are highly adaptable in the hill streams belong to the family Cyprinidae more than any other family. Genus like Garra, Psilorhynchus, Labeo, Cyprinus are inhabitants of hill streams. During the primary survey a total of 6 species were observed from the influence area of proposed project. List of fish species reported/ observed in the study area are listed in **Table 3.54.**

Table 3.54 : Fish Species Composition in Study Area (Umngot River)

S. No.	Family	Fish Species	Local Name (Khasi)	IUCN status
1	Bagridae	*Mystus cavasius*	Kha Kot / Kha Tyngkra	LC

2	Balitoridae	*Balitora brucei*		VU
3	Belonidae	*Xenentodon cancila*	Chowkli	VU
4	Chacidae	*Chaca chaca*	Gajeb-bakau	NT
5	Chandidae	*Chanda nama*	Kha Snad	
6	Cyprinidae	*Chela laubuca*		LC
7	Cyprinidae	*Cirrhinus reba*	Kha mirka	LC
8	Cyprinidae	*Garra gotyla*	Doh Jei	VU
9	Cyprinidae	*Garra lamta*	Doh Jei	LC
10	Cyprinidae	*Labeo boga*	Kha bah	LC
11	Cyprinidae	*Labeo calbasu*	Kha long	LC
12	Cyprinidae	*Labeo gonius*	Kha ski	LC
13	Cyprinidae	*Labeo pangusia*	Kha baw	NT
14	Cyprinidae	*Puntius chola*	Shalynni	LC
15	Mastacembelidae	*Macrognathus aral*	Kha Baien	LC
16	Siluridae	*O. pabo*	Kha Babia	VU

- Migratory Fishes
  Out of 16 fish species *Labeo calbasu* is the only important fish specie which move from down stream to upstream for spawning during May to August (Bulletin No. 156 CIFRI). All other native fish fauna performs local and daily movements for their basic biological needs (access habitat, food and shelter, defend territory). The Pendum fall on Umngot river on d/s of proposed dam site having vertical drop is the major obstacle for movement of fishes from downstream (Dawki) to upstream as the fishes cannot negotiate the excessive vertical drop by jumping. Therefore, the movement of *Labeo Calbasu* is already hampered from downstream. Therefore, the specie like other species shall make lateral movement to upstream into hill streams.

- Breeding Ground
  Several areas along bank having sandy and gravel bed, shallow depth, feeble or no currents constitute preferred sites for fish breeding and spawning. Besides this hill stream/rivulet, like Wah Shyckiang, Um Talu, Um Le, Wah Pashang, Wah Umllong, Wah Jatah etc., which confluence with river have pool and riffle bed configuration have good ground for spawning. But creation of the dam obviously would result in inundations of these sites in the main river resulting in the loss or breeding grounds. The location of some of the breeding grounds is shown in **Figure 2.4.**

3.9.7. *Cropping and Irrigation Practices in the Study Area*

As per Agro-Climate Zone (NARP), the district has been categorized as Sub-Tropical Hill Zone (NEH-5) and is covered under Eastern Himalayan Region (II) as per agro-climate zone (Planning Commission). Major crops grown are Rice, Maize, Pea, Cow pea, Soya bean, sesamum and Mustard. Fruits grown in the area are Khasi Mandrin, Assam Lemon, Pine Apple, Banana and Papaya. The prominent vegetables grown are Potato, Sweet potato, Tapicoa, Cabbage, Cucumber, Carrot, Onion and Pumpkin. Some spices crop like Ginger, Turmeric and Chilies are also grown. Irrigation has so far played only a minimal role in the agricultural development of the district. The topography of the district makes alignment and construction of channels difficult and costly. Even where the lay of the land is favorable, irrigation is confined only to areas bordering major rivers and streams. The

cultivators, therefore, have to depend on rainfalls to irrigate their land which seldom fail them. The study area covering Mawkynrew and Mawryngkneng blocks is a mountainous terrain with Quartzite (Shillong group) forms the main aquifer of the area, development of tube well is not lucrative for practicing irrigation. The people have to depend upon rainfed crops. The statistics of area under different crops, production and productivity is reproduced in **Table 3.54.**

Table 3.55 : Area Irrigated/un-irrigated Under Kharif and Rabi Crops

S.N.	Major Crops	Area(ha)	Production(ton)	Productivity(ton/ha)
1	Rice			
(a)	Autumn	284	932	32.8
(b)	Winter	5439	12554	23.1
(c)	Spring	130	275	21.2
2	Maize	3113	10464	33.6
3	Millets	261	324	12.4
4	Pulses			
(a)	Pea	565	2018	35.7
(b)	Cowpea	17	59	34.7
(c)	Lentil	76	160	21.1
5	Oil Seeds			
(a)	Sesamum	74	110	14.9
(b)	Rape & Mustard	93	82	8.8
(c)	Soya bean	350	446	12.7
6	Tuber Crops			
(a)	Potato	11770	122485	104.1
(b)	Sweet Potato	726	3164	43.6
(c)	Tapioca	510	3412	66.9
7	Fruits			
(a)	Khasi Mandarin	4127	22857	55.4
(b)	Assam Lemon	391	2003	51.2
(c)	Pine Apple	936	7365	78.7
(d)	Banana	776	8526	109.9
(e)	Papaya	122	868	71.1

Source: Directorate of Agriculture, Govt. of Meghalaya (2015-16)

3.10. Socio-economic Environment

3.10.1. *General*

The development projects are invariably planned based on the availability of exploitable natural resources. These projects attract flow of finances, investments, jobs and other livelihood opportunities, which brings in people from different cultural and social background. Such planned activities not only provide impetus to the local economy but also bring about a multi-dimensional economic, social and cultural change. Most often it has been observed that such development projects are commissioned in economically and socially backward areas, which are inhabited by some of the indigenous populations. The development of hydro-power unfortunately heralds displacement of the local people due to formation of reservoir and land required for the project components. This

unpleasant situation is mainly caused due to the agricultural land and settlements being situated near the river banks and due to location of the proposed diversion structures across the river bed and the formation of reservoir at higher levels generally cause submergence of private land and assets besides forests and revenue land. This un-toward situation brings heavy stress into the life of the indigenous people residing in the project area from centuries. The hapless persons are more often than not socio-economically wracked if they are not rehabilitated and resettled and are allowed to continue their traditional activities even after resettlement. The plight of such persons who do not have rights over the land on which they are critically dependent for their bare subsistence becomes gory. The obtaining situation calls for proper assessment of the adverse impact such as economic and socio-cultural on project affected families.

The present socio-economic assessment involves primary field survey of socio-economic status of the people of the study area in general and the project affected villages and the PAF in general. Review of secondary data, such as District Census Statistical Handbooks-2011 and the records of National Informatics Center data, for the parameters of demography, occupational structure of people within the study area which mainly comprises of the villages, where the project area is located as per revenue records. The information in this context was gathered on the following socio-economic parameters viz.

- Demographic profile
- Educational levels
- Occupational Profile
- Cropping pattern
- Other socio-economic parameters

3.10.2. *Project District and Blocks*

3.10.2.1 East Khasi Hills District

The East Khasi Hills district is situated in the south-central part of Meghalaya having a common border with Bangladesh in the south. The district lies in the central part of the State and occupies a total geographical area of 2,748 km2. It is situated approximately between 25°07″ and 25°41″ N latitude and 91°21″ and 92°09″ E longitude. The district comprises of two Civil sub divisions, the Shillong Sadar Subdivision with headquarters at Shillong and the Sohra Subdivision with headquarters at Sohra (Cherrapunjee). The district has eight Community and Rural Development Blocks. The study area covers Mawkynrew and Mawryngkneng blocks

3.10.2.2 Jaintia District

The Jaintia Hills District is located in the easternmost part of Meghalaya. It comprises two administrative civil sub divisions, Khliehriat and Amlarem. There are five Community and Rural Development Blocks in the district. The study area covers Amlarem and Thadlaskein blocks,

3.10.3. *Demography of Project Districts and C D Blocks*

3.10.3.1 Population

The description of the demography of the two district is presented in **Table 3.56.** It could be well inferred from the data below that the population of East Khasi Hills district is 825922 while of Jaintia Hills is 395124 with sex ratio of 1011 and 1015 respectively. The population of Mawkynrew and

Mawryngkneng blocks is 44602 and 67291 respectively with sex ratio of 1017 and 1015 respectively. The population of Amlarem and Thadlaskein blocks is 43844 and 109509 respectively with sex ratio of 1002 and 1009 respectively.

Table 3.56 : Demography of Project District and Blocks

Sl. No.	District	Tehsil/ Block	House hold	Population				
				Total	Male	Female	Below 6 Y	Sex Ratio
A	East Khasi Hills	District	164046	825922	410749	415173	139055	1011
1	Mawkynrew	Block	7995	44602	22118	22484	10501	1017
2	Mawryngkneng	Block	12219	67291	33396	33895	14228	1015
B	Jaintia Hills	District	66028	395124	196285	198839	90911	1013
1	Amlarem	Block	7746	43844	21906	21941	8846	1002
2	Thadlaskein	Block	18205	109509	54230	55279	26441	1019

3.10.3.2 Caste wise Distribution of Population Caste

Table 3.57 provides detailed information about the SC, ST population in both district and blocks affected due to project. From the table it could be understood that East Khasi Hills and Jaintia districts have a total SC population of 5642 (0.68%) and 1317 (0.33%) respectively of the total population. East Khasi Hills and Jaintia districts have a total ST population of 661157 (80.01%) and 376099 (95.19%) respectively of the total population.ST are in majority in Mawkynrew (99.30%) and Mawryngkneng (98.61%) blocks of East Khasi Hills. ST are in majority in Amlarem (92.32%) and Thadlaskein (95.34%) blocks of Jaintia Hills district.

Table 3.57 : Caste wise distribution of population

Sl. No.	District/ Block	Schedule Caste (SC)		Schedule Tribes (ST)	
		Total	% of SC	Total	% of ST
A	East Khasi Hills	5642	0.68	661158	80.01
1	Mawkynrew	0	0	44293	99.30
2	Mawryngkneng	274	0.41	66357	98.61
B	Jaintia Hills	1317	0.33	376099	95.19
1	Amlarem	207	0.47	40476	92.32
2	Thadlaskein	463	0.42	104483	95.34

3.10.3.3 Literacy Rate

The details of literacy rate and literate people in in both district and blocks affected due to project. are provided in **Table 3.58.** The literate population for East Khasi Hills district is 578030 out of which 287270 are male and 290760 are female, which represents 84.51% of the total literate population, the male literates represent 84.51% of the total male population while female represent 83.81% of the female population. The gender gap for literacy at district level for the district is 0.07. The literacy rate of Mawknrew and Mawryngkneng blocks is 70.00% and 77.48% respectively with gender gap of -10.86% and -12.36% respectively. The literacy rate of Jaintia Hills district, Amlarem and Thadlaskein blocks is 61.64%, 70.24% and 56.56 % respectively with gender gap of -6.9, -5.3% and -10.09% respectively.

Table 3.58 : Literacy Rate of Project District and Tehsils

S. No	District/ Block	Number of Literate			Literacy Rate			Gender Gap
		Total	Male	Female	Total %	Male	Female	
A	East Khasi Hills	578030	287270	290760	84.15	84.51	83.81	0.07
1	Mawkynrew	23870	10880	12990	70.00	64.51	75.37	-10.86
2	Mawryngkneng	42668	20105	22563	77.48	71.44	83.80	-12.36
B	Jaintia Hills	187527	87371	100156	61.64	58.14	65.06	-6.9
1	Amlarem	24584	11969	12615	70.24	66.59	71.89	-5.3
2	Thadlaskein	46987	21010	25977	56.56	51.44	61.53	-10.09

3.10.3.4 Workers Scenario

Table 3.59 describes two sections of workers main and marginal with a third category which is non-worker; the total number of workers at district level in East Khasi Hills and Jaintia Hills are 326786(39.57%) and 154180 (39.02%) respectively of which main workers represent 289576(35.06%) and 110617 (28.00%) respectively of the total workers. Marginal workers in East Khasi Hills and Jaintia Hills represent 37210 (4.51%) and 43563 (11.02%) respectively of the total workers. It implies that in East Khasi Hills and Jaintia Hills there are (60.43%) and (60.98%) non-workers. The workers participation of Mawkynrew and Mawryngkneng blocks is 21883(49.06%) and 27883(40.55%) respectively. The workers population of Amlarem and Thadlaskein blocks is 18620(42.47%) and 44924(41.00%) respectively.

Table 3.59 : Statistics of Main and Marginal Workers

S. N.	District /Block	Total workers	Total worker %	Main workers	Main workers %	Marginal workers	Marginal workers %
	East Khasi Hills	326786	39.57	289576	35.06	37210	4.51
1	Mawkynrew	21883	49.06	17890	40.11	3993	8.95
2	Mawryngkneng	27283	40.55	25181	37.42	2102	3.13
B	Jaintia Hills	154180	39.02	110617	28.00	43563	11.02
1	Amlarem	18620	42.47	11726	26.74	6894	15.73
2	Thadlaskein	44924	41.00	34489	31.47	11435	9.53

3.10.4. *Socio-economic of Project Affected Villages*

The project affected villages are those villages within the bounds of which the surface and underground project components and ancillary works are located and which are impacted during construction and thereafter either due to project activities or acquisition of private land and other assets, including the forest/government land and village Panchayat land which are proposed to be utilized for the project purpose in public interest. Due to the project, 13 villages shall be affected. There shall be no displacement of people.

The demographic profile of the project affected villages is presented in **Table 3.60.** The project falls under two districts East Khasi Hills and Jaintia Hills. In the project affected villages the total households are 1338, while the total population is 7946 which comprises of male and female population of 4076 and 3870 respectively. It implies that the sex ratio is 924 females per thousand

males. Sohmynting has maximum population of 3310; whereas Mawsir has the least population of 150.

Table 3.60 : Demographic Profile of the project affected villages

Sl. No.	Village	Household	Population				
			Total	Male	Female	Population below 6 yrs.	Sex Ratio
A-East Khasi Hills District							
1.	Ksanrngi	41	255	143	112	52	783
2.	Mawdulop	27	169	90	79	42	878
3.	Mawjatap	123	700	332	368	190	1108
4.	Mawlang	44	267	138	129	68	935
5.	Mawsir	25	150	86	64	30	744
6.	Pashang	46	290	164	126	78	768
7.	Siangkhnai	38	191	105	86	50	819
8.	Umsawwar	71	409	215	194	108	902
9.	Syntung	172	948	501	447	206	892
10.	Jatah Nonglyer	105	616	302	314	147	1040
Sub total (A)		692	3995	2076	1919	971	924
B-Jaintia Hill District							
1.	Moosakhia	88	442	222	220	115	991
2.	Samanong	32	199	90	109	39	1211
3.	Sohmynting	526	3310	1688	1622	789	961
Sub total (B)		646	3951	2000	1951	943	976
Grand Total		**1338**	**7946**	**4076**	**3870**	**1914**	**950**

**Source: Census of India, 2011*

The cast wise distribution in the project affected villages is depicted in **Table 3.61**. It is inferred from the table that Mawlang has the highest ST populated village having 100% ST population in village, while Pashang has 97.93% ST population. With the exception of Moosakhia village none of other villages has SC populations.

Table 3.61 : Details of SC and ST population of Study Area

S. No.	Village	Schedule Caste (SC)				Schedule Tribes (ST)			
		Total	Male	Female	% of SC	Total	Male	Female	% of ST
A-East Khasi Hills District									
1.	Ksanrngi	0	0	0	0	251	142	109	98.43
2.	Mawdulop	0	0	0	0	168	89	79	99.41
3.	Mawjatap	0	0	0	0	699	332	367	99.86
4.	Mawlang	0	0	0	0	267	138	129	100.00
5.	Mawsir	0	0	0	0	148	85	63	98.67
6.	Pashang	0	0	0	0	284	163	121	97.93
7.	Siangkhnai	0	0	0	0	190	104	86	99.48
8.	Umsawwar	0	0	0	0	408	215	193	99.76
9.	Syntung	0	0	0	0	939	497	442	99.05
10.	Jatah Nonglyer	0	0	0	0	614	302	312	99.68
Sub total (A)		0	0	0	0	3968	2067	1901	99.32
B-Jaintia Hill District									
1.	Moosakhia	1	1	0	0.23	438	219	219	99.10
2.	Samanong	0	0	0	0	198	90	108	99.50

3.	Sohmynting	0	0	0	0	3297	1684	1613	99.61
Sub total (B)		1	1	0	0.23	3933	1993	1940	99.54
Grand Total		**1**	**1**	**0**	**0.01**	**7901**	**4060**	**3841**	**99.43**

*Source: Census of India, 2011

The literacy profile of the project affected villages is presented in **Table 3.62**. It is manifest from the Table that the total literate persons are 3777 of which male and female literate population is 1655 and 24122 respectively, which implies that the literacy rate of the project affected area is 62.62 %. From the data it could be inferred that Samanong has the highest literacy rate (86.25%) followed by Moosakhia (80.43%) and Mawjatap (79.41%).

Table 3.62 : Literacy Rate of the Study Area

S. No	Village	Number of Literate			
		Total	Male	Female	Percentage
A-East Khasi Hills District					
1.	Ksanrngi	90	35	55	44.33
2.	Mawdulop	60	27	33	47.24
3.	Mawjatap	405	181	224	79.41
4.	Mawlang	156	74	82	78.39
5.	Mawsir	40	13	27	33.33
6.	Pashang	140	65	75	66.04
7.	Siangkhnai	103	46	57	73.05
8.	Umsawwar	206	90	116	68.44
9.	Syntung	568	273	295	76.55
10.	Jatah Nonglyer	246	89	157	52.45
Sub total (A)		2014	893	1121	66.60
B-Jaintia Hill District					
1.	Moosakhia	263	125	138	80.43
2.	Samanong	138	66	72	86.25
3.	Sohmynting	1362	571	791	54.03
Sub total (B)		1763	762	1001	58.621
Total		**3777**	**1655**	**2122**	**62.62**

**Source: Census of India, 2011*

The worker participation in the project affected villages is elucidated in **Table 3.63**. It is inferred that the total work participation rate in project affected villages is 44.70%. It is highest in Samanong, 80.00 % followed by Umsawar (72.76%). Mawlang has a very poor work participation rate of 36.18%.

Table 3.63 : Work Participation Rate of the Study Area

S. No.	Village	Total Worker			Work Participation Rate (WPR)			Gender Gap in WPR
		Total	Male	Female	Total	Male	Female	
A-East Khasi Hills District								
1.	Ksanrngi	140	83	57	68.97	71.55	65.52	6.03
2.	Mawdulop	87	46	41	68.50	67.65	69.49	-1.84
3.	Mawjatap	260	174	86	50.98	71.02	32.45	38.57
4.	Mawlang	72	57	15	36.18	54.29	15.96	38.33
5.	Mawsir	79	44	35	65.83	65.67	66.04	-0.37
6.	Pashang	147	81	66	69.34	69.83	68.75	1.08
7.	Siangkhnai	75	49	26	53.19	69.01	37.14	31.87

S. No.	Village	Total Worker			Work Participation Rate (WPR)			Gender Gap in WPR
		Total	Male	Female	Total	Male	Female	
8.	Umsawwar	219	108	111	72.76	71.52	74.00	-2.48
9.	Syntung	390	278	112	41.14	55.49	25.06	30.43
10.	Jatah Nonglyer	261	153	108	42.37	50.66	34.39	16.27
Sub total (A)		1730	1073	657	43.30	51.69	34.23	17.46
B-Jaintia Hill District								
1	Moosakhia	232	112	120	70.95	69.57	72.29	-2.72
2	Samanong	128	65	63	80.00	83.33	76.83	6.50
3	Sohmynting	1432	808	624	56.80	64.33	49.33	15.00
Sub total (B)		1792	985	807	45.35	49.25	41.36	7.89
Total		**3522**	**2058**	**1464**	**44.32**	**50.50**	**37.83**	**12.67**

**Source: Census of India, 2011*

The village wise statistics of main and marginal workers has been abstracted and presented in **Table 3.64.** The data shows that Sohmynting has 98.11% of main workers followed by Mawjatap 91.15% The marginal worker presence is highest in Mawlang (48.61%).

Table 3.64 : Main Worker and Marginal Worker

S. No.	Village	Main Worker				Marginal Worker			
		Total	Male	Female	%	Total	Male	Female	%
A-East Khasi Hills District									
1.	Ksanrngi	101	74	27	72.14	39	9	30	27.86
2.	Mawdulop	70	44	26	80.46	17	2	15	19.54
3.	Mawjatap	237	168	69	91.15	23	6	17	8.85
4.	Mawlang	37	26	11	51.39	35	31	4	48.61
5.	Mawsir	63	43	20	79.75	16	1	15	20.25
6.	Pashang	84	60	24	57.14	63	21	42	42.86
7.	Siangkhnai	62	44	18	82.67	13	5	8	17.33
8.	Umsawwar	120	78	42	54.79	99	30	69	45.21
9.	Syntung	368	262	106	38.82	22	16	6	2.32
10.	Jatah Nonglyer	30	19	11	4.87	231	134	97	37.50
Sub total (A)		1172	818	354	29.34	558	255	303	13.96
B-Jaintia Hill District									
1.	Moosakhia	154	86	68	66.38	78	26	52	33.62
2.	Samanong	115	59	56	89.84	13	6	7	10.16
3.	Sohmynting	1405	793	612	98.11	27	15	12	1.89
Sub total (B)		1674	938	736	42.36	118	47	71	2.99
Total		**2846**	**1756**	**1090**	**35.82**	**676**	**302**	**374**	**8.50**

**Source: Census of India, 2011374*

The distribution in different categories of the main workers is shown in **Table 3.65.** The main workers have been categorized in four categories namely as cultivators, agricultural labors, HH labors and other labors. The percentage of cultivators in Samanong, Moosakhia, Ksanrngi is 83.48, 67.53, 50.50 respectively.

Agricultural labor percentage in Mawdulop and Mawsir are 97.14% and 96.83% respectively. Out of 14 villages, Household workers are only present in 3 villages namely Mawdulop, Umsawwar and Sohmynting. The highest number of other workers are 322 in Syntung.

Table 3.65 : Categorization of Main Worker

Sl. No.	Village	Cultivators		Agricultural Labourers		Household Industrial Workers		Other Workers	
		Number	%	Number	%	Number	%	Number	%
A-East Khasi Hills District									
1.	Ksanrngi	51	50.50	44	43.56	0	0	6	5.94
2.	Mawdulop	0	0.00	68	97.14	1	1.4	1	1.43
3.	Mawjatap	1	0.42	1	0.42	0	0	235	99.16
4.	Mawlang	0	0.00	0	0.00	0	0	37	100
5.	Mawsir	1	1.59	61	96.83	0	0	1	1.59
6.	Pashang	0	0.00	0	0.00	0	0	84	100
7.	Siangkhnai	0	0.00	0	0.00	0	0	62	100
8.	Umsawwar	0	0.00	1	0.83	2	1.6	117	97.50
9.	Syntung	39	10.60	7	1.90	0	0.00	322	87.50
10.	Jatah Nonglyer	0	0.00	0	0.00	0	0.00	30	100.00
Sub total (A)		92	7.85	182	15.53	3	0.26	895	76.36
B-Jaintia Hill District									
1.	Moosakhia	104	67.53	28	18.18	0	0	22	14.29
2.	Samanong	96	83.48	0	0.00	0	0	19	16.52
3.	Sohmynting	672	47.83	448	31.89	27	1.9	258	18.36
Sub total (B)		872	52.10	476	28.43	27	1.61	299	17.86
Total		**964**	**33.87**	**658**	**23.12**	**30**	**1.05**	**1194**	**41.96**

**Source: Census of India, 2011*

The marginal workers have been categorized in four categories namely as cultivators, agricultural labors, HH labors and other labors **(Table3.66).** Out of fourteen villages the maximum percentage of cultivators is in Maswir, 87.50%. In Mawdulop the 70.59% working force of marginal workers are engaged as agricultural labors, followed by Moosakhia where 60.26% workers are engaged as agricultural labors, there are no agricultural labors in Mawjatap, Mawlang, Pashang and Siangkhnai villages.

Table 3.66 : Categorization of Marginal Worker

Sl. No.	Town	Cultivators		Agricultural Labourers		Household Industrial Workers		Other Workers	
		Number	%	Number	%	Number	%	Number	%
A-East Khasi Hills District									
1.	Ksanrngi	31	79.49	5	12.82	0	0.00	3	7.69
2.	Mawdulop	4	23.53	12	70.59	0	0.00	1	5.88
3.	Mawjatap	0	0.00	0	0.00	0	0.00	23	100
4.	Mawlang	0	0.00	0	0.00	0	0.00	35	100
5.	Mawsir	14	87.50	2	12.50	0	0.00	0	0.00
6.	Pashang	8	12.70	0	0.00	1	1.59	54	85.71
7.	Siangkhnai	0	0.00	0	0.00	0	0.00	13	100.00
8.	Umsawwar	14	14.14	2	2.02	3	3.03	80	80.81
9.	Syntung	4	18.18	0	0.00	0	0.00	18	81.82
10.	Jatah Nonglyer	2	0.87	0	0.00	0	0.00	229	99.13
Sub total (A)		77	13.80	21	3.76	4	0.72	456	81.72
B-Jaintia Hill District									
1.	Moosakhia	6	7.69	47	60.26	0	0.00	25	32.05
2.	Samanong	3	23.08	3	23.08	0	0.00	7	53.85

Sl. No.	Town	Cultivators		Agricultural Labourers		Household Industrial Workers		Other Workers	
		Number	%	Number	%	Number	%	Number	%
3.	Sohmynting	9	33.33	2	7.41	0	0.00	16	59.26
Sub total (B)		18	15.25	52	44.07	0	0.00	48	40.68
Total		**95**	**14.05**	**73**	**10.80**	**4**	**0.60**	**504**	**74.55**

**Source: Census of India, 2011*

The education facilities in the project affected villages are shown in (**Table 3.67**). There are Primary schools in all villages, while there are no secondary school, higher secondary school and Degree Colleges in any of the villages.

Table 3.67 : Education Facilities in Village

S. No.	Village	Primary school	Middle	Sec. school	Higher sec.	Arts/ Sc. College
1.	Moosakhia	1	No	No	No	No
2.	Samanong	1	No	No	No	No
3.	Sohmynting	5	2	1	No	No
4.	Ksanrngi	1	No	No	No	No
5.	Mawdulop	1	No	No	No	No
6.	Mawjatap	2	No	No	No	No
7.	Mawlang	2	No	No	No	No
8.	Mawsir	1	No	No	No	No
9.	Syntung	2	1	No	No	No
10.	Jatah Nonglyer	1	No	No	No	No
11.	Pashang	1	No	No	No	No
12.	Siangkhnai	1	No	No	No	No
13.	Umsawwar	2	No	No	No	No

**Source: Census of India, 2011*

The Primary Health facilities at village level is given in **(Table 3.68).** From the table it is clear that there is no PHC and Veterinary doctor in any of the villages. The Anganwadi center is present in 12 village except one (Samanong). Asha Workers are present in every habituated village.

Table 3.68 : Primary Health facilities at village level

S. No.	Village	PHC	Veterinary Doc.	PDS	Anganwadi	Asha worker
1.	Moosakhia	No	No	No	Yes	Yes
2.	Samanong	No	No	No	No	Yes
3.	Sohmynting	No	No	Yes	Yes	Yes
4.	Ksanrngi	No	No	Yes	Yes	Yes
5.	Mawdulop	No	No	No	Yes	Yes
6.	Mawjatap	No	No	No	Yes	Yes
7.	Mawlang	No	No	No	Yes	Yes
8.	Mawsir	No	No	No	Yes	Yes
9.	Syntung	No	No	No	Yes	Yes
10.	Jatah Nonglyer	No	No	Yes	Yes	Yes
11.	Pashang	No	No	No	Yes	Yes
12.	Siangkhnai	No	No	No	Yes	Yes
13.	Umsawwar	No	No	No	Yes	Yes

The availability of water sources in the project affected villages is shown in **Table 3.69.** The data states that the tap water facility is only in four villages (Ksanrngi, Mawdulop, Siangkhnai and Syntung), while tube well facility is not present in any of the villages. The covered and uncovered well are present in six villages (Moosakhia, Samanong, Sohmynting, Mawlang, Mawsir, Jatah Nonglyer). Rest other sources are not present in any of the villages.

Table 3.69 : Water Sources at Village Level

S. No.	Village	Tap	Tube well	Well	River	Other sources
1	Moosakhia	No	No	Yes	No	No
2	Samanong	No	No	Yes	No	No
3	Sohmynting	No	No	Yes	No	No
4	Ksanrngi	Yes	No	No	No	No
5	Mawdulop	Yes	No	No	No	No
6	Mawjatap	No	No	No	No	No
7	Mawlang	No	No	Yes	NA	No
8	Mawsir	No	No	Yes	NA	No
9	Syntung	Yes	No	No	No	No
10	Jatah Nonglyer	No	No	Yes	No	No
11	Pashang	No	No	No	No	No
12	Siangkhnai	Yes	No	No	No	No
13	Umsawwar	No	No	No	No	No
Total		**4**	**0**	**6**	**0**	**0**

3.10.5. *Land Requirement for the Project*

For execution of the project 390.50 ha land shall be required of which the apportionment between, Forest land (dense and open forest), arable land and non-arable land shall be 93.53ha,152.43 ha and 144.54 ha respectively.

3.10.6. *Village-wise Project Affected Families*

The village-wise details of project affected families and assets to be acquired is shown in **Table 3.70**.

Table 3.70 : Village-wise details of PAF and Assets to be Acquired.

S. No.	Name of Village	No. of PAF	Arable Land (ha)	Non-arable Land (ha)	Total Land (ha)
1	Moosakhia	37	16.51	13.34	29.85
2	Samanong	27	10.85	34.79	45.64
3	Sohmynting	20	14.85	3.25	18.1
4	Ksanrngi	32	8.62	4.69	13.31
5	Mawdulop	40	4.94	3.28	8.22
6	Mawjatap	8	4.98	1.97	6.95
7	Mawlang	22	5.59	4.56	10.15
8	Mawsir	38	13.51	21.3	34.81
9	Syntung	38	25.2	16.5	41.7

10	Jatah Nonglyer	23	3.84	1.74	5.58
11	Pashang	28	9.23	4.5	13.73
12	Siangkhnai	35	23.45	29.04	52.49
13	Umsawwar	30	10.86	5.58	16.44
Total		**378**	**152.43**	**144.54**	**296.97**

3.10.7. *Dependence on Forest Produce*

People derive a variety of goods and services from forests. The majority of tribal and indigenous people living in regions rich in forest cover depend on the forests for their livelihoods. Degree of dependence of people on forest is determined by the availability of forest in neighborhood, occupation of the household, remoteness of the place and level of income of the household. The rural people and in particular, shifting cultivators, herbal medicine practitioners, marginal farmers and agricultural laborers are most dependent on the forests. One of the important products extracted from the forests is fuel wood, as most rural and a sizeable section of urban population use fuelwood for cooking and space heating. The community forests, (viz., Law Shnong, Law Raid and Law Kur) are the important source of fuel wood. A section of population also makes their living by collection and selling of fuelwood. The collection of leafy vegetables, mushrooms, edible fruits and tuber is a common sight in rural area. During periods of food scarcity particularly in remote villages, the dependence of people on edible products from forests increases to a great extent (Tiwari and Rani, 2004). There are thousands of herbal medicine practitioners in Meghalaya who are the backbone of health care system of rural as well as some urban centers of the state. A significant section of society still depends on the folk medicines collected from forests (Tiwari et al 2004). However, during recent years the degree of dependency on the forests for fuel wood, edibles, and medicines is on decline.

Chapter 4. IDENTIFICATION, PREDICTION AND EVALUATION OF IMPACTS

4.1. General

Umngot HEP mainly involves construction of high dam, intake structure, underground water conductor system and surface power house. It is expected that there will be certain changes in the overall environmental matrix of the study area. The baseline data of the existing environment, in the absence of the proposed activity, provides the status of natural environment and with the proposed activity it further provides a mechanism for prediction of the changes that are likely to occur. In the present study, evaluation of land, water, air, noise, flora, fauna and socio-economics was undertaken to understand the baseline environmental status of the area and estimation were made as how this will change with the commencement of the proposed activities. Anticipating the quantum of change, efforts were also made to analyze the degree of alternations and strategies for suitable management to ameliorate the negative impacts project activities. This exercise has provided a sound basis for formulation of different management plans, which are presented in the EMP document of the project.

4.2. Impacts Due to Project Location and Mitigation

The environmental impacts before the construction are identified during planning phase. This happens due to identification of the project in a location which may be susceptible to adverse impacts due to natural environment conditions. Impacts of the project due to its location are as follows:

(i) Displacement of People
(ii) Loss of land
(iii) Geological Risk
(iv) Risk due to seismicity & earthquake

4.2.1. *Displacement of people*

For execution of the project 390.50 ha land shall be required of which the apportionment between, Forest land (dense and open forest), arable land and non-arable land shall be 93.53ha,152.43 ha and 144.54 ha respectively. The project components and the submergence area are located at the bottom of very deep gorges near the riverine channel and hence there will be no displacement of any population due to the execution of this project since all habitation are situated on the tableland of the plateau, several hundred meters above the river. Some households though will be affected partially as their land used for broomstick cultivation will come under the submergence area and in some project components. The reservoir submerges an area of 253.75 ha up to FRL 1040 masl.

The project affected villages are those villages within the bounds of which the surface project and ancillary works are located and which are impacted during construction and thereafter either due to project activities or acquisition of private land and other assets, including the government land and community land which are proposed to be utilized for the project purpose in public interest. There are twelve project affected villages which are being impacted due to acquisition of private land and other assets of which none shall be fully submerged. However, 378 families shall be impacted due to involuntary acquisition of their land for project. Land owner will be adequately compensated as per provision of RFCT LARR 2013. The location of dam has been finalized keeping in view minimum displacement of people.

4.2.2. *Loss of land*

Due to project there shall be loss of 152.43 ha arable land and consequently loss of production from the land. The project affected families shall be adequately compensated for land loss and cost of land to be acquired as per provision under RFCT_LARR 2013.

4.2.3. *Geological Risk*

Geological investigation for the project was carried out and details of the geology of the project area have been discussed in Chapter 3 of this report. As per site observations, the rock formations in the area are inherently loose and prone to landslides at various locations. However, as per site specific investigations, the geological formations in the selected project sites are judged stable and will be able to withstand the impacts of drilling and blasting. However, at any unstable formation encountered during tunnelling, blasting may lead to high vibrations, which in turn may result in soil erosion, subsidence and loss of vegetation. Hence, controlled blasting with use of multi-second delay detonators is to be adopted at such geologically fragile locations.

Intensity of anticipated environmental impacts will be low based on environmental value and degree of disturbance. Therefore, intensity of anticipated environmental impact on geology of the area will be weak and extent of anticipated impact will be local. Duration of impact will be medium leading to low significance of the impact.

Since, the project is located in seismic zone V as per Seismic Zonation Map of India and designing of the dam and reservoir will be as per design code. Therefore, suitable seismic co-efficient has been accounted for in the design.

The intensity of anticipated environmental impact on geology of the area will be weak and extent of anticipated impact will be local. No impact is anticipated on the geology of the area during the operation phase

4.2.4. *Risks due to seismicity and earthquake*

The project area is located in seismic zone V as per Seismic Zone Map 2014. Indian Institute of Technology (IIT), Roorkee in its report on "Site specific design earthquake parameters for Umngot H.E Project" have considered the maximum probable magnitude for the seismogenic source as 8.0 for the site which was suggested by NCSDP. The values for Maximum Considered Earthquake (MCE) and Design Based Earthquake (DBE) conditions have accordingly been suggested as 0.36 g and 0.18 g respectively.

4.3. Impacts on Land Environment

4.3.1. *Changes in land use and land cover*

- The land use class of land involved in submergence shall change into waterbody. The change shall be permanent and irreversible. The forest land cover within the submergence area shall reduce due to project during construction.
- The land use class of forest land required for project components shall have land use class changed to built-up area.
- The land use class of forest land required for quarry sites shall remain unchanged as the quarry sites shall later on developed with vegetal cover.
- The land use class forest in respect of forestland required for underground components will not cause any change in the present land use.

4.3.2. *Immigration of Labour/Staff Members*

During the construction phase congregation of approximately 1000 workers is likely to take place in the project area, for which semi-permanent / temporary accommodation would be required. Due to labour inflex, pressure on land and water resource would occur. The disposal of sewage, solid waste would be required. If the labour force is not provided with proper fuel arrangements, the pressure on adjoining forest for fuel wood may take place. To reduce the dependence on forest the project proponent / contractors shall provide alternate fuel substituting fuelwood with LPG for cooking and domestic electricity connection for lighting. Conflict between the migrants and the local population may occur for employment. In order to mitigate the adverse impact due to labour immigration the labourers shall be provided accommodation in labour colony equipped with safe drinking water supply and sanitation arrangement with installation of STP. Medical facilities shall be provided to workforce by establishing a small dispensary near labour colony for which provisions has been made under the EMP. The impact due to labour immigration during construction shall be of temporary nature and shall cease to exist after the completion of the work as the labour shall be repatriated from the construction site. Labour engaged in construction activity will move away once the project work is completed; therefore, no additional impact is expected after completion of project on this count.

In implementation phase about 350 officials/ work-charged workers will be required for which permanent/temporary colony equipped with all facilities like drinking water, electricity, sanitary and sewage with proper disposal arrangement shall be provided. In the operation phase the project will have full-fledged infrastructure to meet the requirement of the reduced strength of project staff of 100 project officials/ workers

4.3.3. *Quarry operation and Muck Disposal*

The total quantity of muck / debris, to be generated due to the project, shall be 7.90 lakh cum, out of which 2.77 lakh cum shall be consumed on project work leaving 5.13 lakh cum, which with 42% swell factor shall amount to 7.28 lakh cum, to be disposed-off away from sites so as to make available the clear site for construction activities. Thus, muck disposal shall neither be problematic nor cause any impact on the environment.

Total raw material requirement for aggregate comes to 15.34 lakh cum, which shall be met from utilization of 2.78 lakh cum of muck and balance 12.56 lakh cum from two rock-in-situ quarry sites. Sand shall be obtained from river bed shoal deposit from Myntdu river at Kharkhana and also from Umiew river, near Mylliem. The plan shall have various ingredients like plantation in the area above thalwage line and also within 7.5-meter safety barrier along the hill side and also at such pockets of the river which are above the HFL and normally not affected due to floods. The mitigation measures have been suggested under the restoration of borrow area plan under EMP.

4.3.4. *Change in Land Quality including Waste Disposal*

Due to excavation activities there shall be disturbance to the land profile which triggers land erosion. The soil erosion in the catchment area of the reservoir and transport of detached material through the drainage network generally gives rise to a series of problems, notably depletion of flow capacity, steady loss of storage capacity. The lack of proper vegetal cover is a factor to cause degradation and thereby results in severe run off/soil erosion, and subsequently premature siltation of the reservoir. Another important factor that adds to the sediment load and which contributes to soil degradation is

grazing pressure. A well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the adverse cause and process of soil erosion. The project activities shall not create any waste per se. The solid waste shall generate from project and labour colony which shall be disposed in designated landfill after segregation. The sewage waste shall be disposed after treatment through STP.

Other source of waste during construction will be construction waste primarily including waste (arising out of the batching & mixing plant), slurry and washings from bins of coarse and fine aggregates etc. If not properly managed, construction waste can reduce land fertility of the project area. Increased dust also deteriorates the land fertility if proper mitigation measures are not taken. The leakage of POL and washings of workshop floors bring oil and grease with it. It shall be collected in oil separators before disposal on land. The soil contamination with oil shall be totally avoided.

4.3.5. *River Bank and Their Stability*

The construction of dam shall involve stripping of the banks but due to good quality rocks the river banks after stripping shall still be sufficiently stable, however, at places where joints and weak seams are encountered rock bolting / fibre link guniting shall be resorted too. Umngot river cuts very deep through the plateau land forming a very deep gorge, with numerous rapids and falls, exposing the underlying bed rock throughout its entire course. The firm bed material is composed of crystalline rocks of the Archaean basement complex, which comprises mostly of granite gneiss, miguratites, granites and biotite schists, which is massive, hard moderately jointed and medium to coarse grained

In the submergence zone the stability of the land slide prone zone shall be strengthened by adapting to engineering and biological measures. The river bank in the reservoir area are stable and no intervention of banks is contemplated except that the banks shall be subject to fluctuating water levels during initial filling and routine regulation/operation of the pond .But the water level drawdown shall be gradual and there is no case for sudden drawdown of the reservoir in normal conditions to ddisturb the stability of banks.

4.3.6. *Impact Due to Submergence*

Due to submergence, the major impacts will be on river regime which will change from riverine to lacustrian state, which implies that the area of water body shall increase as the existing land use under agriculture and forest shall change to water body. The change in land use shall be permanent. The increased water surface area will result in reducing the aridity of the settlement area near the reservoir.

4.4. Impacts on Water Environment

4.4.1. *Change in surface and ground water Quality*

Stratification can limit the mixing of the water body, leading to depletion of DO levels. This can lead to reducing conditions in waters. Enrichment of impounded water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However, this phenomenon is likely to last for a short duration of few years from the filling up of the reservoir. Therefore, any significant impact on reservoir water quality is not anticipated.

Another significant impact, which can accrue in the pond, is the problem of eutrophication. This occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. However, within the catchment, the proportion of agriculture land irrigated is low. The agro-chemical dosing is low in the area. Even in the post project phase, use of fertilizers in the project catchment area is not

expected to raise significantly in view of the maximum rainfed crops being grown in the area. Considering the low fertilizer usage in the area, significant loading of nutrients is not anticipated. Thus, problems due to eutrophication are not anticipated in the proposed project

Construction Phase

- During the construction phase, the river water on d/s of dam is supposed to catch considerable amount of sediment from the underground works for which the water coming out from such area will be dislodged of sediment in the silt trapping tanks before being released to river.
- The silt laden water emanating from all other open-air works and from the foundation works of power house, however will require sediment extraction before releasing the water into the river section.
- The muck disposal yards, quarry areas would be the areas of concerns for leaching of sediments during rains.
- The discharge coming out of batching and crushing plants would also bring considerable sediments in water due to washing of plants and aggregate material.
- The sewage generated at the labour camps and other residential areas may also bring considerable pollutants to river sections, if disposed of in the river section without treatment.

Operation Phase

- In the operation phase of the proposed project the water environment in general will not deteriorate as the water will be continuously used for power generation and will be released simultaneously.
- For downstream usages of river course will have a minimum environmental flow of 0.37cumec released downstream of dam for downstream riparian use of d/s 20 km length, during lean months (January-April). During non-monsoon and monsoon season the ecological flow requirement of 3.43 cumec and 10.33 cumec respectively as worked out in Table no. 3.32 and 3.33 shall be released d/s of dam.
- The regular flushing operation of reservoir during monsoon shall not lead to the development of unwanted heaps / shoal in the flow section of the river bed which cause change in the river regime.

4.4.2. *Impact due to change in Hydrological Cycle*

From intake structure a maximum abstraction of 33.4 cumec discharge through HRT shall be released to the river about 20km through TRC. The abstraction of water through intake shall reduce the river flow up to 20 km d/s of the dam to the extent discharge flowing through intake up to the point of outfall of TRT. This implies that there shall be less evaporation in the 20 km. reach d/s of the dam than before. Thus, the increase in evapo-transpiration due to creation of the reservoir shall be slightly reduced by the decline in the d/s river segment due to water being conducted through underground HRT. Since, the quantity of the water abstracted from the river for non-consumptive use of power generation is again returned to the system without any consumption, there shall not be any remarkable change in hydrological cycle in context to the project absolutely.

4.4.3. *Impact on Ground and Surface Water Use*

On the upstream of the proposed HEP in Umngot basin, at present there does not exist any river valley project /HEP. Within the project reach there is neither any industrial use of water of river for lift or water supply scheme utilizing the direct flow of the river. All flow irrigation schemes (FIS) and

water supply schemes on the upstream and downstream of the project take-off from the local nalas and spring respectively and thus are not dependent upon the discharge of the river. In the study area, irrigation canal / gules off-take from local nalas to meet the water requirement of crops being raised in nearby villages. The irrigated area is very insignificant as always is the case in the hill and the irrigation water requirement is very little due to low evapo-transpiration rates and the variety of the crops raised.

4.4.4. *Impact due to Ground Water Pollution*

The baseline study of water quality in respect of surface water and ground water (spring) has revealed that both are of good quality and the various water characteristics are within the tolerance limit as set-out under IS:2260. The surface water meets the standards of drinking water quality. Therefore, seepage of good quality surface water from reservoir shall least impair the obtaining quality of ground water.

4.4.5. *Backwater Effect*

The proposed reservoir shall extend into Umngot river and its tributaries Wah Pashang, Wah Shyrkiang, Um Mashai. Therefore, the natural effect of backwater shall be restricted with in the short stretch of length in these drains. Since there is no river valley/HEP on U/s there shall not be any case for affecting the tail water level of any u/s hydroelectric project.

4.4.6. *Impact on Performance of Existing Projects*

Either on upstream or downstream of the proposed HEP in Umngot basin, at present there does not exist any river valley project /HEP. Thus, there is no case for any impact on this count. However, due to sediment control through works proposed under Catchment Area Treatment (CAT), Compensatory Afforestation and Green Belt Development, the water quality shall improve and d/s projects in future shall receive comparatively lesser silt laden water which will have far reaching impact on their reservoir life.

4.4.7. *Impact on Turbidity in Construction Phase*

The impact of silt laden water, during construction phase, emanating from excavation of the open-air works at dam complex and power house, from dewatering during underground excavation in HRT / Adits / Shafts and also from discharge coming out of batching and crushing plants bringing considerable sediments, have been discussed in the report along with suggestive measures for redressing. The impact shall be felt during construction with the slight increase in turbidity in the river water d/s of dam despite resorting to de-silting of silt laden discharge coming from various excavation points, but the transparency of the water shall not be impaired to the extent that the available sunlight ceases to power the photosynthetic reactions.

4.4.8. *Impact on Flood Moderation & Drought Mitigation*

The flood discharge shall be slightly moderated due to reservoir having small live storage capacity of 48.90 MCM only. The scheme is located in hilly area where the agriculture land is mostly undulating and available in small holdings with average size less than 0.05 ha and the irrigation is practiced through small channels / kules, which off-take from hill streams / torrents. Thus, covertly the HEP, with no irrigation component, shall not serve in draught mitigation as such.

4.4.9. *Steps to Develop Pisciculture and recreation facilities*

The reservoirs invariably offer scope for inland fish production, if managed on scientific lines and for various other kinds of enhancement leading to higher productivity and income generation for the local community. They have the advantage of enabling quick enhancement of yield due to their small size and easy manoeuvrability of fish stock. For promoting pisciculture and to generate economical help and to maintain fishing rights of tribal, Fisheries management plan for a budgetary provision of Rs 192 lakh has been incorporated in the EMP.

4.4.10. *Change in Hydraulic Regime and Downstream Flows*

Construction Phase

Construction of proposed project may lead to two types of impact on the hydrology of the area i.e. surface water and ground water hydrology. These impacts have been described below:

Impact on the Surface Water Hydrology

The water requirement during construction of the tunnel from other adits will be met from Umngot river at different places like diversion site for construction of dam and intake structure and at adits and part HRT and also at power house site for construction of powerhouse and part HRT etc. Hence, these divided water source will ensure that there is no excessive water demand on any single water resource point. Moreover, if any groundwater is encountered during tunnelling operations, it will be used for construction requirements to reduce surface water requirement. Further the existing drainage system in the area will not be modified or affected during the construction phase.

Hence, the intensity of anticipated environmental impacts is judged as low, based on environmental value and degree of disturbance. Therefore, intensity of anticipated environmental impact on hydrology of the area will be weak, anticipated impact local in extent and duration short leading to low significance of the impact.

Impact on Ground Water Resource

The ground water levels in the region could not be established, as is often the case in mountainous terrain. Since the water usage will be mainly from the river water for construction purposes, no adverse impact on groundwater availability is expected. Dumping of wastes shall also be undertaken at specified exposed surface locations only and hence, no negative effect is envisaged on the groundwater quality of the area.

Some seasonal surface streams shall cross the tunnel alignment with the stream bed well above the crown of the tunnel at the point of crossing. Hence, there shall not be any disturbance to ground water regime consequent to blasting for tunnelling. Moreover, the underground tunnel shall be aligned deep in the mountain below the ground profile. The ground water position of the area shall not change due to existing steep slope of surface and water tight lining of the tunnel. It is only in the area near diversion structure where the ground water level is likely to raise due to maintaining of higher pond level in the river during operation phase.

Operation Phase

During operation phase, the water (maximum 33.4 cumec) from the river will also be diverted for power generation through HRT. Following guidelines issued by the Ministry of Environment & Forest, Govt. of India, the minimum flow based on average lean weather flow that will be maintained in the

river will be 0.37 cumecs down stream of dam for meeting ecological flow requirement. Since, the water from the river is not used by the villages along the river for domestic and irrigation purpose, the reduced flow in 20 km. stretch d/s of barrage is not likely to have any significant adverse impact.

4.4.11. *Water Pollution Due to Disposal of Sewage*

The untreated sewage and other solid waste increases, if discharged to the waterbody increases its BOD loading and render water un-potable without conventional treatment and disinfection. The project colony during construction shall be developed for 50 staff and thus house a population of about 250 people. The domestic water requirement for the project staff shall be of the order of 17.50 m3/day @ 70 lpcd. Assuming that about 80% of the water supplied will be generated as sewage, i.e., 14 m3/day. The BOD load contributed by domestic sources will be about 237.50 mg /litre, assuming per capita BOD contribution as 19 g/day. The sewage waste shall be disposed after treatment through STP. The effluent to be discharged should conform to the Standard adopted vide GSR1265(E), dated 13.10. 2017 **(Table 4.1).** It must be ensured the limits in respect of parameters are not exceeded.

Table 4.1 : Effluent Discharge Standard

S.N.	Effluent discharge parameter	Concentration
1	pH	6.5-9.0
2	Bio- Chemical Oxygen Demand (BOD)	<30 mg/liter
3	Total Suspended Solids (TSS)	<100 mg/liter
4	Fecal Coliform (FC) (Most Probable Number per 100 milliliter, MPN/100ml	<1000

4.4.12. *Water Pollution from Labour colonies/Camps and Washing Equipment*

The labour colonies shall be located at appropriate place in the project area. About 1000 workers (labour and staff) would be engaged temporarily during peak construction period. It is expected that 80% of the total work force shall be locally available from adjacent areas and thus labour colony shall be designed to house 200 workforces. It is proposed to provide family residences to 40 workers while the balance shall remain in bachelor accommodation. Proper care has to be taken to manage the solid waste generated from the labour colony for a population of 360 residential persons and 10 floating population i.e. for 370 persons.

The domestic water requirement for the construction worker and the technical staff migrating into the project area is of the order of 26 m3/day @ 70lpcd. Assuming that about 80% of the water supplied will be generated as sewage, i.e., 20.8 m3/day. The BOD load contributed by domestic sources will be about 237.5mg / litre, assuming per capita BOD contribution as 19 g/day.

Disposal of untreated sewage can lead to water pollution, resulting in increase in coliforms and other various pathogens, which can lead to incidence of water borne diseases. Therefore, project authorities would be taking appropriate measures to check such disposal into the river. In order to avoid any deterioration in water quality due to disposal of untreated sewage from labour camps, appropriate sewage treatment facilities will be commissioned in the labour camps. The sewage waste shall be disposed after treatment through STP. The effluent to be discharged should conform to the laid down Standard **(Table 4.1).**

The leakage of POL and washings of workshop floors and washing of vehicle and equipment bring oil and grease with it and shall increase the concentration of oil and grease in water, if discharged into

the river section. Therefore, it shall be collected in oil separators provided in the concrete drains before disposal on water body/ land. The water and soil contamination with oil and grease shall be totally avoided. Even during construction period vigil should be taken by not allowing washing of any vehicle in the river section .The workshop shall be planned away from the river.

4.5. Impacts on Air Environment

4.5.1. *Change in Ambient air and GLC*

The air pollution impact of excavation in ordinary earth and boulders and also rock is directly dependent upon construction methodology, annual rate of excavation, mode of transport within the construction site. The air pollution sources at the proposed barrage site can be construed as broadly area source due to construction activities spread over area under head works and intake and guide bunds . Extraction of stone by various activities in barrage complex area is construed as an area source which includes excavation and activities happening in the excavation area like drilling, blasting, hauling and loading/unloading. The dust emission from these areas will be fugitive in nature. The excavator operations, loading/unloading operations will also cause dust emission though it will be confined to the area of operation of the machinery. The detonation of explosive shall release SO2 and NOX. Blasting is the major source of instantaneous emission sources of particulate matter SO2 and NOx. The dust will be wind borne. With the proposed control measures, the fugitive emissions will be minimized in terms of their impact on environment.

4.5.2. *Dust Dispersion Modelling for Construction Operation*

In order to predict the particulate emissions, Lakes Environmental Aermod View version 9.8.1 (Air Dispersion Modelling Software) an interface based on ISCST3 - was used to predict changes in air quality i.e., maximum ground level concentration (GLC's) of Particulate Matter. Short term model options were opted for uniform emissions rates. The air modelling was conducted to predict GLC of fugitive dust emission particulate matter i.e., PM_{10} and $PM_{2.5}$ and gaseous polltants SO_2 and NOx, which are released due to detonation of explosives during blasting operations.

In the present study, the emission rates suggested by the United States Environmental Protection Agency (USEPA–42-Fifth Edition, Chapter-13- Miscellaneous Sources, Section 13.2.3 for Heavy Construction Operation and 13.3 for Explosive Detonation) have been used. For emission factors due to detonation of explosives Table 13.3-1 was followed. For largely used explosive ANFO with 5.8-8% Fuel oil, the emission rates for NOx and SO_2 has been adopted as 8 kg/ton and 1 kg/ton. Emission factor of 2.69ton /hectare/month of activity has been adopted for TSP and values for PM10 and PM2.5 have been worked out using relation PM_{10}= 0.34 TSP and $PM_{2.5}$ =0.03 TSP

Isopleth for 24-hourly GLC developed for all pollutants are shown in **Figure 4.1** through **Figure 4.4.** Inside dam complex excavation area, the maximum GLC of pollutants PM10, PM2.5, NOx and SO2 was found to be 17.85 µg/m3, 1.55 µg/m3 ,9.52 µg/m3 and 1.19 µg/m3 respectively. The anticipated values of GLC at other receptors (locations) for various pollutants are shown in **Table 4.2.** At the nearest settlement viz. Moosokhiai, the predicted GLC for PM10, PM2.5, NOx and SO2 would be 1.66 µg/m3, 0.10 µg/m3, 0.90 µg/m3 and 0.11 µg/m3 respectively. At Siangkhnai, the predicted GLC for PM10, PM2.5, NOx and SO2 would be 0.66 µg/m3, 0.10 µg/m3, 0.90 µg/m3 and 0.11 µg/m3

respectively. The spatial distribution of concentration of GLC with distance from source is shown in **Table 4.3** and shown in **Figure 4.5** through **Figure 4.8.**

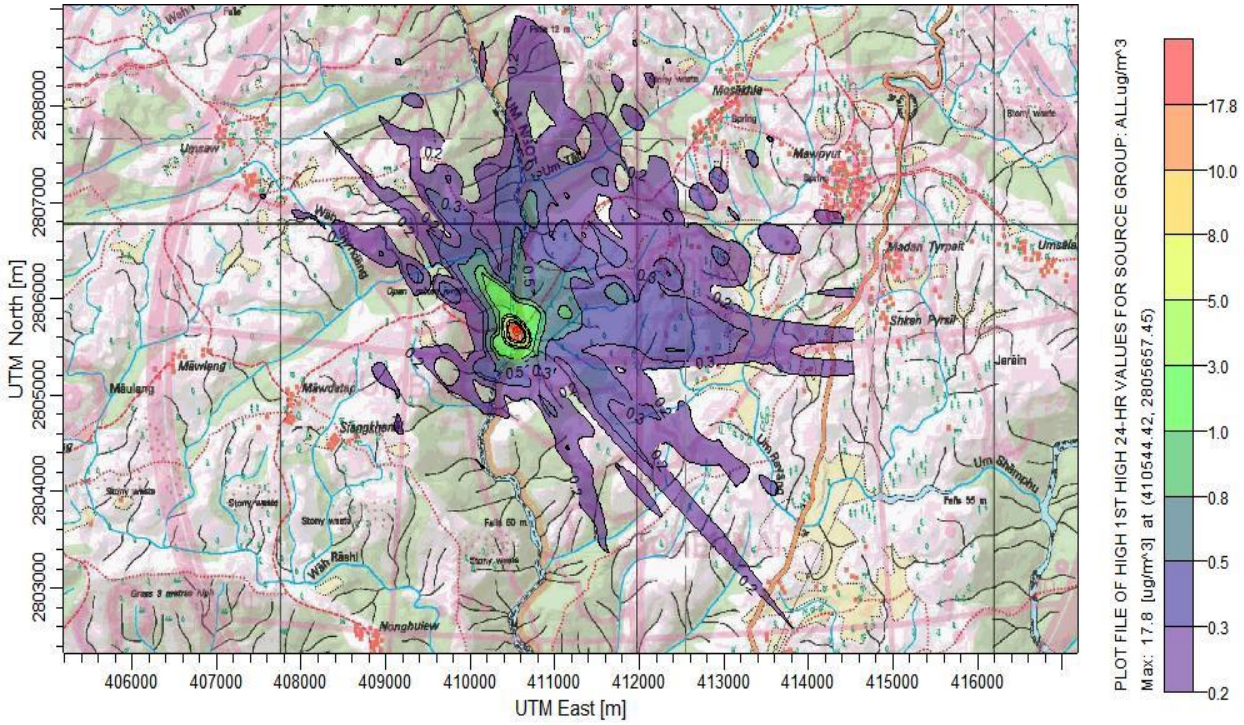


Figure 4.1 : Isopleth of Maximum Predicted 24 hourly Concentrations for PM_{10}

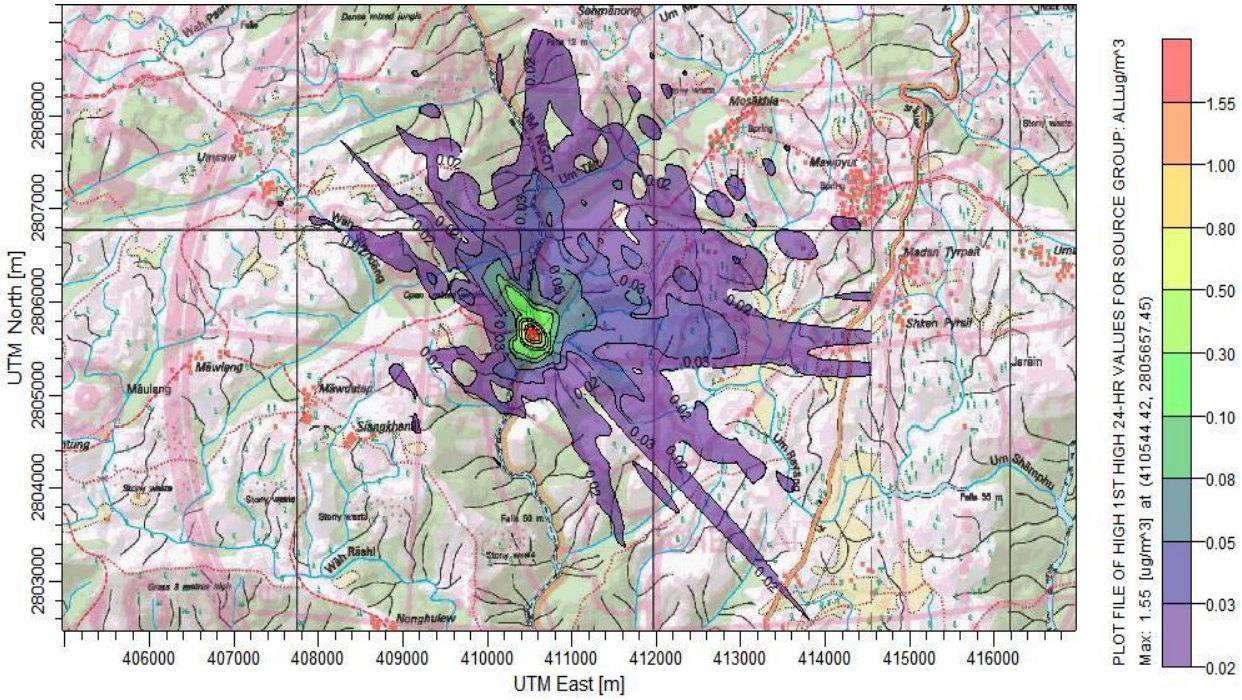


Figure 4.2 : Isopleth of Maximum Predicted 24 hourly Concentrations for $PM_{2.5}$

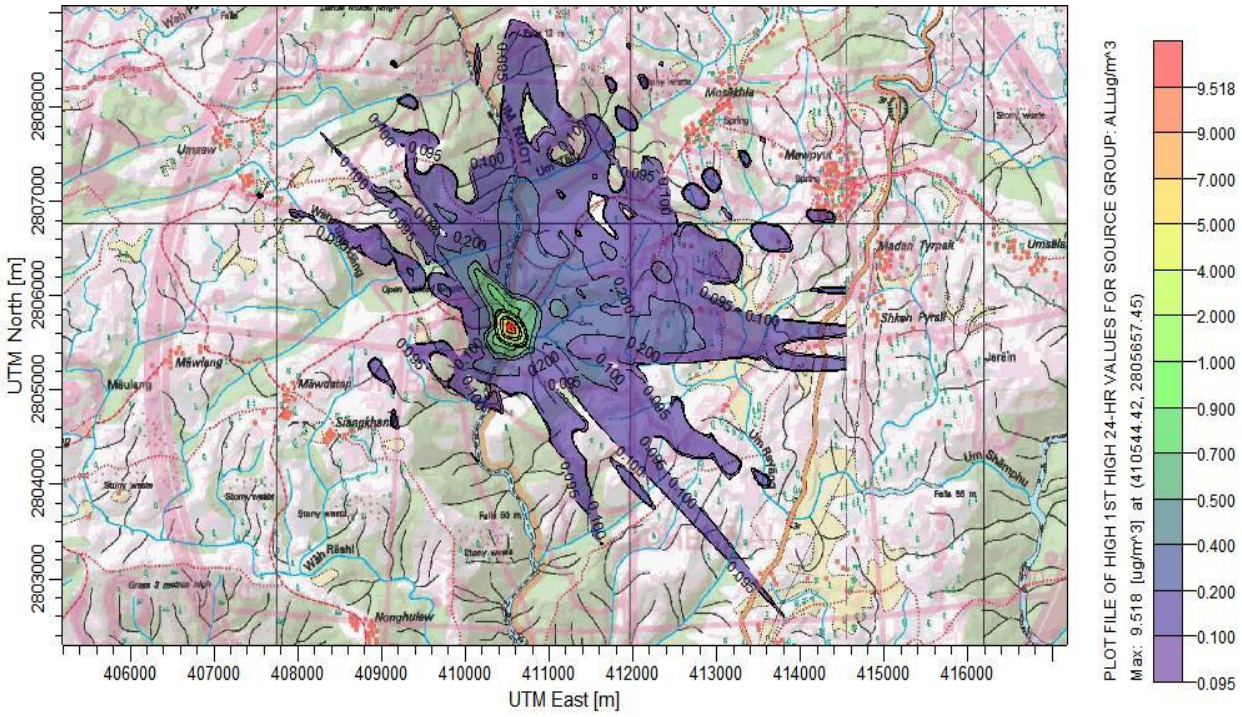


Figure 4.3 : Isopleth of Maximum Predicted 24 hourly Concentrations for NOx

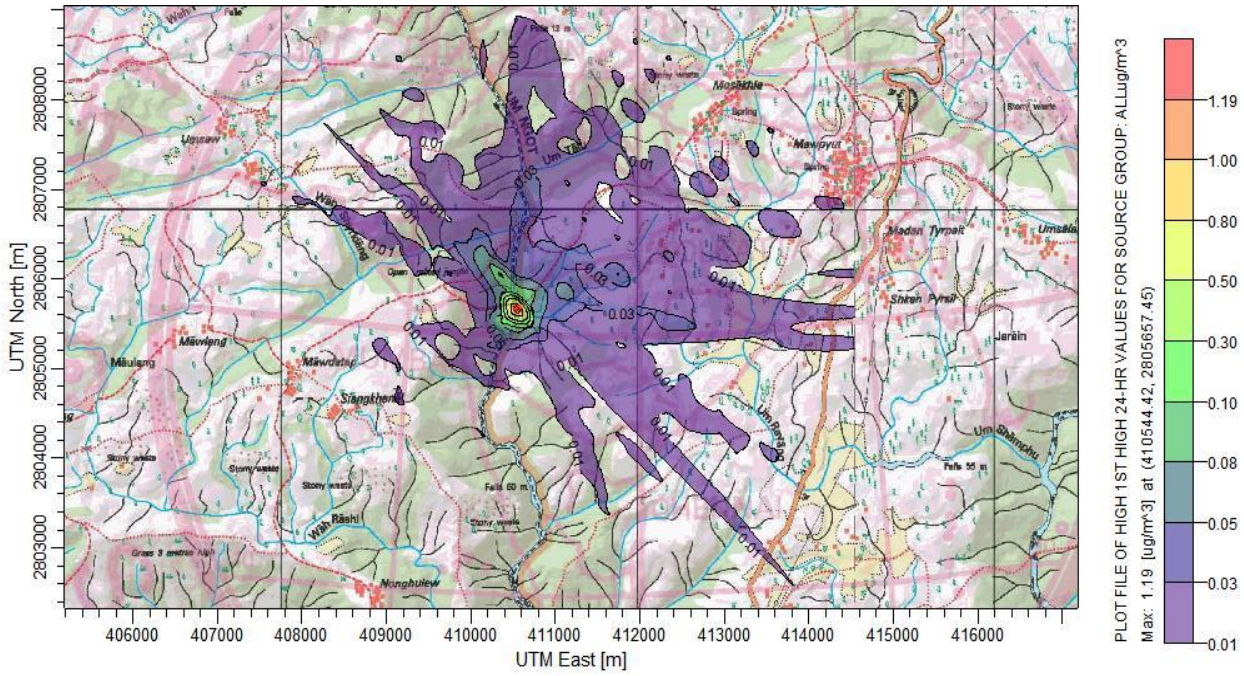


Figure 4.4 : Isopleth of Maximum Predicted 24 hourly Concentrations for NOx

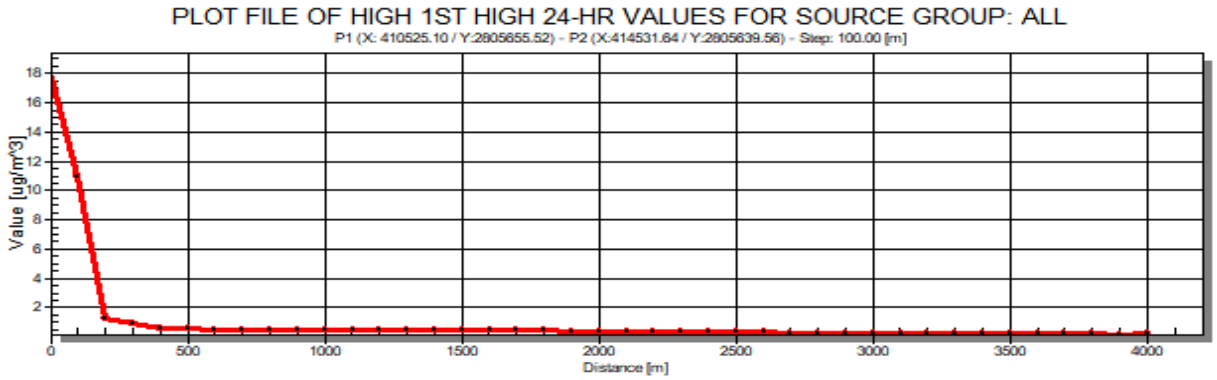


Figure 4.5 : Distribution of Concentration of PM_{10} with Distance

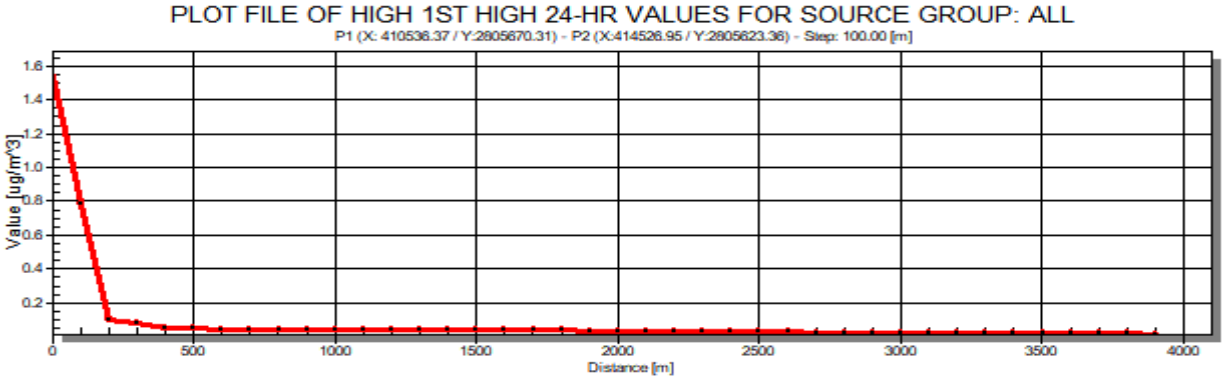


Figure 4.6 : Distribution of Concentration of $PM_{2.5}$ with Distance

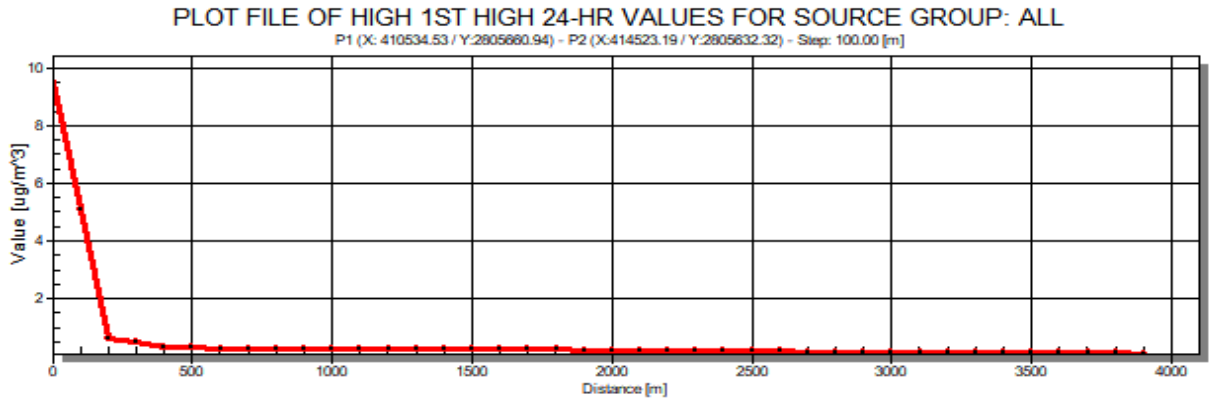


Figure 4.7 : Distribution of Concentration of NOx with Distance

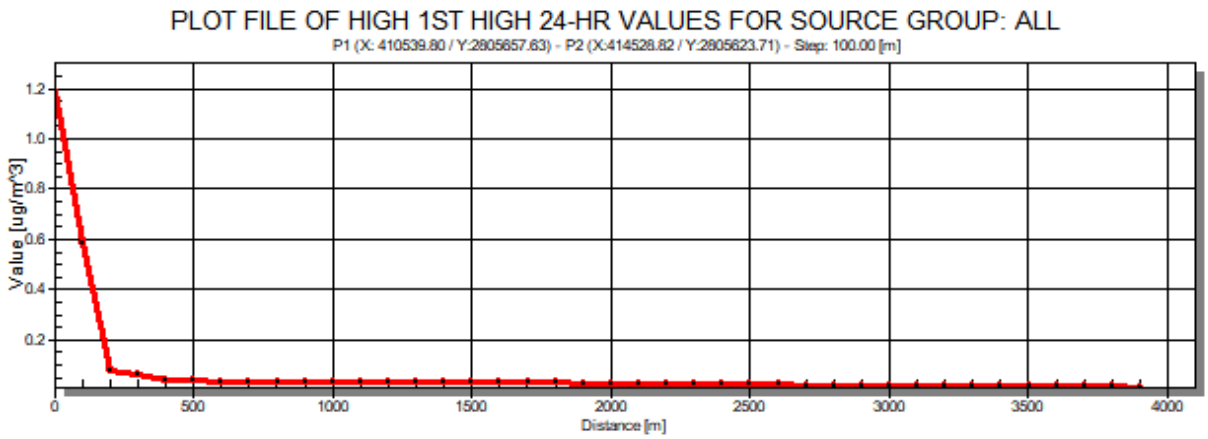


Figure 4.8 : Distribution of Concentration of SO_2 with Distance

Table 4.2 : Maximum Concentration of Pollutants at Different Locations

Location	24 -hourly Maximum Conc (µg/m³)			
	PM_{10}	$PM_{2.5}$	NOx	SO_2
Dam Site	17.85	1.55	9.52	1.19
Siangkhnai	0.66	0.15	0.35	0.05
Moosokhia	1.66	0.10	0.90	0.11

Table 4.3 : Distribution of Concentration of Pollutants with Distance

Distance from Source (m)	24 -hourly Maximum Conc (µg/m³)			
	PM_{10}	$PM_{2.5}$	NOx	SO_2
0	17.85	1.55	9.52	1.19
200	1.24	0.10	0.62	0.08
500	0.60	0.05	0.32	0.04
1000	0.47	0.04	0.25	0.03
2000	0.40	0.03	0.21	0.02
4000	0.20	0.02	0.11	0.01

4.5.2.2 Resultant Impact

The resultant impact due to construction activities on the Ambient air quality for PM_{10} ,$PM_{2.5}$,NOx and SO_2 at the dam complex, nearest air monitoring stations Siangkhnai and Moosokhia is presented in **Table 4.4** which shows that, the resultant concentration levels of all pollutants at each of the locations are within the NAAQS.

Table 4.4 : Resultant levels due to excavation at dam complex

Location	Pollutants	Max. Conc.	Predicted GLC (PM_{10})	Resultant concentration	NAAQS ($\mu g/m^3$)
Dam Site	PM_{10}	44	17.85	61.85	100
	$PM_{2.5}$	22	1.55	23.55	60
	NOx	7.8	9.52	17.32	80
	SO_2	5.0	1.19	6.19	80
Siangkhnai	PM_{10}	45	0.66	45.66	100
	$PM_{2.5}$	21	0.15	21.15	60
	NOx	8.1	0.35	8.45	80
	SO_2	5.0	0.05	5.05	80
Moosokhia	PM_{10}	43	1.66	44.66	100
	$PM_{2.5}$	21	0.10	21.10	60
	NOx	8.8	0.90	9.70	80
	SO_2	5.0	0.11	5.11	80

4.5.2.3 Mitigation Measures

Following mitigation measures shall be adopted during mining activities to control air pollution load below the prescribed limits:

Dust generated due to drilling, blasting, ripping, and vehicular movements will be suppressed by water spraying during and after the operations.

Water sprinkling will be done on the haul road and other roads at regular intervals.

To avoid the dust generation during the drilling operations, wet drilling method will be practiced or wet drill machine will be used.

- Dust mask will also be provided to the workers.
- Proper regular maintenance of machineries will be done.
- Speed of the vehicles will be kept within the prescribed limits.
- Trucks/ dumpers will not be over loaded.
- At the feeding points stone crusher air mist spray shall be carried out.
- Hooded conveyer belts shall be used.

4.5.3. *Effects on Soil Materials, Vegetation and Human Health*

Excavation results in land degradation and formation of loose soil particles which are mainly fugitive dust. The transportation of excavated/construction material on unpaved roads cause fugitive dust emission. These dust particles are usually blown away along the wind direction and get deposited on the canopy of surrounding vegetation and agricultural crops thereby interfering with photosynthesis and other physiological activities of the green cover. Finally, this may result in reduced ecological functions of the forest ecosystems as well as economic productivity of the agro-ecosystems. Since the work is being carried out in river bed plain and the fugitive dust particles neither move far away from point of emission nor ground level concentration (GLC) is high as has been found from dust dispersion modelling that PM10 and PM2.5 at the nearest habitation shall be merely 1.66 µg/m3, 0.10 µg/m3 respectively. Thus, there shall not be significant impact.

Drilling and blasting invariably results in land degradation and formation of loose soil particles which are mainly fugitive dust. These dust particles are usually blown away along the wind direction and get deposited on the canopy of surrounding vegetation and agricultural crops thereby interfering with photosynthesis and other physiological activities of the green cover. Finally, this may result in reduced ecological functions of the forest ecosystems as well as economic productivity of the agro-ecosystems Nitrogen oxides also upset the chemical balance of nutrients in the water, which can cause problems with the animals and plants that are dependent upon the water, leading to reduction of the fish and shellfish population.

The gaseous pollutant Oxides of Nitrogen (NOx) react in the atmosphere to form Nitrogen Dioxide (NO 2) which can have adverse effects on health, particularly among people with respiratory illness. NOx are pollutants that cause lung irritation and weaken the body's defences against respiratory infections such as pneumonia and influenza, can cause shortness of breath and chest pains and increase a person's susceptibility to asthma. Air quality modelling shows that predicted concentration of NOx at the nearest habitation shall be merely 0.90 µg/m3. Thus, there shall not be significant impact. The air quality modelling for haul roads has revealed that the increased GLC in respect of NOx were insignificant being 0.13 µg/m3 up to 25m and 0.11 µg/m3 up to 50m and 0.10 µg/m3 up to 1km.

Carbon monoxide (CO) is a product of incomplete combustion and at low concentrations it may pose a health risk and is especially dangerous to the elderly, people with cardiovascular disease or other circulation disorders, anaemic individuals, young infants, and pregnant women. CO reduces the blood's oxygen carrying capacity, and, when inhaled, blocks the transport of oxygen to the brain, heart, and other vital organs in the body. Extreme levels of exposure, such as might occur due to blockages in tailpipes, can be fatal. Foetuses, new-born children, and people with chronic illnesses are especially susceptible to the effects of CO. In addition, carbon monoxide is directly linked to visual impairment, reduced work capacity and mental dexterity, poor learning ability, nausea, headaches, dizziness, and even death.

Sulphur dioxide can react in the atmosphere to form fine particles and poses the largest health risk to young children and asthmatics. Exposure to SOx can create a number of health problems, including sweating, papillary constriction, muscle cramps, excessive salivation, dizziness, labored breathing, nausea, vomiting, convulsions, and unconsciousness, as well as possibly being absorbed by the skin and creating severe diarrhoea. In addition, it may cause effects on the nervous system, resulting in respiratory depression. It is also quite deleterious for the environment. Air quality modelling shows

that predicted concentration of SO2 at the nearest habitation shall be merely 0.11 µg/m3.Thus, there shall not be significant impact

Particulates are tiny solid particles consisting of particles of soot and metals which can bind to and clog the respiratory tract. These are detrimental when found in both fine ($PM_{2.5}$) and coarse (PM_{10}) forms as it accumulates in the respiratory system, and can lead to decreased lung function, respiratory disease and even death. $PM_{2.5}$ consists of particles less than one-tenth the diameter of a human hair and poses the most serious threat to human health, particularly among those with existing respiratory disorders, as they can penetrate deep into lungs. Of the pollutants emitted by off-road vehicles, particulates are of special concern because their small size makes them easily respirable and thus deliverable directly into the lungs, causing any number of the aforementioned maladies.

4.5.4. *Impacts of Emissions from DG Sets used for Power during construction*

The total requirement of construction power will be about 8MW which shall be required at different consumption points. The construction power shall be tapped from 132/33 KV Mustem Sub-station which is about 26-28 Km from the left bank of the dam site and shall have a line length of about 35 – 45 Km to the different work fronts. In emergent situation resulting due to grid failure or load shedding diesel generator sets of 250KVA /500 KVA capacity shall be deployed for captive power generation.

Emissions from diesel generator sets are a mixture of gases primarily comprising of Carbon Monoxide (CO), Oxides of Nitrogen (NOx), unburned Hydrocarbons (HC), and soot particles i.e. particulate matter). Their impact on human health has been brought out in sub-section 4.4.2.

The emission norms in India cover CO, NOx, PM, and HC and are specified based on the number of grams of these compounds present in diesel exhaust when one kilowatt-hour of electricity is generated. These norms have been revised in December 2013 (G.S.R. 771 (E) / 11th Dec 2013 notification) , its amendment vide GSR 232(E) dated 31st March,2014 and GSR(E) dated 7th March ,2016 and have come in force from 1st July 2016. These norms are presented in **Table 4.5**.

Table 4.5 : Emissions Limits for DG Sets

Power Category	Emission Limits (g/kWh)			Smoke Limit (Light absorption co-efficient per meter)
	NOx+THC or NOx+NMHC or RHC	CO	PM	
Upto 19 kW	≤ 7.5	≤3.5	≤ 0.3	≤0.7
More than 19 Kw Upto 75 kW	≤4.7	≤3.5	≤0.3	≤0.7
More than 75 kW Upto 800 kW	≤4.0	≤3.5	≤0.2	≤ 0.7

NOx also contributes to smog formation, the formation of particulate matter, acid rain, can damage vegetation and contributes to ground level ozone formation. Nitrogen oxides also upset the chemical balance of nutrients in the water, which can cause problems with the animals and plants that are dependent upon the water, leading to reduction of the fish and shellfish population. When carbon monoxide comes in contact with oxygen, carbon monoxide is formed which fall in category of greenhouse gases which contribute to global climate change.

To mitigate adverse impact DG sets should be located from the consideration of prominent and first prominent wind direction so that on the downwind direction the human habitats are least impacted by the flue gas emissions. The norms prescribed by the CPCB in respect of fixing the minimum stack height for generator, should be strictly complied with. In no case, it should be lesser than the 20% of the under root of generator capacity in KVA added to the height of the building where it is installed.

4.5.5. *Pollution Due to Fuel Combustion in Equipment and Vehicle*

The increased traffic load in any particular segment of the road will result into direct increase in pollutants released from the vehicles. The rate of emissions of various types of vehicles is presented in **Table 4.6.** However, the extent of these impacts, at any given time will depend upon the rate of vehicular emission within a given stretch of the road; and the prevailing meteorological conditions. The impacts will have strong temporal dependence as both of these factors vary with time. The temporal dependence would have diurnal, seasonal as well as long-term components.

Table 4.6 : Emission factors by vehicle type (gm/km/vehicle)

CPCB/ ARAI - Emission Factor development for Indian Vehicles – 2008						
Type of vehicle	Make considered	Emission norms	Emission Factors (g/km)			
			CO	NO2	PM10	SO2*
Trucks (HCV Diesel driven)	Post 2000	BS-II	6.00	9.30	1.24	0.03
Passenger Cars (Diesel driven)	Post 2005	BS-II	0.06	0.28	0.015	0.004
Buses HCV Diesel driven)	Post 2005	BS-II	3.92	6.53	0.30	0.026

** Note: Emission Factor of SO2 is calculated based on Sulphur content calculations considering Bharat Stage IV fuel norms*

California Line Source Dispersion Model (Caline 4 ver.2.1) was used to assess the emission load for PM10 and NOx due to increased transportation. During construction phase 190,20 and 40 tipper trucks (10 tonne) shall be deployed on the road for carriage of muck, construction material (cement and steel) and crushed stone aggregate/sand. The model was run for one hour considering worst case angle. The receptors location and model results for worst case wind angle are shown in **Table 4.7.** The results show that at 25 m predicted concentration is 11.6 µg/m3 which reduces to 7.3 µg/m3, 3.2 µg/m3 and 1.3 µg/m3 at 50m, 150m and 500m respectively. Thus the impact on the pollutant level (PM10) due to increased traffic due to transportation of material shall be minimal. The increased GLC in respect of NOx were insignificant being 0.13 µg/m3 up to 25m and 0.11 µg/m3 up to 50m and 0.10 µg/m3 up to 1km.

Table 4.7 : Receptor Locations and Model Results (Worst Case Wind Angle)

Distance from the Road (m)	Incremental GLC PM $_{10}$(ug/cum)	Incremental GLC NOx (µg/m^3)
25	11.6	0.13
50	7.3	0.11
100	4.4	0.10
150	3.2	0.10
200	2.6	0.10
300	1.9	0.10
400	1.5	0.10
500	1.3	0.10
750	1.1	0.10
1000	1.0	0.10

Following control measures have been suggested to prevent air pollution due to the transportation activities:

- Transport trucks/tippers shall be properly maintained.
- Only PUC certificate issued vehicles shall be used.
- Avoiding of overloading of trucks beyond stipulated capacity by installing weigh bridges.
- Strict compliance of traffic rules and regulations

Operation Phase

The ambient air quality during the operation phase either at dam site or the muck disposal site is expected to improve as the fugitive dust and flue gas emission sources of air pollution shall be conspicuously absent

4.5.6. *Fugitive Emissions from Various Sources*

Basically, dust sources in excavation at construction site can be categorized as primary sources that generate the dust and secondary sources, which disperse the dust and carry it from place to place called as fugitive dust.

Impacts of surface excavation with or without drilling and blasting on air quality are cause for concern mainly due to fugitive emissions of particulate matter. The major operations producing dust are drilling and blasting, pit excavation, segregation and screening of material, loading and transporting. Exhaust emissions from vehicles deployed are also likely to result in inconsequential increase in the levels of SO2, NOx, and CO.

4.5.7. *Impact on Micro-Climate*

Major construction activities involve surface excavation and concreting works at dam site and excavation in borrow areas. These activities shall not affect the ambient temperature, humidity, rainfall, wind speed and direction and other meteorological parameters during construction.

Wind Speed: The wind speed in any area is dependent upon local topography and is intimately connected with the development as high- and low-pressure zones. The controlling factors for the pressure changes lie much beyond the mining operation in small mining area which stands inconsequential as compared to the vast extent of a region in general. Thus, no adverse impact on the regional wind speed is anticipated due to the construction activities.

Rainfall: The trend of rainfall follows a regional pattern and is mainly governed by the south west monsoon and disturbances in the Arabian Sea. The construction activities, therefore, are not likely to have any adverse impacts on rainfall pattern.

Humidity: The pattern of relative humidity depends mainly on the rainfall, wind, temperature and other weather phenomenon that are regional in behavior. The excavation activities are not likely to have any impact on the relative humidity in the surrounding. However, the humidity in the area may slightly increase due to creation of waterbody. The change in land use pattern due to submergence will have impact on the local climate due to marginal increase in humidity.

Temperature: There shall be felling of trees in the reservoir area in the last year of construction before filling of the reservoir which may cause a localized temperature increase which shall be moderated

by the trees in the green belt around the reservoir periphery. The temperature pattern is a regional behavior and is not likely to be affected appreciably by the construction activity.

4.6. Impacts Due to Noise and Vibration

4.6.1. *Impact on Noise Level*

A cumulative effect of surface excavation activities at Dam complex generates enormous noise and vibration in the project area and its surrounding areas. Prolonged exposure to high noise levels over a period of years invariably causes permanent damage to the auditory nerve and/or its sensory components (Banerjee and Chakraborty, 2006; Krishna Murthy et al,). The irreversible damage, commonly referred as noise-induced hearing loss (NIHL), is the commonest occupational diseases amongst the construction workers especially at such sites which have multiple noise sources. Besides this the fauna of surrounding area is also affected by noise as the wildlife is more sensitive to noise and vibration than the human beings (Mathur, 2005).

Noise Due to Drilling

The drilling is contemplated to be carried out by Jack hammer rock drills with air compressor which entail a noise level of 88.0 dB (A) and will be a worst-case scenario. Nonetheless, the noise generated due to drilling is within the standards prescribed by Occupational Safety and Health Administration (OSHA) for 8-hour exposure i.e., 90 dB (A). It is worth mentioning here that mining shall be carried in a shift of 8 hours and the equivalents noise level exposure during the shift shall be less than the safety limit of 90 dB(A),

Noise due to Blasting

Blasting generates instantaneous and impulsive noise and is site specific dependent on many factors like the dimension of the holes, type and quantity of explosive i.e., charge/delay and degree of stemming in the hole. At the blast site with the given diameter of holes and their pattern, the noise levels are expected to be in the range of 120-130 dB (A) and tend to decrease with increase in distance of receptor. As the blasting is envisaged over a fixed time period in a day the blasting is considered to last for 2-3 minutes for one blasting operation depending on the charge. The noise levels over this time would be instantaneous and short in duration thus implying that impact on noise levels from blasting are not of concern.

Noise due to crushing, Screening and Loading Plant

The average noise levels generated due to proposed crushing activities will be about 88.5 dB(A) which is within the exposure limit of 90 dB(A). The crusher within the project area shall be housed in a shed to contain noise. Screening activities shall generate average noise level of about 96.5 dB (A). Workers in the noise generating zone will be provided with earmuffs/earplugs besides dust mask.

Noise due to excavation and transportation

In order to predict ambient noise levels due to the mining activities from various sources at different location within the dam complex the noise dispersion modeling has been done on the assumption that all noise sources are acting as a single source generating approximately 90 dB(A). Noise generated due to deployment of rock breaker, excavators, loaders and dump trucks are shown in **Table 4.8.**

Table 4.8 : Standard Values of Noise Levels

S.N.	Machinery/ Activity	Noise Produced in dB(A) at 50 ft from source*
1.	Excavator/Shovel	85
2.	Front end loader	85
3.	Dump Truck/ Tippers (at full throttle)	92
4	Near Haul road (while dumpers are moving)	88
5	Dozer (when dozing)	102
6	Drill machine (drilling with Jack hammer)	88
7	Aggregate processing unit / Stone Crusher	86

*50 feet from source = 15.24 meters

Source: *U.S. Department of Transportation (Federal Highway Administration) – Construction Noise Handbook*

Model for sound wave propagation during mining

For an approximate estimation of dispersion of noise in the ambient air from the point source, a standard mathematical model for sound wave propagation is used. The noise generated by equipment decreases with increased distance from the source due to wave divergence. An additional decrease in sound pressure level with distance from the source is expected due to atmospheric effect or its interaction with objects in the transmission path.

For hemispherical sound wave propagation through homogenous loss free medium, one can estimate noise levels at various locations, due to different source using model based on first principles, as per the following equation:

LP2=LP1 – 20Log (r2 / r1) - AE …….. (1)

Where,

LP2 and L P1 are the Sound Pressure Levels (SPL) at points located at r2 and r1 from the source. AE is attenuations due to Environmental conditions (E). The combined effect of the entire source can be determined at various locations by the following equation.

LP (total) = 10Log (10 (Lpa)/10 + 10 Lpb)/10 + 10 Lpc)/10 + ……) (2)

Where Lpa, LPb, LPc are noise pressure levels at a point due to different sources.

Environment Correction (AE)

The equivalent sound pressure level can be calculated from the measured sound pressure level (Leq measured) averaged over the measurement surface area ‘S’ and from corrections K1 and K2 and is given by;

(Leq measured) = (Leq measured) – K1 – K2 (3)

Where,

K1 = Factor for the background noise correction. The correction was not applied in this modelling exercise, as it was not possible to measure the background noise levels by putting off machines hence it was considered as zero.

K2 = Environmental correction

In the present study dhwani PRO Version 3.6, a noise propagation modelling software developed to undertake construction, industrial and traffic noise propagation studies. A variety of scenarios can be created quickly in dhwani PRO, allowing the user to determine the impact of changing the source, layout and adding /removing the effects of shielding due to noise mitigation devices such as barriers.

Input for the model

Base Map, Point Source and Receptors

Base maps identifying the location of the site, noise sources, receptors and other important characteristics of the surrounding area is the foremost requirement. In this study jpeg raster maps created in Google map showing the locations of the construction site where the maximum excavation is to be carried out has been captured and imported for registering the map and setting up of the scale. The point source is the location where the maximum noise generating construction equipment is to be operated. The receptors are the nearby settlements where the impact of propagation of noise is to be evaluated.

Hourly noise level

Hourly nose levels observed for 24 hours at the point source have been observed and adopted in studies. The noise levels to be generated intermittently due to running of construction equipment for different hours have also been incorporated. Besides this, the background levels at the receptors have been entered into the corresponding windows.

Model outputs

After running the model, the graphical results in the form of noise level contours **(Figure 4.9)** have been produced which has been captured and exported. Besides this the output in the tabular form showing the estimated noise levels at different receptors owing to the impact of operation of construction machinery has been generated **(Table 4.9).**

Table 4.9 : Modelling Output

Project Title: Noise Modelling Umngot
Project Subtitle: HEP Project Shillong
Client: MEPGCL

Receptor	Zone meter	X	Y	Estimated Background	+Backgound* Level dB(A)	Standards Level dB(A)*Lday dB(A)	Background Lnight dB(A)
R_1-Siangkhnai	Residential	1358.4	849.5	34.0	50.0	55.0	45.0
R_2-Moosakhai	Residential	3291.0	2027.1	33.0	50.0	55.0	45.0

Inference and Mitigation Measures

It is evident from the modelling results that due to running of construction machinery the estimated noise levels at Barrage complex shall be 71 dB(A),whereas at two receptors i.e. ,Siangkhnai and Moosakhai shall be 34 dB(A) and 33 dB(A) respectively and the resultant levels (estimated +background level) at these receptors shall be 50 dB(A) and 50 dB(A) respectively which are less than the standard values 55 dB(A) for day time for Siangkhnai and Moosakhai but at night time these marginally exceeds the standard limit by 5 dB(A) and are not much perceptible. An increase of about 8 −10 dB(A) is required before the sound subjectively appears to be significantly louder.

The following control measures will be adopted at the points near to the source of noise to keep the ambient noise levels below permissible limits 75 dB (A).

- Provision and maintenance of thick tree belts to screen noise.
- Avenue plantation within the project area to dampen the noise.
- Regular maintenance of noise generating transport vehicles and HEM machinery.
- Regular noise level monitoring shall be carried out for taking corrective action
- To check the noise, pollution noise filters may be erected around batching plant

To protect the workers from exposures to higher noise levels provision of protective devices like ear muffs/ear plugs to those workers who cannot be isolated from the source of noise and reducing the exposure time of workers to the higher noise levels by rotation.

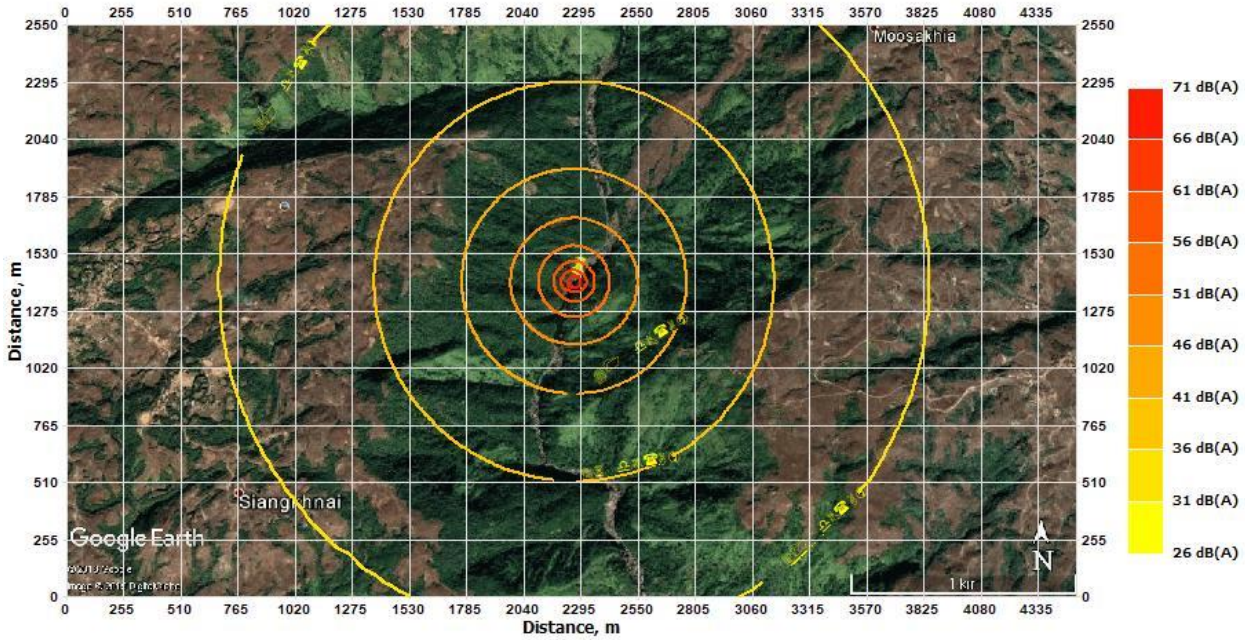


Figure 4.9 : Noise Graphical Results

During Operation Phase

After completion of the project and during the operational phase the noise levels shall not be impacted as there are no noises emitting sources except the noise created during passing of surplus discharge through spillway, which shall persist for a few hours till the flood subsides. At the proposed dam site, the existing leq day and night noise level is 76 dB(A) which is mainly due to the noise generated due to flow of river. During the operation phase, due to filling of the reservoir the obtaining situation shall lead to reduction of the noise level owing to change in flow regime i.e. from riverine to

lacustrine state. It is only during the opening of gates in flood season for spilling the water through spillway, the noise level shall increase. At the powerhouse site the existing leq day and night noise level is 75.9 dB(A) which is mainly due to the noise generated due to the flow of the river. During operation phase the noise levels shall increase. The space averaged turbine hall and generator floor sound levels will be governed by the following relation.

Sound level in dB(A) at turbine floor = 7 log 10 MW +80
Sound level in dB(A) at Generator floor = 82+3.5 log 10 MW
The noise levels predicted to result from running of one and three turbines at a time are shown in **Table 4.10.**

Table 4.10 : Predicted Noise Levels

No. of Turbines Running	Noise levels dB(A)	
	Turbine Hall	Generator Floor
One	92.9	85.0
Three	96.3	90.2

4.6.2. ***Impacts due to Ground Vibration (due to blasting)***

The ground vibrations, noise and fly rock constitutes the chief environmental impact of blasting. When an explosive charge detonates the chemical reaction takes place and the chemical energy is converted into shock and gas energy thereby setting prolific dynamic waves around the blast hole mainly brought by sudden acceleration of stationary rock mass. While a small portion of energy liberated during blasting is consumed in fragmentation of rock mass and fly rock apart from dissipation through ground vibration and air over pressure (noise) heat and light. The ground vibration sets the ground in transverse, longitudinal and vertical direction and which in turn causes the foundation of structure to vibrate in these directions and damage the structures.

Air overpressure is transient impulse, which traverses through the atmosphere and is both audible and inaudible and have the energy to vibrate a structure like ground vibration and is much of concern as animals are more sensitive than human being. This is mainly manifest as energy released from unconfined explosives such as uncovered detonating cord trunk. It is also caused due to various other factors like too small burden, excessive powder factor, insufficient stemming length, incorrect drilling etc., which are controllable if properly addressed by the blaster.

The fly rock comes from face and top of bench and is often associated with improper blast design, inadequate burden, insufficient and ineffective stemming, wrong blast hole sequence. Sometimes it is caused when the explosive energy is rapidly vented through a plane of weakness in the rock. Thus, it is also controllable if properly addressed by the blaster. Thus, it is also controllable if properly addressed by the blaster.

Ground vibrations are acoustic waves that propagate through rocks. Although the difference in accelerations, amplitude, particle velocities and the frequencies in three direction result into damage to structures but the peak particle velocity and frequency are normally taken into consideration for evaluating the structural response. The various aspects of ground vibration triggered by open cast blasting and consequent-damaging effects on different types of structures is usually computed based on the value of the Peak Particle Velocity (PPV) induced at the foundation of the distant structure. PPV criteria are considered the best predictor for ground vibration caused by blasting. It takes into consideration the total energy of ground motion induced around a blast and is a function of the

distance of the location of blast from the gauge point and quantity of explosive per blasting. In case of surface excavation at the dam site the PPV is worked out based on various empirical formulas. In the present case, the PPV has been worked out based on following empirical equation.

$V=880 (D/\sqrt{Q})^{-1.265}$ mm/s, where,
D=Distance (m) between location of blast and gauge point
Q=Quantity (kg) of explosive per blasting
The resulting value of PPV has been compared with the limiting values for dominant excitation frequency less than 8 Hz as prescribed by the Director General of Mines Safety, India (DGMS) in Circular 7 of 1997. The study shows ppv value at different nearby location at distance mentioned against each as is lower than the prescribed limiting value(**Table 4.11).**

Table 4.11 : Computation of Peak Particle Velocity at Nearest Settlement from Dam Site

Name of nearest village	Quantity of explosives / delay (kg)	Distance (D) from dam Site (m)	Peak Particle Velocity in mm/s	Limiting value of PPV (mm/s) prescribed by DGMS, India
Siangkhnai	40	1000	0.67	5
Moosakhai	40	1200	0.53	5

In order to minimize vibration, the following shall be adopted:

- Blast holes shall be initiated by non-electric (NONEL down-the-hole (DTH) delay detonators.
- Care shall be taken to ensure that effective burden is not excessive and the face shall be kept sufficiently long.
- Optimum charge per delay shall be kept as low as possible.
- Adoption of two row blasting and V pattern of firing
- The firing of maximum possible no. of blast holes towards free face.
- Use of milli-second delay detonators between the holes and rows of blasting.

4.6.3. *Air Blast over Pressure*

Propagation of blast induced air over pressure has been studied by various investigators and is generally reported as cubic root rather than square root scaled distance. In context of mining operation in the cluster the overpressure is predicted by equations applicable for confined bore hole charges.

$p=3.3 [3\sqrt{Q}/R]1.2$, where,
p= pressure in Kpa
Q=Explosive charge in kg
R= is a distance from the charge
On the basis of the distance and charge per delay the predicted air over pressure values are shown in **Table 4.12.**

Table 4.12 : Predicted Air over Pressure

S. No.	Nearest Village	Distance (R) from dam Site (m)	Charge / Delay (kg)	Predicted Air over pressure in dB(A)
1	Siangkhnai	1000	40	105.2
2	Moosakhai	1200	40	103.3

The predicted air over pressure in dB(A) shall be lower due to attenuation and the blasting being carried out at pit level which are lower than the elevation of Siangkhnai and Masokhai which are higher level than the river bed which is subject to blasting on account of rock excavation.

4.7. Impacts on River Ecology

4.7.1. *Creation of a reservoir*

Creation of a reservoir upstream of shall bring about changes in the riverine ecology to lacustrine ecology flooding the natural habitats that existed before the construction. Reservoirs contribute to greenhouse gas emissions as well. The initial filling of a reservoir floods the existing plant material, leading to the death and decomposition of the carbon-rich plants and trees. The rotting organic matter releases large amounts of carbon into the atmosphere. The decaying plant matter itself settles to the non-oxygenated bottom of the reservoir, which is almost at a stagnant state. The decomposition eventually releases dissolved methane.

4.7.2. *Fragmentation of river ecosystems*

The dam also acts as a barrier between the upstream and downstream habitat of migratory fishes. In case no fish ladder / pass is provided, it blocks their migration upstream to spawning areas, threatening to decrease reproduction numbers and reduce the species population.

In general, permanent inundation caused by reservoir flooding also alters the wetlands, forests and other habitats surrounding the river. Further ecosystem disruption occurs along the banks of the river and downstream. However, the river is flowing through deep gorges of rocky hills with steep slopes. The torrent flow which consists of cascades and rapid habitat due to rocky substratum and high gradient that is attributed to the poor biodiversity. No reserved or protected forests and sanctuary are found in the project influenced area.

4.7.3. *Sedimentation behind the Dam*

The river is having fluvial geomorphology. Sedimentation in pond will reduce water-storage capacity due to the exchange of storage space for sediment which is generally reflected by the formation of shoals / islands on the u/s. Since the project is a storage scheme with diversion structure being 111 m high dam, with average rate of siltation of 17.65 Ham/100 Sq. Km/Yr the sediment deposition at the end of 50 years and 100 years is expected to be 2200.55 ham and 4201.89 ham respectively. The new zero elevation for the dam has been computed taking the aspect into consideration.

4.8. Impact on Biological Environment

4.8.1. *Impacts on Flora*

- It is evident from this study that from the submergence and influence zone of the proposed project none of tree species, shrub, herb or any climber or grass species are either vulnerable or endangered.
- Interestingly the vegetation composition of the submergence zone is also widely distributed in the influence zone in abundance and there will be no significant loss to the habitat. However, any loss of riverine vegetation during the project activity period will be restored in the reservoir periphery in due course of time.

- Due to construction of proposed project, riverine regime of submergence area will change into lacustrine environments.
- The floral abundance of the project area in post construction phase will increase by many folds as the plantation under catchment area treatment, reservoir rim treatment, green belt, restoration and landscaping will be completed.
- 93.53 ha of forest land shall be brought under submergence along with trees. For mitigating loss due to forestland compensatory afforestation plan has been formulated, which shall be implemented by the Forest Department.

4.8.2. ***Impacts on Fauna***

- As the project activity is not going to submerge all the major habitats, there is little concern for these niche birds. As both banks of the river up to 10 km u/s and also on d/s have very sparse human habitation and very little project related activities above the barrage site is expected, there will be no alteration to the existing habitat of faunal species. There is also no wildlife sanctuary, national park and biosphere reserve near the project area.
- During survey, the encounter rate of butterflies was more in dense forests than in open habitats. The area will continue to support the present population of butterflies. As, butterflies prefer habitat with more flowering species and moist condition, increase in the humidity in and around reservoir, and development of green belt will further enhance the butterfly diversity. As the project is having its submergence mostly along the valley, the project is not likely to be a threat to any of the recorded butterfly species.
- A few mammalian species were recorded during the survey. The primary reason for this low figure could be large-scale anthropogenic pressures: disturbance due to agriculture activities, road construction, etc. It is anticipated that with the upliftment of rural economy dependency on forest will be reduce poaching and will ease out pressure on wildlife. The anticipated impacts on the present status of fauna during and after construction are summarized below.

Construction Phase

- Increase in temporary stress levels of wildlife during construction phase due to noise, human interference and reduction in present habitat.
- Threat due to poaching might increase.

Operational Phase

- Improved habitat for mainly water birds, reptiles, mammals, amphibians and plankton due to reservoir creation.
- Improvement in food chain of some reptiles, birds and carnivorous mammals due to creation of reservoir and increase in humidity level.
- The butterfly diversity in the area would be enhanced, as scrub habitat around the submergence will receive substantial amount of moisture, which will help in natural regeneration of forest canopy.

4.8.3. ***Impacts on Aquatic Life***

- The completion of the proposed project would bring about significant changes in the riverine ecology, as the river transforms from a flowing water system to a quiescent lacustrine

environment. Such an alteration of the habitat would bring changes in physical, chemical and biotic life. Among the biotic communities, certain species can survive the transitional phase and can adapt to the changed riverine habitat. There are other species amongst the biotic communities, which, however, for varied reasons related to feeding and reproductive characteristics cannot acclimatize to the changed environment, and may disappear in the early years of impoundment of water. The micro-biotic organisms especially diatoms, blue-green and green algae before the operation of project, have their habitats beneath boulders, stones, fallen logs along the river, where depth is such that light penetration can take place.

- The construction of project shall have impact on the fisheries as the movement on upstream of dam shall be impacted.
- The construction of 111 m high Umngot HEP, with no techno-economical provision for fish ladder/fish pass plausible on river, shall have slight impact on the migratory fishes.
- The proposed project would envisage construction of labor camps to accommodate labors engaged in the project. Sewage generated from the labor colony may have impact on the aquatic ecology, if discharged directly into the river without any treatment or in case of open defecation.
- The congregation of labor force in the project area may result in enhancement in indiscriminate fishing in the project area.
- The reduced flow on downstream of dam up to power house site shall reduce the availability of nutrients on flood plain and bed of the river and thus lower the primary productivity of the river
- On creation of the reservoir and after implementing the fisheries development plan, it shall continue a habitat for the indigenous species as well as reservoir species.

4.9. Impacts on Socio-Economic Aspects

4.9.1. *Impacts on Local Community including Demographic Profile*

During the construction phase, a large labour force, including skilled, semi-skilled and un-skilled labour force of the order of about 1000 persons, is expected to work in the project area at peak construction activity period. It is expected that 80% of the total work force shall be locally available and manpower to the tune of 200 persons shall migrate from other parts of the district or adjacent districts of the state. This will lead to a small change in demographic profile of the area albeit during construction phase only. The temporary labour camps will be established at suitable location in the project area. The fuel need of the labourers/ workers shall be attended in an organized manner by providing LPG and safe drinking water so that any altercation between migrated labour and locals' overuse of natural resources and facilities is averted.

Christians constitute the pre-dominant religious community of the study area. They have deep religious faiths and celebrate festivals with great fervors and enthusiasm. During construction phase, migratory population though in limited numbers, is expected from other parts of the state having more or less similar cultural habits. However, no cultural conflicts are foreseen due to the migratory population, as they will be largely settled in separate conglomerates having all inbuilt facilities. Since major work force will be drawn from the local populace, which by interaction with outside labour during course of construction, shall develop affinity and friendship with the outside workers, thus, minimizing the chances of conflict.

4.9.2. *Impacts on Socio-Economic Status*

Apart from direct employment, the opportunities for indirect employment will also be generated which would provide great impetus to the economy of the local area. Various types of business-like shops, food-stall, tea stalls, etc. besides a variety of suppliers, traders, transporters will concentrate here and benefit immensely as demand will increase significantly for almost all types of goods and services. The business community as a whole will be benefited. The locals will avail these opportunities arising from the project and increase their income levels. With the increase in the income levels, there will be an improvement in the infrastructure facilities in the area.

4.9.3. *Impact on Human Health due to Water/Waterborne Dieses*

Construction of the proposed project may cause impacts on health of local residents and the work force. Fuel and dust emission may cause respiratory problems like asthma for which mitigating measures like wet excavation of exposed surfaces shall be deployed. Frequent water sprinkling at least thrice a day shall be carried out on haul roads in the project activity area. All approach roads to site shall be metaled. Migrant workers might act as carriers of various diseases like AIDS, VDS, etc. The project authority should follow proper quarantine and screening procedures.

Localized stagnation in borrow pit areas is expected during construction in some of the areas, which may require sprinkling of anti-bacterial/insecticides to control propagation of bacteria related disease. The influx of labour-force during construction warrants proper sanitation and hygiene facilities to avoid diseases related to sewage pollutants such as Typhoid, Cholera & Gastroenteritis.

4.9.4. *Impact on Increased Traffic*

Increased use of existing public infrastructure i.e., road due to vehicular traffic involved in transportation of construction materials and muck and earthmovers may cause congestion on roads. However, the state highway and the national highways in the district in general have been designed keeping in view the futuristic vehicular traffic. At present the level of convenience on the basis of traffic volume is “A” which shall alter to “B” due to increased traffic on Mawkynrew MDR. However, due to increased traffic the impact shall be prominent on the Siangkhnai village road (rural) leading to river bed where the level of confidence shall change from “A” to “B”. The increased traffic shall cause more fugitive dust emission and gaseous pollution, which when added to the existing concentration the resultant concentration shall be within the limits. Regular maintenance of road and copious sprinkling of water shall be carried. Transport trucks/tippers shall be properly maintained. Only PUC certificate issued vehicles shall be used. Avoiding of overloading of trucks beyond stipulated capacity by installing weighbridges at the check posts or near to it. Strict compliance of traffic rules and regulations shall be ensured. The movement of trucks/trippers/tractors for loading /transportation within the project area and haul road area shall be regulated by a trained supervisor who shall be responsible for the safety of vehicle movement and prevention of accidents or incidents associated with the vehicular movement.

4.9.5. *Impact on Holly Places and Tourism*

The project is located in East Khasi Hills district with dam and reservoir situated in rural set up, very close to MDR Mawkynrew. The nearest place of tourist’s importance is famous Wahrashi waterfalls. The Wahrashi Falls/Kshaid is a waterfall along with several waterfalls in one location in Syntung village under Mawkynrew C and RD Block.

There are 8 waterfalls just in this location and good for explorers who want to see them all. It’s a great place to spend the whole entire day for a Picnic, Trekking, Camping and taking pictures with everyone.

The proposed project, which is nearby, shall create a substantial increase in tourism due to reservoir. For attracting people for picnic excursion, some picnic park shall have to be developed near dam with facility for water sports.

4.9.6. *Impact of Blasting*

Blasting is accompanied by the generation of the dust and the fumes and fly rock. which pose a significant danger to the people who are in the vicinity of the work site. It also leads to ground vibrations which cause the ground to vibrate in transverse, longitudinal and the vertical direction leading to its damage. Due to blasting the people of the nearby villages are always physiologically impacted as they are constantly under apprehension of damage to their structures. Blasting also causes air overpressure is a transient impulse that travels through the atmosphere. Much of the air overpressure produced by blasting has a frequency below the audible limit of 20 Hz. Air overpressure, both audible and inaudible, can cause a structure to vibrate in much the same way as ground vibrations It is a frequent cause of the complaints as a person senses air overpressure more than vibrations. The noise due to air over pressure is instantaneous a short lived and may cause annoyance to vulnerable people.

Blasting shall have adverse impact on fauna using the area contiguous with the surrounding habitation area as habitat. The noise generation has an adverse impact on terrestrial fauna and avi-fauna. Intervention in the project area will impact butterflies and birds which are quite sensitive to noise and human presence. The traffic noise has detrimental effect on the survival rates and breeding success of such fauna which reside in the small habitats along road side communicating using acoustic signals. Sometime as a result of habitat loss and physical disturbance, the fauna shall move from the habitat along road side. Based on the field observations and interaction with local people and forest officials it was noted that the project area does not constitute part of any wildlife migratory routes and mining activities won't affect animal movement.

All precautions shall be taken as envisaged under the relevant acts in respect of handling of explosive material and blasting which shall invariably be carried out by a qualified blaster.

4.9.7. *Positive and Negative Impacts likely to be accrued due to Project*

The positive impacts

The advent of project shall herald overt changes in the socio-economic conditions of the affected people and the population, living in the project affected zone who shall be directly benefitted. Some of prominent positive impacts are: -

- Average annual generation of 708.98 MU of energy in a 90 % dependable year.
- Better living Standards.
- Employment opportunities/fisheries.
- Benefits to economy and commerce.
- Access to improved infrastructure facilities.
- Recreation and tourism potential
- Improvement in environment through implementation of CAT, Compensatory Afforestation, Green belt Development and different other plans.

Major negative impacts

The pang of involuntary displacement shall cause many social pressures and stress on the PAFs because they shall lose their roots from their ancestral land and move in bewilderness of new place and environ to which they may adapt in due course of time. Some of prominent major negative impacts are: -

- Land of thirteen Villages (296.97 ha) shall be partially affected due to acquisition of land for project purpose.
- 378 families shall be impacted due to project.
- The loss of arable land (152.43ha).
- Loss of livelihood and income.
- Loss of homestead and other assets over which the PAFs have developed affinity.
- The change of river status from riverine to lacustrine regime
- The loss of forest due to construction of dam, reservoir and appurtenant works
- Likely decrease in agriculture and horticulture production due to air pollution
- Disturbance to the fauna of the study area during construction
- Pressure on the existing provincial / state road will increase.

Chapter 5. : ANALYSIS OF ALTERNATIVES

5.1. Introduction

The consideration of alternatives from environmental and project economics is one of the cardinal and proactive aspects in conception of a project. It is mainly instrumental for proper project planning, safe and economical designing and adoption of state-of-the-art technology through examining options instead of only focusing on the more defensive task of reducing adverse impacts of a single design. This includes the systematic comparison of feasibility alternatives to the proposed project, inter alia specific project site, technological and operational alternatives. Alternatives are compared in terms of their potential environmental impacts, project economics, and suitability under local conditions.

In the process of EIA, analysis of alternatives is the key tool to examine the extent of environmental impacts both beneficial and adverse, posed by the construction and operation of the proposed project vis-à-vis the environmental status of the region without the development of the project. It also involves comparison and environmental evaluation of the different alternatives proposed in the project. The assessment has been carried out for project alternative in no hydropower scenario, the with and without project scenario, alternate sites and different tunnelling methods.

5.2. Project Alternatives

The installed capacity of the project is 210 MW and it would generate 708.98 GWh of power in a 90% dependable year. In no project scenario, in order to generate this power by thermal power plant about 0.75 million tons of the coal would be utilized considering specific fuel consumption as 1.06 kg/KWh. The state is known to have no fossil fuel and thus thermal power generation by importing coal is not at all a lucrative and valuable proposition mush so when the state is bestowed with enormous hydro-power potential.

5.3. No Project Scenario

In the interest of energy security and achieving a low carbon growth, it is required to tap available hydro potential in the country. A “no-project” scenario will ensure that the resulting increased demand-supply gap for electricity will be filled up by development of additional coal fired power stations (the fuel of choice given India’s abundant coal reserves) during off-peak time and small diesel or coal fired plants during peak time. These would result in significant net increase in GHG emissions.

Due to the finite nature and limited number of feasible hydropower projects, it is unlikely that a gap created by not developing this HEP project can be filled up by developing another hydropower project.

At the state level, hydropower is a major resource, important for the state’s economic progress and revenue accrual. A “no-project” scenario would mean an annual revenue loss for the state. It is unlikely that a coal-fired plant (that would come up as a response to the “no project” scenario) may come up within state, being away from both the coal mines and the centres of power demand. Overall, the “no project” alternative is not a desirable option.

5.3.1. *Environmental Conditions*

The environmental conditions have been assessed in both the scenarios viz. with and without project for the two aspects viz.

- The impact of construction and operation of the project
- The environmental status of the area if the project is not undertaken.

The analysis has been carried out for the 'with project' and 'without project' scenario associated with hydrology, air quality, flora and fauna, socio-economic and infrastructure. No analysis has been carried out with respect to climatology and meteorological conditions which will be localized and insignificant impact on either of the scenarios.

Table 5.1 : Alternative Analysis for Proposed Project

Issues	Without Project	With Project
Hydrology	The surface and groundwater hydrology will not be altered. The river water is not used for any purposes downstream of the intake point up to TRC outfall.	From intake structure a maximum abstraction of 33.4 cumec discharge through HRT shall be released to the river about 20km through TRC.The abstraction of water through intake shall reduce the river flow up to 20 km d/s of the dam to the extent discharge flowing through intake up to the point of outfall of TRC. The abstraction of water through intake shall reduce the river flow up to 20 km d/s of the dam to the extent discharge flowing through intake tunnel, up to the point of outfall of TRC. As such there will be significant impact on the environment due to this alteration. For downstream usages of river course will have a minimum environmental flow of 0.3 cumec in four consecutive leanest months (Jan to April). During non-leanest and non-monsoon months of October, November, December and May, (March - April) 3.43 cumecs shall be released. During monsoon months (June-September) ,10.33 cumecs shall be released downstream of barrage site. The project does not envisage draft of underground water; therefore, underground hydrology will not charge. The annual recharge shall not be affected due to the project
Land use and Soil	The study area has open forest with percentage as high as 45.4%. The tree density is found thin in the project area mainly due to illegal felling of trees. The cultivable land is also less. This situation is likely to worsen if some mitigative measures are not timely adopted.	The land use class of 253.75 ha land involved in submergence shall change into waterbody. The land use class of forest land and agriculture land required for project components and internal roads shall have land use class changed to built-up area. The land use class of forest land required for quarry and muck disposal sites shall remain unchanged as these sites shall

		later on developed with vegetal cover. The implementation of various management plans viz. CAT plan, compensatory afforestation, greenbelt etc. shall improve the land cover of the area. Hence the land use will improve in the long run.
Air Quality & Noise Level	Ambient air quality is good to satisfactory and noise levels are not high at present. Due to socio-economic factors and development activities in the area these are expected to deteriorate gradually with time.	Air quality may deteriorate during the construction period at project sites. However, this will be a temporary phenomenon, and will be confined to the location and duration of the construction activities. The air quality is thus likely to improve due to improved road conditions proposed in the project for transportation of construction material. The noise quality of the area is likely to be moderately affected during the operation phase and also construction phase due to sporadic use of DG sets and increased traffic. However, since the DG sets will be housed inside enclosure and the increase in traffic will be negligible post construction, no significant adverse impact is envisaged.
Rehabilitation and Resettlement	No resettlement and rehabilitation issues arise without the project	Due to project, there shall be loss of 152.43 ha agricultural land and consequently loss of production from the land. The project affected families shall be adequately compensated for land loss and cost of land to be acquired as per provision under RFCT_LARR 2013. However, acquired land will be compensated for as per the market rate and acceptance of the affected people
Ecological Impact	The vegetation of study area comprises dense/open forest and cultivated land. The situation is not expected to change without project scenario. There will be no impact on wildlife in such a scenario	Site selection throughout the length of the project is such that there is minimal tree cutting involved. Further, because most of the proposed components are underground, tree felling will be mainly involved at the tunnel portals and in submergence. Owing to the underground activities at considerable depth from the surface, the wildlife of the area will also not be affected other than during the construction phase for which Wildlife Management Plan has been formulated. The construction of project shall have

		impact on the fisheries as the movement on upstream of dam shall be impacted.
Socio-culture issue	The local residents are mainly cultivators and make a living by selling their produce in local market and exporting apples. However, with increasing population, requirement for other job opportunities is also being felt	Due to project activities, local and regional people will get direct and indirect employment opportunities not only during construction phase but also during the operation phase, too. The staff residences are proposed for running and maintenance of the power plant. With proper measures no impact is expected on local crops.

Based on the above discussions, it is found that with the project, no significant impact is likely although air and noise quality will deteriorate during the construction phase. The project implementation shall however lead to economic benefits to the local people. However, considering the national importance of the project in generation of the much-needed electricity, the 'with project' option along with proposed mitigation measures is preferred.

5.4. Alternative Studies for Siting and Project Component and Tunnelling Methods

The siting and alignment of the project components. is mainly based on site configuration and the geological assessment of the rocks and the stability of banks on upstream and downstream of diversion site. Alternative locations for dam location and tunnel alignment, powerhouse location is selected and investigated. During investigation and planning stage and at the time of preparation of DPR, detailed surface investigations are carried out at different alternative sites and balance is struck in favor of the best alternative.

5.4.1. *Original Proposal*

The initial proposal contemplated a two-stage development for exploiting the enormous hydro-power potential of Umngot river. The first stage envisaged construction of a 40 m high dam of effective storage (15MCM) on the Umngot river near village Siangkhnai, 2.5 diameter and 2.975 km long HRT, a surge tank and a surface penstock up to a surface powerhouse (27MW) proposed near village Syntung to be kept at elevation is at EL. 660 m. The second stage was planned to further utilize the still available head of another 240 m to generate another 30 MW.

5.4.2. *Revised Proposal*

The revised proposal evolved during 2000-01, envisaged utilisation of 720m drop in the riverbed by developing a 70 m high concrete gravity dam at the same location of the dam of the first stage during the initial planning. The water in this case would be led through a 5.7 km HRT and a 2.8 km long Penstock to a surface powerhouse at EL. 220 m just upstream of the confluence of Um Sot and Umngot to generate 150 MW.

5.4.3. *Final Proposal*

The final layout is proposed to contain a 111 m high and 362 m long concrete gravity dam, a 3.4 m diameter and 5646 m long HRT, a 12 m diameter and 68.10 m high surge shaft and a 2.50 m diameter and 2209 m long underground pressure shaft to feed 3 nos. of Pelton turbines each of 70 MW capacity seated in a surface powerhouse (210 MW). The total annual energy in a 90% dependable year is 708.98 MU and the continuous power is 27 MW.

5.4.4. *Alternatives for Tunneling Methods*

The project will involve construction activities in hilly terrain, more specifically through rocky hills, where tunnelling is required. Tunnelling can be carried out using following two methods.

- By 'Tunnel Boring Machines (TBM) and
- Conventional drilling and blasting

These two techniques are analysed on techno-economic and environmental aspects (**Table 5.2**).

Table 5.2 : Comparison of Tunneling Techniques

S.N.	Issues	Tunnel Boring Machine	Drilling and Blasting
		Techno economic Feasibility	
1	Techno economic feasibility	Requires larger platform for its functioning. Machines are heavy and require specific efforts for its movement and handling especially in difficult terrains. The project area has steep inclinations and is prone to landslide at certain locations. Development of required platform at various adit points, is in itself a difficult task and expensive. Such operations may not be techno-economically feasible	Drilling and blasting can be carried out in rocky terrains. Although the rock formations are soft in general, but the tunnel routing has been considered through stable formations in the mountains. Hence, drilling and blasting is considered feasible
		Environmental Feasibility	
2	Noise and vibration	The generation of noise and vibration would be of medium intensity, through it will be continuous in nature	The generation of noise and vibration would be of high intensity, but will be instantaneous and intermittent in nature. Since, tunneling would be about half a kilometer under the surface and through stable formations, vibrations are not likely to traverse long distances. Noise will also be contained within the tunneling area
3	Air Emissions	There will be continuous dust generation of small magnitude which will have to be ventilated out though ID fans. The use of water sprinkler system on the dust plume trail will ensure the non-dispersion of the dust to long distances	There will be intermittent dust generation of medium magnitude which will be ventilated out though ID fans. The use of water sprinkler system on the dust plume trail will ensure the non-dispersion of the dust to long distance

4	Seepage water generation and disposal	The detection of water seepage can be easily noticed. However, as per the hydro-geological report, there are no aquifers in the tunneling routes. Hence, the seepage water generation likelihood is less	Due to blasting, the flooding of the tunnels may be sudden. However, since there is no presence of water aquifers, the possibility of flooding in the tunnel due to blasting is not anticipated
5	Debris disposal	The debris generated from tunneling will be disposed in identified disposal sites and shall not affect the environment adversely	The debris generated from tunneling will be disposed in identified disposal sites and shall not affect the environment adversely
6	Impact on flora and fauna	The continuous generation and dispersion of dust from tunneling may affect the productivity of apple orchards. Hence water sprinklers shall be used to control the dust dispersion	The intermittent generation and dispersion of dust from tunneling may affect the productivity of apple orchards. Hence, water sprinklers shall be used to control the dust dispersion.

Based on above analysis, it is inferred that the environmental impact associated with the above two methods of tunnelling are similar and that no major preference can be attached to either of the techniques on environmental considerations. However, due to the emerging techno-economic feasibility, the drilling and blasting method is found to be the more feasible option.

Chapter 6. ENVIRONMENTAL MONITORING PLAN

6.1. General

Sustainability of water resource project depends on continuous monitoring. Monitoring is an integral part of any environmental assessment process. Water resource development project creates a new environment with complex inter-relationships between people and natural resources. The magnitude of changes being created due to alteration of landscape, water, air and noise quality and other environmental parameters can be quantified and evaluated only by carrying out monitoring of various parameters during different phases of project construction and operation.

The monitoring and evaluation of environmental parameters indicates potential changes occurring in the environment which paves way for implementation of rectifying measures wherever required to maintain the status of the natural environment. Evaluation is also a very effective tool to judge the effectiveness or deficiency of the measures adopted and provides insight for future corrections.

6.2. Areas of Concern

In case of hydro power projects, the changes relating to water, aquatic biota, air, noise, biodiversity of the area and compensatory afforestation programmes need special attention, from monitoring point of view, during project construction as well post construction stages to judge the efficacy of measures implemented for conservation of environment.

6.3. Environmental Monitoring

The overall impact assessment of the proposed project was carried out and monitoring plans have been framed based on the severity of impacts in different areas. During the EIA study it has been observed that the air quality and water quality are not going to be affected significantly and only, temporary changes in these parameters are expected. The preventive/ curative measures to reduce the ill effects of construction activities on these parameters have been suggested under various plans. A holistic approach has been adapted for monitoring of air, noise and water related factors under different heads with suitable financial provisions for their implementation.

i. Air Quality Monitoring and Management

Pollutant which may be generated during the construction phase of the project will alter the local environment temporally and shall subside once the major constructional activities are over. During the construction phase of the project, the ground level concentration of the pollutant like SO_2, NOx and PM_{10} are likely to increase but shall be within the threshold limit especially in surface excavation areas but may exceed the threshold limit for underground work areas which is to be controlled by use of ventilator fans. It should be made mandatory on the part of the contractors that they use the required equipment for monitoring gaseous pollutants in and around the project and submit a detailed report every fortnight to the project authorities for evaluation and monitoring purposes. The air quality in and around the project area can be improved by the application of following practices/ methods.

- Excavation work may be carried out by pre-splitting and controlled blasting techniques
- Control blasting be carried out as far as possible and use of explosive also be bare minimum.
- The type of explosive used in blasting may be selected as per the requirement.

- To settle down the dust in project area especially around crushing plants, excessive use of water sprinklers is the best method.

The work of Air Quality Monitoring may be assigned to either Meghalaya State Pollution Control Board or any other agency approved by MOEF. For this a lump-sum provision of Rs. 10.5 Lac for 6 and 1-year during construction and operation phases respectively shall be sufficient to cater to the quarterly monitoring of air quality parameters such as SO_2, NOx and PM^{10}. The monitoring site should be

- dam Site
- Power house site
- Rock-in-situ quarry site
- Aggregate processing and batching plant

The total financial implication of this plan stands as **Rs 10.50 Lakh**.

ii. Noise Quality Monitoring and Management

The level of noise will definitely rise above threshold level in the project area due to different types of construction activities: blasting for tunnels, powerhouse, dam etc., movement of heavy and small vehicles and the crushing plants. All these activities will generate high noise and vibrations which can cause health hazards among the labours, local inhabitants and wildlife present in the area. Therefore, it would be most appropriate if following measures are rigorously applied during construction phase of the project.

- Continuous monitoring of sound level within the project area.
- Extensive plantation to be carried out in the project area as plants absorb sound and make a barrier for its travel to long distances.
- Pre-split and controlled blasting.
- Provision of Air muffs to workers working in underground excavation works.
- Compulsory Periodic Maintenance of high earth movers, batching and crushing plants.

Monitoring and measuring the sound level can be again assigned to either State Pollution Control Board or any other external agency. The financial implication for monitoring of noise pollution is proposed for every three months during construction phase of six years and post construction phase for one year. The total financial implication for construction and post-construction phase works out to **Rs. 3.5 lakh**. The noise shall be monitored at the following locations: -

- Dam Site
- Power house site
- Adit near Surge shaft
- Aggregate processing and batching plant

iii. Water Quality Monitoring and Management

Water is one of most precious natural resources. Human beings are highly dependent on water for various purposes such as domestic needs, sanitation irrigation, industry, and disposal of wastes etc. The catchment of Umngot up to the power house site does not host any industry. Thus, the stream water is almost free from major industrial chemical pollutants. Besides this, the catchment is sparsely populated with small chunks of agricultural fields. Therefore, the water of river bears some load of

silt mainly from glacier melts i.e., moraine deposit and domestic wastes. Further, due to congregation of labourers during the construction phase, the water quality in this stretch may get deteriorated if proper sanitation facilities are not provided to them. The probable water pollutants which may cause pollution during the construction phase of this project are: -

- Suspended solids
- Biodegradable organic matters
- Pathogens and vectors
- Nutrients
- Dissolved inorganic solids

The Government of India has prescribed clear cut guidelines for the maintenance of water quality standards which are given in **Table-6.1**.

Table 6.1 : National River Water Quality Standards for Different Uses*

Sl. No.	Characteristics	Tolerance Limit				
		Drinking water source with conventional treatment	Outdoor bathing	Drinking water source with conventional treatment but after disinfection	Fish culture and wildlife propagation	Irrigation industrial cooling or controlled water disposal
		A	B	C	D	E
1.	pH value	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
2.	Dissolved Oxygen (mg/l), min	6	5	4	4	-
3.	BOD (5-days at 20^0 C, mg/l, min	2	3	3	-	-
4.	Total Coliform Organism, MPN/100, max	50	500	5000	-	-
5.	Colour, Hazen units, max	10	300	300	-	-
6.	Odour	10	300	300	-	-
7.	Taste	Tasteless	-	-	-	-
8.	Total Dissolved Solids, mg/l, max	500	-	1500	-	2100
9.	Total Hardness (as $CaCO_3$),mg/l, max.	300	-	-	-	-
10.	Calcium Hardness (as $CaCO_3$), mg/l, max	200	-	-	-	-
11.	Magnesium Hardness (as $CaCO_3$), mg/l, max	100	-	-	-	-
12.	Copper (as Cu), mg/l, max	1.5	-	1.5	-	-
13.	Iron (as Fe), mg/l, max	0.3	-	0.5	-	-
14.	Manganese (as Mn), mg/l, max	0.5	-	-	-	
15.	Chloride (as Cl), mg/l, max	250	-	600	-	600
16.	Sulphates (as SO_4), mg/l, max	400	-	400	-	1000
17.	Nitrates (as NO_3), mg/l, max	20	-	50	-	-

18.	Fluorides (as F), mg/l, max	1.5	1.5	1.5	-	-
19.	Phenolic Compounds (as C6H5OH), mg/l, max	0.002	0.005	0.005	-	-
20.	Mercury (as Hg), mg/l, max	0.001	-	-	-	-
21.	Cadmium (as CD), mg/l, max	0.01	-	0.01	-	-
22.	Selenium (as Se), mg/l, max	0.01	-	0.05	-	-
23.	Arsenic (as As), mg/l, max	0.05	0.2	0.2	-	-
24.	Cyanide (as CN), mg/l, max	0.05	0.05	0.05	-	-
25.	Lead (as Pb), mg/l, max	0.1	-	0.1	-	-
26.	Zinc (as Zn), mg/l, max	15	-	15	-	-
27.	Chromium (as Cr^{6+}), mg/l, max	0.05	-	0.05	-	-
28.	Anionic Detergents (as MBAS), mg/l, max.	0.2	1	1	-	-
29.	Polynuclear Aromatic Hydrocarbons (as PAH)	0.2	-	-	-	-
30.	Mineral Oil, mg/l, max	0.01	-	0.1	0.1	-
31.	Barium (as Ba), mg/l, max	1	-	-	-	-
32.	Silver (as Ag), mg/l, max	0.05	-	-	-	-
33.	Pesticides	Absent	-	-	-	-
34.	Alpha emitters, uC/ml, max	10^{-9}	10^{-9}	10^{-9}	-	-
35.	Beta emitters, uC/ml, max	10^{-8}	10^{-8}	10^{-8}	10^{-8}	10^{-8}
36.	Free Ammonia (as N), mg/l, max	-	-	-	1.2	
37.	Electrical Conductance at 25^0C, mhos, max	-	-	-	1000×10^{-6}	2250×10^{-6}
38.	Free Carbon dioxide (as CO), mg/l, max	-	-	-	61	
39.	Sodium absorption ratio	-	-	-	-	26
40.	Boron (as B), mg/l, max	-	-	-	-	-
41.	Percent sodium, max	-	-	-	-	-

* IS: 2296-1982

The water quality in and around the project area may, therefore, be monitored regularly, and certain necessary corrective measures be introduced accordingly to maintain it. The project proponent shall also ensure Environmental flow of water immediately below the dam at all times including lean seasons.

Proposed Water Quality Monitoring Plan

It is anticipated that during the construction period of the project the generation of waste water from construction sites, residential colonies and labour camps may increase and facilitate transport of sediment laden waters to the river. Pollutants resulting from the sewage waste would definitely degrade river water quality further. The following measures are, therefore, proposed for water quality management:

- Sufficient water should be supplied to the labour camps and residential colonies.
- Water should be treated before use to prevent pathogenic and coli form organisms.
- Sewage waste be released in river only after proper treatment.

It is proposed that the sediment laden water from different project components may be collected in sedimentation tanks/water tanks to dislodge the sediments before releasing the sediment free water to river/streams.

Adequate solid waste management practices shall be adopted in colonies and labour camps as suggested in solid waste management plan. It would be eco-friendly if sewage water after disposal of solid waste may be used in watering of parks and gardens. In addition to this, periodical monitoring of water for its physico-chemical and bacteriological parameters may be conducted quarterly at under mentioned sites.

- Umngot river 200 m u/s of dam site
- Umngot river d/s of labour colony
- Umngot river d/s of Power house site
- Umngot river near aggregate crushing and batching plant

The financial provision of **Rs 14.0 lakh** however is made for the period of six years from the date of project execution and for 1-year post-construction. The water quality parameters to be monitored quarterly are shown in **Table 6.2.**

Table 6.2 : Water Quality parameters to be monitored periodically

pH	DO	Phosphates
Electrical Conductivity	BOD	Nitrates
Turbidity	COD	Sulphates
Water Temperature	Free CO_2	Fluorides
TDS	Alkanity	Iron
Total hardness	Chlorides	Manganese
Magnesium	Total Coliform	
Calcium	E-Coli	

Monitoring of Incidences of Water-Related Diseases

Identification of water related diseases, adequacy of local vector control and curative measures, status of public health are some of the parameters which need close monitoring. The monitoring of water related vectors may be executed in collaboration with State Health Department and data so generated may also be preserved by them for future reference. For monitoring twice, a year for six years during construction and one-year post-construction a provision of **Rs. 2.10 lac** and **Rs. 0.50 lakh** respectively has been made.

6.4. Monitoring of Erosion & Siltation

During the construction period, the project proponent shall monitor daily the suspended silt load of the river. Besides this, the stability of river banks shall be closely monitored. After completion of the project, the project proponent shall monitor the daily suspended silt load of the river and work out yearly silt load in ha.m/year/100 sq. km of the catchment area and keep a record of it. On these counts a financial provision of **Rs 6.0 lakh** for monitoring during construction alone is being made as the post construction daily monitoring of silt load is the requirement for running the machines and the responsibility anyway rests with the project proponent.

6.5. Environment Monitoring Through Remote Sensing

The use of remote sensing technology can be aptly made for monitoring of the progress of the works proposed under catchment area treatment, compensatory afforestation, and green belt. This can be achieved by the periodically study of digital satellite data IRS P6 LISS-IV for the specific site and evaluated on ERDAS imagine software. The standard False Colour Composite (FCC) generated by assigning blue, green and red colours to visible green, visible red and near infrared bands respectively. Expressing image pixel addresses in terms of a map coordinate base is often referred to as geo-coding. As various thematic layers are to be overlaid for this project, all the layers shall be geo-referenced to real world coordinates. The comparative study of change in land use pattern, the change in extent of forest areas, the growth of new plantation, the development of new landslide zones can be established by periodical study of the scene obtained from the satellite. The technique can also be made use of in establishing the expanse of sedimentation in the reservoir by comparing the scene obtained from remote sensing after every three years or so.

6.6. Ecosystem Studies

Efficacy of conservation measures to be implemented in catchment area treatment plan such as afforestation and soil conservation measures, and their effects on flora, terrestrial fauna, aquatic fauna (fish migration) are the aspects which should be evaluated and monitored under the head monitoring of ecosystem. The findings of this study should be made available to authority implementing CAT plan, restoration of muck disposal and quarry areas, reservoir rim treatment on periodic basis so as to make necessary change if need arise and the implementation more meaningful during construction and operation phase of the project. Since, the study is subject specific, services of expert agencies will be required to carry out the same. Therefore, the financial provisions of **Rs. 6.00 Lakh** has been made and provided in the final cost estimate of environmental monitoring plan. This fund will also take care of the expenditure for other studies which are required by the regulatory authority from time to time and also cater to the needs of expenditures to be incurred on public awareness programmes for environmental conservation.

6.7. Monitoring of Muck Disposal

It has already been made eloquent in the relevant muck management plan that the excavated material shall be evacuated from site with suitable usable muck to be utilized in project works by the project proponents and also allowed to be used by private users and the non-usable muck is to be disposed of on designated areas so as not be interfere with either environment/ecology or the river flow regime. Thus, these is an imperative need to monitor regularly the quantum of muck generated and its disposal for which purpose the project proponent shall furnish monthly statement of muck/debris disposal to project proponent and State Pollution Control Board.

6.8. Monitoring of Minimum Flow

During operational phase, minimum release of water as prescribed immediately downstream of diversion structures shall be monitored daily by the project proponent who is bound to submit monthly statement to State Pollution Control Board, who should also conduct surprise checking in this regard and submit its report to the MoEFCC, New Delhi.

6.9. Sharing of Monitoring Results

The results of monitoring of various environment attributes either during or post construction would be shared by the monitoring agency, whosoever including State Pollution Control Board, with the

project proponents and other agencies of the Government as and when required. Monitoring agency may disseminate the results in any other forms.

6.10. Cost of Environment Monitoring Programme

The total cost of environment monitoring plan works out to **Rs. 60.00 lakh** and is given in **Table 6.3.**

Table 6.3 : Summary of Environment Monitoring Programme

Sl. No.	Aspect	Parameters to be monitored	Frequency		Location	Cost Estimates (Rs. lakh)			Implementing and Pursuing Agency
			During Construction	During Operation		During Construction	During Operation	Total	
1	Air Quality monitoring	SO_2, NO_X, PM10	Quarterly for 6 years	Quarterly for 1 years	4 locations as specified	9.00	1.50	10.50	SPCB or any approved agency of MOEF
2	Noise Quality Monitoring	Noise level	Quarterly for 6 years	Quarterly for 1 years	4 locations as specified	3.00	0.50	3.50	SPCB or any approved agency of MOEF
3	Water quality Monitoring	All parameters given in water quality	Quarterly for 6 years	Quarterly for 1 years	4 locations as specified	12.00	2.00	14.00	SPCB or any approved agency of MOEF
4	Water-related diseases	Identification of water-related diseases,	Half yearly for 6 years	Half yearly for 1 years	Villages adjacent to project sites	3.10	0.50	3.60	C. M. O.
5.	Soil Monitoring	Physical and chemical properties	Half yearly for 6 years	Half yearly for 1 years	4 locations as specified	5.00	0.00	5.00	SPCB or any approved agency of MOEF
6.	Erosion and Siltation	Soil erosion rates, Stability of banks	summer and post monsoon for 6 years	Daily Silt observation	Dam site	6.00	0.00	6.00	Project Proponent
7.	Ecosystem monitoring:	Wild life census, field surveys	Once	Once	Catchment area of the project	6.00	0.00	6.00	Forest dept. or WII
8.	Celebration of Environment Day		Yearly for 6 years	-	At block H.Q.	1.40	0.00	1.40	Forest Deptt.
9.	Study on ecological flow and research on endemic fish fauna					10.00	0.00	10.00	
						55.5	**4.50**	**60.00**	

Chapter 7. ADDITIONAL STUDIES

7.1. General

After having gone through the various aspects of project activities involved in construction of dam at the proposed site and the related documents like Form–I and PFR, the MoEFCC, set out the scoping clearance and issued ToR for environmental impact assessment studies and preparation of environmental management plan for the project and for submission of report. The Terms of Reference issued by the MoEFCC are very comprehensive and subjective covering every aspect of project activity and the related environmental issues to be addressed.

7.2. Public Hearing

In consonance with the EIA notification 14th September 2006, vide section 7(i) related to public consultation, the draft report shall be submitted to the SPCB for conducting public hearing within the validity period of 4 years as applicable under O.M. dated 8.10.2014 and OM dated 12.01.2017.

7.3. Risk Assessment

The project activities involve certain types of hazards, during construction and operation, which can disrupt normal activities abruptly and lead to disaster like fires, failure of machinery, explosion, to name a few. The impending dangers or risks, which need be investigated addressed, disaster management plan formulated with an aim to taking precautionary steps to avert disaster and to take such action after the disaster, which limits the damage to the minimum. Following problem may be encountered during construction at the project site.

- Accidents due to explosives/blasting
- Failure of stripped slope.
- Accidents due to HEMM
- Sabotage in case of magazine

In order to take care of above hazards/disasters, the following safety measures will be strictly complied with in the current project:

- Handling of explosives, charging and blasting shall be carried out by competent persons only.
- Provision of magazine at a safe place with proper fencing and necessary watch and ward. Adequate safety equipment will be provided at magazine and project site.
- Regular maintenance and testing of all project equipment/machinery and transport vehicles as per manufacturers guidelines
- Entry of unauthorized persons will be prohibited.
- Firefighting and first –aid provisions in the project office/complex and project area and ensuring periodic checking of worthiness of firefighting and first aid provision.
- Training and refresher courses for all the employees working in hazardous points. All employees shall have to undergo the training at a regular interval.
- As a part of disaster management plan, a rescue team will be formed by imparting specialized training to select project staff.

7.4. Possible Hazards

There are various factors which singularly and severally can cause disaster in a river valley project. The project activity is associated with many hazards which are discussed in the following sub sections:

7.4.1. *Blasting*

The accidents from the blasting are mainly manifest as projectiles which some time traverse beyond the danger zone and trespass the project boundary. It is largely due to overcharging of blast holes and also during secondary blasting. During initial and final blasting operations flying rocks are encountered. Ground Vibration caused due to blasting lead to displacement of adjoining areas and result in fallout of loose rock-mass if not properly scaled in earlier blasting cycle. The following measures are suggested to avoid accidents due to blasting:

- All blasting operations shall be supervised by a competent person appointed for the purpose and strictly conducted as per guidelines contained
- Danger zone area falling within a radius of 500m from the blast site shall be demarcated;
- Guards shall be posted at all access points leading to the blast area to prevent and control movement of persons/ stray animal;
- All employees and equipment shall be cleared off the blast area to a safe location prior to any scheduled blasting; and
- Audible signals such as sirens whistles and mikes etc., shall be put to use to caution the workers, passer-by about the scheduled blasting events.

7.4.2. *Heavy Machinery*

Most of accidents during transport of dumpers, excavators, dozers and other transport vehicles are often attributed to mechanical failures and human errors and can be significantly averted by adapting to following:

- All HEMM and transport vehicle movement within the project area should be carried out under the direct supervision and control of the management;
- All project machinery and vehicles should be periodically maintained and weekly checked by a competent person authorized by the management;
- Conspicuous sign board should be provided at each and every bend for guidance of the operators/drivers during day/night time; and
- To avoid dangers while reversing the trackless vehicles, especially at the embankment and tripping points, all areas for reversing of vehicles should, as far as possible, be made man free, and should be a light and sound device to indicate reversing of trucks/project machinery.

7.4.3. *Storage of Explosive*

The explosive magazine shall be located outside the project area. For the purpose of transportation of explosives, explosive van shall be deployed. The main hazard associated with the storage, transport and handling of explosives is fire and explosion. The rules as per Indian Explosive Act-1983 and Explosive Rules-2008 should be followed for handling of explosives, which includes transportation, storage and use of explosives.

7.4.4. *Fuel Storage*

All project machinery will operate on diesel for which no storage point is envisaged in the project area. It will be stored in the central workshop area of the proponent.

7.5. Disaster Management Plan During Construction

In order to handle disaster/emergency situations, an organizational chart entrusting responsibility to various project personnel will be prepared with their specific roles during emergency.

Planning

- Identification and Prevention of Possible Emergency Situations
- Possible emergency situations can broadly be classified into vehicle collision, and inundation off project area. Some of the ways of preventing emergencies are as follows:
- Preparation of a Preventive Maintenance Schedule Programme and also covering maintenance schedules for all project machinery/equipment and instruments as well as transport vehicles as per recommendations of the manufacturer's user manuals
- Ensuring the compliance of traffic rules strictly along Kuccha roads (haul roads) within the project lease area as well as outside the project lease area.
- Emergent situation arises due to happening of some incident culminating into an abnormal situation. It implies that sufficient time space running from a few seconds to few minutes is always invariably available to arrest an incident of abnormal situation from turning in to an emergency.

Implementation

Following key personnel, identified for carrying out specific and assigned duties in case of any kind of emergency, shall be available on call on holidays and off duty also.

- Project Manager
- Personnel Officer
- Foreman
- Essential workers

Responsibilities of Project Manager

- To take overall charge at the place of incident and activate the Emergency Preparedness Plan according to severity of situation.
- Inform doctor to be ready for treatment of affected employees and intimate their relatives.
- To depute staff, carry out following functions -
- To liaison with district administration and other departments and guide their personnel
- To supervise assembly and evacuation at all points
- To look after patients who are bed ridden and any casualties and give psychological support
- Inform and liaison with project proponent, Police department and District Emergency Authority.
- Arrange for chronological records of emergency to be maintained.

- Issue authorized statements to news media.

Responsibilities of Projects Foreman

- To take immediate charge at the site of incident and ensure that immediate steps as per Emergency Preparedness Plan are taken and immediately inform Projects manager.
- Shall disseminate the information regarding emergency by blowing of siren / hooter.
- Supervise assembly and evacuation as per plan, if required and ensure that casualties are receiving proper medical care.
- Ensure accounting for personnel and rescue of missing persons.
- Control traffic movement in project area.

Responsibilities of Trained Workers

A task force comprising of specially trained staff to act and deliver in the emergency situation shall carry out the following work.

- Fire-fighting and spill control till fire brigade takes the charge and thereafter assist the fire brigade
- Ensuring safety and isolating equipment, materials, urgent repairing or replacement, electrical work etc.
- Controlling movement of equipment, transport vehicles, special vehicle at the project site.
- Extending first - aid and medical help.
- Assistance at casualty's reception areas to record details of casualties

7.6. Disaster Management Plan During Operation

Though through detailed field investigations it has been ensured that the dam is founded on firm foundation, designed for suitable seismic design parameters and the spillway has been designed for passing 615 cumecs discharge, yet in view of that uncertain element of "Force majeure" the eventuality of a disaster caused due to dam break cannot be ignored but a rescue plan must be devised for confronting such an exigency without being caught in the vast realm of unpreparedness. The dam break analysis and detailed disaster management plan have been dealt in depth under Chapter 11 of EMP.

Chapter 8. PROJECT BENEFITS

8.1. General

There will be number of positive changes on the socio-economic conditions of the people in the surrounding area. There will be obvious change in the scenario leading into the Socio-economic development of the area.

- Increased Power Generation
- Contribution to Development
- Employment Potential / Fisheries
- Guaranteed Energy and Price Stability
- Flexibility to Utilise Other Renewable Source of Energy
- Tourism / Recreation Facilities
- Fundamental Instrument for Sustainable Development
- Increased Green cover
- Improvement in Life Style, Status and Confidence-building
- Solution of the problem of migration

8.2. Increased Power Generation

Umngot Hydro-Electric Project (210 MW), conceived as storage scheme in East Khasi Hills District of Meghalaya, will utilize maximum gross head of about 808.60 m for annual generation of 708.98 MU of energy in a 90 % dependable year.

8.3. Contribution to Development

Hydroelectric installations bring electricity, highways, industry and commerce to communities, thus developing the economy, expanding access to health and education, and improving the quality of life. Hydroelectricity is a technology that has been known and proven for more than a century. offers a vast potential and is available where development is most necessary. There shall be widening and strengthening of roads leading to project sites to carry the heavy equipment and machinery etc.

8.4. Employment Potential / Fisheries

The project will provide adequate employment opportunity during construction as well as after the completion of the project when the benefits will start accruing. About 1000 local people are likely to be engaged as un-skilled/semi-skilled/skilled labour in construction activities. Besides this due to implementation of labour-oriented works under CAT Plan, Green Belt Development Plan a large number of local people are likely to be engaged.

The creation of the reservoir will increase the fish production and development of pisciculture in the region. Many families will get job in the fisheries which will improve their socio-economic condition.

8.5. Guaranteed Energy and Price Stability

River water is a domestic resource which, contrary to fuel or natural gas, is not subject to market fluctuations. In addition to this, it is the only large renewable source of electricity and its cost-benefit ratio, efficiency, flexibility and reliability assist in optimizing the use of thermal power plants

8.6. Flexibility to Utilise Other Renewable Source of Energy

Hydroelectric power plants with accumulation reservoirs offer incomparable operational flexibility, since they can immediately respond to fluctuations in the demand for electricity. The flexibility and

storage capacity of hydroelectric power plants make them more efficient and economical in supporting the use of intermittent sources of renewable energy, such as solar energy or Aeolian energy.

8.7. Tourism/Recreation Facilities

Due to formation of reservoir, the project will result in increase of tourist recreation facilities generating the opportunities of self-employment to the local population. The creation of a large and impressive dam shall lead to the development of visitor facilities and recreational sites associated with the dam. The reservoir may also provide opportunities for boating, water sports, picnic areas etc.

8.8. Fundamental Instrument for Sustainable Development

Hydroelectric enterprises that are developed and operated in a manner that is economically viable, environmentally sensible and socially responsible represent the best concept of sustainable development. That means, "development that today addresses people's needs without compromising the capacity of future generations for addressing their own needs" (World Commission on the Environment and Development, 1987)

8.9. Increased Green Cover

Under the Catchment Area Plan it is proposed to carry out afforestation/plantation in about 1100 ha besides pasture development in 60 ha area. Besides this around dam site and in the periphery of the reservoir 30 ha area shall be brought under plantation. Apart from these 24500 saplings shall be planted as avenue plantation along roads. The implementation of all these plans shall increase the vegetal cover in the area

8.10. Improvement in Lifestyle, Social Status and Confidence Building

When there will be economic growth due to availability of more job opportunities in the area there will be improvement in lifestyle and social status of the people. The social status of the people can change only when there is economic growth in the society. The construction of the project will bring many positive changes resulting in the development of the area. This will give immense confidence to the people to achieve better prospects in life which is certainly going to increase their social status.

8.11. Solution of The Problem of Migration

The forthcoming project will open many avenues for the livelihood in the project area. There will be more job opportunities once tourism and recreation activities develop here. If ample opportunities are available in the village itself then they don’t have to leave the village and migrate to other cities for earning their livelihood. In addition, there will be a number of business opportunities created for service industries, e.g., building construction, repair and mechanics shops.

8.12. Conservation of Forest and Fuel

After the relocation of the affected population, they will be living near some town where they will have the availability of cooking gas and other means of fuel so there will be saving of fuel wood resulting into conservation of forests when people will not cut the forest for fuelwood for cooking purposes. After getting the compensation of houses people will be constructing concrete houses so there will be saving of timbre

Chapter 9. ENVIRONMENTAL COST BENEFIT ANALYSIS

9.1. General

After having gone through the various aspects of the project at the proposed site and the related documents like Form–I and PFR, the MoEF while setting out the scoping clearance and had not recommended any study on Environmental cost benefit analysis

Chapter 10. ENVIRONMENTAL MANAGEMENT PLAN

Site-specific Environmental Management Plans (EMP) has been prepared for avoiding, mitigating, checking the adverse impacts envisaged during EIA studies on various environmental components during construction and operational phase of the project. The environmental management plan covering the following components, as specified in the ToR, has been prepared as a separate volume.

10.1. Catchment Area Treatment Plan

10.1.1. *Introduction*

The study of erosion and sediment yield from catchment is of utmost importance as the deposition of sediment in reservoir reduces its capacity, thus affecting the water available for the designated use. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil from catchment also adversely affects the agricultural production. Another important factor that adds to the sediment load and which contributes to soil degradation is grazing pressure. A large number of cattle, sheep, and goats graze the pastures continuously for about six months in a mountainous region.

The lack of proper vegetal cover is a factor to cause degradation and there by results in severe run off/soil erosion, and subsequently premature siltation of the reservoir. Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above-mentioned adverse cause and process of soil erosion. The catchment area treatment involves the understanding of the erosion characteristics of the terrain and suggesting remedial measures to reduce the erosion rate. For this reason, the catchment of the directly draining rivers, streams, tributaries, etc. are treated and the cost is included in the project cost.

The pre-requisite for a watershed management is the collection of multipronged data e.g., geology, geomorphology, topography, soil, land use/ landcover, climate, hydrology, drainage pattern, etc. The multi-pronged data generated from various published sources and actual data collected from these watersheds on the above-mentioned parameters forms the basis of the Action Plan for Catchment Area Treatment is presented here.

Catchment Area Treatment (CAT) plans for the free draining catchment area of the proposed 'Umngot HEP' has been prepared for areas with high soil erosion intensity. The CAT Plan targets towards overall improvement in the environmental conditions of the region. All the activities are aimed at treating the degraded and potential areas with severe soil erosion. The plan provides benefits due to biological and engineering measures and its utility in maintaining the ecosystem health. The plan with objectives addresses issues such as prevention of gully erosion, enhancing the forest cover for increasing soil holding capacity; and arresting total sediment flow in the reservoir and flowing waters.

10.1.2. *Objectives*

Integrated watershed management plan minimizes the sedimentation of reservoir. The main aim of the Catchment Area Treatment Plan is to rejuvenate various potential and degraded

ecosystems in the catchment area for longevity of the reservoir storage capacity. For this purpose, the action plan has been prepared with the following objectives:

1. To facilitate the hydrological functioning of the catchment and to augment the quality of water of the river and its tributaries.
2. Conservation of soil cover and to arrest the soil erosion, floods and siltation of the river along with its tributaries and consequent reduction of siltation in the reservoir of the project.
3. Demarcation of the priority of watersheds for treatment on the basis of soil erosion intensity in the catchment area.
4. Rehabilitation of degraded forest areas through afforestation and facilitating natural regeneration of plants.
5. Mitigation of landslide, landslip and rock falls.
6. Soil conservation through biological and engineering measures to reduce sediment load in river and tributaries, incidentally improving the quality of water.
7. Ecosystem conservation resulting from increased vegetal cover and water retaining properties of soil.
8. To meet the fuel and fodder requirements of local people.
9. Promotion of non-conventional energy device to reduce pressure on forest.
10. Employment generation through community participation and conservation.

10.1.3. *Methodology Used for The Study*

Superimposing topography, slope, soil and land use data/maps, a tentative estimation of erosion prone areas and landslides area in the catchment were made. The vulnerable and problematic areas were identified in different physiographic zones. These data sets were used for preparation of the thematic maps, calculation of sediment yield index and Erosion Intensity Units.

Soil Loss Using Silt Yield Index (SYI) Method

- The Silt Yield Index Model (SYI), considering sedimentation as product of erosivity, erodibility and aerial extent was conceptualized in the All-India Soil and Land Use Survey (AISLUS) as early as 1969 and has been in operational use since then to meet the requirements of prioritization of smaller hydrologic units within river valley project catchment areas.
- Methodology for the calculation of sediment yield index developed by All India Soil & Land Use Survey (Development of Agriculture, Govt. of India) was followed in this study.

(i) Erosion Intensity and Delivery Ratio

- Determination of erosion intensity unit is primarily based upon the integrated information on soil characters, physiography, slope, land-use/land-cover, litho logy and structure. This

is achieved through super-imposition of different thematic map overlays. Based upon the field data collected during the field survey and published data, weightage value and delivery ration were assigned to each erosion intensity unit. The composite map for delineating different erosion intensity units was prepared through superimposition of the maps showing soil types, slope and land-use/land-cover. This thematic mapping of erosion intensity for entire catchment was done using the overlay and union techniques. Based on ground truth verification conducted during fieldwork and published data, weightage and delivery ratio was assigned to each erosion intensity units. The composite erosion intensity map was then superimposed on the drainage map with sub-watershed boundaries to evolve CEIU for individual sub-watershed.

- Each element of erosion intensity unit is assigned a weightage value. The cumulative weightage values of the erosion intensity units represent approximately the relative comparative erosion intensity within the watersheds. A basic factor of K=10 was used in determining the cumulative weightage values. The value of 10 indicated an equilibrium condition between erosion and deposition. Any value of K (10+X) is suggestive of erosion intensity in an ascending order whereas the value of K (10-X) is suggestive of deposition intensity in descending order.
- The delivery ratios were calculated for each composite erosion intensity unit. The delivery ration suggests the percentage of eroded material that finally finds entry into the reservoir or river/stream. Total area of different erosion intensity classes (composite erosion intensity unit) in each watershed was then calculated.
- The delivery ratio is generally governed by the type of material, soil erosion, relief length ratio, cover conditions, distance from the nearest stream, etc. However, in the present study the delivery rations to the erosion intensity units were assigned upon their distance from the nearest stream (being the most important factor responsible for delivery of the sediments) according to the following scheme. The delivery ratio criteria adopted for the study is presented in **Table 10.1.**

Table 10.1 : Delivery Ratio (DR) Criteria Adopted

Nearest Stream	Delivery Ratio (DR)
0-0.9 km	1.00
1.0-2.0 km	0.90
2.1-5.0 km	0.80
5.1-15.0 km	0.70
15.1-30.0 km	0.50

(ii) Sediment Yield Index & Prioritization of Sub-Watersheds

- The erosivity determinates are the climatic factors and soil and land attributes that have direct or reciprocal bearing on the units of the detached soil material. The relationship can be expressed as:

Soil erosivity = f (Climate, physiography, slope, soil parameters land use/land cover, soil management)

- The Silt Yield Index (SYI) is defined as the Yield per unit area and SYI value for hydrologic unit is obtained by taking the weightage arithmetic mean of the products of the weightage value and delivery ratio over the entire area of the hydrologic unit by using suitable empirical equation.
- Prioritization of smaller hydrological units within the vast catchments is based on the SYI of the smaller units. The boundary values of range of SYI values for different priority categories are arrived at by studying the frequency distribution of SYI values and locating the suitable breaking point. The watersheds/sub-watersheds are subsequently rated into various categories corresponding to their respective SYI values.
- The application of SYI model for prioritization of sub-watersheds in the catchment areas involves the evaluation of:
    - Climatic factors comprising total precipitation, its frequency and intensity
    - Geomorphic factors comprising land forms, physiography, slope and drainage characteristics
    - Surface cover factors governing the flow hydraulics
    - Management factors.
- The data on climatic factors can be obtained for different locations in the catchment area from the meteorological stations whereas the field investigations are required for estimating the other attributes.
- The various steps involved in the application of model are:
    - Preparation of a framework of sub-watershed through systematic delineation
    - Rapid reconnaissance surveys on 1:50,000 scale leading to the generation of a map indicating erosion-intensity mapping units.
    - Assignment of weightage values to various mapping units based on relative silt-yield potential.
    - Computing Silt Yield Index for individual watersheds/sub watersheds.
    - Grading of watersheds/sub-watersheds into very high, high medium, low and very low priority categories.
- The area of each of the mapping units is computed and silt yield indices of individual sub-watersheds are calculated using the following equations:

Silt Yield Index

SYI = (Ai x Wi x Di) x 100/Aw; where I = 1 to n

Where

Ai	=	Area of ith (EIMU)
Wi	=	Weightage value of ith mapping unit
Di	=	Delivery ratio
n	=	No. of mapping units
Aw	=	Total area of sub-watershed

The SYI values for classification of various categories of erosion intensity rates were taken for the present study as:

	Priority Category	SYI Values
1.	Very High	>1300
2.	High	1200-1299
3.	Medium	1100-1199
4.	Low	1000-1099
5.	Very low	<1000

10.1.4. *Catchment Area*

The Catchment area is 304sq. km with no intercepted catchment up to dam site. The catchment area is located in the southern part of this plateau which is marked by deep gorges, spurs and abrupt slopes. Through the deep-cut valleys and escarps, the river Umngot rush down swiftly towards the southern plains leaving in its wake numerous cataracts and waterfalls which are very amenable for development of hydro-power. The Umngot HEP is located in the southern part of this plateau. The plateau extends east –west with altitudes ranging from 150 masl to 1965 masl. The entire plateau is mountainous but the eastern and western extensions are relatively lower. Shillong peak is the highest point on the plateau where the origin of the river Umngot is very near its vicinity. As there is no river valley project on upstream of the proposed dam site on Umngot river, the free draining catchment area up to dam site shall be 304sq km. The area under different micro-watersheds is illustrated in **Table 10.2.**

Table 10.2 : Area Under Different Micro-watersheds

S. No	MWS No.	Total Area(ha)
1	3C1C2.1	1788
2	3C1C2.2	2093
3	3C1C2.3	1597
4	3C1C2.4	2166
5	3C1C2.5	2171
6	3C1C2.6	754
7	3C1C2.7	1587
8	3C1C2.8	1915
9	3C1C2.9	1048
10	3C1C2.10	2376
11	3C1C2.11	1230
12	3C1C2.12	2736
13	3C1C2.13	1402
14	3C1C2.14	2258
15	3C1C2.15	898
16	3C1C2.16	1062
17	3C1C2.17	1119
18	3C1C2.18	1148

19	3C1C2.19	1085
	Total	**30433**

10.1.5. *Topography*

The entire catchment area is a plateau interspersed with high hills and deep valleys. The site where the Umngot HEP is located is marked by deep gorges, spurs and abrupt slopes. The catchment is situated in the mid- central upland, specially called the Shillong Plateau. The plateau extends east west with altitudes ranging from 933 masl to 1965 masl. The entire plateau is mountainous but the eastern and western extensions are relatively lower. The digital elevation map of free draining catchment is shown in **Figure 10.1.**

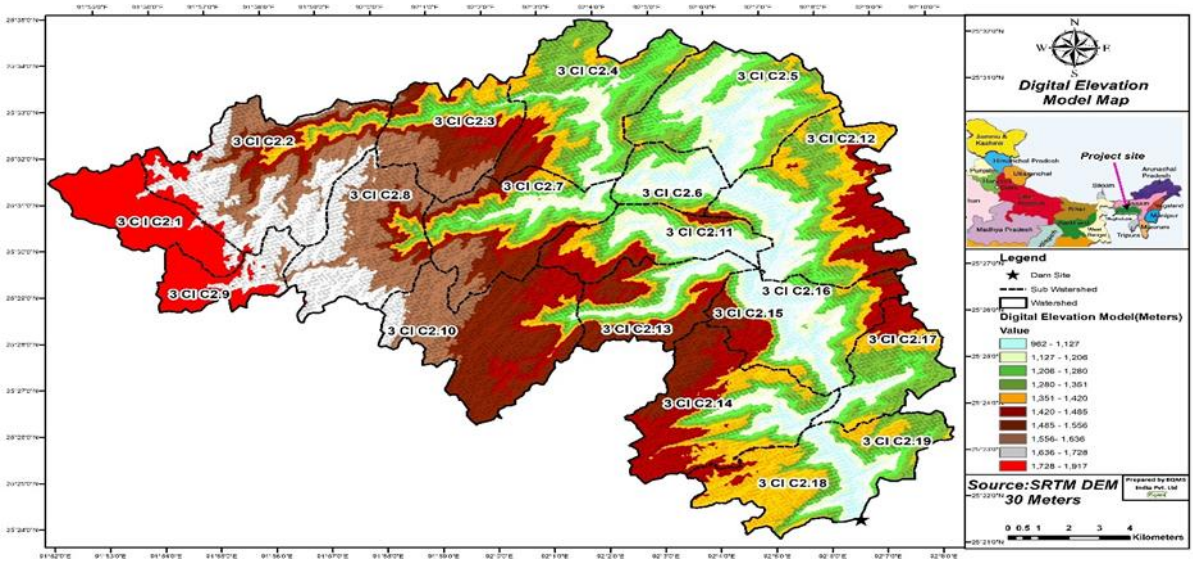


Figure 10.1 : Digital Elevation Map of Free Draining Catchment

10.1.6. *Soil*

The soil resource maps of Meghalaya (NBSS Publication No 52) have been used in the present study. The soil is predominantly fine to coarse loamy soil. The description of the soil of different soil units of the catchment and sub-watersheds wise breakup of different soil units is given **Table 10.3**. The soil map of free draining catchment area is presented in **Figure 10.2**.

Table 10.3 : Soil Types and Their Description

S.No.	Soil Unit No.	Classification	Area (ha)	%
1.	1	Moderately deep, excessively drained coarse loamy soils on gently sloping hill tops with very severe erosion hazard and strong stoniness	9018	29.63
2.	5	Moderately deep, excessively drained, fine loamy soils, on gently sloping hill tops with very severe erosion	8590	28.22

3.	7	Deep excessively drained, Coarse loamy soils steep sloping hill tops with severe erosion hazard and strong stoniness	12455	40.93
4.	8	Shallow, excessively drained loamy skeletal soils on moderately steep side slopes of hill with very severe erosion hazard and strong stoniness	370	1.22
Total			**30433**	**100.00**

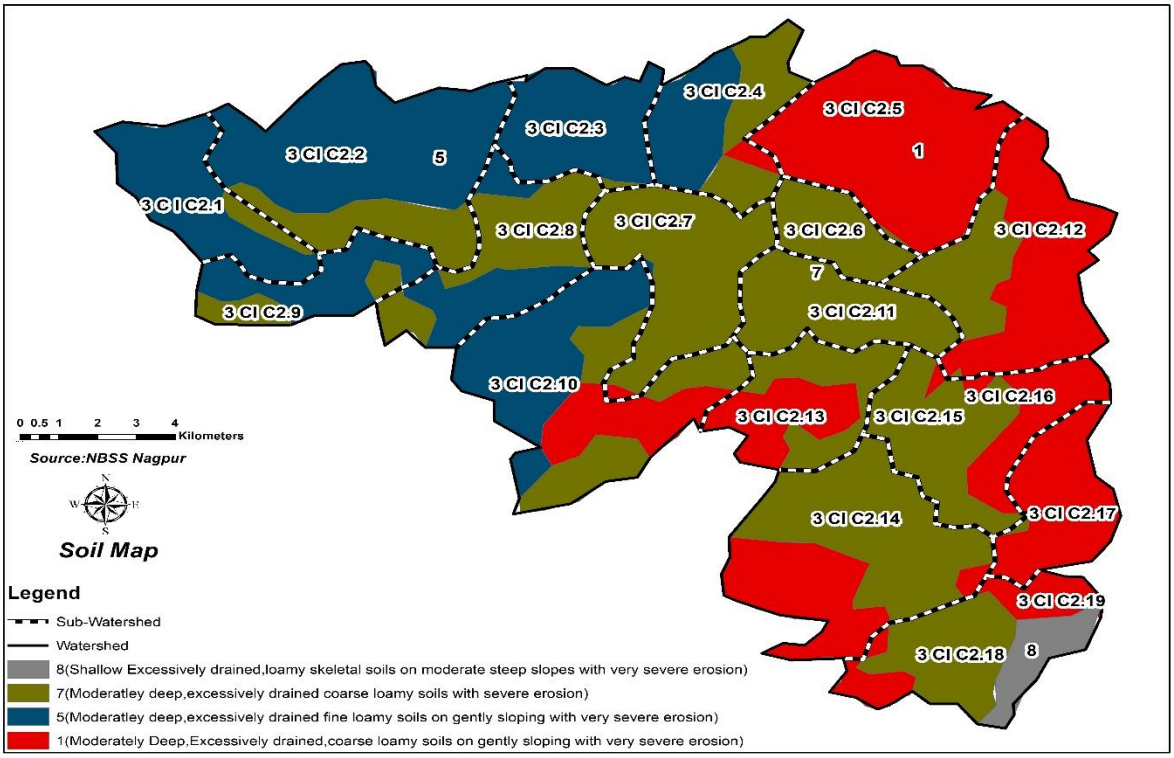


Figure 10.2 : Soil Map of the Free Draining Catchment

10.1.7. *Land use*

10.1.7.1 Land use-Land Cover Classification

Based on satellite data and topo-sheets, a land-use map has been prepared and will be verified in detail during ground surveys i.e., cross checked with ground truths. The Land use/ Land-cover map of the free draining catchment area is presented in **Figure 10.3** and its details in each sub-watershed under free draining catchment area are presented in **Table 10.4**.

10.1.7.2 Land use Categories and Erosion

The erosion acts differently in different land-use types. It is important to understand the nature of erosion in a particular land-use class to further plan for treatment.

10.1.7.2.1 Agricultural Land and settlement

6245 ha area of the free-draining catchment constituting 20.52% of the total free drainage catchment comes under this category. Well-planned and developed terraces were seen at some places. Almost 50% of the terraces are properly stabilized by using the stones which itself will manage to reduce the erosion. In general, at places the sheet and rill type of soil erosion predominates with few gullies in early stage of its development. Runoff often exceeds the safe velocity on long slope lengths. It is suggested to repair and better design the agricultural terraces, which follows the faulty agricultural practices. Temporary and semi-permanent soil conservation structures like brushing dams, wiring woven and gabion check dams etc. shall *be* made for effective adaptive management.

10.1.7.2.2 Built-up land

Around 1216 ha area constituting 4.00% of the free draining catchment area is classified under this land-use category.

10.1.7.2.3 Shifting cultivation

Around 1611 ha area constituting 5.30% of the free draining catchment area is classified under this land-use category.

10.1.7.2.4 Scrub Land

Around 10058 ha area constituting 33.05% of the free draining catchment area is classified under this land-use category. These areas are characterized by highly degraded land surface. Very little and only seasonal vegetation cover exists. Huge gullies, frequent land slips and high to extremely high erosion rates are other prominent features. Stream bank protection works followed by well-planned afforestation are suggested for such land-use category. Silvi-pasture plantation and natural regeneration can also be done.

10.1.7.2.5 Open Forest Land

Under open forest category about 6475 ha, constituting 21.28% of the free draining, is present catchment. Forest crown density ranges from 0-40% or on average 20% crown density can be assumed to be present in the area. Soils have relatively good water holding capacity, humus, nutrient content and moderate to slight erosion rates on steeper slopes. Therefore, rill erosion predominates which in due course leads to scrub land formation with gullies. Afforestation is suggested so as increase the crown density by 20% in whole of the area to reduce erosion.

10.1.7.2.6 Dense Forest

Dense forest covers about 3963 ha area constituting 13.02% of the free draining catchment with the forest crown density above 40%. Soils are very good in water holding capacity, humus and nutrients with no erosion but due to steeper slopes some area requires soil conservation measures.

10.1.7.2.7 River / Water body

Around 865ha area constituting 2.84% of the free draining catchment area is classified under water bodies. The category needs no treatment except that the unstable bank shall be provided stream bank stabilization through protection measures whenever required.

Table 10.4 : Land use Details of Sub-watersheds

S. No	Micro WSNO	Shifting Cultivation	Arable Land	Dense Forest	Open Forest	Tree Clad/Scrub Land	Built-up	River	Total
1	3C1C2.1	224	845	57	279	324	59	0	1788
2	3C1C2.2	279	422	248	709	266	128	41	2093
3	3C1C2.3	37	410	104	277	576	152	41	1597
4	3C1C2.4	141	314	102	716	811	28	54	2166
5	3C1C2.5	56	272	65	616	948	34	180	2171
6	3C1C2.6	9	58	83	128	405	17	54	754
7	3C1C2.7	48	98	278	482	508	124	49	1587
8	3C1C2.8	228	421	20	503	584	73	86	1915
9	3C1C2.9	103	517	27	129	198	74	0	1048
10	3C1C2.10	24	908	158	140	1021	125	0	2376
11	3C1C2.11	20	69	333	301	357	79	71	1230
12	3C1C2.12	122	395	188	551	1307	92	81	2736
13	3C1C2.13	35	152	354	429	303	48	81	1402
14	3C1C2.14	30	554	646	247	713	50	18	2258
15	3C1C2.15	26	74	305	196	244	19	34	898
16	3C1C2.16	14	58	134	226	504	88	38	1062
17	3C1C2.17	101	165	273	311	269	0	0	1119
18	3C1C2.18	61	326	317	116	299	10	19	1148
19	3C1C2.19	53	187	271	119	421	16	18	1085
	Total	**1611**	**6245**	**3963**	**6475**	**10058**	**1216**	**865**	**30433**

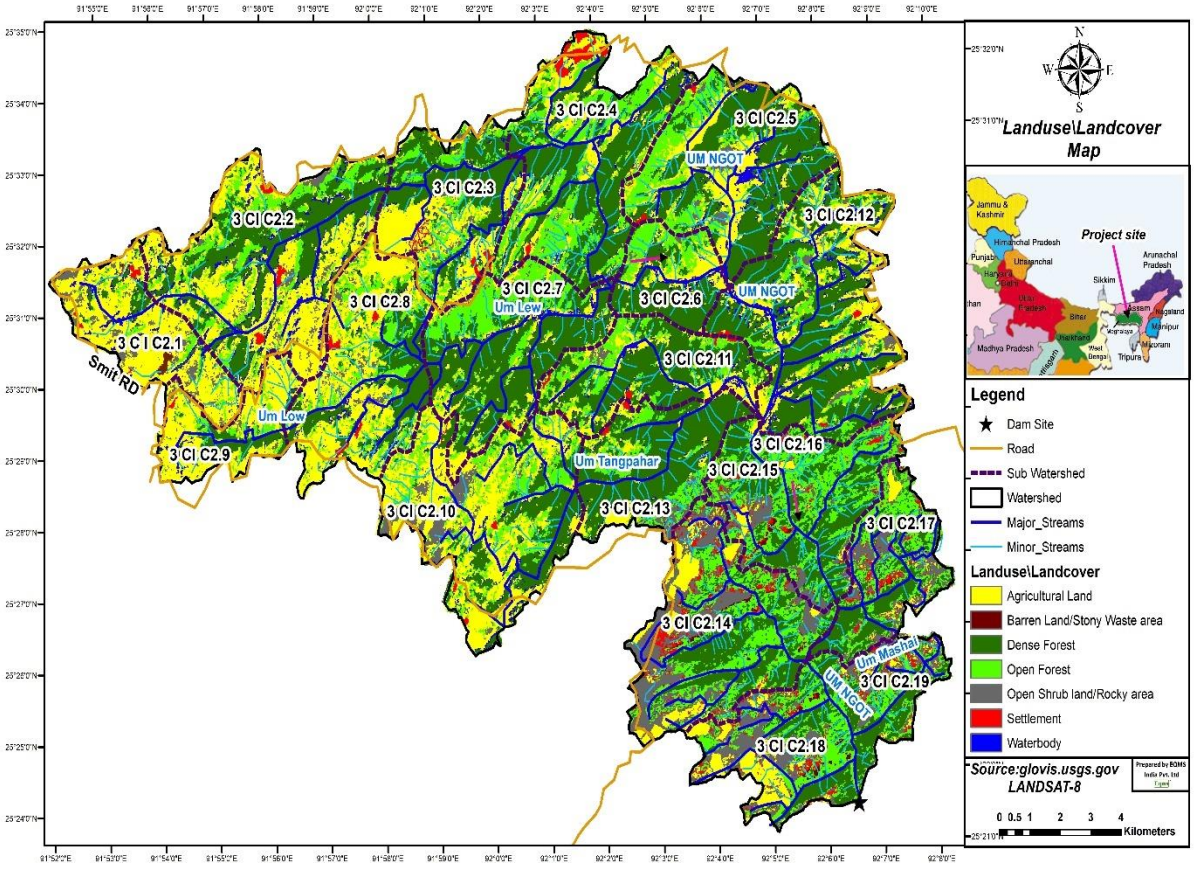


Figure 10.3 : Land use Map of Free Draining Catchment Area

10.1.8. *Slope*

The slope of a watershed plays an important role in controlling the soil and water retention thereby affecting the land-use capability. The percentage of the slope in a watershed determines the soil erosion susceptibility and forms the basis for classifying different of the watershed into suitable classes for formulating effective soil erosion conservation measures. Broadly, the following slope classes and ranges **(Table 10.5)** as per norms of All India Soil & Land Use Survey were adopted to classify the slopes for the present study.

Table 10.5 : Slope Ranges showing the intensity of catchment area

Sr. No	Slope Range (Degrees)	Description
1.	0-5	Gentle to moderate Sloping
2.	5-10	Gentle Steep
3.	10-15	Moderate steep
4.	15-35	Steep
5.	>35	Very Steep

The Slope map of the free draining catchment is presented in **Figure 10.4** and slope details are as presented under **Table 10.6**. The data shows that about 23.82% area lies between gentle to moderate steep category of slope and balance 76.18% falls from steep to very steep category.

Table 10.6 : Area under different Slope Classes

S. No	MWS	Gentle to Moderate (0-5)	Gentle Steep (5-10)	Moderate steep (10-15)	Steep (15-35)	Very Steep (>35)	Total (ha)
1	3C1C2.1	171	195	197	647	578	1788
2	3C1C2.2	81	99	126	467	1320	2093
3	3C1C2.3	64	98	117	407	911	1597
4	3C1C2.4	163	134	134	609	1126	2166
5	3C1C2.5	206	137	177	813	838	2171
6	3C1C2.6	34	18	27	224	451	754
7	3C1C2.7	58	105	97	468	859	1587
8	3C1C2.8	183	159	179	507	887	1915
9	3C1C2.9	111	142	116	349	330	1048
10	3C1C2.10	265	405	350	855	501	2376
11	3C1C2.11	52	68	95	435	580	1230
12	3C1C2.12	180	220	230	1015	1091	2736
13	3C1C2.13	138	110	87	365	702	1402
14	3C1C2.14	220	235	231	656	916	2258
15	3C1C2.15	45	32	32	152	637	898
16	3C1C2.16	59	77	71	378	477	1062
17	3C1C2.17	64	83	74	326	572	1119
18	3C1C2.18	98	103	90	313	544	1148
19	3C1C2.19	46	83	79	342	535	1085
	Total	**2238**	**2503**	**2509**	**9328**	**13855**	**30433**

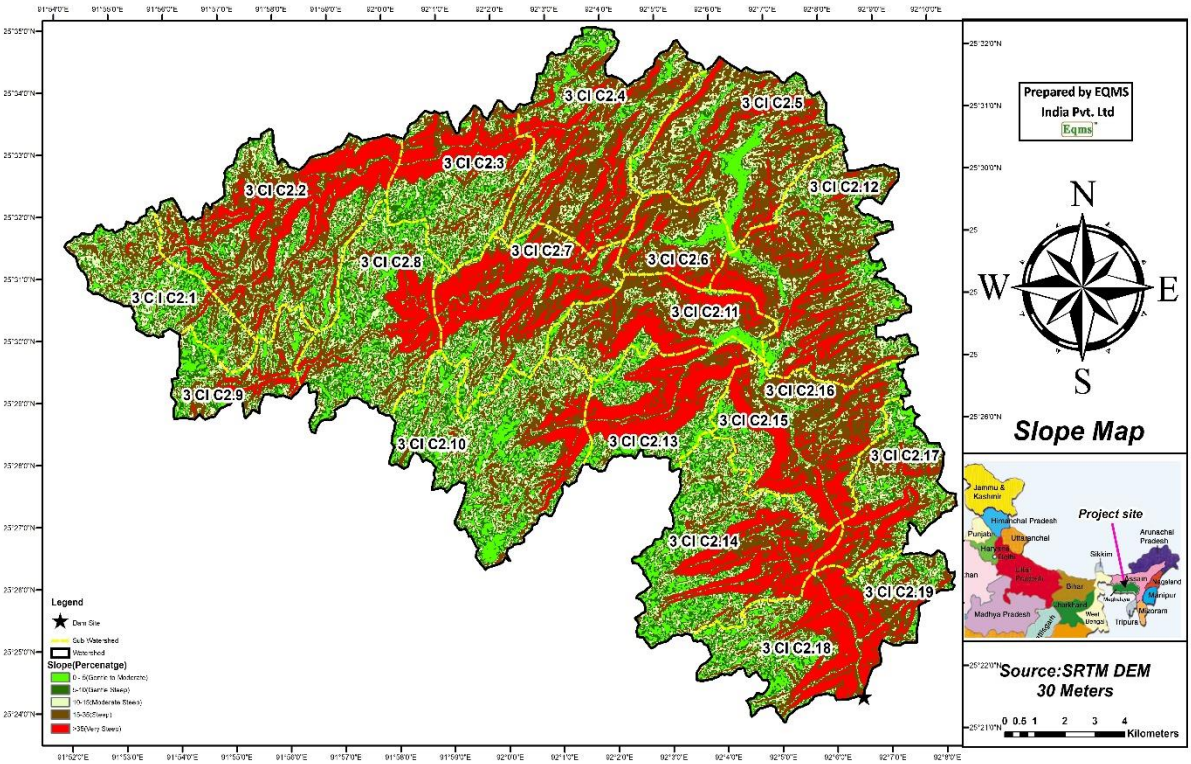


Figure 10.4 : Slope Map of Free Draining Catchment

10.1.9. *Sediment Yield Index Status and Prioritisation of MWS*

Sediment Yield Index has been calculated for all micro-watersheds. The computed value of SYI for each MWS is presented in **Table 10.7.** As per Table there are 1,4,9 and 5 MWS under low, medium, high and very high priority category respectively.

Table 10.7 : SYI and Priority Rating as per Erosion Intensity

S.No.	Micro-water sheds No.	Area (Ha)	SYI	Priority
1	3C1C2.1	1788	1238	High
2	3C1C2.2	2093	1326	Very High
3	3C1C2.3	1597	1364	Very High
4	3C1C2.4	2166	1345	Very High
5	3C1C2.5	2171	1261	High
6	3C1C2.6	754	1266	High
7	3C1C2.7	1587	1283	High
8	3C1C2.8	1915	1307	Very High
9	3C1C2.9	1048	1319	Very High
10	3C1C2.10	2376	1210	High
11	3C1C2.11	1230	1265	High
12	3C1C2.12	2736	1263	High

13	3C1C2.13	1402	1108	Medium
14	3C1C2.14	2258	1106	Medium
15	3C1C2.15	898	1252	High
16	3C1C2.16	1062	1256	High
17	3C1C2.17	1119	1174	Medium
18	3C1C2.18	1148	1178	Medium
19	3C1C2.19	1085	1088	Low

10.1.10. *Catchment Area Treatment Plan*

It is known that there are mainly five categories of Land uses for which a proper treatment plan should be developed. First is the Agricultural Land as this activity can never be eliminated, because the faulty practice results in heavy loss of fertile soil. Second, being open forest land for obvious conservation reasons. Third is scrub or degraded land, which contributes heavily to the silt load and possibilities exist to bring this area under pastures and other plantation to meet the local demand of fuel and fodder and thus decreasing the biotic pressure on the forests and leading to environment friendly approach of sustainable development. The fourth and most important category is Barren land because with practically no vegetal cover, the area produces huge amount of silt load. The fifth is dense forest land where in a few places soil conservation measures are required. For treatment of catchment area, the areas that require treatment have been delineated from the Composite Erosion Intensity Unit Map. The sum of weightages was reclassified as per the **Table 10.8** below to further subdivide the area as per the erosion intensity classes. The weightages for Land use, Slope & Soil were summed to get the erosion intensity classes.

Table 10.8 : Erosion Intensity & Weightages

Erosion Intensity Class	Sum of weightages
Very severe (E5)	12 to 14
Severe (E4)	9 to 11
Moderate (E3)	6 to 8
Low (E2)	4 to 5
Negligible (E1)	0 to 3

After exclusion of rocks and inaccessible terrain, only those areas which fall under very severe and severe erosion intensity category would be taken up for conservation treatment measures in very high priority category micro-watersheds, whereas in the rest of micro-watersheds belonging to other priority categories, the area falling under very severe erosion intensity class shall be taken for treatment with biological and engineering measures under the CAT Plan. The Erosion Intensity Map of the free draining catchment has been generated on the basis of SYI data and is presented in **Figure 10.5** and the statistics are presented in **Table 10.9**.

Table 10.9 : Area under different Erosion Intensity Categories

Class Erosion	Area(ha)
Low Erosion	997
Moderate Erosion	6776
Severe Erosion	13763
Very Severe Erosion	8897
Total	**30433**

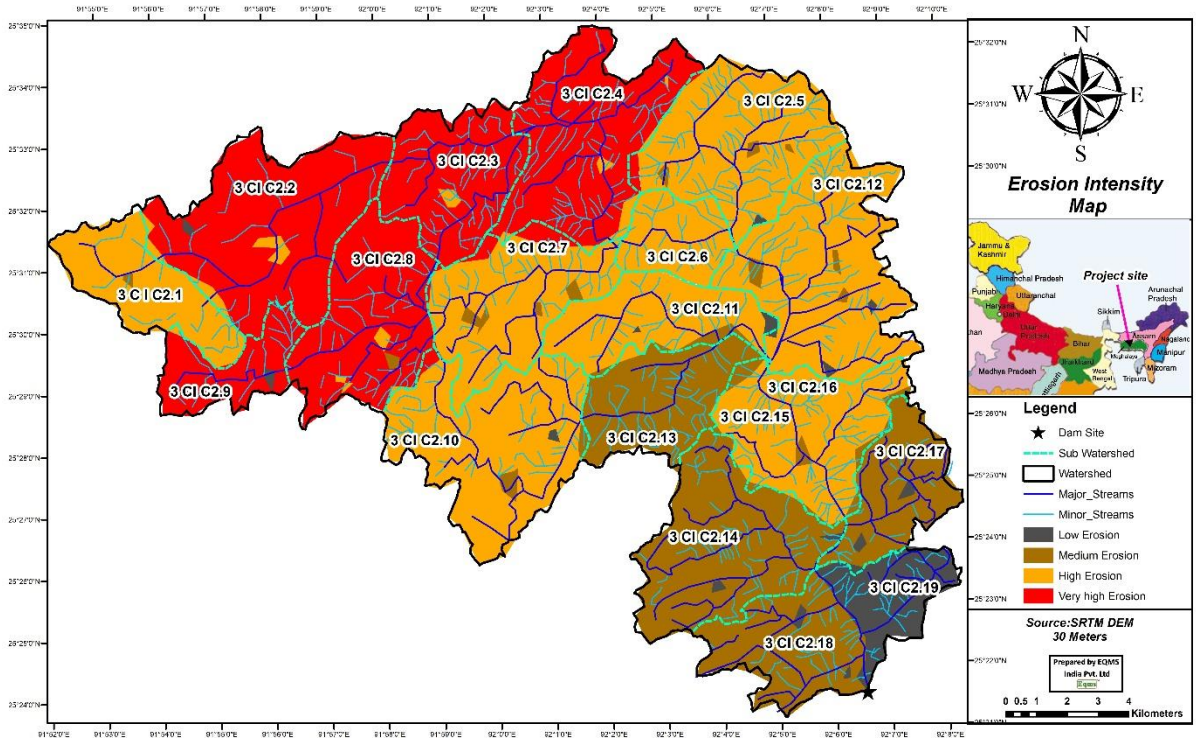


Figure 10.5 : Erosion Intensity Map of Free Draining Catchment Area

10.1.11. *Treatment of Individual Sub-Watershed*

There are mainly five categories of land uses for which a proper treatment plan should be developed. First is the agricultural land as this activity can never be eliminated. And, agriculture activities, if faulty, result in heavy loss of fertile soil. Second, is open forest land for conservation reasons Third is scrub or degraded land, which contributes heavily to silt load. Possibilities exist to bring this area under pastures and plantation to meet local demand of fuel and fodder and thus decreasing the biotic pressure on the forests leading to environment friendly approach of sustainable development. The fourth and most important category is barren land because with practically no vegetal cover the area produces huge amount of silt load. The fifth is dense forest land where at few places soil conservation measures are required.

Areas falling under very severe and severe erosion intensity category would be taken up for conservation treatment measures after excluding the percentage of area above 50^0 slopes from the area coming under very severe and severe erosion intensity class falling under rocks and inaccessible terrain where no treatment is feasible, the rest of area of very severe and severe categories is to be treated with biological, bio-engineering and engineering measures under CAT Plan. In the present case, an area of 585 ha has been proposed to be treated under Forestry and Silvi-Pastoral Measures. Under engineering measures 1405 ha area of free draining catchment which shall be treated. Under control of shifting cultivation measures jhum land treatment of 788 ha shall be taken up.

Considering the topographic factors, soil type, climate, land-use/land-cover in the catchment area following measures have been proposed to be undertaken with aim to check soil erosion, prevent/check siltation of reservoir and to maintain its storage capacity in the long run.

10.1.11.1 Activities to be Undertaken

10.1.11.1.1 Normal Afforestation

In critically degraded areas, plantation of locally useful diverse and indigenous plant species such as timber plantation species, fodder species, fuel wood species, grasses, shrubs and legumes, medicinal and aromatic plants would be undertaken. The forestation will include rising of multi-tier mixed vegetation of suitable local species in the steep and sensitive catchment areas of rivers/streams with the objective of keeping such areas under permanent vegetative cover. Furthermore, degraded areas would also be brought under vegetation cover. Suitable trees of economic value to local people shall be raised in the degraded forest areas near to villages with the objective of supplementing income of the villagers.

With a view to conserve and augment the state's rich medicinal plant resources in its natural habitat through adaptive and participatory management of the local people, cultivation of high priority medicinal plant species shall be undertaken. Thrust shall be given to organic cultivation of medicinal plants.

Effective fencing would also be provided for protection of saplings. Before any new area is taken up, eradication of weeds and unpalatable grass species is important. It is, therefore, recommended that some parts of the pasture should be closed for seeding purpose only.

10.1.11.1.2 Choice of Species

The choice of species depends on the various factors, such as climatic, edaphic, topographic and biotic but the surviving indigenous species give a clear indication of the most suitable species. Since most of areas included in this component, are situated at lower elevations, therefore, preference should be given to indigenous, fast growing, hardy, species which can survive under the adverse condition of the locality. Sincere and strenuous efforts should be made to bring the blank areas under forest cover as early as possible. In order to cover up the blank areas expeditiously, at the earliest, the maximum area has been suggested to be taken up during the 1st & 2nd years. Soil conservation works have also been prescribed along with afforestation measures where ever necessary.

10.1.11.1.3 Plantation Technique

Site Selection

Specific sites have been suggested and location of plantation is also indicated in the above statement. However, if the deviation is absolute necessary, some changes can be done by the Divisional Forest Officer after spot inspection.

Closure Notification

Each plantation area will be notified for closure and supervision of rights, one year in advance of plantation work. According to provision made in Forest Settlement, one third of total area of forest can be closed for thirty years, but it is normally not practicable. The area should remain closed effectively till the regenerated crop reaches the stage beyond any damage due to frost, drought, and weeds and needs no longer protection from animals. Hence the period of closure may be kept 10-20 years depending upon growth of species planted.

Fencing

Where necessary plantation areas will be effectively closed by laying 3 strand barbed wire fencing on wooden posts. Non-palatable fast-growing shrub species shall be planted along the barbed wire fence at a close spacing of 50 cm to form a live hedge.

Preparation of Site

Pits on standard size 30 cm diameter for coniferous and 45cm is diameter for broadleaved well in advance so as to provide an interval of 2-3 months between pit digging and planting for weathering of soil. Contour trenching may be necessary in exceptional cases where soil is refractory and moisture conservation is a must for success of plantation.

Spacing

Planting for coniferous at space of 2.5m X 2.5m and that of broad leaved 3m X 3m is general practice and it should be continued however while treating eroded portions suitable broad leaved may be planted at the space of 1.5m X 1.5m.

Sowing and Planting

Planting should be preferred to sowing, though the later operation may be cheaper. Success is more certain and initial growth more rapid, in case sturdy nursery raised plants are used. Sowing may be carried out only on comparatively better sites, where these are expected to be easily successful. Local people should be involved in all plantation works and future protection may be ensured through Joint Forest Management approach, wherever possible. The supply of plantable seedlings by organizing Kisan Nurseries may also be looked into. Intensive weeding and cleaning are also provided for.

Enrichment Plantation

There are a few locations within forest in the catchment area where the crown density is poor and plantation can be done to increase the patch density of crop. In such areas, plantation of 500 seedlings per hectare is likely to create dense forest.

Treatment of Pasture

The flora is herbaceous and the pastures have the potential to support regulated grazing. The restoration and management of degraded pasture is a vital objective, both to provide sufficient habitat for spatial movement of the spill over species outside and within catchment area and to provide biological resources to the local populace. The pastures have their own unique significance in the geophysical, environmental and socio-economic set-up of the region. They are the prime and continual source of herbage for the wild herbivores which are prey base for carnivores, cattle, sheep and goats. These pastures are extensively grazed by the live stocks of the local people during summers for 3-4 months and also frequented by large herds of goats and sheep. The large scale and indiscriminate grazing of these pasture over a prolong time has left these pastures ominously degraded. The palatable grasses are no more than a few inches tall and the other related pasture species have also started showing signs of stress. As a result of continuous and heavy pressure of grazing, barren patches have developed over vast areas and soil erosion is rampant in these alpine pastures. There is an imperative need to address this abysmal and alarming situation immediately before these pastures are brought to such a condition, where, their rejuvenation becomes impossible. Owning to traditional rights of the grazers, it is difficult to restrict the number of animals grazing there. Thus, the only alternative left is to increase the productivity of these pastures to cope with the grazing pressures. The situation warrants for a realistic survey and allied research in context of entire grazing issues and formulation of an action plan for corrective measures within the gambit of the state policy on the subject matter. Till such time the following recommendations are made for the management of pastures.

- Assessment of the carrying capacity of the pastures through surveys so as to ascertain allowable size of live stocks.
- Periodical field checking of the size of the herds mentioned in the permits so as to avoid misuse by some permit holders.
- Public awareness.
- Periodical closure of areas in pastures for the proliferation of seeds of desirable grass species.
- Implementation of rotational deferred grazing system to derive the advantage of early nutritive growth and rest period during the growing season.
- Interaction with the local people and the migrating grazers so that a sort of social fencing could be achieved.
- Assessment of the carrying capacity of alpine pasture and grazing land in forests. Role of different categories of livestock and their grazing requirement needs to be investigated.

Nursery Support

In order the meet the huge requirement of saplings required under biological / bio-engineering measures and reservoir rim treatment new nursery has to be developed along with support to the existing nurseries which shall also augment the supply of saplings for the works proposed. The cost component of development of nursery has been included in the rate analysis for advance and plantation works.

Civil Structures

- **Brush wood Check Dams and Retaining Walls**

Brushes wood check dams are useful in arresting further erosion of depressions, channels, and gullies on the denuded landslides. In addition, retaining walls of stone masonry and RCC would be constructed to provide support at the base of threatened slopes.

- **Slope Modification by Stepping or Terracing**

The slope stability increases considerably by grading it. The construction of steps or terraces to reduce the slope gradient is one of the measures.

- **Bench Terracing**

The area under moderately steep slope i.e., between 10^0-25^0 slopes would be subjected to bench terracing. The local people would be convinced to follow this type of terracing for comparatively better yield and with minimum threat to erosion While making bench terraces, care will have to be taken not to disturb the topsoil by spreading earth from the lower terraces to higher terraces. The vertical intervals between terraces will not be more than 1.5m and cutting depth may be kept at 50 cm. The minimum average width of the terrace would be kept from 4 to 6 m in order to enable usage of prolong hinge. The shoulder bunds of 30 x 30 cm with 1:1 side slope would also be provided. Staggered channels will drain off the excess water from the terraces. 8 drains /ha with bottom width 0.3m and depth 0.3m with side slope 1:1 have been proposed. Such terracing, in addition, also will help uniform distribution of soil moisture and retention of soil, manure etc. Out of different types of bench terraces, Table Top / Level Terraces and Sloping Inward terraces are suggested.

- **Gully Control-Check Dams**

Gullies are mainly formed on account of physiographic, soil type, and heavy biotic interference in an area. The scouring of streams at their peak flows and sediment-laden run-off cause gullies. The gullies would be required to be treated with engineering/mechanical as well as vegetative methods. Check dams would be constructed in some of the areas to promote growth of vegetation that will consequently lead to the stabilization of slopes/area and prevention of further deepening of gullies and erosion. Different types of check dams would be required for different conditions comprising of different materials depending upon the site conditions and the easy availability of material (stones) at local level and transport accessibility. Generally, brush wood check dams are recommended to control the erosion in the first order basin/streams in upper reaches and dry random stone masonry check dam shall be provided in the lower reaches where discharge is higher. In such stream where discharge and velocity of flow are still higher gabion structure shall be provided. Lower down the sub-

watershed, i.e., in the third order drainage silt retention dams in the form of gabion structure shall be provided.

- **Contour Staggered Trenches**

  Contour staggered trenches are mainly provided to trap the silt and runoff. This is also done to prepare a fertile base for plantation, in moderately steep to very, very steep slopes. Contour staggered trenches of width 45cm and depth 50cm shall be provided in 5m length each with spacing of 3.3m between the trenches in same row Continuous trench after every 5 rows of trenches, to be provided to arrest excess run-off and silt. The trenches will be constructed across the slope and along the contour line to make it efficient System for conservation of soil and water. Staggered contour trenches along with development of pasture and fodder grasses, in the inter-spaces, have been planned. These are mostly scrub lands, open forest lands and fallows. It is assessed that staggered trenches @ 5 numbers per ha can recharge soil profile and ground water to meet the water requirement of pasture and fodder grasses of the patchy areas. Further, planting of fast-growing species, as recommended under Forestry and Silvi-Pasture Management will also be made for this area.

10.1.12. *Cost Analysis of Different Works Under Biological Measures*

10.1.12.1 Afforestation

Out of the total stock to be planted under afforestation, 20% species shall be tree species having medicinal values and 10% of fruit bearing wild species useful to wildlife shall also be planted. Rate per man-days/unit adopted in the report Meghalaya Forests & Environment Department, Letter FOR.85/86/461, dated 5.6. 2017.The cost analysis per hectare of afforestation, inclusive of maintenance has been worked out as Rs. 1.75 lakh/ ha as shown in **Table-1.010.** The rate analysis is as per minimum labor wages of Rs. 300/ day as fixed vide Notification 75/2012/36, Shillong, dated 7.1.2019. Plantation under normal afforestation component shall be carried through identified user groups in catchment area. For mobilization of user group provision of funds has been made under the plan.

The cost of works under normal afforestation component (70 ha) encompassing the free draining catchment area of the project has been assessed as **Rs. 122.50 lakh** and is shown in **Table-10.11**.

Table 10.10 Afforestation cost/ha of Normal plantation including maintenance

S.N.	Item of Work	Man days	Wage /day	Amount (Rs)
A	**Preliminary works/Advance works**			
(i)	Survey and demarcation	20	300	6000.00
(ii)	Jungle clearance and burning	15	300	4500.00
(iii)	Cost of barbed wire in five strands with2m high RCC pole @ 2.5m c/c i/c cost of nails and wire @Rs 33700/ha			33700.00
(iv)	Contour trenching	30	300	9000.00
(v)	Nursery cost of plant (1320with 20% mortality Rs37/each)			48840.00
(vi)	Digging pits 30cmx30cmx30cm	14	300	4200.00
(vii)	Filling of pits	3	300	900.00

	Sub-total (A)			**107140.00**
B	**CREATION OF PLANTATION (1st year)**			
(i)	Planting of nursery seedlings including. carriage from nursery centers to plantation sites and proper ramming after planting etc., complete	16	300	4800.00
(ii)	Weeding - 3 times weeding @10-man days per weeding	30	300	9000.00
(iii)	Fire protection works		300	
	(i) Wages of fire watcher	7	300	2100.00
	(ii) Fire line clearance including controlled burning	7	300	2100.00
	Sub-total (B)	60	300	**18000.00**
C	**Maintenance of Plantation (2nd year)**			
(i)	Weeding - 5 times weeding @10-man days per weeding	50	330	16500.00
(ii)	Fire protection works			
	(i) Wages of fire watcher	7	330	2310.00
	(ii) Fire line clearance including controlled burning	7	330	2310.00
(iii)	Vacancy filling in mortality areas	4	330	1320.00
	Sub-total (C)	68	330	**22440.00**
D	**Maintenance of Plantation (3rd year)**			
(i)	Weeding - 2 times weeding @10-man days per weeding	20	363	7260.00
(ii)	Fire protection works			
	(i) Wages of fire watcher	7	363	2541.00
	(ii) Fire line clearance including controlled burning	7	363	2541.00
(iii)	Misc. cost like repair of fencing & inspection path	4	363	1452.00
	Sub-total (D)	38	363	**13794.00**
E	**Maintenance of Plantation (4th year)**			
(i)	Weeding - 2 times weeding @10-man days per weeding	20	399	7980.00
(ii)	Fire protection works			
	(i) Wages of fire watcher	7	399	2793.00
	(ii) Fire line clearance including controlled burning	7	399	2793.00
	Sub-total (E)	34	399	**13566.00**
	Total Per Hectare Cost of Enrichment Plantation			**174950.00**
			Say	**175000.00**

Table 10.11 : Cost Estimate for Afforestation Measures

S. No	MWS No.	Area(ha)	Cost @ Rs. 1.75 lakh/ha
1	3C1C2.2	15	26.25
2	3C1C2.3	15	26.25
43	3C1C2.4	20	35
4	3C1C2.8	15	26.25
5	3C1C2.9	5	8.75

	Total	**70**	**122.50**

10.1.12.2 Enrichment Plantation

The cost analysis of gap/enrichment plantation per hectare with 500 plants and protection of thorny bushes / twigs for individual plant, with no maintenance cost has been assessed as Rs. 148000/ha as shown in **Table 10.12.** The cost of works under enrichment plantation (515 ha) for the SWS encompassing the free draining catchment area of the project has been assessed as **Rs. 762.20 lakh** and is shown in **Table 10.13**.

Table 10.12 : Cost Analysis per ha. of Enrichment Plantation

S.N.	Item of Work	Man days	Wage /day	Amount (Rs)
A	**Preliminary works/Advance works**			
(i)	Survey and demarcation	20	300	6000.00
(ii)	Jungle clearance and burning	15	300	4500.00
(iii)	Cost of barbed wire in five strands with2m high RCC pole @ 2.5m c/c i/c cost of nails and wire @Rs 33700/ha			33700.00
(iv)	Contour trenching	30	300	9000.00
(v)	Nursery cost of plant (600 with 20% mortality Rs37/each)			22200.00
(vi)	Digging pits 30cmx30cmx30cm	14	300	4200.00
(vii)	Filling of pits	3	300	900.00
	Sub-total (A)			**80500.00**
B	**CREATION OF PLANTATION (1st year)**			
(i)	Planting of nursery seedlings including. carriage from nursery centers to plantation sites and proper ramming after planting etc., complete	16	300	4800.00
(ii)	Weeding - 3 times weeding @10-man days per weeding	30	300	9000.00
(iii)	Fire protection works		300	
	(i) Wages of fire watcher	7	300	2100.00
	(ii) Fire line clearance including controlled burning	7	300	2100.00
	Sub-total (B)	60	300	**18000.00**
C	**Maintenance of Plantation (2nd year)**			
(i)	Weeding - 5 times weeding @10-man days per weeding	50	330	16500.00
(ii)	Fire protection works			
	(i) Wages of fire watcher	7	330	2310.00
	(ii) Fire line clearance including controlled burning	7	330	2310.00
(iii)	Vacancy filling in mortality areas	4	330	1320.00
	Sub-total (C)	68	330	**22440.00**
D	**Maintenance of Plantation (3rd year)**			
(i)	Weeding - 2 times weeding @10-man days per weeding	20	363	7260.00
(ii)	Fire protection works			
	(i) Wages of fire watcher	7	363	2541.00
	(ii) Fire line clearance including controlled burning	7	363	2541.00
(iii)	Misc. cost like repair of fencing & inspection path	4	363	1452.00
	Sub-total (D)	38	363	**13794.00**
E	**Maintenance of Plantation (4th year)**			
(i)	Weeding - 2 times weeding @10-man days per weeding	20	399	7980.00
(ii)	Fire protection works			

	(i) Wages of fire watcher	7	399	2793.00
	(ii) Fire line clearance including controlled burning	7	399	2793.00
	Sub-total (E)	34	399	**13566.00**
	Total Per Hectare Cost of Enrichment Plantation			**148300.00**
			Say	**148000.00**

Table 10.13 : Cost Estimate for Enrichment Plantation

S. No	MWS No.	Area(ha)	Cost @ Rs. 1.48 lakh/ha
1	3C1C2.1	12	17.76
2	3C1C2.2	97	143.56
3	3C1C2.3	73	108.04
4	3C1C2.4	89	131.72
5	3C1C2.5	10	14.80
6	3C1C2.6	10	14.80
7	3C1C2.7	10	14.80
8	3C1C2.8	57	84.36
9	3C1C2.9	57	84.36
10	3C1C2.10	10	14.80
11	3C1C2.11	10	14.80
12	3C1C2.12	10	14.80
13	3C1C2.13	10	14.80
14	3C1C2.14	10	14.80
15	3C1C2.15	10	14.80
16	3C1C2.16	10	14.80
17	3C1C2.17	10	14.80
18	3C1C2.18	10	14.80
19	3C1C2.19	10	14.80
	Total	**515**	**762.20**

Civil Engineering Measures Under Soil and Water Conservation Measures

These structures are to be constructed as land slide control and stream bank stabilization over visually active slides and eroded banks of the main rivers and their tributaries falling under “Severe” and “Very Severe” erosion intensity areas to control the sediment flow and further degradation of the free draining catchment areas. Since these measures are to be carried out by construction of individual structure such as wire crate spurs, check dams, contour staggered trenches, catch water drains, retaining walls etc. on-site specific basis, the cost of each of such structure has to be analyzed on the basis of dimensions adopted. The analysis of rates of such structures is presented in **Table 10.14.**

Table 10.14 : Cost Analysis of Engineering Structure

S. N.	Item	Quantity	Unit	Rate	Amount
1.	**Dry Rubble Stone masonry (DRSM) Check Dam**				
(a)	Excavation in foundation in E & B in 5.60 m x 1.80 m x 0.50 m = 5.04 cubic meter	5.04	Cum	135	680.40
(b)	Collection of boulders	23.52	Cum	850	19992

	I-Step 5 x 1.5 x 1.25 = 9.38 II – Step 7 x 1.0 x 0.75 = 5.25 Wing Walls 2 x 3.75x 0.6 x 1.5 = 6.75 Total 21.38 x1.1= 23.52				
(c)	Carriage of boulder by manually beyond initial 100 m lead up to 0.750 km	21.38	Cum	660	14110.80
(d)	Labour charges for dry stone masonry with outer face stone dressed & 100 m lead.	21.38	Cum	500	10690
				Total	45473.21
				Add 3% Contingencies	1364.20
				Grand Total Rs.	46837.40
				Say Rs.	47000.00
2.	**Double row brush wood check dam**				
(a)	Earth work for excavation of bed and abutments (12.36mx0.15mx1.0m)	1.85	cum	135	249.75
(b)	Cost of posts to be fixed at 0.5m c/c in two rows	28	No.	120	3360.00
(c)	Miscellaneous like GI wire for holding posts in rows	1	Job	LS	700.00
(d)	Filling of gaps between rows of brush wood with the bundles of bushes and tied with ropes of grass	01	Job	LS	400.00
(e)	Labour charges for fixing of vegetative spurs double row @ 2labours	2	No.	300	600.00
				Total	**5309.75**
				Or Say	**5300.00**
3	**Contour staggered trenches(ha)**				
(a)	Excavation (0.45 x0.5x1200)	270	Cum	135	36450
(b)	Jungle clearance in 1 m width @15 labour /ha	0.12	ha	4500	540
				Total	**36990**
				Add 3% Contingencies	**1110**
				Grand Total	**38000**
4	**Per hectare Bench Terracing on average slope of land 10%, riser slope 1:1 and average depth of cut 0.30m**				
(a)	Excavation (1492*6.7*0.7)/8	875	cum	135	**118125**
(b)	Earthwork in shoulder bund/levee (0.3+0.9)/2 x0.3x1492	269	cum	135	**36315**
(c)	Earthwork in 8 drains /ha with bottom width 0.3m and depth 0.3m with side slope 1:1 (0.3+0.9)2/*0.3*54m	9.72	cum	135	**1312**
				Total	**155752**
				Add 3% Contingencies	**4672**
				Grand Total	**160424**
				Say	**160000**

10.1.12.3 Abstract of Works under Civil Structures

The Break-up of works under different sub-watersheds in respect of vegetative structure, civil structures for land slide and stream bank stabilization and moisture retention operations with their costs is shown **in Table 10.15**.

Table 10.15 : Abstract of Works under Civil Structures

MWS	Contour Staggered Trenches		Bench Terracing		Double row brush wood check dam		Soil water improvement work/Percolation tank		DRSM Check Dams		Total Cost (Rs lakh)
	Area (ha)	Cost @ Rs. lakh 0.38/ha	Area (ha)	Cost @ Rs. lakh 1.60/ha	Number	Cost @ Rs. Lakh 0.053/no.	Number	Cost @ Rs. lakh 2.50/no.	Number	Cost @ Rs. lakh 0.470/no.	
3C1C2.1	20	7.60	40	64.00	50	2.65	0	0	10	4.70	78.95
3C1C2.2	35	13.30	50	80.00	50	2.65	1	2.5	25	11.75	110.20
3C1C2.3	35	13.30	45	72.00	30	1.59	2	5	10	4.70	96.59
3C1C2.4	70	26.60	60	96.00	30	1.59	2	5	15	7.05	136.24
3C1C2.5	20	7.60	30	48.00	25	1.325	0	0	10	4.70	61.63
3C1C2.6	20	7.60	35	56.00	15	0.795	0	0	10	4.70	69.10
3C1C2.7	20	7.60	50	80.00	25	1.325	0	0	10	4.70	93.63
3C1C2.8	75	28.50	65	104.00	40	2.12	1	2.5	25	11.75	148.87
3C1C2.9	55	20.90	60	96.00	40	2.12	1	2.5	5	2.35	123.87
3C1C2.10	20	7.60	45	72.00	30	1.59	0	0	15	7.05	88.24
3C1C2.11	20	7.60	30	48.00	20	1.06	1	2.5	5	2.35	61.51
3C1C2.12	20	7.60	35	56.00	20	1.06	0	0	5	2.35	67.01
3C1C2.13	20	7.60	40	64.00	30	1.59	0	0	5	2.35	75.54
3C1C2.14	20	7.60	45	72.00	20	1.06	0	0	5	2.35	83.01
3C1C2.15	20	7.60	35	56.00	15	0.795	0	0	5	2.35	66.75
3C1C2.16	20	7.60	55	88.00	20	1.06	0	0	5	2.35	99.01
3C1C2.17	20	7.60	50	80.00	20	1.06	1	2.5	5	2.35	93.51
3C1C2.18	20	7.60	40	64.00	30	1.59	1	2.5	5	2.35	78.04
3C1C2.19	20	7.60	45	72.00	20	1.06	1	2.5	5	2.35	85.51
Total	**550**	209.00	**855**	1368.00	**530**	28.09	**11**	**27.5**	**180**	84.60	1717.19

10.1.13. ***Control of Shifting Cultivation in Catchment***

The shifting cultivation is a primitive method of cultivation in the tribal states like, Meghalaya, in the Garo Hills shifting cultivation or jhum kheti or 'aba-oa' has historically been the principal mode of agricultural production. The practice is carried out in semi-evergreen forest in the upper reaches and most deciduous forest at lower elevation. Shifting cultivation practices are linked with the ecological, socio-economic, and cultural life of the people and are closely connected to their rituals and festivals. Shifting cultivation in the region is not only the way to earn livelihood of rural tribes but also it contributes to the state domestic product substantially of the respective states.

But the shifting cultivation has been creating serious impact on geographical and environmental conditions of the region. Frequent shifting from one land to the other, has affected the ecology of these regions. The area under natural forest has declined; the fragmentation of habitat, local disappearance of native species and invasion by exotic weeds and other plants are some of the other ecological consequences of shifting agriculture. Apart from the loss of soil fertility and productivity as mentioned above jhumming is also responsible for large scale deforestation in the hills, siltation of reservoir, flooding the plains, drying up of the natural stream and waterfalls and irreparable damages to region's unmatched flora and fauna.

Due to its evil effects on environment and ecological balance in the region, the time comes to think about the alternative of this traditional system. ICAR has already suggested in this line. Considering the physiographic characters of land, climate conditions, social customs, food habits etc. alternative system of farming like diversified farming should be introduced. Scientific studies suggest that mixed land use system is quite suitable for hilly areas from the point of view of production as well as conservation. In this context, the latest and most effective land and water management techniques, popularly known as 'Watershed Management programme' along with land development, soil conservation, agriculture, horticulture, plantation crop, forestry, animal husbandry and fishery can safely be considered as most vital and important strategy. The alternative which may come in the way include:

- Agricultural (settled) land use system through terracing and contour binding
- Horticulture and cash crop plantation land use system for developing fruit orchard, rubber, coffee and oil palm cultivation.
- Multi-storey cropping land use pattern for differential harvesting of solar energy utilization of soil fertility at variable depth.
- Agri-Horti-Silvipastoral land use system with the strategy to adopt agriculture at the foothills, horticulture at the mid-portion of the hill slope and silvipastoral land use at the top of the hill.
- Livestock based land use system for developing livestock farming along with fodder production system.

10.1.13.1 Crop Management

The primary objectives for development of agriculture in the catchment area are to reduce the dependency of the farmers on shifting cultivation and to motivate them to take up settled farming systems. The following strategies may be adopted to achieve the objectives. Soil conserving methods of crop cultivation have to be propagated on the hill slopes, including current and abandoned jhum fields, through motivation of the jhumias to take to settled cultivation, after giving up the shifting habit. Producing agriculture on foothills up to 35% slope is found to be profitable with adequate returns. For cultivation on hills slopes, arranging of crops on topo-sequential manner is most important. For example, Rice in the bottom, Maize and Millets in middle and Tapioca, Ginger, Chillies, Turmeric in the upper part of the hill slopes, may be arranged.

The agronomic crops can be adopted on hill slopes up to 50 % gradient where soil depth is greater than 1.0 m. Contour bunding at 0.5 to 1.0 m vertical interval draining into a common grassed waterway is an essential requirement. The criteria for selection of crops should be based on the priority of crops that are already grown in the area, crops which have market potential such as spices and introduction of rabi crops such as mustard (*Brassica spp*), potato (*Solanum tuberosum),* pea (*Pisum sativum*), buckwheat (*Fagopyrum esculentum*) etc. in the irrigated area. Rice crop should be preferred in lower terraces. In general, ridge should be kept under fuel-fodder-timber trees, which can be planted, based on the requirement of farmers. On steep slopes about 30 % of land is to be occupied under bunds and terrace risers. These areas have a great potential for taking fodder crops. Amongst perennial grasses and legumes for the North East *Setaria sphacelata*, Napier (**Pennisetum purpureum**), Guinea (*Panicum maximum*) and *Stylosanthes guyanensis* were found good for terrace risers.

10.1.13.2 Crop Rotation

In many parts of India, a particular crop is sown in the same field year after year. This practice takes away certain elements from the soil, making it infertile and exhausted rendering it unsuitable for that crop. Rotation of crops is the system in which a different crop is cultivated on a piece of land each year. Thus, it is best to alternate crops in the field. Legumes such as peas, beans, clover, vetch and many other plants, add nitrates to the soil by converting free nitrogen in the air into nitrogenous nodules on their roots. Further, there are some crops such as maize, cotton, tobacco and potato which can be classed as erosion inducing, whilst some other crops such as grass, forage crops and many legumes are erosion resisting. Small grain crops like wheat, barley, oats and rice are between these two extremes. Higher return can be achieved by resorting to crop rotations with selected crops, such as (a) Rice-Maize (b) Maize-Ground nut/Soyabean.

10.1.13.3 Strip- Cropping (Contour Stripping)

Crops may be cultivated in alternate strips, parallel to one another. Some strips may be allowed to lie fallow while in others different crops may be sown e.g., grains, legumes, small tree crops, grass etc. Various crops ripen at different times of the year and are harvested at intervals. This ensures that at no time of the year the entire area is left bare or exposed. The tall growing crops act as wind breaks and the strips which are often parallel to the contours help in increasing water absorption by the soil by slowing down run off

Strip-cropping is the practice of growing crops in systematic arrangements of strips or bands which serve as vegetative barrier to erosion. It included the utilization of crop rotation, contour cultivation, proper tillage, cover crops and other related practices. The arrangement of crop in strips should be such that erosion and semi-erosion-resistant crops are alternated with clean cultivated crops that are conducive to erosion.

A total area of 788 ha of shifting cultivation area in the prioritized watershed has been identified to be managed through alternative farming system having a mix technology of strip and alley farming systems with combinations of livestock-based farming, which is less hazardous and more remunerative. Under the model, a unit of 2.20 Ha land will be allotted

to each farmer. The area and number of strips under different land use with one unit (2.2 ha) having 11 strips of size 20mx100 is shown in **Table 10.16.**

Table 10.16 : Details of Strip Farming

S.N.	Type of Crop strip	Area (ha)	No. of Strips
A	Agricultural Land use Crop Area		
(I)	Cover Crop with Vegetative hedge	215	98
(ii)	Mixed Crop with Vegetative hedge	143	64
	Sub-total (A)	358	162
B	Silvi-horticultural Crop		
(I)	Silvi-horticultural Crop with staggered trenches	88	40
(ii)	Silvi-pasture Crop	215	98
	Sub-total (B)	430	196
	Grand Total (A)+(B)	788	358

- Horticulture and Plantation Crops Land Use System

Contour bunds at 2-meter vertical interval, half-moon or crescent shape circle should be made at the location of planting, grassed waterways and making of few bench terraces at the lower slope towards foothills for growing vegetables and fruits are essential conservation measures. The recommended horticulture crops are Orange, Pineapple, Papaya, Guava and Lemon. On the basis of cost norms for open field cultivation under NHB Scheme and fertilizer rates as per Agriculture Department of Meghalaya, the cost for plantation of some of fruit trees has been worked in **Table 10.17.**

Table 10.17 : Cost of Horticulture Crops under Integrated Strip Farming Programme

S.N.	Fruit crop	Yr	Cost of Plant material /ha (Rs lakh)	Total cost Fertiliser (Rs lakh)	Cost of plant protection (Rs lakh)	Total Input Cost (Rs lakh)	Fruit Crop Area(ha)	Total Cost for Horticulture land use System (Rs lakh)
1	Pineapple @44400 Plant/ha	I	1.7	0.550	0.03	2.280	5	14.30
		II	0	0.550	0.03	0.580		
	Total		**1.7**	**1.100**	**0.06**	**2.860**		
2	Orange@500 plants/ha	I	0.18	0.125	0.02	0.325	5	10.69
		II	0.02	0.250	0.03	0.300		
		III	0	0.365	0.03	0.395		
		IV	0	0.509	0.03	0.539		
		V	0	0.549	0.03	0.579		
	Total		**0.2**	**1.798**	**0.14**	**2.138**		
3	Lemon@1100 plants/ha	I	0.4	0.392	0.02	0.812	5	15.23
		II	0.04	0.392	0.02	0.452		
		III	0	0.392	0.02	0.412		
		IV	0	0.667	0.02	0.687		
		V	0	0.667	0.02	0.687		
	Total		**0.44**	**2.511**	**0.1**	**3.051**		
4	Guava@550 plants/ha	I	0.17	0.522	0.01	0.702	5	14.26
		II	0.02	0.522	0.01	0.552		

		III	0	0.522	0.01	0.532		
		IV	0	0.522	0.01	0.532		
		V	0	0.522	0.01	0.532		
	Total		**0.19**	**2.611**	**0.05**	**2.851**		
5	Papaya@2800 plants/ha	I	0.42	0.319	0.01	0.749	24	41.78
		II	0	0.486	0.01	0.496		
		III	0	0.486	0.01	0.496		
	Total		**0.42**	**1.291**	**0.03**	**1.741**		
Grand Total							**44**	**96.26**

- Cover Crops Land Use System

The cover crops are a very important element of sustainable agriculture. These crops add fertility to the soil without chemical fertilizers using biological nitrogen fixation. A cover crop can offer a natural way to reduce soil compaction, manage soil moisture, reduce overall energy use & provide additional forage for livestock. Cover crops are plants grown outdoors for the use of enhancing the quality of the soil. They help create soil fertile, prevent erosion, regulate water, reduce weeds, increase biodiversity, and develop farming as a whole. On the basis of Practices for crops of Assam, published by Assam Agricultural University, Jorhat and fertilizer rates as per Agriculture Department of Meghalaya, the cost for plantation of some of mixed crops has been worked in **Table 10.18.**

Table 10.18 : Cost of Cover Crops under Integrated Strip Farming Programme

S.N.	Crop	Seed		Cost of Fertilizer (Rs lakh)	Cost of plant protection (Rs lakh)	Cost of input (Rs lakh)	Area under crop (ha)	Total Cost (Rs lakh)
		Qty (kg)	Cost (Rs lakh)					
1	Cowpea	30	0.06	0.123	0.01	0.193	50	9.65
2	Urad	30	0.042	0.048	0.01	0.100	50	5.0
3	Soyabean	60	0.15	0.066	0.01	0.226	22	4.97
4	Green Manure	30	0.01	0.000	0	0.010	120	1.2
Total			0.262	0.237	0.03	0.499	242	20.82

- Mixed Crops Land Use System

This is highly productive, sustainable and very practicable system. To increase the cropping intensity multi-storey crop combination consisting of crop of varying canopy orientation and rooting have also been developed which entails differential harvesting of solar energy and recycling of nutrients of variable depth based on the principle of canopy dimension and rooting pattern. Some of the recommended Crop combination for the area are Cowpea+ Maize; Maize+Urad; Maize+ Soyabean; Millet+ Urad and Millet+ Green gram. On the basis of Practices for crops of Assam, published by Assam Agricultural University, Jorhat and fertilizer rates as per Agriculture Department of Meghalaya, the cost for plantation of some of mixed crops has been worked in **Table 10.19.**

Table 10.19 : Cost of Mixed Crops under Integrated Strip Farming Programme

S.N.	Mixed Crop	Crop	Seed		Cost of Fertilizer (Rs lakh)	Cost of plant protection (Rs lakh)	Cost of input (Rs lakh)	Area under crop (ha)	Total Cost (Rs lakh)
			Qty (kg)	Cost (Rs lakh)					
1	Cowpea+ Maize	Cowpea	15	0.03	0.062	0.005	0.097	30	6.84
		Maize	10	0.02	0.106	0.005	0.131		
		Total	25	0.05	0.168	0.01	0.228		
2	Maize+ Urad	Maize	10	0.02	0.106	0.005	0.131	30	5.43
		Urad	15	0.021	0.024	0.005	0.050		
		Total	25	0.041	0.130	0.01	0.181		
3	Maize+ Soyabean	Maize	10	0.02	0.063	0.005	0.088	30	4.95
		Soyabean	20	0.05	0.022	0.005	0.077		
		Total	30	0.07	0.085	0.01	0.165		
4	Millet+ Urad	Millet	20	0.02	0.057	0.005	0.082	80	9.36
		Urad	10	0.014	0.016	0.005	0.035		
		Total	30	0.034	0.073	0.01	0.117		
5	Millet+ Green gram	Millet	20	0.02	0.057	0.005	0.082	80	8.96
		Green gram	10	0.01	0.015	0.005	0.030		
		Total	30	0.03	0.072	0.01	0.112		
Total								**270**	**35.54**

- Silvi-Pasture Crops Land Use System

Adoption of silvi pastoral systems in the hills ensures adequate soil cover thereby minimizing the hazards of runoff and soil losses. Runoff and soil losses are substantially reduced when small watershed with agriculture is replaced by trees or grasses or with mechanical measures (Singh et al., 1990). Studies had shown that protected silvi pasture cover is best in erosion control than agricultural crops (Chinnamani, 1992). Resorting to silvi-pastoral technique with soil and water conservation measures not only increased forage production, but helped in reducing soil loss from barren hillock and from waste lands (Hazra and Singh, 1994 and Hazra, 1993).

Silvi-Pasture Crop Strips, 20m wide will be provided below the Cover Strips to serve as a vegetative barrier for conserving soil and rain water. Grass/ Legumes and Fodder Trees, about 200 nos per ha, will be grown in each strip, succeeding downstream, to work as buffer. The common local pasture grasses recommended are (a) *Calopogonium mucunoides* (b) *Cenchrus eiliaris* (c) *Cynondon dactylon* (d) *Dichathium annulatum* and *Pueraria thundergiana.* The Cost of Silvi-Pasture Crop in 232 ha is shown in **Table 10.20.**

Table 10.20 : Cost of Silvi-Pasture Crop under Integrated Strip Farming Programme

S.N.	Crop	Seed		Cost of Fertilizer (Rs lakh)	Cost of plant protection (Rs lakh)	Cost of input (Rs lakh)	Area under crop (ha)	Total Cost (Rs lakh)
		Qty (kg)	Cost (Rs lakh)					
1	*Calopogonium mucunoides*	6	0.004	0.074	0.002	0.08	232	92.80
2	Fodder Trees (200/ha)							
(i)	Preliminary works	As per Table 1.11				0.25		
(ii)	Creation of Plantation	As per Table 1.11				0.07		
	Total					0.40		

- Vegetative Barriers

Vetiver Grass Technology (VGT) as compared to stone barriers, lemon grass, and bare ground (control) under natural and artificial rainfall conditions proved to be the most effective technology for reducing soil and water losses. VGT reduced rainfall run off and soil loss by about 57% and 80 % respectively (Rao et al., 1991). Vetiver showed a distinct improvement in efficiency as the hedges become older and denser (Rao et al., 1992). Trenches combined with living hedges or grassed lines are less labor-intensive method that is practiced in the highlands. The method involves digging trenches which have grass-stabilized banks, or simply planting grass strips and vegetative barriers across the slope to reduce runoff. This method, locally referred to as 'progressive terracing', is more adaptable by individual farmers across the country.

Normally, hedges are established by jabbing slips into holes or furrows. To establish the hedge quickly, large clumps can be planted close together (10 cm). On the other hand, when planting material is scarce, slips can be spaced as far apart as 20 cm. In this case, the hedge will take longer to close

The vegetative barriers / hedges will be created by growing vetiver grasses in rows along the contour. Within the row, spacing between the plants would be 10 cm. Slips planted singly will take a long time to form a clump. It is, therefore, advisable to use at least three slips per hill. Number of hills for 100m length of plantation at 10cm spacing shall be 1000.Assuming three slips per hill, number of slips shall be 3000. Cost of vegetative barriers with vetiver grass hedges in the middle of 20 m width strips of mixed and cover crops (512ha) is shown in Table **10.21.**

Table 10.21 : Cost of Vegetative Barriers under Integrated Strip Farming Programme

S.N.	Item of work	Cost (Rs)
1	Purchase price of clumps	200.00
2	Cost of uprooting clumps @0.25 labour/day	75.00
3	Transportation cost of clumps including loading and unloading and staking	150.00
4	Cleaning and separation of slips from clump@0.5 labour/day	150.00

5	Digging 10cmx10cm size trench in 100 m length @0.25 labour/day	75.00
6	Cost of planting 1000 hills @0.5 labour/day	150.00
7	Miscellaneous and contingencies (LS)	50.00
Total		850.00
Cost of planting of 500 m length in the middle of 20 m wide strips for 2.2 ha unit		4250.00
Cost of vegetative barriers with vetiver grass hedges in the middle of 20 m width strips of mixed and cover crops(512ha)		**21,76,000**

10.1.13.4 Cost of Control Measures for Shifting Cultivation

The overall cost of works proposed under this head work out to Rs. 267.18 lakh and is shown in **Table 10.22.**

Table 10.22 : Cost of Control Measures for Shifting Cultivation

S.N.		Area(ha)	Cost (Rs Lakh)
1	Horticultural plantation	44	96.26
2	Planting cover crops	242	20.82
3	Planting mixed crops	270	35.54
4	Planting Silvi-pastural Crops	232	92.80
5	Vegetative barriers with vetiver grass hedges		21.76
Total		**788**	**267.18**

10.1.14. *Cost of Other Components of Cat Plan*

Apart from the forestry works and drainage line treatment in the catchment area there are other aspects of the CAT Plan to be addressed and their cost included in the overall cost estimate of the plan. The eco-restoration works, livelihood support works, social mobilization, documentation and publication, monitoring and evaluation and providing environmental services are some of the integral ingredients which have to be considered and included while formulating the CAT plans.

10.1.14.1 Implementation of Support Infrastructure Cost

In order to execute the catchment area treatment plan, the forest department would be requested to establish a catchment area treatment cell for which the executing agency shall need necessary infrastructure support. Accordingly, provisions have been made for purchase of office equipment and survey equipment. For movement of the field staff and labour, forest footpath and bridges/culvers would need construction and repair. The cost of works proposed under the head works out to **Rs. 4.00 lakh** and is shown in **Table 10.23.**

Table 10.23 : Cost Estimate for Support Infrastructure

S. No	Particular	Quantity	Unit	Rate (Rs. Lakh)	Amount (Rs. Lakh)
(A)	**Officer Equipment's**				
1	Purchase of Computers complete with accessories and Laser printer	2	No.	0.75	1.50
2	Purchase of Photocopy Machine	1	No.	1.00	1.00
3	Purchase of Fax Machine	1	No.	0.10	0.10
4	Purchase of GPS and Survey instruments	LS	-	-	1.40
	Total				**4.00**

10.1.14.2 Training and Extension Programme

There is a need to keep all members of the existing registered VFDCs and committees to be constituted in other villages and NGOs involved in programme implementation so that they can play an active role in implementation of the CAT plan by associating with the development work in their areas. For this purpose, people need to be trained in respect of different measures for habitat improvement by afforestation techniques, nursery development, pasture development, soil conservation and moisture retention works, horticulture development and agriculture practices in respect of land under the CAT plan with special thrust to local technique with the use of indigenous material without deteriorating ecology of the area. The technique of river-training work needs to be explained properly so that desired results are achieved. For this purpose, a training programme has to be properly devised and carried out at range office for which a provision of **Rs. 3.00 lakh** is being made.

10.1.14.3 Provision for Micro Plans

Based on the ground truth reality in each of the village forest department committee or society under different sub-watersheds, comprehensive micro plan for execution of the work has to be prepared as per norms. The micro plan for each beats of sub-watershed shall be prepared in consultation with the members of concerned VFDCs with due regards to the environmental functions and productive potential of the forests and their carrying capacity. For this purpose, a provision of **Rs. 4.00 lakh** is being made.

10.1.14.4 Provision for Proper Documentation

Emphasis should be laid on the publicity of the work proposed under the plan and work carried out on annual basis so that transparency is maintained and proper documentation of the work is also carried out for future reference, and testing the efficacy of the work in due course of time. On this count a provision of **Rs. 3.00 lakh** is being made. The documentation would inter alia include implementation report, progress reports, photography, videography etc. Publication of the work done may be distributed to concerned panchayat and village Forest Development Committees/Societies for wider dissemination.

10.1.14.5 Gender Support

By far women folk are more industrious than men in the hills. There is a need to keep them in center stage in programme implementation so that they can play an active role in preservation of the ecology as well as the socioeconomic development of the area. Considering the immense potential and genuine needs for women's participation in JFM programme, proper training with respect to work related to NTFP cultivation, animal husbandry, gardening and farm works etc. shall be imparted for which a provision of **Rs. 4.00 lakh** is being made.

10.1.14.6 Provision for Mobilizing User Groups

Based on the ground truth reality in each of the Village Forest Development Committee or Society falling under the different sub-watersheds, mobilizing the user groups will be of utmost importance so as to involve them in afforestation and other agreed activities of the CAT Plan. For this purpose, a provision of **Rs. 2.00 lakh** is being made.

10.1.14.7 Funds for Educational Activities related to Medicinal Plant Sector

A provision of **Rs. 6.00 lakh** is being made for various conservation and educational activities related to medicinal plant sector.

10.1.14.8 Provision for Floristic Survey and Forestry Research

Though a provision has been made in environment monitoring plan for ecosystem monitoring including environmental studies during construction and post constructional stages respectively, an additional provision of Rs. 6.00 lakh is being made for carrying out floristic survey of the area after complete implementation of CAT Plan, i.e., immediately after the fifth year of maintenance.

10.1.14.9 Provision for Monitoring and Evaluation

The success of implementation of a CAT Plan can be fathomed by increase in vegetal cover on hill slopes and the enhancement. Various engineering and biological measures have been aimed at treating degraded and potential areas of severe to very severe soil erosion by increasing soil holding capacity and thus reducing sediment flow in the water. Therefore, for recording soil and silt data at regular intervals one small laboratory/observatory shall be established at dam site where the regular discharges of the streams and silt samples shall be monitored twice a day for five years.

A close watch on annual basis shall be maintained in respect of such areas where habitat improvement works have been carried out so as to verify the work executed on site itself and also to ascertain the rate of survival of plants and / or any damage to the new work. For monitoring of works under forestry operation, the use of remote sensing technique by using digital satellite imagery of IRS P6 LISS-III with high resolution (2.5 m x 2.5 m) should be made obligatory. The monitoring through satellite scene should be done before commencement of works under CAT plan and in a block of two years after completion of CAT plan. The work of monitoring of various works under the CAT plan should be entrusted to an external agency which has long experience of carrying out similar work on land use data and evaluating environment impact.

A provision of **Rs. 10.00 lakh** is being made for monitoring and evaluation activities including the expenditure likely to be incurred on conducting meetings / seminar / workshops at the head quarter and outside. This will include payments made to the non-official members of the monitoring evaluation committee on accounts of their expenditure on traveling and boarding etc. The payment to the external agencies shall also be met out from this part.

10.1.14.10 Provision for Forest Protection

The need for rigorous watch and ward of the forest covered under the catchment area becomes more imperative in view of proposed new plantation under the CAT plan and due to increased human activity in the form of labour, who shall be engaged for forestry works. Thus, fire protection measures including construction and maintenance of fire lines, construction of check-posts, watch towers have to be undertaken. Besides these construction / repair of forest boundary pillars shall also be carried out. The forest staff shall have to be properly equipped with modern utility gadgets like walky-talky, GPS and fire-fighting equipment's. For these a provision of **Rs. 5.00 lakh** is being made.

10.1.14.11 Capacity Building

Since the effectiveness of the biological and engineering measures and their proper implementation will depend on the understanding and preparedness of the forest staff. It is important that the Forest Department makes efforts to sensitize the staff on implementation and management of plantation issues, soil conservation, flood protection works and also provide guidance and encourage them to build requisite capacities. Capacity building can be achieved through training programmes for which a provision of **Rs. 2.0 lakh** is being made in the plan.

10.1.15. *Institutional Mechanism*

10.1.15.1 Role of Project Proponent

The forest department would implement the Catchment Area Treatment Plan. A joint inspection group is suggested that would include officers drawn from State Forest Department, Autonomous council for East Khasi Hills district and officials from the Environment Cell of the Meghalaya Energy Corporation Ltd. The management will have liaison with the forest officials. As far as the financial disbursement to undertake activity involvement of various stake holders and collaborative public participation should be encouraged to have transparency in the system.

10.1.15.2 CAT Implementation

The designated Environmental Officer of Meghalaya Energy Corporation Ltd., would coordinate with the forest department and Autonomous council for East Khasi Hills district for the implementation of the proposed Plan. The Environment Officer would evaluate/monitor financial aspects. The modalities of financial disbursement need to be worked out. The implementing agency shall submit completion certificate in the light of guidelines fixed by the State Forest Department. The implementation of CAT Plan should have enough flexibility and should be subject to changes as per requirements of specific ecosystem and periodic gains. A monitoring committee as per the MoEF guidelines such as Umngot CAT Plan Society with its

headquarters at Shillong may be constituted for the project for administrative guidance and smooth realization of targets.

10.1.15.3 Project Monitoring and Reporting Procedures

Meetings would be held every three months to resolve problems arising in plan implementation. A Joint committee may be formed with the Environment Cell of Meghalaya Energy Corporation Ltd., and State Forest Department; the team members must ensure implementation and monitoring of the CAT works and review the progress from time to time. Quarterly progress reports and completion certificates would be submitted to Meghalaya Energy Generation Corporation Ltd., for evaluation and disbursement of finance. In addition, the work done should be published through public awareness campaigns. Visual and print media may be used to gain maximum benefit by beneficiaries. Such efforts would resolve conflicts which otherwise are potential sources for project delays.

10.1.16. *Summary of Cost of Works*

The cost of all works proposed in the CAT plan is enumerated in **Table 10.24.**

Table 10.24 : Cost Estimate of CAT Plan

S. N.	Particulars	Amount (Rs. Lakh)
1.	**Habitat treatment works under free draining catchment**	
(a)	Normal afforestation (70 ha @ Rs. 1.75 lakh/- per ha)	122.50
(b)	Enrichment Plantation (515 ha @ Rs. 1.4 lakh/- per ha)	762.20
	Sub- total (1)	**884.70**
2.	**Soil and water conservation measures**	
(a)	DRSM check dam (180 no. @ 47000 each)	84.60
(b)	Double row brushwood check dam (530 no. @ 5300 each)	28.09
(c)	Percolation Tank (11no. @ 250000/no.)	27.50
(d)	Bench Terracing (855 ha @ Rs1.60 lakh/ha)	1368.00
(e)	Contour staggered trenches (550 ha @ Rs38000/ha)	209.00.00
	Sub- total (2)	1717.19
	Sub-total (1) & (2)	**2601.89**
3.	**Control of Shifting Cultivation**	
(a)	Horticulture development (44 ha)	96.26
(b)	Planta ting Cover Crops (220 ha)	20.82
(c)	Planta ting Cover Crops(270ha)	35.54
(d)	Planting Silvi-pastural Crops (232)	92.80
(e)	Vegetative barriers with vetiver grass hedges (512)	21.76
	Sub- total (3)	**267.18**
4	**Other Components of CAT Plan**	
(a)	Implementation of Support Infrastructure cost	4.00
(b)	Training and Extension Programme	3.00

(c)	Provision for Micro Plan	4.00
(d)	Documentation	3.00
(e)	Gender Support	4.00
(f)	Mobilizing user groups	2.00
(g)	Funds for Educational activities related to medicinal plant sector	6.00
(h)	Provision for floristic survey and forestry research	6.00
(i)	Provision for Monitoring and Evaluation Activities	10.00
(j)	Forest Protection	5.00
(k)	Capacity building	2.00
Sub- total (4)		**49.00**
Grand Total		**2917.37**
Say Rs.		**2917.00**

10.2. Compensatory Afforestation Scheme

10.2.1. *General*

The compensatory afforestation scheme would be implemented through State Forest Department. The activities include soil conservation works, fencing, protection, awareness, monitoring and evaluation along with maintenance for a period of five years. It is very essential to create more resources for fuelwood to check further degradation in the area where most of human and livestock population stay. This shall provide vegetal cover to barren slopes to check soil erosion and cater to the increasing demand of fuel wood and fodder. The plan envisages afforestation on the following model of plantation scheme.

The plantation of vacant land would be carried out depending on plant species. Soil binding species are proposed to be planted @ 2000 plants per ha. Similarly, broad –leaved species meant mainly for their fodder and fuel wood utility shall be planted at the rate of 2000 plants per ha. Fuel wood species will be planted with fodder species. As there is great pressure of grazing, it is proposed to raise mixed plantation of fuel wood and fodder together. Each plantation shall have at least 20-30 % of fodder species and 40 – 50% fuel wood species and the rest would be timber species.

10.2.2. *Compensatory Afforestation*

Under Forest (Conservation) Act, 1980, in case of diversion of forest land for non-forestry purpose, the compensatory afforestation shall be done over equivalent area of non -forest land made available to the Forest Department and its ownership transferred and the same is notified as FR.As far as possible, the non –forest land should be identified contiguous to or in proximity of Reserved Forest or Protected Forest in the same district and in case if it is not available, it should be identified anywhere else in the state, so as to minimize the micro-ecology of the area.

Where non-forest lands are not available or non-forest land is available in less extent to the forest area being diverted, the compensatory afforestation may be carried out over degraded forest land and available non-forest land, as the case may be. Compensatory afforestation

may be raised over degraded forestland twice in extent of the forest area being diverted/deserved.

10.2.3. *Provision of Sixth Schedule of Constriction of India*

As per Paragraph 1, sub- para 1 of Sixth Schedule of Constitution of India, the tribal areas in the appended to Paragraph 20 of the schedule, shall be an autonomous district.

As per provision of Paragraph 20 regarding 1[20. Tribal areas-

The areas specified in Parts I, II 2[, IIA] and III of the table shall respectively be the tribal areas within the State of Assam, the State of Meghalaya, the State of Tripura] and the State of Mizoram. The Government of Meghalaya vide Notification No. DCA 31/72/11 dated the 14th June, 1973, Gazette of Meghalaya, Pt. VA, dated 23-6-1973, has declared, Khasi Hills and Jaintia Hills as autonomous district.

(1) The areas specified in Parts I, II 2[, IIA] and III of the table below shall respectively be the tribal areas within the State of Assam, the State of Meghalaya 2[, the State of Tripura] and the 3[State] of Mizoram

As per paragraph 3, sub- section 1 of Sixth Schedule of Constitution of India, the Regional Council for an autonomous region in respect of all areas within such region and the District Council for an autonomous district in respect of all areas within the district except those which are under the authority of Regional Councils, if any, within the district shall have power to make laws with respect to-

(a) the allotment, occupation or use, or the setting apart, of land, other than any land which is a reserved forest for the purposes of agriculture or grazing or for residential or other non-agricultural purposes or for any other purpose likely to promote the interests of the inhabitants of any village or town: Provided that nothing in such laws shall prevent the compulsory acquisition of any land, whether occupied or unoccupied, for public purposes 1[by the Government of the State concerned] in accordance with the law for the time being in force authorizing such acquisition;

(b) the management of any forest not being a reserved forest;

As defined in section 3, sub- section (2), a “reserved forest” means any area which is a reserved forest under the Assam Forest Regulation, 1891, or under any other law for the time being in force in the area in question.

Therefore, in view of above statutory provisions, the forest areas other than those of reserve forests under the control of state forest department are managed by the respective district councils of East Khasi Hills and Jaintia Hills districts.

10.2.4. *Forest Land requirement of the Project*

The forest likely to come under submergence are under community forest maintained by the district and village councils. Hence the Forest Conservation Act,1980, may not be applicable to the forest area under the project submergence area. Hence equivalent area is proposed to be delineated for afforestation. The forest area likely to be submerged due to the project consisted dense forest and open forest besides scrubs in smaller areas. The total forest land required to be diverted is 93.53 ha of which 12.91 ha is covered under Dense forest whereas 80.62 ha is covered under open forest classification **(Table 10.25).**

Table 10.25 : Total Land Under Different Forest Division

S.N.	Unreserved Forest classification	Forest (ha)	Legal Status
A	**East Khasi Hills and Jaintia Hills District Council**		
(i)	Dense Forest	12.91	District Council Forest
(ii)	Open Forest	80.62	District Council Forest
Total		**93.53**	

10.2.5. *Status of Forest Land Diversion*

The P. P has already moved on line the application for Forest clearance for diversion of 93.53 ha vide proposal No. FP/ML/HYD/7562/2014, dated 27.8.2015. The case for stage -1 clearance for diversion of 93.53 ha Forest land has been returned by Nodal officer and is pending at the level of User Agency.

10.2.6. *Trees Affected due to Diversion of Forest land and their Management*

The enumeration of the trees of all species standing on the land proposed to be diverted shall be carried out by Project Proponent conjointly with the concerned Forest Divisions. All trees standing 4 m below the FRL, over forest land to be diverted, shall be clear felled by the Forest Department before transfer of land to the P.P. The logs of cut trees shall be cleared from site and disposed as per Forest Department guidelines. A few months before first filling of reservoir the whole root mass of the trees should be removed and the pits so created should be filled with stones, this will help in reducing formation of methane to some extent in the initial years.

10.2.7. *Land for Compensatory Afforestation*

Under Forest (Conservation) Act, 1980, in case of diversion of forest land for non-forestry purpose, the compensatory afforestation shall be done over equivalent area of non -forest land made available to the Forest Department and its ownership transferred and the same is notified as FR. As far as possible, the non –forest land should be identified contiguous to or in proximity of Reserved Forest or Protected Forest in the same district and in case if it is not available, it should be identified anywhere else in the state, so as to minimize the micro-ecology of the area.

Where non-forest lands are not available or non-forest land is available in less extent to the forest area being diverted, the compensatory afforestation may be carried out over degraded forest land and available non-forest land, as the case may be. Compensatory afforestation

may be raised over degraded forestland twice in extent of the forest area being diverted/deserved.

As there is no Reserved Forest in the study area, land for raising compensatory afforestation has been identified near the forestland of State Forest Department at Maweit in West Khasi Hills, where private land shall be acquired around the RF area of Forest Department situated at Maweit.

10.2.8. *Comprehensive Scheme for Compensatory Afforestation*

A comprehensive compensatory afforestation scheme shall be formulated by the concerned Divisional Forest Officer and submitted for sanction to the Conservator Forests along with the proposal for forest clearance. It inter alia shall include land area identified for compensatory afforestation along with the map of the areas, year-wise phased forestry operations, details of species to be planted. The main features of the scheme which runs for 10 years incorporating first year for preparation works, second year designated for plantation works and fourth to tenth year being earmarked for annual maintenance operations are:

- Survey and demarcation of area.
- Boulder fencing.
- Plantation at the rate of 2000 plants /ha by indigenous species like
- Beating up operation with 10% mortality rate.
- Soil amelioration with FYM/Fertilizers/vermin compost and fertile soil.
- Periodic application of pesticide
- Construction of check-dams and water harvesting structures.
- Maintenance of fire lines.
- Watch and ward.

10.2.9. *Plant Species Identified for Afforestation*

The Indigenous plant species conforming to site specific importance will be chosen for plantation. The plant species have been identified based on soil and climate conditions of the proposed compensatory afforestation areas. Some of the suggested species which are proposed for normal plantation in the degraded area having gaps are given in **Table 10.26.**

Table 10.26 : Suggested Species for Afforestation

S.No.	Plant Species	Family	Local Name
1	*Albizia procera*	Mimosaceae	Safed Siris
2	*Altsonia scholaris*	Apocynaceae	Saptparni
3	*Aphanomixis polystachya*	Meliaceae	Banderiphal
4	*Bauhinia purpurea*	Caesalpiniaceae	Khairwal
5	*Beilschmiedia roxburghiana*	Lauraceae	Kamatti
6	*Bombax ceiba*	Bombacaceae	Semal
7	*Caryota urens*	Arecaceae	Mari

8	*Casearia vareca*	Flacourtiaceae	Sikarguti
9	*Castanopsis indica*	Fagaceae	Dalne Katus
10	*Cinnamomum tamala*	Lauraceae	Tejpata
11	*Engelhardtia spicata*	Juglandaceae	Gandmowa
12	*Erythrina stricta*	Papilionaceae	TaungKathit
13	*Garcinia xanthochymus*	Cluciaceae	Jharambi
14	*Gynocadia odorata*	Flacourtiaceae	Lemtem
15	*Lagerstroemia hirsuta*	Lythraceae	Taman
16	*Lannea coromandelica*	Anacardiaceae	Jhingran
17	*Macaranga denticulata*	Euphorbiaceae	Burna
18	*Michelia glabra*	Magnoliaceae	Pan-sopa
19	*Miliusa globosa*	Anonaceae	Jhora-Bhanora
20	*Oroxylum indicum*	Bignoniaceae	Pharri
21	*Parkia roxburghii*	Mimosaceae	Supota
22	*Persea odoratissima*	Lauraceae	Kaula
23	*Schima wallichii*	Theaceae	Laukya
24	*Stereospermum chelonoides*	Bignoniaceae	Padal
25	*Syzygium cuminii*	Myrtaceae	Jamun

10.2.10. *Cost of Compensatory Afforestation Scheme*

The scheme has been based on the man-days for creation of nursery and plantation including maintenance based on cost norms for developing nursery and raising plantation etc., as approved by Government of Meghalaya, Forest and Environment Department vide letter No FOR.85/86/461, dated 5.1. 2017.Wage rate of Rs 300/day as fixed by Labour Department vide Notification No. LBG75/2012/361, dated 7.1.2019, with 10% annual hike have been adopted. The cost for compensatory plantation has been worked out in **Table 10.27**.

Table 10.27 : Total Cost of Compensatory Plantation

S.N.	Particular	Man days	Wage /day	Amount (Rs)
	A-CREATION OF Poly Pot NURSERY			
1	**First year creation of 1 bed nursery**			
(i)	Preparation of standard size bed (13.0 m x 1.30 m x 0.30 m) for placement of polyethene bags	1.575	300	472.50
(ii)	Cost of polyethene bags (22.5 cm x 15 cm)	8	300	2400.00
(iii)	Cost of manure mixed with top soil & filling in polyethene bags and pounding	9	300	2700.00
(iv)	Cost of cow dung manure including transpiration	1	300	300.00
(v)	Cost of seeds	2	300	600.00
(vi)	Cost of Goat proof fencing net, wooden fencing post & erecting, fixing fitting complete	1.65	300	495.00
(vii)	Cost of seed sowing including hoeing & mulching etc.	1	300	300.00

(viii)	Cost of prickling & transportation of seedlings from germination bed to poly pot	2	300	600.00
(ix)	Cost of construction of sheds for protection of the seedlings from frost and direct heat of sunlight			
	(a) cost of materials	1.5	300	450.00
	(b) Labour cost	2.5	300	750.00
(x)	Cost of weeding 4 times	3	300	900.00
(xi)	Cost of watering during dry season	1.2	300	360.00
(xii)	Miscellaneous expenses	0.2	300	60.00
	Total in the first year	34.625	300	**10387.50**
			Say	**10388.00**
2	**Maintenance of 1 bed nursery during second year**			
	Cost of weeding 2 times	2		600.00
	Cost of watering during dry season	0.572		171.60
	Total in the second year	2.572		**771.60**
			Say	**772.00**
	B-CREATION OF NAKED ROOT NURSERY			
1	**First year creation of 1 bed nursery**			
(i)	Preparation of standard size bed (13.0 m x 1.30 m x 0.30 m) for placement of polyethene bags	1.575	300	472.50
(ii)	Cost of seeds	2	300	600.00
(iii)	Cost of Goat proof fencing net, wooden fencing post & erecting, fixing fitting complete	1.65	300	495.00
(iv)	Cost of cow dung manure including transpiration	1	300	300.00
(v)	Seed treatment	0.3	**300**	90.00
(vi)	Cost of seed sowing including hoeing & mulching etc.	1	300	300.00
(vii)	Cost of weeding 4 times	4	300	1200.00
(viii)	Cost of construction of sheds for protection of the seedlings from frost and direct heat of sunlight			
	(a) cost of materials	1.5	300	450.00
	(b) Labour cost	2.5	300	750.00
(ix)	Cost of watering during dry season	1.2	300	360.00
(x)	Miscellaneous expenses	0.2	300	60.00
	Total in the first year	16.925	300	5077.50
			Say	**5078.00**
2	**Maintenance of 1 bed nursery during second year**			
	Cost of weeding 3 times	3	300	900.00
	Cost of watering during dry season	0.572	300	171.60
	Total in the second year	2.572	300	1071.60
			Say	**1072.00**
	C-CREATION OF PLANTATION			
1	**Preliminary Works for Creation of Plantation**			
(i)	Survey & demarcation i/c fixing of boundary marks etc.	2	300	600.00

(ii)	Jungle clearance, burning, land prep., collection of stacks, rope etc.	24	300	7200.00
(iii)	Fencing with 3 strand barbed wire and wooden fencing posts including cost of staples, fixing, fitting etc. complete	64	300	19200.00
(iv)	Construction of camp hut, inspection path and cost of T&P	14	300	4200.00
(v)	Supervisory staff(casual) to be engaged from locals	12	300	3600.00
	Total Preliminary works	116	300	**34800.00**
2	**Creation- (First year of plantation)**			
(i)	Planting of nursery seedlings including. carriage from nursery centers to plantation sites and proper ramming after planting etc., complete	16	300	4800.00
(ii)	Weeding - 3 times weeding @15-man days per weeding	45	300	13500.00
(iii)	Fire protection works		300	
	(i) Wages of fire watcher from Nov. of the creation year to April of following year	7	300	2100.00
	(ii) Fire line clearance including controlled burning	7	300	2100.00
	Total Creation- (First year of plantation)	75	300	**22500.00**
3	**Maintenance- (Second year of plantation)**			
(i)	Weeding - 5 times weeding @15-man days per weeding	75	330	24750.00
(ii)	Fire protection works			
	(i) Wages of fire watcher from Nov. of the creation year to April of following year	7	330	2310.00
	(ii) Fire line clearance including controlled burning	7	330	2310.00
(iii)	Vacancy filling in mortality areas	4	330	1320.00
	Total Maintenance- (Second year of plantation)	93	330	**30690.00**
4	**Maintenance- (Third year of plantation)**			
(i)	Weeding - 5 times weeding @15-man days per weeding	75	363	27225.00
(ii)	Fire protection works			
	(i) Wages of fire watcher from Nov. of the creation year to April of following year	7	363	2541.00
	(ii) Fire line clearance including controlled burning	7	363	2541.00
(iii)	Vacancy filling in mortality areas	4	363	1452.00
(iv)	Miscellaneous cost like repair of fencing &inspection path	4	363	1452.00
	Total Maintenance- (Third year of plantation)	97	363	**35211.00**
5	**Maintenance- (Fourth year of plantation)**			
(i)	Weeding - 4 times weeding @15-man days per weeding	60	399	23940
(ii)	Fire protection works			
	(i) Wages of fire watcher from Nov. of the creation year to April of following year	7	399	2793.00
	(ii) Fire line clearance including controlled burning	7	399	2793.00
	Total Maintenance- (Fourth year of plantation)	74	399	**29526.00**
6	**Maintenance- (Fifth year of plantation)**			
(i)	Weeding - 3 times weeding @15-man days per weeding	45	439	19755.00
(ii)	Fire protection works			

	(i) Wages of fire watcher from Nov. of the creation year to April of following year	7	439	3073.00
	(ii) Fire line clearance including controlled burning	7	439	3073.00
(iii)	Singling out	6	439	2634.00
(iv)	Miscellaneous cost like repair of fencing &inspection path	3	439	1317.00
	Total Maintenance- (Fifth year of plantation)	68	439	**29852.00**
7	**Maintenance- (Sixth year of plantation)**			
(i)	Weeding - 2 times weeding @15-man days per weeding	30	483	14490.00
(ii)	Fire protection works			
	(i) Wages of fire watcher from Nov. of the creation year to April of following year	7	483	3381.00
	(ii) Fire line clearance including controlled burning	7	483	3381.00
(iii)	Singling out	6	483	2898.00
(iv)	Miscellaneous cost like repair of fencing &inspection path	3	483	1449.00
	Total Maintenance- (Sixth year of plantation)	53	483	**25599.00**
8	**Maintenance- (Seventh year of plantation)**			
(i)	Weeding - 2 times weeding @15-man days per weeding	30	531	15930.00
(ii)	Fire protection works			
	(i) Wages of fire watcher from Nov. of the creation year to April of following year	7	531	3717.00
	(ii) Fire line clearance including controlled burning	7	531	3717.00
(iii)	Singling out	6	531	3186.00
(iv)	Miscellaneous cost like repair of fencing &inspection path	3	531	1593.00
	Total Maintenance- (Seventh year of plantation)	53	531	**28143.00**
9	**Maintenance- (Eight year of plantation)**			
(i)	Weeding - 1 times weeding @15-man days per weeding	15	584	8760.00
(ii)	Fire protection works			
	(i) Wages of fire watcher	7	584	4088.00
	(ii) Fire line clearance including controlled burning	7	584	4088.00
(iii)	Singling out	6	584	3504.00
(iv)	Miscellaneous cost like repair of fencing &inspection path	3	584	1752.00
	Total Maintenance- (Eight year of plantation)	38	584	**22192.00**
	TOTAL COST FOR COMPENSATORY AFFORESTATION			
1	Creation of 225 bedded poly pot nursery	225 No	10388	2337300
2	2nd Year maintenance of poly pot nursery	225No	772	173700
3	Creation of 1125 bedded naked root nursery	1125No	5078	5712750
4	2nd Year maintenance of naked root nursery	1125No	1072	120600
5	Preliminary Works for Creation of Plantation	94 ha	34800	3271200
6	First year Creation of plantation	94 ha	22500	2115000
7	2nd Year maintenance of 94 ha plantation	94 ha	30690	2884860
8	3rd Year maintenance of 94 ha plantation	94 ha	35211	3309834
9	4th Year maintenance of 94 ha plantation	94 ha	29526	2775444
10	5th Year maintenance of 94 ha plantation	94 ha	29852	2806088

11	6th Year maintenance of 94 ha plantation	94 ha	25599	2406306
12	7th Year maintenance of 94 ha plantation	94 ha	28143	2545442
13	8th Year maintenance of 94 ha plantation	94 ha	22192	2086048
	Total CA			32544572
14	Cost of staff quarter (2)	2	900000	1800000
15	Construction of solar lighting system	10	300000	300000
Total				**34644572**

10.2.11. *Payment of Net Present Value of Land Transferred*

The MoEFCC New Delhi Circular F. No. 5-1 / 98-FC (Pt-II), dated 17/18 September, 2003, issued pursuant to the order of the Hon'ble Supreme Court of India, makes obligatory for the State Government to charge from the user agency the Net Present Value (NPV) of land to be converted for non-forestry purposes under the Forest (Conservation) Act, 1980. Depending upon the forest density the rates of NPV have been finalized. In the present context the value of NPV of the forest land in question @ Rs. 9.31lakh/ha for dense forest and 7.30 lakh/ha for open forest has been assessed as Rs 708.72 lakh. After realizing the amount, the state Government shall transfer these funds to CAMPA.

10.2.12. *Cost Estimate of Compensatory Afforestation Works*

The overall cost estimate for compensatory afforestation works to **Rs. 2308.00** lakh as shown in **Table 10.28.**

Table 10.28 : Total Cost of Compensatory Afforestation Plan

S. N.	Particulars	Quantity	Rate (Rs. Lakh)	Amount (Rs. Lakh)
1.	Cost of compensatory afforestation Scheme as per detailed estimate	Asper Table 10.27		346.45
2	Cost of 93.53 ha non-forest land proposed at Maweit in West Khasi Hills for raising compensatory afforestation	93.53 ha		1177.80
3.	NPV of Forest Land to be diverted (a)Dense Forest (b) Open Forest	12.91 80.62	9.31/ha 7.3/ha	120.19 588.53
4	Cost of trees to be felled		-	75.00
			Grand Total	**2307.97**
			Say	**2308.00**

10.3. Wildlife and Biodiversity Management Plan

10.3.1. *Introduction*

The main objective of Biodiversity Conservation and Management plan is sustainable use of natural resources, which involves scientific management of natural wealth vis-à-vis developmental activities, is likely to affect these resources. The threats to natural terrestrial

and aquatic ecosystems generally arise due to by anthropogenic activities that may arise because of construction and associated activities of proposed Umngot HEP. A detailed biodiversity conservation and management plan has been proposed and the main objectives of said plan are as follows:

- Maintenance of ecological balance through preservation and restoration of wherever it has been disturbed due to project developmental activities,
- Conservation and preservation of natural habitats in catchment area
- Rehabilitation of critical species (endangered, rare and threatened species), if any with provisions for *in-situ* or *ex-situ* conservation of critical/ important plant/ animal species,
- Mitigation and control of project induced biotic and/or abiotic pressures/influences that may affect the natural habitats,
- Habitat enhancement in project catchment area by taking up afforestation and soil conservation measures,
- Creating all round awareness regarding conservation and ensuring people's participation in the conservation efforts and minimizing man animal conflict.

10.3.2. *Protected Areas*

No National Park, Sanctuary, Notified Eco-sensitive areas protected under Wild Life (Protection) Act exists within the project area or within 15 km distance from it

10.3.3. *Conservation of Rare, Endangered & Threatened species.*

As per the primary survey no RET species were recorded. However, as per secondary data records 8 RET species have been reported from Khasi and Jaintia hills area (**Table 10.29).**

Table 10.29 : List of Orchids reported in Khasi and Jayanta Hills

Family	Name of plant species	Status as per IUCN / BSI
Asclepiadaceae	*Ceropegia angustifolia*	Vulnerable NE Hilly region, Khasi
Cyperaceae	*Fimbristylis stolonifera*	Rare in abandoned jhum of Khasi hills
Elaeocarpaceae	*Elaeocarpus prunifolius*	Rare
Orchidaceae	*Paphiopedilum venustum*	Vulnerable
Orchidaceae	*Vanda coerulea*	Rare
Theaceae	*Cleyera japonica*	Rare
Thelypteridaceae	*Metathelypteris decipiens*	Rare / Endemic
Thelypteridaceae	*Coryphopteris didymochlaenoides*	Rare / Endemic Fern

The propagation and cultivation method for this species has been standardized by the State Forest Department, consulting with Forest Research institute. The planting of this purpose may be produced by seed germination or any other conventional methods instead of tissue-cultured plants for mass multiplication to save genetic diversity. For conservation of RET species a budget of Rs. 5.0 lakh has been earmarked and which shall be given to State Forest Department for conservation of RET species.

10.3.4. *Conservation and Cultivation of Medicinal Plants*

An Herbal nursery shall be developed at an appropriate location. Farmers shall be trained to make them aware of the use of herbal plants and in animal health care also. For creating one herbal garden in 2 ha area a sum of Rs. 5.00 lakhs have been earmarked.

10.3.5. *Endemic, Threatened and Endangered species of mammals*

No endemic mammalian species has been recorded during primary survey. As per the list of fauna recorded from the study area the *Panthera pardous* is the schedule-I mammalian species present in the study area besides four species of herpetofauna. As per local people *Panthera pardus* occasionally can be seen nearby the river banks and villages. For conservation and management of Scheduled-I fauna separate budget has been earmarked.

10.3.5.1 Conservation Plan:

The people living in the surrounding area and employee of the company would be motivated towards the protection of the animal. Motivation will lead to timely information to the concerned authorities about any threat to wild life or any cases of poaching/hunting. Proper incentive shall be given to such locals who pass on information about the illegal poaching. Water holes should be made away from such places where the local people bring their animals for grazing. The ban on use of plastic bags should be strictly followed. The dangerous chemicals should not be indiscriminately disposed near to the water holes otherwise the water quality shall be impaired to dangerous proportion. The database of natural habitat of wild animals should be prepared and the information disseminated to the gram Panchayat. A great deal of wildlife also inhabits the area outside of the forests which do not fall under jurisdiction of the Forest Department. In context of such areas the revenue department and the NGOs may take joint and concerted efforts for protection of animals. The following conservation measures are proposed.

- Conservation of Soil and Improvement of Water Regime
- Habitat Improvement
- Creation of Conservation awareness
- Provision of Salt Lakes
- Incentives to Informers of Illegal hunting /poaching of animals
- Fencing of natural habitat to check the encroachment of shrinking habitat
- Strengthening of translocation centres of the district by one-time financial aid.

10.3.5.2 Wildlife Management Plan for Panthera Pardus

The buffer areas are essential for ensuring forest connectivity for Leopard/Panther land tenure dynamic as these constitute habitats for sub-adult, transients and old members of the Wildlife population. The aging wild animals from the source population residing in core zone migrate to the buffer zone while the adult replace them in source population zone (core zone). With habitat depletion of the buffer area, the source population shall be easily targeted and will always be at the risk of being eliminated. The buffer / fringe areas have immense importance as they have high corridor value which calls for maintaining and improving their ecological sustainability. Otherwise, they are likely to become ecological source sinks.

Forest areas can be developed as wildlife habitat by resorting to restorative strategies which *inter alia* would into the following:

1. Redressing man animal conflict
2. Habitat improvement measures
3. Anti-poaching operations
4. Capturing problematic and aberrant animals
5. Staff development and capacity building

Redressing Man Animal Conflict

The villages near forest have small chunk of agricultural land and people are mainly depending upon rain fed crops. Wild animals like often damage their crops which is the main man-animal conflict around the area. Though Wildlife (Protection) Act, 1972 authorizes Chief Wildlife Warden and Officers acting on his behest to permit killing of such wild animals causing destruction to life and property, yet the local due to religious sentiments do not opt for animal killings. In such a scenario adequate compensation shall be made to suffering stake holders near the buffer areas. To avoid revenge killing the compensation in case of loss of human life, resulting from man-animal conflict, shall be made @ Rs. 5.0 lakh / victim while for serious injuries Rs. 2.0 lakh / person.

Besides this crop protection structures can be erected at prominent places and cages/traps to catch problematic animals can be deployed.

Habitat Improvement Measures

The activities under this sub-head mainly comprises of such initiative which will improve the forage and browse values of the habitat for wild animals. The works like creating water holes, water retaining structures, pasture land reclamation (grass improvement) and eradication of weeds. The improvement in the floral diversity in the buffer area can be partly achieved from plantation under green belt to be carried out under the environment management plan proposed under the EIA/EMP report.

Anti-Poaching Operations

Under this sub-head deployment of anti-poaching squads drawn from army personnel and home guard; deployment of special tiger protection force (STPF) shall be the main constituent of the plan. Besides this establishment and maintenance of patrolling camps/ chokies equipped with wireless sets/mobile phones and procurement of field gear, night vision devices shall be the other ingredients.

Capturing problematic and aberrant animals

This will involve procurement and deployment of traps, cages to catch aberrant animals besides procurement of tranquilizing equipment.

Staff development and capacity building

Under this sub-head specialized training in the field of management planning, park interpretation through conducting workshops / seminars / study tours for appraisal of good practices followed in other reserves. Apart from this training in the use of GIS systems and anti-poaching operations shall be imparted.

10.3.5.3 Financial Projection of Conservation Plan

To implement the conservation plan following works are proposed within forest and civil forest. More emphasis will be given to soil and water conservation structures and creation of water holes along with the habitat development works. To improve the habitat and conserve the flora and fauna following items of works are proposed and tentative financial allocation for the same is given in **Table 10.30**.

Table 10.30 : Cost under Conservation Plan

S. No.	Item	Amount (Rs. Lakh)
1. Conservation of Soil and Water		
1.1	Improvement of existing water sources (Small Ponds)	2.00
1.2	Development of new water sources (Water Holes)	2.00
1.3	Construction of Anicut / Check Dams on small Nalas	3.00
2. Habitat Improvement		
2.1	Plantation / Pasture Development	20.00
2.2	Burning regime, seeding and grass cutting	5.00
2.3	Improvement of Escape cover	2.00
2.4	Improvement of Reproductive cover	7.00
3. Creation of Conservation Awareness		3.50
4. Provision of Salt Licks		0.50
5. Incentives to informers of illegal game / poaching		5.00
6. Fencing of Natural Habitat to check the encroachment		6.00
7. Compensation for loss of human life, resulting from man-animal conflict		10.00
8 Motor Bikes for patrolling by Front Line Staff (Forest Guard and Forester)		3.00
Total		**69.00**

10.3.6. *Cost Estimates*

Table 10.31 shows the overall cost of works under the plan. Funds to the tune of **Rs. 55.00 lakh** shall be allocated to the forest department for implementing plan.

Table 10.31 : Estimated cost of Biodiversity Conservation and Management Plan

S. N.	Item	Amount (Rs. Lakh)
1	Conservation of Rare, Endangered & Threatened species of plants	5.00
2	Medicinal Plants Cultivation and Conservation	5.00
3	Conservation Plan for Wildlife (Schedule – I)	69.00

4	Wildlife survey & research	0.00
(i)	Survey of wildlife & wildlife habitats	2.50
(ii)	Survey for sensitive / unique wildlife habitats in the free draining catchment area.	2.50
5	Development of habitat improvement measures in the degraded areas of the impact area d/s of dam	0.00
(i)	Normal Plantation	5.00
(ii)	Enrichment Plantation	5.00
(iii)	Construction of watch Towers and Drinking water ponds for wildlife	3.00
(iv)	Vaccination and Medical facilities to domestic cattle	3.00
	Total	**100.00**

10.4. Fisheries Management Plan

10.4.1. *Introduction*

Hydroelectric power project may have some negative or positive effects on the fish species found in the river flows at the project site, depending upon the particular situation and the fish fauna inhabiting the concerned river. The construction of a hydraulic structure like dam/dam leads to the fragmentation of habitat which may have adverse impact on the fishes especially the migratory fishes. Possible fish passage/fish ladder/fish bypass to provide migratory passage have been assessed to evolve effective conservation strategies for sustainable management of aquatic biodiversity. However, these passages have been found more effective in low head barrage but for high barrage passage are not found viable due to immediate loss of habitats.

10.4.2. *Fisheries Status*

A total of 16 fish species from 7 families were reported from Umngot river from all primary as well as secondary sources. Considering the number of fishes in Umngot river and adjacent area, it can be concluded that the area is not rich ichthyol faunal diversity. The low fish diversity in this area can be attributed to the nature of river and land use/ land cover in the catchment and habitat structure including river morphology. It is observed that 50% of the fish species collected belonged to the family Cyprinidae. This perhaps may be due to the fact that fishes which are highly adaptable in the hill streams belong to the family Cyprinidae more than any other family. Genus like Garra, Psilorhynchus, Labeo, Cyprinus are inhabitants of hill streams.

Out of 16 fish species *Labeo calbasu* is the only important fish species which move from downstream to upstream for spawning during May to August. All other native fish fauna performs local and daily movements for their basic biological needs (access habitat, food and shelter, defend territory).

10.4.3. *Impacts on Fisheries*

The possible disturbance to the fishes may be due to siltation and turbidity during construction phase. There may be a possibility of increase in soil erosion due to clearance of vegetation. The construction of 111 m high Umngot HEP, with no techno-economical provision for fish ladder/fish pass plausible on river, shall have slight impact on the migratory fishes. The Pendum fall on Umngot river on d/s of proposed dam site having vertical drop is the major obstacle for movement of fishes from downstrem (Dawki) to upstream as the fishes cannot negotiate the excessive vertical drop by jumping. Therefore, the movement of *Labeo Calbasu* (migratory specie) is already hampered from downstream.

Not only the fish but fishermen of the vicinity would also suffer. Thus, not only the conservation of indigenous fish but protection of fishermen's interest should be given priority. The conservatory measures and fisheries development can be achieved through establishment of fish farms, reservoir fishery and hatchery development.

Project may affect changes in the river ecosystem, as the river transforms from a fast-flowing water system to slow moving and less water stream. The aquatic animals affected most may be fishes due to disturbances and alterations to their habitat.

10.4.4. *Fisheries Development Plan*

Small reservoirs are predominantly culture-based fisheries systems and the management norms are based on the principle of stock manipulation, adjustment in fishing effort, observation of conservation measures and gear selectivity. The reservoir is expected to retain water throughout the year and offers an opportunity for fishery development to help in the increasing employment potential and provide alternate employment to poor and to produce protein rich food improve human dietary standards in rural area and raising the net income of rural community. Fisheries are a dynamic source which when exploited replenishes the loss and hence a maximum sustainable yield from this resource is possible. The proposed reservoir, having the productive water area of about 254 ha at FRL, shall be managed by District Council by leasing out the reservoir to the registered fishermen co-operative societies for a reasonable period, say 10 years.

10.4.4.1 Stock Management

The Management of fish stocks in reservoir entails maintenance of enough quality stocks in adequate number in order to sustain the fishery. This involves several steps such as; stocking, conservation of fish habitat including breeding, dwelling and feeding grounds, fishing gear and effort regulation, mesh regulation, observance of dose season, regulation on exotic fishes.

10.4.4.2 Stocking

It is well known that a reservoir passes through period of trophic burst during the first few years after its impoundment. During this period, there is a sudden surge in plankton and benthic communities due to high level of nutrients derived from the submerged organic

material in the reservoir bed. This is the right time to stock desirable species in to the reservoir. Heavy stocking with fast growing fishes on a short food chain is essential during trophic burst along with the protection of breeding ground. This will facilitate establishment of desirable species, which convert primary energy in to fish flesh at more economic rate of the reservoir. Any lapse in this management measure may cause proliferation of trash fishes, which in turn provide forage base for catfishes (predominantly predators).

Stocking of fish seed from extraneous sources is the most important management practice in reservoir development. Under the multispecies culture system, the indigenous species like Cirrhinus *reba*, *Labeo Calbasu* will be extensively stocked in reservoir. All these species constitute the native fauna of river. Stocking is considered successful only, when the stocked fish are recaptured. As the Indian reservoirs are developed based on stocking-cum-capture fisheries, the stocked species should form a breeding population.

During trophic burst period, means just after the nala closure stocking will be resorted. After first two years of stocking fishing will be started. The fingerlings stocked will be advanced fingerlings measuring up to 100 mm and weighing about 25 to 30 grams. The stocking of fingerlings in initial years is particularly important to ensure their better survival and especially in the presence of predator species like catfishes, feather backs and murrels.

10.4.4.3 Stock Density

Based on recommendation of National Fisheries Development Board, the requirement of fingerlings (100mm) @500/ha works out to 1,27,000 which is proposed to be apportioned among different carp species as shown in **Table 10.32.**

Table 10.32 : Requirement of Fingerling

Sl. No	Particular	Quantity			Total
1.	Species	*Labeo Calbasu*	*Cirrhinus reba*	*Catla*	-
2.	Stocking ratio	50%	40%	10%	100%
3.	Number of fingerlings	63500	50800	12700	127000

10.4.4.4 Development of Hatchery

A hatchery is the main center of seed production of different fish species. From these centers the seeds can be propagated in the proposed reservoir and lower reaches of various rivers in Sikkim. The hatchery **(Figure 10.6)** is proposed in the vicinity of Umngot. Initially all the running and maintenance of expenditure would be borne by the project authorities for a period of at least 2 years. Thereafter, it is assumed that it will be taken over by the District Council of East Khasi Hill, who will be solely responsible for the monitoring, maintenance and overall management of the plan including fish release to reservoir, training to fisherman/ unemployed youth, further assistance to them.

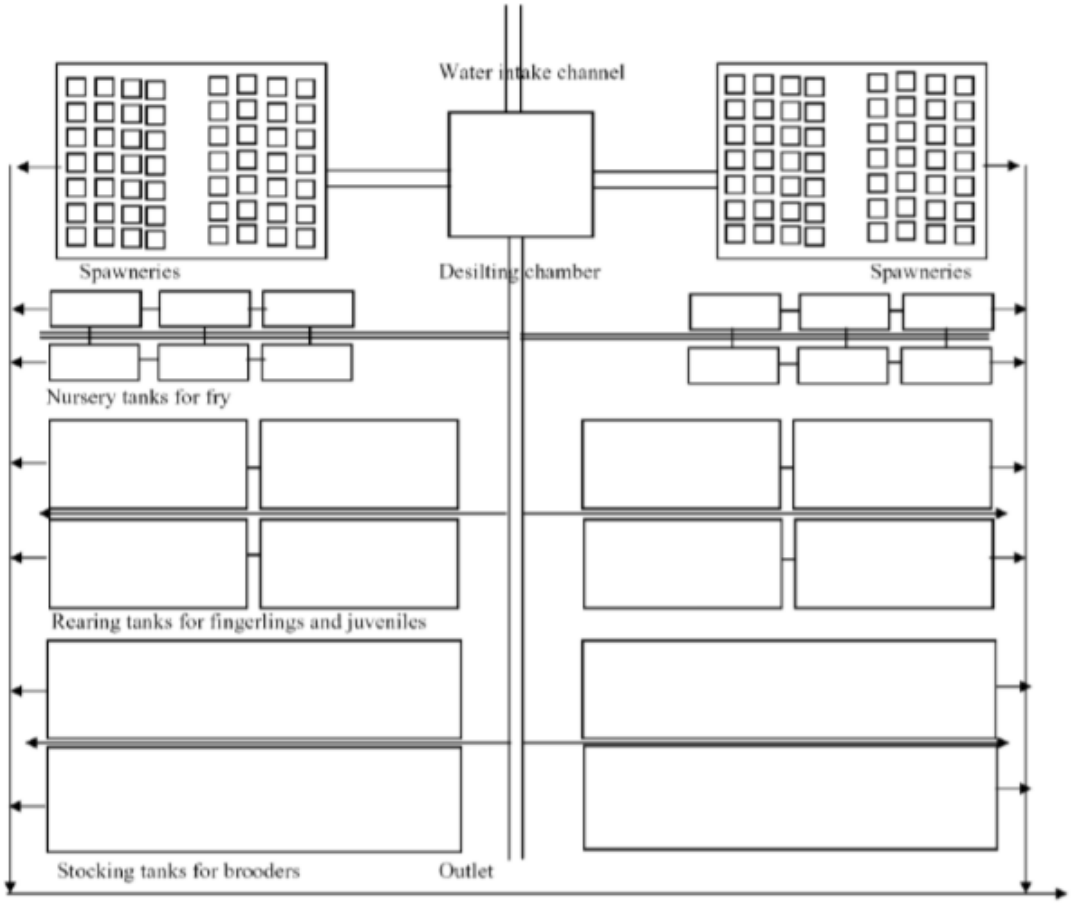


Figure 10.6 : Schematic Arrangement of Hatchery

10.4.4.5 Cost Estimate for Fisheries Management Plan

The cost estimate as prepared under various head is enumerated in **Table 10.33.** The funding (100%) will be done by MPGCL.

Table 10.33 : Cost Estimate of Fish Management Plan

S.N.	Particular	Qtty	Unit	Rate	Amount (Rs lakh)
A	Cost of establishing Hatchery				
(i)	Acquisition of land and its development	3	ha	10.0	30.00
(ii)	Construction of Hatchery House and provision of equipment's like troughs (40) and trays (150-200)	1	Job	L.S.	10.00
(iii)	Construction of Feed Store	1	Job	L.S.	4.00
(iv)	Construction of nursery ponds (3mx0.75mx0.5m)	12	Nos.	0.50	6.00
(v)	Construction of rearing ponds (10mx1.5mx0.5m)	8	Nos.	1.00	8.00
(v)	Construction of stocking ponds (30mx6.0mx1.5m)	4	Nos.	5.00	20.00
(vi)	Construction of office	1	No.	5.00	5.00
(vii)	Construction of Chowkidar hut	1	No.	4.00	4.00
(viii)	Construction of Water Intake Channel/pipe line	1	Job	L.S.	4.00
(ix)	Construction of Laboratory and Cost of Equipment	1	No.	6.00	7.00

(x)	Cost of Vehicles for transportation of seed	1	Job	L.S.	5.00
(xi)	Construction of fish landing center	1	Job	L.S.	10.00
(xii)	Cost of boats and motor boat	10	Nos.	0.40	4.00
(xiii)	Cost of one motor boat	1	No.	5.0	15.00
	Sub Total; I (A)				**132**
B	Salary, TA of one inspector,1Assistant,1Clerk,1 peon and 2 Chowkidars @ Rs2.50lakh/month for 24 months	24	Month	2.50	60.00
	Grand Total (A+B)				**192.00**

10.5. Resettlement and Rehabilitation Plan

10.5.1. *Introduction*

Like any other development / infrastructure project for the public purpose, land (Public and Private) invariably is to be acquired by the appropriate government either for its own use or for a requiring body, as the case may be. For execution of the project 390.50 ha land shall be required of which the apportionment between, Forest land, arable land and non-arable land shall be 93.53 ha, 152.43 ha and 144.54 ha respectively. The total arable/non- arable land required for the project is 296.97 ha, which is spread over 10 villages in East Khasi Hills District (203.38 ha) and 3 villages of Jaintia Hills District (93.59 ha). Though the project has been conceived with the sole objective of minimal displacement of people because their property in the project affected area, the compulsory acquisition of land for public purpose has been necessitated. The acquisition of the land shall be in consonance with "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013", (RFCTLARRA 2013) which has come into force from 1-1-2014, notified by Government of India. The provision/procedure under "Meghalaya Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Rules, 2017" shall also be followed.

10.5.2. *Social Impact Assessment Studies*

The Socio-economic survey of the project-affected village (PAV) and project affected Families (PAF) in the form of household survey was undertaken for gathering baseline information on various socio-economic parameters, which included the following:

a. Assessment as to whether the proposed acquisition serves public purpose.

b. Estimation of project affected families including families likely to be displaced.

c. Extent of land (Public / Private), houses and other assets, to be affected by the acquisition.

d. Feasibility of Acquisition at an alternative place.

e. Assessment of bare minimum extent of land needed for the project.

f. Study of social impact and mitigate cost in addressing these and its ramification on the overall cost of the project vis-à-vis the benefits of the project.

10.5.2.1 Public Purpose

In the wake of the fact that the land to be acquired is within the territory of, the State Government of Meghalaya is the Appropriate Government intends to acquire the land for construction of the infrastructure projects. In the preset case, the proposed Irrigation project is essentially an infra-structure project included in the Annexure-I of the Notification of the Govt. of India, Department of Economic Affairs (Infrastructure Section) No. 13/6/2009-INF dated 27 March 2012 and even no. amendment dated 1st April 2013. Thus, the provisions of "The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013" applies in respect of all activities related to land acquisition for the project.

10.5.2.2 Village-wise Project Affected Families

The village-wise details of project affected families and total private land to be acquired in the village is shown in **Table 10.34**. It is evident that there shall be 3788 affected families (whose land or immovable property shall be acquired) of which there shall be no displaced families (who because of acquisition of land and house has to be re-located and resettled from the affected area to the resettlement area).

Table 10.34 : Village-wise details of Land to be Acquired/PAF

S. No.	Name of Village	No. of PAF	Arable Land (ha)	Non-arable Land (ha)	Total Land (ha)
A	**Jaintia Hills District**				
1	Moosakhia	37	16.51	13.34	29.85
2	Samanong	27	10.85	34.79	45.64
3	Sohmynting	20	14.85	3.25	18.10
Total		**84**	**42.21**	**51.38**	**93.59**
B	**East Khasi Hills District**				
1	Ksanrngi	32	8.62	4.69	13.31
2	Mawdulop	40	4.94	3.28	8.22
3	Mawjatap	8	4.98	1.97	6.95
4	Mawlang	22	5.59	4.56	10.15
5	Mawsir	38	13.51	21.3	34.81
6	Syntung	38	25.2	16.5	41.7
7	Jatah Nonglyer	23	3.84	1.74	5.58
8	Pashang	28	9.23	4.5	13.73
9	Siangkhnai	35	23.45	29.04	52.49
10	Umsawwar	30	10.86	5.58	16.44
Total		**294**	**110.22**	**93.16**	**203.38**
Grand Total		**378**	**152.43**	**144.54**	**296.97**

10.5.2.3 Feasibility of Acquisition at an alternative place.

The siting and alignment of the project components. is mainly based on the geological condition of the rocks. During investigation and planning stage and at the time of preparation

of DPR, detailed surface and sub-surface investigations are carried out at different alternative sites and balance is struck in favor of the best alternative.

Thus, it is abundantly clear that the proposed project is site specific. Thus, it is abundantly clear that the proposed project is site specific. Thus, it is clear that land acquisition at any other alternative place for locating the project components is not plausible by any stretch of imagination. Various alternatives in the location of the Dam, Intake, HRT alignment, Surge Shaft and the Powerhouse have been considered before arriving at the proposed final layout of the Project. The Dam location is selected from the geological as well as from the overall economic considerations which benefits its location at the present site. The intake has been chosen closer to the dam, which would be advantageous from silting consideration and the HRT on this chosen alignment would be straight, without any bends, up to the Surge Shaft whereas the alternative intake, further upstream, would entail a longer HRT as a deep perennial stream has to be avoided. The selected powerhouse location on the surface with an underground shaft is considered a better option from economic considerations compared to the various alternatives examined like an underground powerhouse and a surface powerhouse with a combination of an underground shaft and a surface penstock.

10.5.2.4 Assessment of bare minimum extent of land needed for the project.

The land requirement for various components of the project i.e., dam have been in sync with the dimensions determined based on detailed hydraulic as well as structural design. The land required for various components of dam and spillway to pass the design flood discharge is based on as per standard designed practices, IS: 6966(Part-I). likewise, the alignment of water conductor system and their diameter has been finalized based on economical diameter keeping in view the velocity of flow corresponding to minimum losses. Some quantity of the muck generated has been proposed for consumptive use for construction material thereby implying minimization of land required for muck disposal site as well as quarry sites. Thus, to keep the land requirement to the minimum, an all-out effort has been made.

10.5.3. *Resettlement & Rehabilitation Principles*

Based on the primary and secondary data collected in respect of the project affected families a draft R & R Plan has been formulated in consonance with the principles enunciated in “The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013”, which has come into force from 1-1-2014, notified by Government of India. Besides this meeting the mandatory requirement, certain works relating to social welfare and community development are also considered in consultation with local authorities and representatives of affected families to make the R&R Plan for the proposed project so that more acceptability for implementation of the plan is achieved.

10.5.3.1 Definitions Followed in the Present R & R Plan

For this project, procedure and compensation will be as per the RFCT_LARR 2013 and following key definitions will be followed:

(a) "Administrator" means an officer appointed for the purpose of rehabilitation and resettlement of affected families under sub-section (l) of section 43;

(b) "Affected area" means such area as may be notified by the appropriate Government for the purposes of land acquisition; (c) 'affected family" includes-

(i) A family whose land or other immovable property has been acquired;

(ii) A family which does not own any land but a member or members of such family may be agricultural labourers, tenants including any form of tenancy or holding of usufruct right, share-croppers or artisans or who may be working in the affected area for three years prior to the acquisition of the land, whose primary source of livelihood stand affected by the acquisition of land;

(iii) The Scheduled Tribes and other traditional forest dwellers who have lost any of their forest rights recognized under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 due to acquisition of land;

(iv) Family whose primary source of livelihood for three years prior to the acquisition of the land is dependent on forests or water bodies and includes gatherers of forest produce, hunters, fisher folk and boatmen and such livelihood are affected due to acquisition of land;

(v) A member of the family who has been assigned land by the State Government or the Central Government under any of its schemes and such land is under acquisition;

(vi) A family residing on any land in the urban areas for preceding three years or more prior to the acquisition of the land or whose primary source of livelihood for three years prior to the acquisition of the land is affected by the acquisition of such land;

(c) "Agricultural land" means land used for the purpose of--

(i) agriculture or horticulture;

(ii) dairy farming, poultry farming, pisciculture, sericulture, seed farming breeding of livestock or nursery g rowing medicinal herbs;

(iii) raising of crops, trees, grass or garden produce; and

(iv) and used for the grazing of cattle;

(d) "Appropriate Government" means, -

(i) In relation to acquisition of land situated within the territory of, a State, the State Government:

(ii) In relation to acquisition of land situated within a Union territory (except Puducherry), the Central Government;

(iii) in relation to acquisition of land situated within the Union territory of Puducherry, the Government of Union territory of Puducherry;

(iv) In relation to acquisition of land for public purpose in more than one State, the Central Government, in consultation with the concerned State Governments or Union territories; and

(v) In relation to the acquisition of land for the purpose of the Union as may be specified by notification, the Central Government:

(vi) Provided that in respect of a public purpose in a District for an area not exceeding such as may be notified by the appropriate Government, the Collector of such District shall be deemed to be the appropriate Government;

(e) "Authority" means the Land Acquisition and Rehabilitation and Resettlement Authority established under section 5l;

(f) "Collector" means the Collector of a revenue district, and includes a Deputy Commissioner and any officer specially designated by the appropriate Government to perform the functions of a Collector under this Act;

(g) "Commissioner'' means the Commissioner for Rehabilitation and Resettlement appointed under sub-section (l) of section 44;

(h) "Cost of acquisition" includes-

(i) Amount of compensation which includes solatium, any enhanced compensation ordered by the Land Acquisition and Rehabilitation and Resettlement Authority or the Court and interest payable thereon and any other amount determined as payable to the affected families by such Authority or Court;

(ii) Demurrage to be paid for damages caused lo the land and standing crops in the process of acquisition;

(iii) Cost of acquisition of land and building for settlement of displaced or adversely affected families;

(iv) Cost of development of infrastructure and amenities at the resettlement areas;

(v) Cost of rehabilitation and resettlement as determined in accordance with the provisions of this Act:

(vi) Administrative cost, -

(A) For acquisition of land, including both in the project site and out of project area lands, not exceeding such percentage of the cost of compensation as may be specified by the appropriate Government;

(B) For rehabilitation and resettlement of the owners of the land and other affected families whose land has been acquired or proposed to be acquired or other families affected by such acquisition;

(i) Cost of undertaking 'Social impact Assessment study'; (j) "company" means-

(ii) A company as defined in section 3 of the Companies Act, 1956. Other than a Government company:

(iii) A society registered under the Societies Registration Act, 1860 or under any

corresponding law for the time being in force in a State;

(k) "Displaced family" means any family, who on account of acquisition of land has to be relocated and resettled from the affected area to the resettlement area;

(l) "Entitled to act" in relation to a person, shall be deemed to include the following persons, namely:

(i) Trustees for other persons beneficially interested with reference to any such case, and that to the same extent as the person beneficially interested could have acted if free from disability;

(ii) The guardians of minors and the committees or managers of lunatics to the same extent as the minors, lunatics or other persons of unsound mind themselves, if free from disability, could have acted:

Provided that the provisions of Order X XX II of the First Schedule to the Code of Civil Procedure,

I908 shall, mutatis mutandis, apply in the case of persons interested appearing before a Collector or Authority by a next friend, or by a guardian for the case, in proceedings under this Act:

(m) "family" includes a person, his or her spouse, minor children, minor brothers and minor sisters dependent on him:

Provided that widows. divorcees and women deserted by families shall be considered separate families:

Explanation. -An adult of either gender with or without spouse or children or dependents shall be considered as a separate family for the purposes of this Act.

(n) "Holding of land" means the total land held by a person as an owner, occupant or tenant or otherwise;

(o) "Infrastructure project" shall include any one or more of the items specified in clause (b) of subsection (/) of section 2;

(p) "Land" includes benefits to arise out of land, and things attached to the earth or permanently fastened to anything attached to the earth:

(q) "Landless" means such persons or class of persons who may be, -

(i) considered or specified as such under any State law for the time being in force; or

(ii) in a case of landless not being specified under sub-clause (i), as may be specified by the appropriate Government;

(r) "land owner" includes any person, -

(i) Whose name is recorded as the owner of the land or building or part thereof, in the

records of the authority concerned; or

(ii) Any person who is granted forest rights under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 or under any other law for the time being in force; or

(iii) Who is entitled to be granted Patta rights on the land under any law of the State including assigned lands: or

(iv) Any person who has been declared as such by an order of the court or Authority;

(s) "Local authority" includes a town planning authority (by whatever name called) set up under any Law for the time being in force, a Panchayat as defined in article 243 and a Municipality as defined in article 243P, of the Constitution;

(t) "Marginal farmer" means a cultivator with an un-irrigated land holding up to one hectare or irrigated land holding up to one-half hectare;

(u) "Market value" means the value of land determined in accordance with section 26;

(v) "Notification" means a notification published in the Gazette of India or, as the case may be, the Gazette of a State and the expression "notify" shall be construed accordingly;

(w) "Patta" shall have the same meaning as assigned to it in the relevant Central or Slate Acts or rules or regulations made thereunder; (x) "person interested" means-

(i) All persons claiming an interest in compensation to be made on account of the acquisition of land under this Act;

(ii) The Scheduled Tribes and other traditional forest dwellers, who have lost any forest rights recognized under the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006;

(iii) a person interested in an easement affecting the land;

(iv) persons having tenancy rights under the relevant State laws including share-croppers by whatever name they may be called; and

(v) any person whose primary source of livelihood is likely to be adversely affected;

(x) "prescribed" means prescribed by rules made under this Act;

(y) "project" means a project for which land is being acquired, irrespective of the number of persons affected;

(Ya) "Public purpose" means the activities specified under sub-section (l) of section 2;

(Yb) "Requiring Body" means a company, a body corporate, an institution, or any other organization or person for whom land is to be acquired by the appropriate Government, and includes the appropriate Government, if the acquisition of land is for such Government either for its own use or for subsequent transfer of such land is for public purpose to a company, body corporate, an institution, or any other

organization, as the case may be, under lease, license or through any other mode of transfer of land;

(zc) "Resettlement Area" means an area where the affected families who have been displaced as a result of land acquisition are resettled by the appropriate Government;

(zd) "Scheduled Areas, means the Scheduled Areas as defined in section 2 of the Provisions of the Panchayats (Extension to the Scheduled Areas) Act, 1996;

(ze) "small farmer" means a cultivator with an un-irrigated land holding up to two hectares or with an

Irrigated land holding up to one hectare, but more than the holding of a marginal farmer.

10.5.4. *Compensation for Land Owners*

The land acquisition process as per RFCTLARRA 2013, has not been completely initiated so far. As a matter After hearing of the objection under Section 15, the administrator for Rehabilitation and Resettlement shall prepare a draft Rehabilitation & Resettlement Scheme for the review of the Commissioner Rehabilitation

The Collector based on the following criteria shall determine the market value of land:

a. The market value, if any, specified in the India Stamp Act, 1899 (2 of 1899) for the registration of sale deeds or agreements to sell as the case may be, in the area, where the land is situated; or

b. The average sale price for similar type of land situated in the nearest village or nearest vicinity area; or

c. Consented amount of compensation as agreed upon under sub-section (2) of section 2 in case of acquisition of lands for private companies or for public private partnership projects, whichever is higher:

Provided that the date of determination of market value shall be the date on which the notification has been issued under section 11.

The market value shall be calculated as per above shall be multiplied by a factor to be specified in first schedule.

First Schedule

[See section 31(2)]

The following components shall constitute the minimum compensation package to be given to those whose land is acquired and to tenants referred to in clause (c) of Section 3 in a proportion to be decided by the appropriate Government.

S. No.	Component of compensation package in respect of land acquired under the Act	Manner of determination of value
1	Market value of land	To be determined as provided under section 26.
2	Factor by which the market value is to be multiplied in the case of rural areas	1.00 (one) to 2.00 (Two) based on the distance of project from urban area, as may be notified by the appropriate Government
3	Factor by which the market value is to be multiplied in the case of urban areas	1 (One)
4	Value of assets attached to land or building	To be determined as provided under section 29
5	Solatium	Equivalent to one hundred per cent of the market value of land mentioned against serial number 1 multiplied by the factor specified against serial number 2 for rural areas pot serial number 3 for urban areas plus value of assets attached to land or building against serial number 4 under column (2)
6	Final award in rural areas	Market value of land mentioned against serial number 1 multiplied by the factor specified against serial number 2 plus value of assets attached to land or building mentioned against serial number 4 under column (2) plus solatium mentioned against serial number 5 under column (2).
7	Final award in urban areas	Market value of land mentioned against serial number 1 multiplied by the factor specified against serial number 3 plus value of assets attached to land or building mentioned against serial number 4 under column (2) plus solatium mentioned against serial number 5 under column (2).
8	Other component, if any, to be included	

10.5.5. *Elements of Rehabilitation and Resettlement Entitlement for Affected Families*

Under Chapter V Section 31, the collector has been empowered to pass the Rehabilitation and Resettlement award for each affected family in terms of entitlement provided in the Second Schedule.

Second Schedule

[See section 31(2)]

Elements of Rehabilitation and Resettlement entitlements for all the affected families (both land owners and the families whose livelihood is primarily dependent on land acquired) in addition to those provided in the first schedule.

S. No.	Elements of Rehabilitation and Resettlement Entitlements	Entitlement/ provision
1.	Provisions of housing units in case of displacement	If a house is lost in rural areas, a constructed house shall be provided as per the Indira Awas Yojana specifications. If a house is lost in urban areas, a constructed house shall be provided, which will be not less than 50 sq. m in plinth area. The benefits listed above shall also be extended to any affected family which is without homestead land and which has been residing in the area continuously for a period of not less than three years preceding the date of notification of the affected area and which has been involuntarily displaced from such area: Provided that any such family in urban areas which opts not to take the house offered, shall get a onetime financial assistance for house construction, which shall not be less than one lakh fifty thousand rupees: Provided further that if any affected family in rural areas so prefers, the equivalent cost of the house may be offered in lieu of the constructed house: Provided also that no family affected by acquisition shall be given more than one house under the provisions of this Act. Explanation- The houses in urban areas may, if necessary, be provided in multi-storied building complexes.
2.	Land for Land	In the case of irrigation project, as far as possible and in lieu of compensation to be paid for the land acquired, each affected family owning agricultural land in the affected area and whose land has been acquired or lost, or who has, as a consequence of the acquisition or loss of land, been reduced to the status of a marginal farmer or landless, shall be allotted, in the name of each person included in the records of rights with regard to the affected family, a minimum of one acre of land in the command area of the project for which the land is acquired: Provided that in every project those persons losing land and belonging to the Scheduled Castes or the Scheduled Tribes will be provided land equivalent to land acquired or two and a one-half acre, whichever is lower.
3	Offer for Developed Land	In case the land is acquired for urbanization purposes, twenty per cent of the developed land will be reserved and offered to land owning project affected families, in proportion to the area of their land acquired and at a price equal to the cost of acquisition and the cost of development. Provided that in case the land-owning project affected family wishes to avail of this offer, an equivalent amount will be deducted from the land acquisition compensation package payable to it.
4	Choice of Annuity or Employment	The appropriate Government shall ensure that the affected families are provided with the following options: (a) Where jobs are created through the project, after providing suitable

S. No.	Elements of Rehabilitation and Resettlement Entitlements	Entitlement/ provision
		training and skill development in the required field, make provision for employment at a rate not lower than the minim um wages provided for in any other law for the time being in force, to at least one member per affected family in the project or arrange for a job in such other project as may be required; or (b) One-time payment of 5 lakh rupees per affected family; or (c) Annuity policies that shall pay not less than 2000 rupees per month per family for 20 years, with appropriate indexation to the consumer price index for agricultural labourers
5	Subsistence grant for displaced families for a period of one year	Each affected family, which is displacing from the land acquired shall be given a monthly subsistence allowance equivalent to 3000 rupees per month for a period of one year from the date of award. In addition to this amount, the schedule castes and the scheduled tribes displaced from scheduled areas shall receive and amount equivalent to 50000 rupees. In cases of displacement from the scheduled areas, as far as possible, the affected families shall be relocated in a similar ecological zone, to preserve the economic opportunities, language, culture and community life of the tribal com munities.
6	Transportation cost for displace families	Each affected family which is displaced shall g et a one-time financial assistance of 50000 rupees as transportation cost for shifting of the family, building materials, belonging s and cattle.
7	Cattle shed / Petty shops cost	Each affected family having cattle or having a petty shop shall get one-time financial assistance of such amount as the appropriate Government m ay, by notification, specify subject to a minimum of 25000 rupees for construction of cattle shed or petty shop as the case may be.
8	One-time grant to artisan, small traders and certain others	Each affected family of an artisan, small traders or self-employed person or an affected family which owned non-agricultural land or commercial, industrial or institutional structure in the affected area, and which has been involuntarily displaced from the affected area due to land acquisition, shall get one-time assistance of such amount as the appropriate Government may, by notification, specify subject to a minimum of 25000 rupees
9	Fishing rights	In cases of irrigation or hydel projects, the affected families may be allowed fishing rights in the reservoirs, in such manner as may be prescribed by the appropriate Government
10	One-time Resettlement Allowance	Each affected family shall be given a onetime “Resettlement Allowance” of 50000 rupees only
11	Stamp duty and registration fee	(1) The stamp duty and other fees payable for registration of the land or house allotted to the affected families shall be borne by the Requiring Body. (2) The land for house allotted to the affected families shall be free from all encumbrances. (3) The land or house allotted may be in the joint names of wife and

S. No.	Elements of Rehabilitation and Resettlement Entitlements	Entitlement/ provision
		husband of the affected family.

10.5.5.1 Land Acquisition

Village wise cost of land acquisition and other assets for project affected villages in each of the district, as per rate of land approved by the respective District Collector, has been worked out in **Table 10.35.**

Table 10.35 : Village wise Land Acquisition Cost

S. No.	Name of Village	Total Land (ha)	Collector's approved rate/ha	Cost of Land (Rs lakh)	Cost of trees (Rs lakh) Tentative
A	**Jaintia Hills District**				
1	Moosakhia	29.85	40.0	1194.00	1.21
2	Samanong	45.64	35.0	1597.40	1.84
3	Sohmynting	18.10	42.0	760.20	0.73
Total		**93.59**	**-**	**3551.60**	**3.78**
B	**East Khasi Hills District**				
1	Ksanrngi	13.31	12.40	165.04	0.54
2	Mawdulop	8.22	12.40	101.93	0.33
3	Mawjatap	6.95	12.40	86.18	0.28
4	Mawlang	10.15	12.40	125.86	0.41
5	Mawsir	34.81	12.40	431.64	1.41
6	Syntung	41.7	12.40	517.08	1.69
7	Jatah Nonglyer	5.58	12.40	69.19	0.23
8	Pashang	13.73	12.40	170.25	0.55
9	Siangkhnai	52.49	12.40	650.88	2.12
10	Umsawwar	16.44	12.40	203.86	0.66
Total		**203.38**	**-**	**2521.91**	**8.22**
Grand Total		**296.97**		**6073.51**	**12.00**

Component of compensation package in respect of land acquired under the Act as contained in First Schedule is tabulated in **Table 10.36.**

Table 10.36 : Compensation for Land Acquisition

S.No.	Component of compensation package	Quantity	Unit	Rate	Amount (Rs lakh)
1	Value of land as per collector' rate	296.97	ha	-	6073.51
2	Multiplying factor of 2, vide Notification RDA.27/2014/5, dated 10th		Rs	2.0	12147.02

	Septembe,2014, as the aerial distance of rural land from Urban Centre is above 60 km.				
3	Value of assets attached to land or building	-	-	-	12.00
4	Solatium @ 100% of sum of S.N.2 and S.N.3, u/s 30(3)		Rs	100%	12159.02
5	Damage u/s 23(1), if any	-	-	-	0.00
6	Interest for one year on compensation @12% w.e.f. date of publication of notification u/s 11	12159..02	Rs	12%	1459.08
7	Total (S.N.2,3,4,5 and 6)		Rs		25777.12
8	Establishment Cost @8%	25777.12	Rs	8%	2062.17
9	Crop compensation for standing crops (30%)	152.43	ha	L.S.	15.50
10	Contingency @2%	25777.12	Rs	2%	515.54
Total Compensation sum of S.N.7,8, 9,10					**28370.33**

10.5.6. *Budget for R&R Benefits*

Budget for R&R benefits has been prepared keeping in view the numbers of project affected families losing houses. The elements of rehabilitation and resettlement entitlement as elaborated in Second Schedule has been followed as shown in **Table 10.37**.

Table 10.37 : Budget for various R&R benefits

Clause No.	Provision as per "New LA, R&R Act, 2013"	No. of Eligible nuclear families	Rate as per Act/Notification	Cost (in Rs lakh)
Rehabilitation & Resettlement package for affect5ed families (as per RFCTLARR Act, 2013)				
1	Provisions of housing units in case of displacement (in rural areas as per Indira Awas Yojana specifications).	0	Rs 132000	0.00
2	Choice of Annuity or employment	378	Rs. 5 lakhs per affected family (Option b)	1890.00
3	Subsistence grant for displaced families for a period of one year	0	Rs. 3000/- per month	0.00
4	Transportation Cost for displaced families	0	Rs. 50000	0.00
5	Fishing Rights (Provision has been made for ensuring fishing rights of fisherman in the reservoir by way of Fisheries Development Plan	-	-	-
10	One – time Resettlement Allowance	0	Rs. 50000	0.00
			Total	**1890.00**

10.5.7. *Specific Provision for Tribal Development Plan*

As per Paragraph 1, sub- para 1 of Sixth Schedule of Constitution of India, the tribal areas in the appended to Paragraph 20 of the schedule, shall be an autonomous district. As per provision of Paragraph 20 regarding Tribal areas specified in Parts I, II 2[, IIA] and III of the table shall respectively be the tribal areas within the State of Assam, the State of Meghalaya,

the State of Tripura] and the State of Mizoram. The Government of Meghalaya vide Notification No. DCA 31/72/11 dated the 14th June, 1973, Gazette of Meghalaya, Pt. VA, dated 23-6-1973, has declared, Khasi Hills and Jaintia Hills as autonomous district. The East Khasi Hills district has the highest Scheduled Tribe population among the districts of Meghalaya. Most of project-affected families belong to the scheduled tribe. The PAF from affected villages shall have to undergo the trauma of losing their land. For these weaker sections of society, the Ministry of Tribal Affairs extends special central assistance to the TSP States and Union Territories and also to North Eastern States of Assam, Manipur and Tripura as an additional grant to these states/UTs. These grants are basically meant for family-oriented income generating scheme in various TSP areas to meet the gaps, which have not otherwise been taken care of by the State Plan. The works under tribal Plan in the project area to be funded by project proponent shall mainly include the following activities: -

(a) Upgradation of village primary schools

(b) Financial help to school going students by way of scholarship

(c) Financial help way of scholarship to meritorious students for pursuing higher education

(d) Running village grain bank scheme

(e) Promotion of self-help groups by proposing livelihood activities in goatry, poultry, bee keeping, tailoring

Provision has been made in **Table 10.38.**

Table 10.38 : Budget for Tribal Area Plan

S.N.	Scheme/Activities	Amount (Rs lakh)
1	Upgradation of 2 primary schools @ Rs 10 lakh each	20.00
2	Scholarship for School going students (20students x 9000/yr for 12yr	21.60
3	Scholarship for college students pursuing technical/medical course	0.00
(i)	Hostel Expenses for 20 students @ 60000/yr for 4 years	48.00
(ii)	Tuition fees and course material for 20 students @ 40000/yr for 4 years	24.00
3	Running village grain bank scheme	23.00
4	Promotion of self-help groups by proposing livelihood activities in goatry, poultry, bee keeping, tailoring	20.00
Total		**156.60**

10.5.8. *Compensation Disbursement*

All the compensation related to land, property, infrastructure development should be made transparent for which a suitable mechanism may be worked out in consultation with district administration and preferably all the payments should be made through bank drafts.

10.5.9. *Dispute Redressal Mechanism*

For ensuring the implementation of rehabilitation and resettlement scheme and compliance under the agreed policy, during the implementation of the scheme and thereafter monitoring and evaluation shall be carried out by departmental and monitoring committee. The appropriate Govt., for implementing the rehabilitation and resettlement scheme and monitoring and review of the progress thereof and conducting social audit by Rehabilitation & Resettlement Administration, where it has been so designated and where it has not been designated, in that scenario, shall constitute a committee to be called as resettlement and rehabilitation committee under Chairmanship of a Senior Government Officer

The Resettlement & Rehabilitation Committee constituted as above besides the officers of Madhya Pradesh Govt. shall inter-alia include as one of its members: -

a) A representative of women residing in the affected zone;
b) A representative, each from of the Scheduled Castes and Scheduled Tribes residing in the affected zone;
c) A representative from a voluntary organization;
d) A representative of the lead bank.
e) A representative of the land acquisition officer;
f) Chairman or his nominee from Panchayat Raj Institutions located in the affected zone
g) MPs/MLAs of the area included in the affected zone.
h) Representative for Project Proponent.
i) Representative for Autonomous District Council (s).

10.5.10. *Appointment of Ombudsman*

For Timely Redressal of Grievances/Complaints touching and arising within the framework of this policy, the State Govt. of Meghalaya. shall appoint an ombudsman.

10.5.11. *Summary of Cost*

The cost because of land acquisition, R&R entitlement and Tribal Plan is presented in **Table10.39**.

Table 10.39 : Total Cost under R&R Plan

S.No.	Particular	Amount (Rs lakh)	Reference
1	Land Acquisition Cost	28370.33	Table 10.36
2	R&R Grants	1890.00	Table 10.37
3	Tribal Plans	156.60	Table 10.38
Total		**30416.93**	
			Say Rs 30417.00 lakh

10.6. Green Belt Development Plan

10.6.1. *Introduction*

While improving the aesthetic of the area the greenbelt though functioning as pollutant sinks while scavenging pollutants, also incidentally help in developing habitats for birds and animals. The plants in their function as scavenger of pollutants are also prone to suffer toxicity of air pollutants like any other living organism. In order to mitigate and minimize environmental impacts from air pollution, noise pollution, soil erosion etc. arising due to construction of project, greenbelt development around the project sites is a good option. Green canopy not only absorbs some of these pollutants but also improves the environment. Therefore, a "Green Belt Development Plan" by using the local species has been proposed around the project area, colonies and the project roads

10.6.1.1 Development of Greenbelt

The green belt is proposed to be developed within the project area around reservoir periphery, surge shaft site, power house site, along the network of approach roads, residential areas and other working areas like crushing and aggregate processing plant, batching plant and workshops.

Green belt around the reservoir would be created to avoid erosion of soil and prevention of land slips from the banks surrounding the pond. Most of the area near proposed reservoir of the Project is under vegetation. The green belt will start from the immediate vicinity of the reservoir rim on both the banks, where moderate slopes are available for plantation. The average width of the green belt will be around 5 m varying depending upon the physiographic and land features. There would be at least 3 layers of plantation. Water loving species will be planted in the row nearest to the reservoir rim.

The area for green belt development around reservoir rim (60 km) shall be about 30 ha over which 45000 saplings would be planted (**Figure 10.7**). Along the approach roads (60 km) plantation will be done on both sides where ever feasible as such plantation of about 24000 saplings will be done. Plantation along roads must consider visibility aspects on curves so as to ensure safe driving. Plantation at the Dam site on either bank in about 1 ha has been proposed for control of erosion and siltation of the stream and aesthetic importance. Plantation (500 plants) around the office complexes is proposed to be done so that greenery is developed. Precaution should be exercised by not planting large size trees around buildings and other similar structures as during winter the sun rays are obstructed by them invariably and much wanted sunshine is impaired.

The schematic arrangement of greenbelt development proposed along the roads and office/colony is presented in **Figure 10.8**. It is proposed that extensive plantation in degraded forest land around the periphery of diversion dam, area around power house will be taken up besides road side plantation along approach/haul roads. In areas wherever, private land falls along the periphery of the project area the plantation will be done by distributing saplings free of cost to villagers, so that they are motivated to take up plantation in their land.

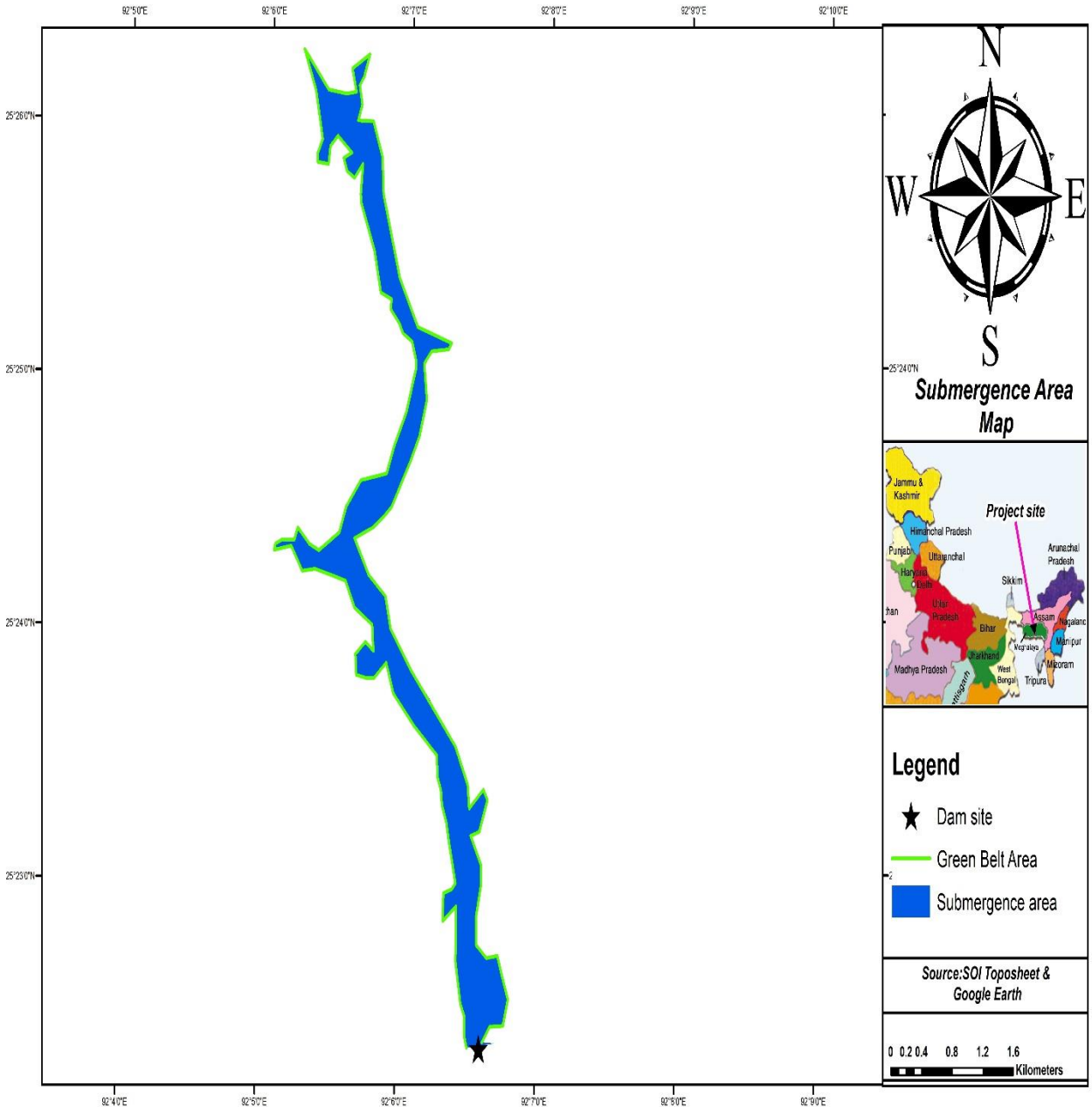


Figure 10.7 Layout of Greenbelt Plan Around Reservoir

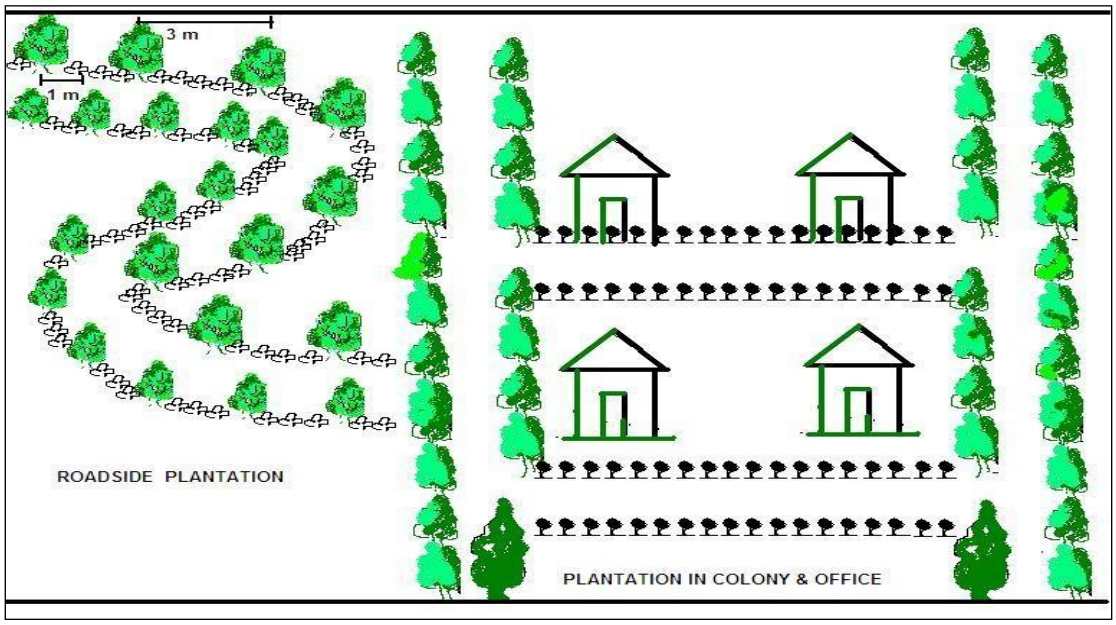


Figure 10.8 : Schematic Arrangement of Greenbelt Plantation

10.6.1.2 Strategy for Greenbelt

The green belt is proposed to be developed within the project area around reservoir periphery, along the network of approach roads, residential areas and other working areas like crushing and aggregate processing plant, batching plant and workshops. The strategy worked out for development of green belt consists of the following:

- The species selected should be capable of growing fast,
- The species should be wind firm and long lived.
- Broad leaf trees growing above 10 m in height should be planted along the roads, offices and infrastructure facilities.
- The species should form a dense crown cover.
- The species should form a litter in abundance on the plantation flow.
- Generally local/indigenous fast-growing trees shrubs should be planted.
- The trees should be protected by plantation of non-palatable shrub species to avoid browsing by animals.
- Placement of tree guards (metal tree guard, pre-fab RCC tree guard, Fibre tree guard etc.), should be provided to save avenue plantation.
- For protection against biotic interference thorn fencing around the plantation, circular trench around the planting pit and sown with fast growing thorny shrubs on the ridge should be followed'

10.6.1.3 Size of Nursery

The total requirement of saplings shall be approx. 7000 for road side plantation, green belt around surge shaft and power house area, and township / office complex respectively. To produce and maintain 7000 plants a nursery of about 0.1 ha area would be required. Keeping in view the small requirement of saplings it is proposed to be purchase them from nearby Forest Nursery over the complete duration of the plan

10.6.1.4 Nursery Site Selection

A well-drained site near the areas where plantation is to be carried out is always preferred. Light shading site for the nursery is important for protection of the seedlings against sun, frost, hailstorms or heavy rains. Sites shall be selected in consultation with Forest Department preferably near the existing one and such sites which are prone to water logging, should not be selected sites. Modernization of existing nursery may also be explored.

10.6.1.5 Transportation

The nursery should be readily accessible all the year round in order to facilitate transportation of materials required in the nursery and dispatch of seedlings from the nursery.

10.6.1.6 Fertilizer Application

The organic fertilizer produced through domestic organic waste coupled with vermin-compost can be utilized for the nursery. Farmyard manure (FYM) can also be used but chemical fertilizer should be avoided. The compost / vermin-compost, proposed to be developed through solid waste management, shall be used.

10.6.1.7 Soil and Soil Fertility

The best site for raising the nursery is the area, which has got a thick layer of humus. The fertile and well-drained soil with sandy loam to loamy texture, pH varying from 6.5-7.5 should always the preferred for nursery sites.

10.6.1.8 Water Supply and Drainage

The site should have perennial water supply. The drainage of soil has important bearing on the health of seedlings.

10.6.1.9 Precautions during Plantation

Some important precautions should be taken during the plantation, which are as under:

- Open grazing is practiced in general in the area; therefore, protection should be provided in advance.
- Polyculture should be practiced. Mixture by group should be preferred over intimate mixture.
- The species mentioned should be planted in sufficient numbers so as to increase their population size in the area.
- Multipurpose species should be planted in large numbers, so as to provide direct benefit to people living around.

10.6.1.10 Species to Be Planted

To maintain the scenic beauty of the Reservoir/ pond, the most basic would be planting shorter plants in the middle of the greenbelt, taller plants on the edges and immediate vicinity of the reservoir comprised with water-loving plants. The development of water dependent vegetation along the shoreline is beneficial for water birds and mammals. Plant species which are economically important, perfect soil binder, sustained in high humid and flood conditions will be chosen for plantation. Fruit bearing species would also be encouraged to plant in order

to provide food for birds and other animals. The species to be planted in green belt are shown in **Table 10.40.**

Table 10.40 : Plant Species for Green Belt Development

S.No.	Plant Species	Family	Local Name
1	*Albizia procera*	Mimosaceae	Safed Siris
2	*Altsonia scholaris*	Apocynaceae	Saptparni
3	*Aphanomixis polystachya*	Meliaceae	Banderiphal
4	*Bauhinia purpurea*	Caesalpiniaceae	Khairwal
5	*Beilschmiedia roxburghiana*	Lauraceae	Kamatti
6	*Bombax ceiba*	Bombacaceae	Semal
7	*Caryota urens*	Arecaceae	Mari
8	*Casearia vareca*	Flacourtiaceae	Sikarguti
9	*Castanopsis indica*	Fagaceae	Dalne Katus
10	*Cinnamomum tamala*	Lauraceae	Tejpata
11	*Engelhardtia spicata*	Juglandaceae	Gandmowa
12	*Erythrina stricta*	Papilionaceae	TaungKathit
13	*Garcinia xanthochymus*	Cluciaceae	Jharambi
14	*Gynocadia odorata*	Flacourtiaceae	Lemtem
15	*Lagerstroemia hirsuta*	Lythraceae	Taman
16	*Lannea coromandelica*	Anacardiaceae	Jhingran
17	*Macaranga denticulata*	Euphorbiaceae	Burna
18	*Michelia glabra*	Magnoliaceae	Pan-sopa
19	*Miliusa globosa*	Anonaceae	Jhora-Bhanora
20	*Oroxylum indicum*	Bignoniaceae	Pharri
21	*Parkia roxburghii*	Mimosaceae	Supota
22	*Persea odoratissima*	Lauraceae	Kaula
23	*Schima wallichii*	Theaceae	Laukya
24	*Stereospermum chelonoides*	Bignoniaceae	Padal
25	*Syzygium cuminii*	Myrtaceae	Jamun

10.6.2. *Green Belt Development*

In order to raise the green belt around project area and roads, the total requirement of different species of plants will be 76000 saplings including mortality. Since the green belt is to be created over a period of five years the maintenance for a period of five years of nursery and plantation works will be required. The beating up of mortality may be done with the plant stocks proposed to be purchased from nearby Forest Nursery over the complete duration of the plan.

10.6.2.1 Road side plantation

Cost of the plantation has been calculated as per the existing schedule of rate, material cost (plants, FYM, tree guard, etc.) and the total area of treatment. One row each for tree, shrub and bio-fencing has been proposed with a spacing of 3 m x 3 m for trees and 2 m x 2 m for shrubs (to take care of the mortality in the next season). The pit size has been recommended

as 45 x 45 x 45 cm for trees and 30 x 30 x 30 cm for shrubs. For the protection of trees from the cattle and other losses, tree guards are required. Along the approach roads plantation will be done on both sides wherever feasible. Plantation along roads must take into account visibility aspects on curves so as to ensure safe driving.

10.6.2.2 Green Belt around Diversion Dam/Reservoir/Power House

Plantation at surge shaft area and power house site in about 30 ha has been proposed for control of erosion and siltation of the stream and aesthetic importance. The total cost for planting in 30 ha area @ Rs. 1.84 lakh/ha including establishment charges works out to Rs. 55.20 lakh.

10.6.2.3 Green Belt around Residential Area and Office Complex

Plantation around the office complexes is proposed to be done so that greenery is developed. Precaution should be exercised by not planting large size trees around buildings and other similar structures as during winter the sun rays are obstructed by them invariably and much wanted sunshine is impaired. Besides this, it is also proposed to develop green belt around the working areas for trapping the dust and noise. Plantation of avenue, ornamental and fruit trees is proposed in these areas along with the area around office complex. The ornamental, fruit plants will be procured from the local market while the avenue plants will be raised in the project nursery.

10.6.3. *Cost Estimate of Green Belt Development*

The itemized summery of cost for green belt development is presented in **Table 10.41.**

Table 10.41 : Summary of Cost for Green Belt Development

S. N.	Component	Cost (Rs Lakh)
1.	Development around reservoir periphery,30ha @ Rs.1.84 lakh/ ha	55.20
2	Protection guard for 24500 saplings @ 100/No.	24.50
3	Cost of planting 24000 saplings along road side @ Rs.50/- each	12.00
4	Plantation of 500 saplings around colonies and office complex @Rs 50/- each	2.50
5	Contingency	1.80
Total		96.00
Less Provision made under sub-head 'M-Plantation' in DPR		20.00
Grand Total		**76.00**

10.7. Reservoir Rim Treatment Plan

10.7.1. *Introduction*

Detailed investigations were carried out along the periphery of proposed reservoir along river in order to delineate the active as well as potential landslide zones. The study reveals that there are no active or dormant landslide/landslip zone along the periphery of the reservoir extending in the river. Umngot river cuts very deep through the plateau land forming a very deep gorge, with numerous rapids and falls, exposing the underlying bed rock throughout its entire course. The firm bed material is composed of crystalline rocks of the Archaean

basement complex, which comprises mostly of granite gneiss, miguratites, granites and biotite schists, which is massive, hard moderately jointed and medium to coarse grained. The overburden material consists of mainly clays and sands. The bed of the reservoir is therefore expected to be competent to hold back the water of the reservoir without any significant loss of storage

10.7.2. *Mitigation Measures*

Though no active slide zone exists in the reservoir area which has the exposed rocks on either bank of river, yet. the fluctuation of the reservoir can trigger landslides in this portion for which mitigative measures are suggested.

10.7.2.1 Protection of Houses / Fields

The human settlements and agricultural fields at the place mentioned above are very close to FRL of reservoir. Therefore, such places need protection for their land and houses for which it is proposed to construct concrete retaining wall along the stretch of reservoir at potentially vulnerable places having a combined length of about 150 m. The cost of protection walls of 6 m height has been assessed as Rs. 65.59 lakh and is shown in **Table 10.42**.

Table 10.42 : Cost of Protection Walls

Sl. No.	Particulars	Quantity	Unit	Rate (Rs.)	Amount (Rs. lakh)
1	Length of R.R. Stone Masonry in Cement Mortar 1:5 with 0.15 m thick PCC 1:3:6 in foundation				
	PCC 1:3:6 in foundation				
a.	150 X 2.94 X 0.15 = 66.15 say 66 cum	66	cum	6377	4.21
	R.R. Stone Masonry in C.M. 1:5				
b.	150 X 0.5 (0.6+2.54) X 6.0 = 1413cum	1413	cum	4344	61.38
				Total	**65.59**

10.7.2.2 Treatment at the Mouth of Streams Joining Reservoir

The torrents / rivulet has steep gradient and during rains very high discharges flow in them with high velocity. Wherever these torrents meet main rivers there is a large difference in their bed levels. Such torrents are also potential carrier of highly sediment concentrated flows resulting from high velocities attained by them during flash floods which some time becomes as high as 5m/sec. Loose deposits or shoal are therefore often witnessed just upstream of confluence point of such streams with main river. The mouths of these streams have a tendency of sliding and widening because of following reasons:

The mouth of the streams is generally constituted of riverine material usually shingle, pebbles, boulder and fine sediments like clay, silt and sand which have lower shear strength. Swelling caused due to hydration of clay is the main cause of mass movement. Therefore, the mouth of these streams directly draining into pond need to be protected against toe-erosion at the level of FRL of reservoir by gabion retaining wall. The sediment load transported by the

streams can be minimized by making check dam size 10 m x 1.5 m x 3.0 m, in Nadi / Nala meeting the reservoir. The cost of these works has been assessed as **Rs. 19.50 lakh (Table 10.43).**

Table 10.43 : Cost Estimate of Mouth Treatment of Stream

S.N.	Measures	Quantity	Unit	Rate	Amount (Rs. Lakh)
1.	Gabion wall approx. 200m length = 200 x 2x 1.5x1	600	m^3	1000.00	6.00
2.	Check dams 15 no. of size 10x 1.5x 3	675	m^3	2000.00	13.50
				Total	**19.50**

10.7.3. *Green Belt around Reservoir*

Green belt around the reservoir would be created to avoid erosion of soil and prevention of land slips from the banks surrounding the pond. On the hill slope immediately above the pond, in such reach 10m wide green belt has been proposed. The creation of green belt on either side of the reservoir will ensure protection of the reservoir rim area from any minor slips triggered due to fluctuation in the water level. The slopes on both the banks will be planted with suitable tree species. In areas with moderately steep slopes indigenous, economically important, soil binding tree species, which are able to thrive well under high humidity and flood conditions, will be planted. The cost of plantation in rim area of reservoir is included in Green Belt Development Plan**.**

10.7.4. *Cost Estimate*

The combined cost estimate for protection works and green belt development is shown in **Table 10.44.**

Table 10.44 : Cost of Reservoir Rim Treatment

S. N.	Particulars	Amount (Rs. Lakh)
1	Cost of 150m Protection Wall	65.59
2	Mouth treatment of streams	19.50
	Total	**85.09**
	Say	**85.00**

10.8. Muck Management Plan

10.8.1. *General*

For construction of different components of Umngot HEP, open excavation for foundation of dam, coffer bunds, intake and surface power house besides substantial underground excavation in over burden and rock for diversion tunnel, headrace tunnel, adit, surge shaft would be required. The excavation shall result in large quantity of excavated material i.e., muck which shall have to be evacuated, disposed of and roller compacted or laid on mild slopes *pari-passu* with the excavation work, to such designated areas where the muck piles

do not substantially interfere with either environment / ecology or the river flow regime and cause turbidity impairing the quality of water. The disposal of muck has to be scientifically planned keeping in view the pecuniary aspects necessitating nearness to the generating component of work, which understandably reduce the travel time of dumpers, interference to surface flow and ground water aquifer, and disposition of habitation. In the present case, the total quantity of muck / debris, to be generated due to the project, shall be 15.5 lakh cum, out of which 3.29 lakh cum (30%) shall be consumed on project work leaving 12.23 lakh cum, which with 42% swell factor shall amount to 17.36 lakh cum, to be disposed-off away from sites so as to make available the clear site for construction activities. The muck which is suitable for use as aggregate material for concrete on non-wearing surface, backfill concrete and for widening of the road shall be properly stacked. The muck unsuitable for use in concrete etc. shall be dumped on slopes and treated to mix and match with the surrounding environment with least change in landscape.

Based on the quantities of underground excavation including over break a muck management plan, therefore, has been formulated to manage the disposal of muck and restore such areas from further degradation of the environment. During construction of the project, huge quantities of excavation will be carried out from the underground and open-air components and shall be either roller compacted to provide stable terraces for erection of labour camps, job facilities and storage area, or dumped in designated areas to provide stable slopes as per details given in **Table 10.45**.

Table 10.45 : Component Wise Details of the Muck Generated and its Management

S. No.	Project Component	Quantity of Muck/Debris generated (cum)	Estimated Quantity of Muck/Debris proposed to be utilized (cum)	Estimated Quantity of Muck to be Disposed (cum)	Estimated Quantity of Disposable Muck with 42% swell factor (cum)	Name of the dumping site as shown in the plan
1	Diversion Tunnel	13500	4650	8850	12567	D-1
2	Coffer dam	1580	1580	0	0	
3	Concrete Dam	403220	109750	293470	416727	D-1, D-2
4	Intake	16695	6800	9895	14051	D-2
5	Head race Tunnel	124800	62400	62400	88608	D-2, D-3
6	Adits	30920	12760	18160	25787	D-2, D-3
7	Surge shaft	9445	4600	4845	6880	D-3
8	Pressure shaft	41800	20900	20900	29678	D-3
9	Valve chamber	4200	2100	2100	2982	D-3
10	Power house	126800	47800	79000	112180	D-4
11	TRT/TRC	16800	3300	13500	19170	D-4

	Total	789760	276640	513120	728630	

10.8.2. *Quantity of Muck Generated and Its Consumptive Use*

It is eloquent from **Table-8.1** that the excavated quantity shall be 7.90 lakh of which 2.77 lakh cum is proposed to be utilized as construction material for consumptive use in wearing and non-wearing surface like back fill, shotcreting and plumb concrete in construction of dam/intake, feeder tunnel, desilting chamber water conductor system like HRT, surge shaft, pressure shaft, TRC, adits and in development works. Thus, the remaining 5.13 lakh cum quantity which on swell basis becomes 7.28 lakh cum shall be disposed-off at four sites. At some places, muck shall be roller compacted to develop terraces for erecting labour camps. All the dumping locations shall be well supported at base and at also at higher elevation by suitable retaining structures. Subsequently all the spoil tips (muck disposal sites) will be developed by taking up plantation through bio-technological method to generate a thick forest canopy over them. The location of all dumping sites is depicted in **Figure-10.9**.

The muck disposal sites were identified during course of detailed survey for DPR and the sites have been selected keeping in view the lead consideration. Thus, dumping sites D-1 & D-2 shall store muck received from dam, intake complex works, part HRT, whereas dumping site D-3 has been earmarked for muck generated through excavation of part HRT, Surge Shaft and D-4 for pressure shaft, power house complex and TRC. The sites have been thus identified considering the quantity of the muck, landscape, cost effectiveness, nearness to source of generation, absence of ground and surface water, relief and scope for afforestation works. The details of dumping sites along with their total capacity and amount of muck to be disposed are enumerated in **Table-10.46**.

Table 10.46 : Muck Disposal Site Details

S. No.	Location of Dumping Site	Area ha	Capacity in lakh cum	Quantity to be dumped	Remarks
1.	D-1, L/B of Umngot	12.77	1.92	1.58	The muck shall be roller compacted
2.	D-2, R/B of Umngot river	15.85	3.17	2.75	The muck shall be roller compacted
3.	D-3, near Sure Shaft	12.96	1.94	1.54	The muck shall be roller compacted
4.	D-4, near power house	23.12	3.47	1.41	The muck shall be roller compacted
	Total	**64.7**	**10.50**	**7.38**	

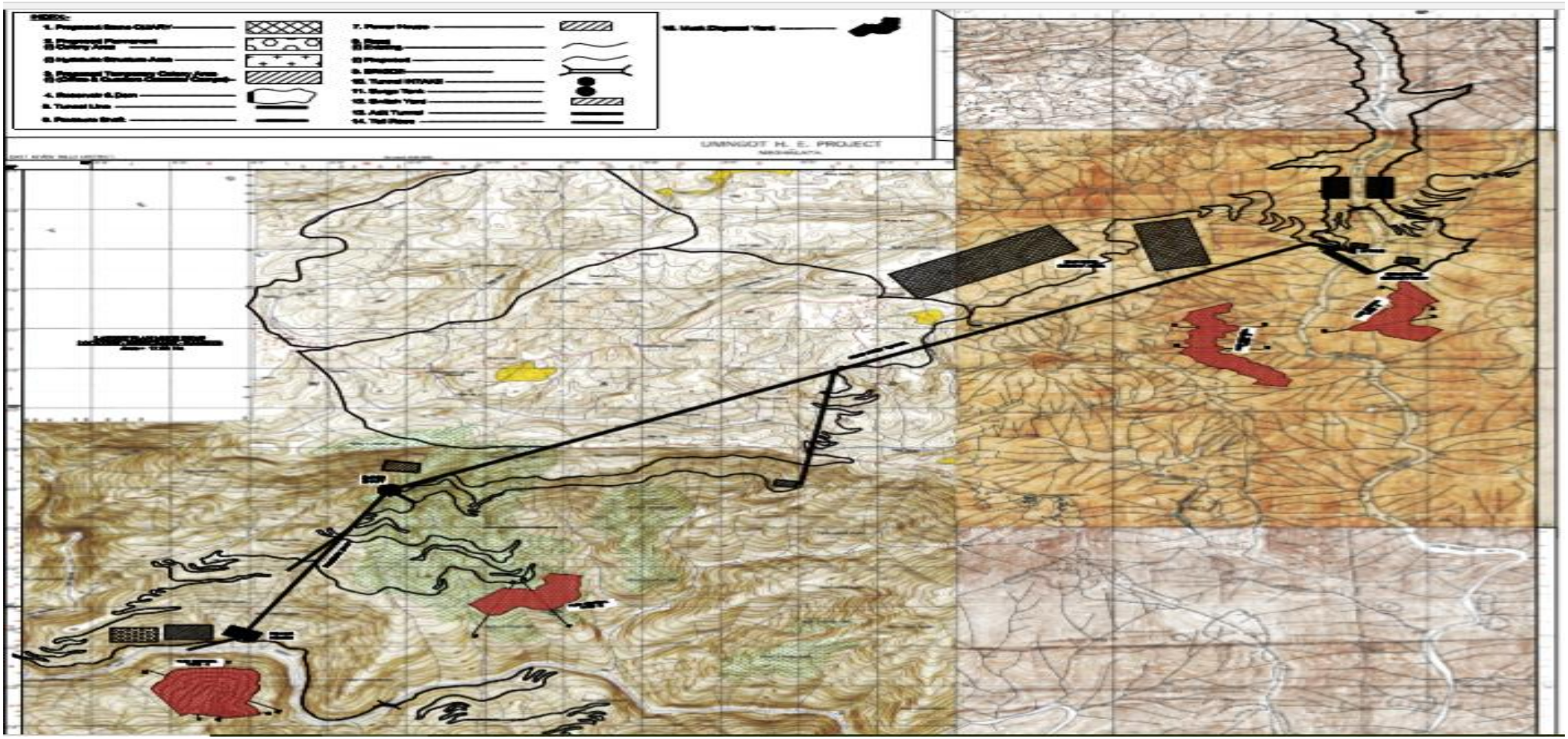


Figure 10.9 : Location of Muck Disposal Sites

10.8.3. *Description of Muck Disposal Sites*

10.8.3.1 Muck Disposal Site D-1

The muck disposal sites D-1 is located on left bank of Umngot River and is about 300m d/s of dam. The muck site has an area of 12.77 ha. The general view of the site with typical cross sections is shown in **Figure 10.10**. The muck site is about 490 m long along river with average width of 200 m. The average height of the muck pile is 1.5m and it has capacity to store 1.92 lakh cum of muck against which 1.58 lakh cum shall be dumped.

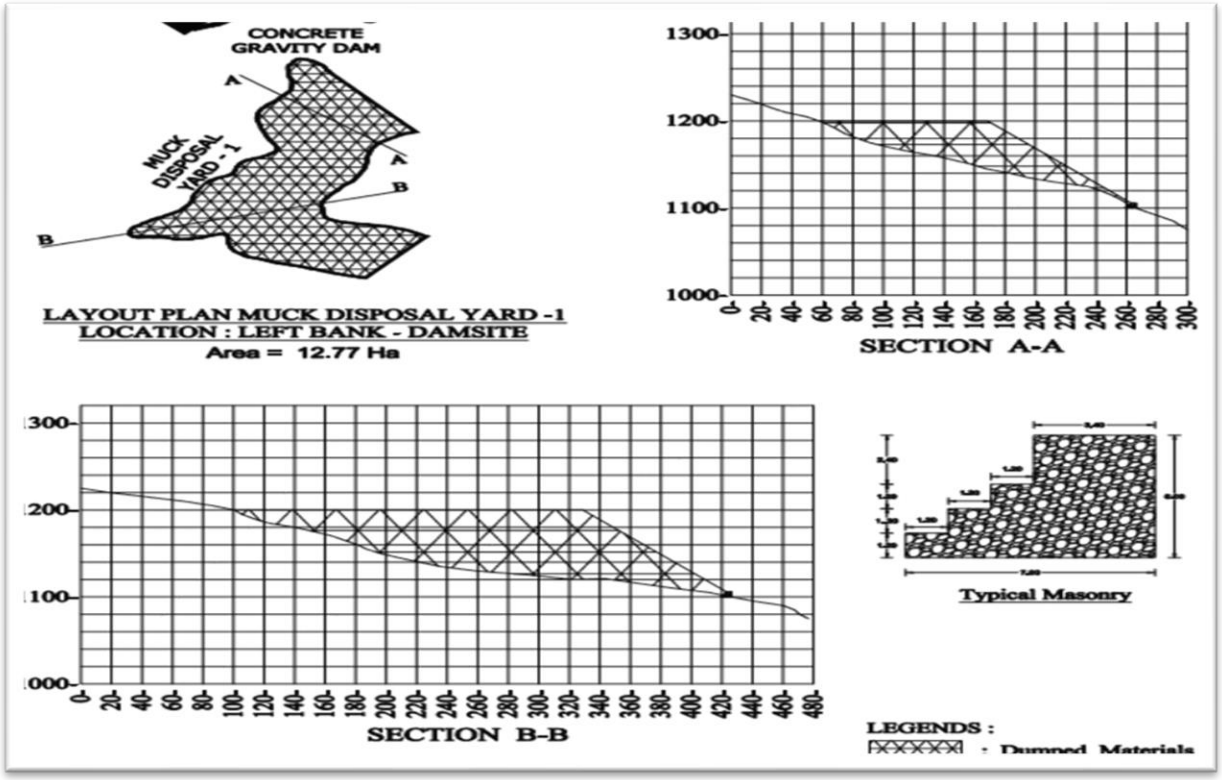


Figure 10.10 : Layout Plan and cross-section of D-1

10.8.3.2 Muck Disposal Site D-2

The muck disposal sites D-2 is located on right bank of Umngot River and is about 1000m d/s of dam. The muck site has an area of 15.85 ha. The general view of the site with typical cross sections is shown in **Figure 10.11**. The muck site is about 830 m long along river with average width of 190 m. The average height of the muck pile is 2.0 m and it has capacity to store 3.17 lakh cum of muck against which 2.75 lakh cum shall be dumped

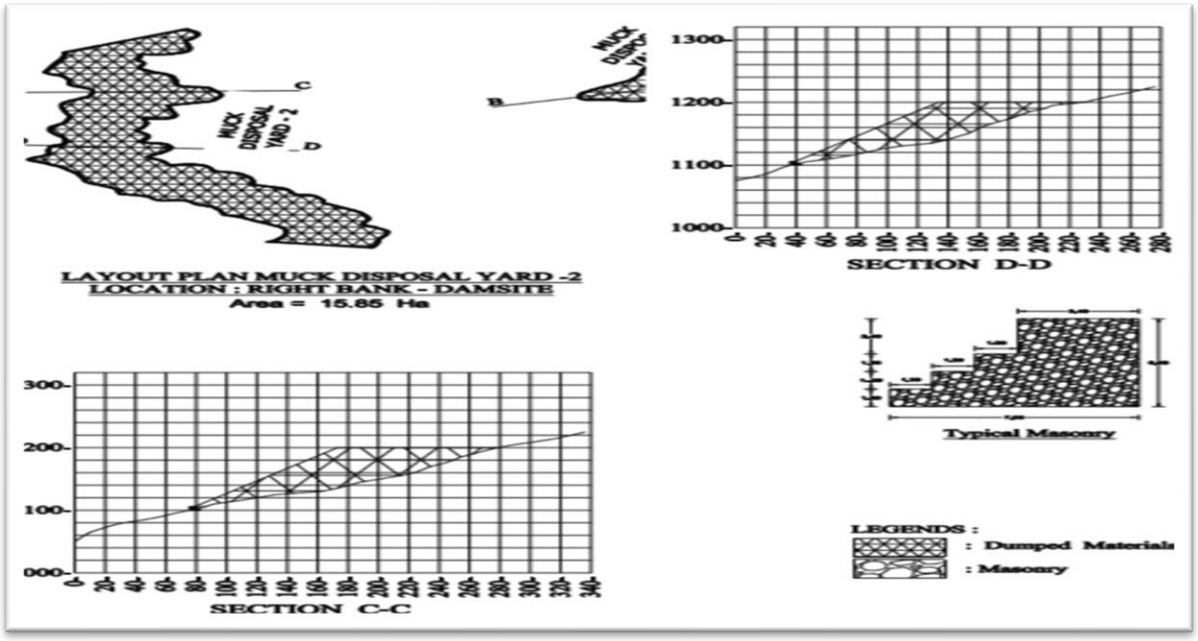


Figure 10.11 : Layout Plan and cross-section of D-2

10.8.3.3 Muck Disposal Site D-3

The muck disposal sites D-3 is located on left bank of Umngot River and is near to surge shaft area. The muck site has an area of 12.96 ha. The general view of the site with typical cross sections is shown in **Figure 10.12.** The muck site is about 518 m long along river with average width of 250 m. The average height of the muck pile is 1.5m and it has capacity to store 1.94 lakh cum of muck against which 1.54 lakh cum shall be dumped

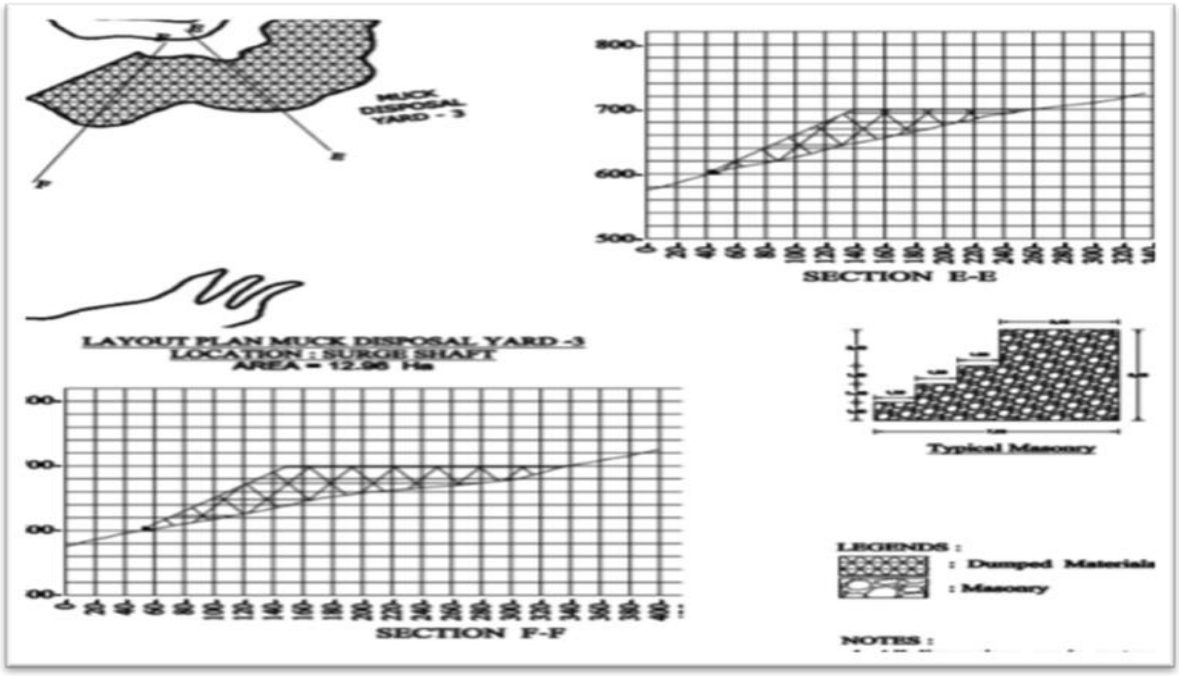


Figure 10.12 : Layout Plan and cross-section at D-3

10.8.3.4 Muck Disposal Site D-4

The muck disposal sites D-4 is located on right bank of Umngot River and is opposite to power house site. The muck site has an area of 23.12 ha. The general view of the site with typical cross sections is shown in **Figure 10.13.** The muck site is about 642 m long along river with average width of 320 m. The average height of the muck pile is 1.5m and it has capacity to store 3.47 lakh cum of muck against which 1.41 lakh cum shall be dumped

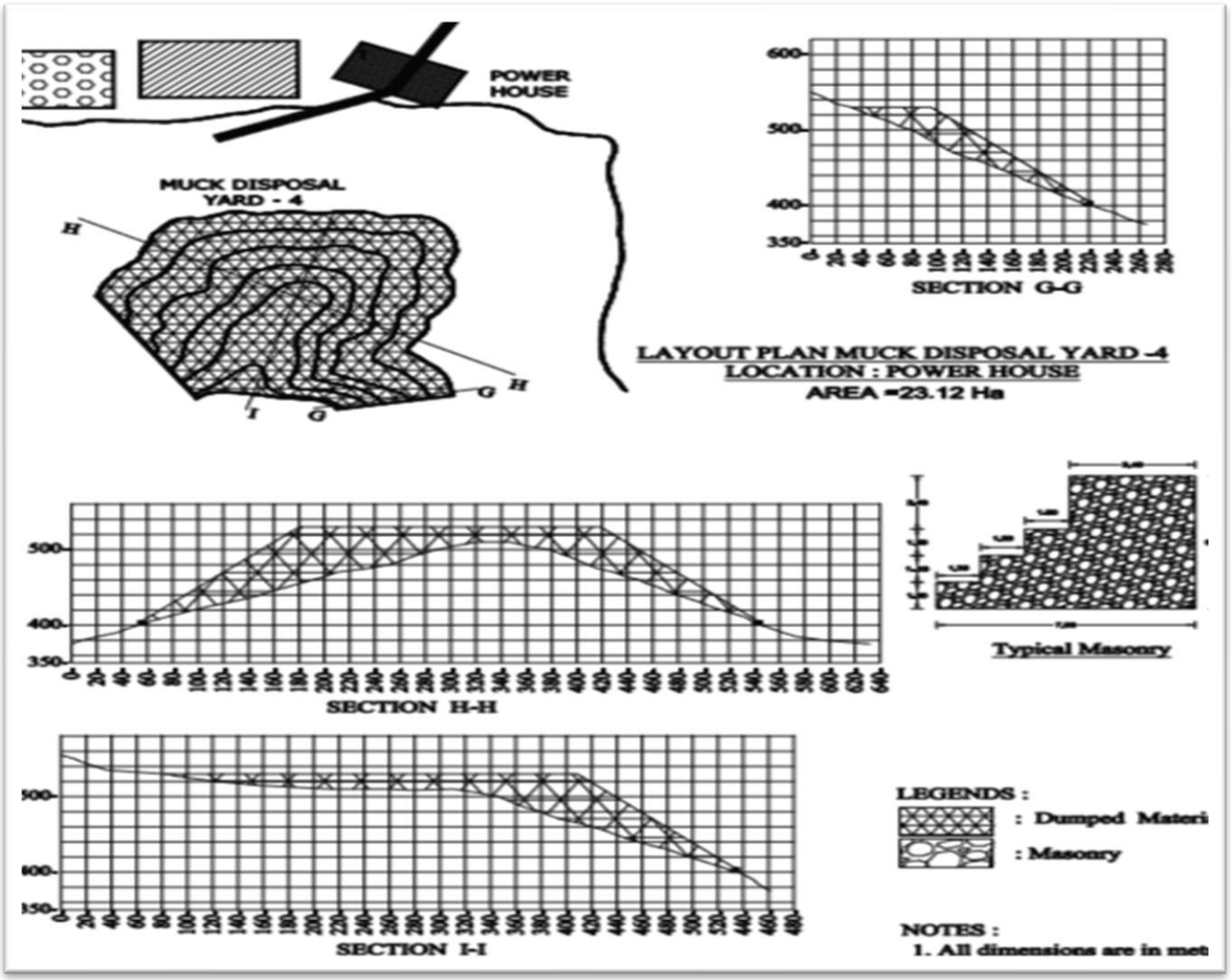


Figure 10.13 : Layout Plan and typical X-Section at D-4

10.8.4. *Implementation of Engineering & Biological Measures*

As already explained engineering measures like providing of GI wire crates and retaining walls and compaction of muck will provide stability to the profile of muck piles.

10.8.4.1 Engineering Measures

It has been observed that after excavation the disposal of muck creates problem as it is susceptible to scattering unless the muck disposal yards are supported with engineering measures such as retaining structures, crate walls and gabions. All the dumping sites need proper handling to avoid spilling of muck either on the adjoining and or into the river water while dumping and in the post dumping stages. The muck disposal sites shall have to be

developed from below the ground level by providing 6 m high R.R. Stone Masonry retaining wall. The retaining wall shall be kept at least 10m away from the point of intersection of HFL of the river with the hill slope. After construction of retaining wall, the muck brought in dumpers shall be dumped and manually spread behind the wall. The muck shall be laid with vertical angle not exceeding 28^0 in such a manner that rock mass is properly stacked behind the wall with minimum of voids. The muck pile shall be later covered with geo-Geo-coir textile properly held to the ground by steel wire U-nails and rehabilitated by afforestation of herbs and shrubs. Geo-coir textile should also be provided on surface of muck piles where top surface is to be vegetated. The typical section of retaining wall is shown in **Figure 10.14.**

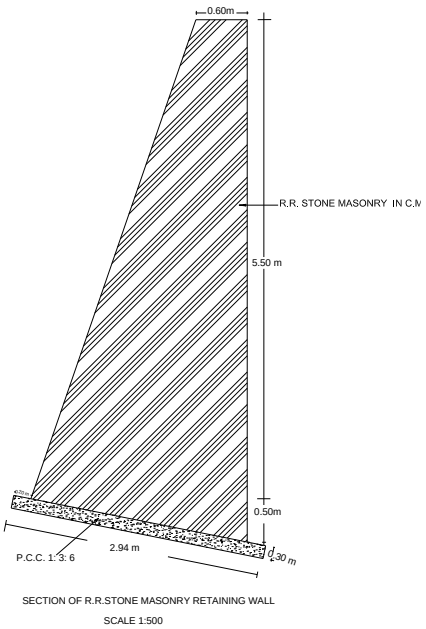


Figure 10.14 : Section of retaining wall 6m high

10.8.4.2 Biological Measures

Biological measures, however, require special efforts as the muck disposed in disposal yards will in general be devoid of nutrients and soil contents to support vegetation. The selection of soil for spreading over such an area would require nutrient profiling of soil for different base elements. Suitable ad mixture of nutrients would be done before placing the soil on the top surface of muck disposal areas to have administered growth of forest canopy.

10.8.4.3 Plantation Technique

In view of the peculiar site conditions particularly the soil conditions, the planting technique for all the categories of the plants has to be very site specific and suited to the stress conditions as anticipated and discussed above. The planting substrates would need to be considerably improved to support the plants in their initial stages of establishment. The moisture retention capability, availability of nutrients and soil aeration, permeability and porosity would require intervention and assistance.

Multistoried and multipurpose plantations are proposed to be raised on the muck dumping sites as also in road side strips using grasses, shrubs and bushes in the under story and trees in the upper story. Nursery raised grass slips, seedlings of shrubs & bushes and tree species would be planted in the area combined with grass sowing in patches. In addition, cuttings of bushes and shrubs can also be planted to supplement the nursery raised stock but this would substitute requirement of raising the nursery of these species. Intimate mixture of species would be avoided right at the planning stage and would be strictly followed during planting. Each patch should contain maximum of two species. Grasses would be mixed by groups in rows, shrubs and bushes by group again in rows.

Grass slip planting and grass seed sowing would be done in strips at 0.10 m x 0.10 m spacing in the prepared staggered patches of 1 m x 0.5 m with a depth of 0.30 m. Soil mixture would be used while filling the patches. Balance dug up soil/muck will be stacked along the patch on the downhill side for rain water tapping and enhanced percolation in the patch. Number of such patches in each hectare is proposed at 500.

Shrubs and bushes would be planted in elongated strips of 1.5 m x 0.5 m with a depth of 0.45m. Soil mixture would be used while filling the patches. Balance dug up soil/muck will be stacked along the patch on the downhill side for water tapping and better percolation in the patch. These would be staggered throughout the area numbering 500 per hectare. Each patch would have two rows of planting with staggered spacing between plants in a row as 15 cm and distance between rows as 15 cm.

Planting of trees would be done in contour staggered pits of 0.60 m x 0.60 m x 0.60 m size numbering 800 per hectare. Out of these 800 plants, about 200 plants per hectare are meant for planting along the periphery of the area. If the periphery gets filled up with lesser numbers, the remainder would be planted in the core/main area. Soil mixture would be used while filling the pits. Balance dug up soil/muck will be stacked on downhill side of the pit for trapping the rain water and allowing it to percolate in the pit.

It is proposed to use soil mixture in the pits & patches consisting of soil imported from nearby areas mixed with compost or human or vermin-compost or all of these. The ratio for the mix would be 5 parts: Compost/manure 2 parts: Sand 2 part: and humus or vermin-compost 1 part. This will make nutrients really available for the plants in the preliminary stages and also help increase soil aeration, porosity & permeability and improved moisture available for the plants.

The stabilization sites from the time of execution of biological measures would be protected with barbed wire fencing on 2m high RCC posts and provided with inspection paths. Since the muck dumping sites are being provided with either RCC walls or the wire crate (gabion) wall on the valley side (towards river) which is not negotiable by animals and human beings, fencing would not be required along the entire perimeter. Hence, it would be done on the vulnerable sections i.e., towards the hillside only.

The proposed costs include nursery costs for initial planting and also for mortality replacement.

The biological measures shall be taken up towards the end of construction. The plantations would be maintained for a period of 5 years by irrigating the plantation during dry seasons, mortality replacement and repair of fencing & inspection paths within the area. The task of irrigation would be performed by the watch & ward (chowkidar) provided in the cost estimate.

10.8.5. *Species for Plantation*

Afforestation with suitable plant species of high ecological and economic value and adaptable to local conditions will be undertaken at the rate of 800 plants per hectare in accordance with canopy cover requirement. The major plant species which can be used in the area shall belong to indigenous species.

10.8.6. *Cost Model for Plantation*

The cost model for plantation on muck dumping sites is given in **Table-10.47**.

Table 10.47 : Cost Model for Plantation on Muck Dumping Sites (For One-hectare Area)

S. No.	Particular	Qty.	Unit	Rate (Rs.)	Amount (Rs.)
A.	**PALANTATION:**				
(1)	**GRASS SLIP PLANTING AND GRASS SEED SOWING:**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	75.00	Cum.	850.00	63750
2	Digging of staggered patches 1 m x 0.50 m x 0.30 m @ 500 patches/ha.	75.00	Cum.	50.00	3750
3	Filling of staggered patches with imported soil mixture.	75.00	Cum.	15.00	1125
4	Extraction of grass slips from nursery beds @ 50 slips per patch.	25000	Per Slip	0.12	3000
5	Carriage of grass slips from nursery to work site.	25000	Per Slip	0.15	3750
6	Planting of the extracted grass slips in above patches @ 50 slips per patch.	25000	Per Slip	0.18	4500
7	Cost of grass slips (in nursery).	25000	Per Slip	0.5	12500
8	Purchase of grass seeds @ 5 gm. Per patch.	2.50	Kg.	115.00	288
9	Sowing of grass seeds in furrows in each patch.	500	Patch.	2.50	1250
				TOTAL	**93913**
(II)	**SHRUBS AND BUSHES PLANTATION:**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	168.75	Cum.	850.00	143438
2	Digging of elongated patches 1.5 x 0.50 m x 0.45 m @ 500 patches/ha.	168.75	Cum.	50.00	8438
3	Filling of elongated patches with imported soil mixture.	168.75	Cum.	15.00	2531

4	Extraction of shrubs & bushes from nursery beds @ 50 per patch.	25000	Per plant	0.15	3750
5	Carriage of shrubs & bushes from nursery to work site.	25000	Per plant	0.15	3750
6	Planting of the extracted shrubs & bushes un above patches @ 50 per patch.	25000	Per plant	0.20	5000
7	Cost of shrubs & bushes (in nursery).	25000	Per plant	1.00	25000
				TOATL	191906
(III)	**FOUR LINE STRIP PLANTATION (TREE SPECIES):**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site.	18.225	Cum.	850.00	15491
2	Digging of pits (45cm x 45cm x 45cm) in periphery of area.	200	No.	4.45	890
3	Filling of pits (45cm x 45cm x 45 cm) with imported soil mixture.	200	No.	1.27	254
4	Extracted of plants from nursery beds.	200	No.	0.25	50
5	Carriage of plants from nursery to the work site over average distance of 10 km uphill carriage.	200	Nos. per Km.	0.17	340
6	Planting of extracted plants in above pits including ramming.	200	No.	0.86	172
7	Mulching of plants with grass.	200	No.	0.28	56
8	Cost of plants (in nursery).	200	No.	1.00	200
				TOTAL	**17453**
(IV)	**PLANTATION OF TREE SPECIES IN BLANK AREA:**				
1	Preparation of soil mixture (soil, sand, humus & compost) including digging, purchase, carriage to the site of work and mixing at site	54.675.	Cum.	850.00	46474
2	Digging of pits (45cm x 45cm x 45cm) for B/L plantation.	600	No.	4.45	2670
3	Filling of pits (45cm x 45cm x 45cm) for B/L plantation with imported soil mixture.	600	No.	1.27	762
4	Extraction of plants from nursery beds.	600	No.	0.25	150
5	Carriage of plants from nursery to the work site over an average distance of 10 Km uphill carriage.	600	No. per Km.	0.17	1020
6	Planting of B/L plants in pits including ramming.	600	No.	0.86	516
7	Mulching of B/L plants with grass.	600	No.	0.28	168
8	Cost of plants (in nursery).	600	No.	4.00	2400
				TOTAL	**54160**
(V)	**MAINTENANCE:**				

1	1st year maintenance.	1	Ha.	4000	4000
2	2nd year maintenance.	1	Ha.	3600	3600
3	3rd year maintenance.	1	Ha.	3200	3200
4	4th year maintenance.	1	Ha.	2800	2800
5	5th year maintenance.	1	Ha.	2000	2000
6	Watch and ward of plantation for 5 years (60 months @ 1000/=) including irrigation during lean seasons.	1	Ha.	1000	60000
				TOTAL	**78000**
B.	**SOIL CONSERVATION:**				
1.	Construction of gulley plugs, small check walls/dams etc.			LUMP-SUM	**50000**
				TOTAL (A) + (B)	
				GRAND TOTAL	**4,85,432**

10.8.7. *Cost Estimate for Muck Management Plan*

The cost estimate for muck management plan indicating engineering, biological, bio-technological measures and maintenance is provided in **Table-10.48**.

Table 10.48 : Cost Estimate for Muck Management Plan

Sl. No.	Particulars	Quantity	Unit	Rate (Rs.)	Amount (Rs. lakh)
A. Engineering Measures					
1	Length of R.R. Stone Masonry in Cement Mortar 1:5 with 0.3 m thick PCC 1:3:6 in foundation at dumping site D-1 to D-4 is 490m +830m +518m +642m = 2480 m				
	PCC 1:3:6 in foundation				
a.	2480 X 2.94 X 0.3 = 1133.37 say 1134 cum	2187	cum	3200	69.98
b.	R.R. Stone Masonry in C.M. 1:5 2480 X 0.5 (0.6+2.54) X 6.0 = 23361.6 cum say 23362 cum	23362	cum	2510	586.39
				Sub-total (A)	**656.37**
B. Biological Measures					
1.	Plantation of muck disposal sites	25.0	ha	485432	121.36
2.	Barbed wire fencing on 2m high RCC posts	25.0	ha	30000	7.50
3.	Providing and laying Geo-coir textile	10.0	ha	7,50,000	75.00
4.	Cost of portable pump with accessories	4	No.	400000	16.00
5.	Cost of sprinkler system of irrigation	25.0	ha	50000	12.50

6.	Watch and ward 4 no. @ Rs. 12000 p.m. for 4 years	192	Man month	12000	23.04
				Subtotal (B)	**255.40**
				Grand Total (A) + (B)	**911.77**
				Say Rs.	**912.00**

10.9. Restoration Plan for Quarry Sites and Landscaping of Colony Areas etc.

10.9.1. *General*

Umngot HEP mainly involves construction of concrete dam, intake, head race tunnel, surge shaft, pressure shaft, surface powerhouse and tail race channel with outlet structures and adits. For the construction of such component's substantial quantities of concrete work, structural steel work, shotcreting and grouting and fixing of pre-cast lagging is involved for which construction materials like coarse and fine aggregates, boulders, stones and earth for backfilling are required besides cement, structural steel and reinforcement steel. The quantities of construction material like fine aggregate, shingle or coarse aggregate for various uses and their potential quarry/mining sites are mentioned in **Table 10.49**. Assuming the total losses (18%) for in the quantity estimation of raw material from quarry site to aggregate processing plant for producing aggregates, the total quantity of raw material works out to be 15.34 lakh cum for coarse aggregate and for sand 7.08 lakh cum. Thus, the total raw material requirement for aggregate comes to 15.34 lakh cum, which shall be met from utilization of 2.78 lakh cum of muck and balance 12.56 lakh cum from two rock-in-situ quarry sites, the location of which is depicted in **Figure 10.15.**

Table 10.49 : Quantity of Various Materials (Lakh cum)

S. No	Material	Estimated Quantity (lakh cum)	Quantity retrieved from excavated muck	Balance quantity to be obtained from quarries	Quarry/ Mining Sites
1	Coarse aggregate	15.34	2.78	12.56	Rock-in-situ quarry sites at left/right bank of Umngot river.
2	Fine aggregate	7.08	0.0	7.08	River bed shoal deposit from Myntdu river at Kharkhana and also from Umiew river, near Mylliem.
3	Stone/Boulder	0.47	0.47	0.00	From excavated muck
	Total	**22.89**	**3.25**	**19.64**	

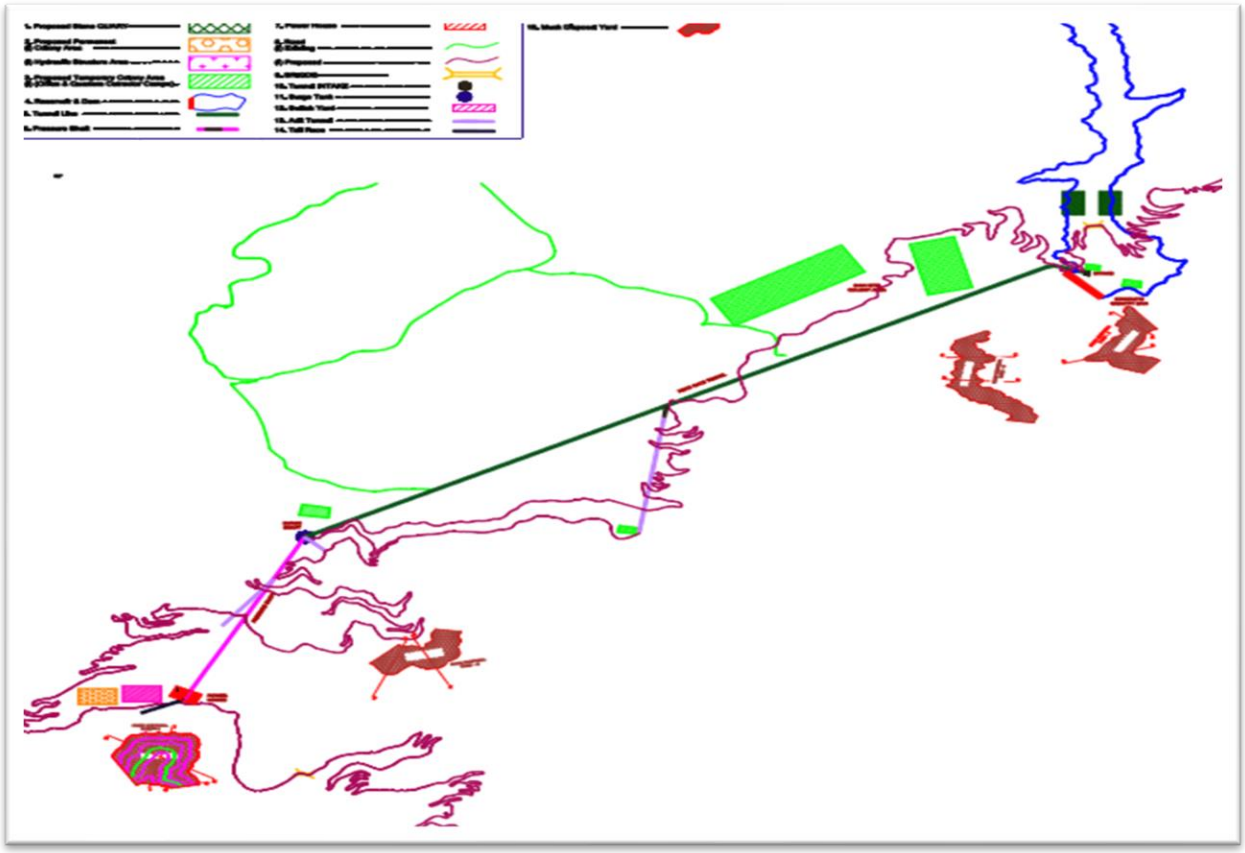


Figure 10.15 : Location of Quarry Sites

10.9.2. *Details of Quarry Sites*

For Umngot HEP, the balance requirement of coarse aggregate for wearing and non-wearing concrete surface shall be met from two rock-in-situ quarry sites within 3km distance from dam site have been identified and the sample have been investigated to find out the suitability as coarse aggregate material. Sand shall be obtained from river bed shoal deposit from Myntdu river at Kharkhana and also from Umiew river, near Mylliem. The material obtained from the excavation at the dam site/tunnel has good rock mass suitable for use as aggregate for concrete in non-wearing surface and also filter material.

Rock-in-situ Quarry Site: Q-I

The quarry site in approximately 3 ha, lies 3km u/s of the dam site on the left bank of river. The quarry site can be approached by planning haul road on left bank. The quarry material from this site shall be utilized in construction of dam and appurtenant works. Assuming the proposed quarry dimension of 300 m x 100 m and with 30 m height of excavation on a hill slope of 35^0, the quarry shall yield about 7.5 lakhs cum of blasted material.

Rock-in-situ Quarry Site: Q-2

The quarry site in approximately 3 ha, lies 3km u/s of the dam site on the right bank of river. The quarry site can be approached by planning haul road on right bank. The quarry material

from this site shall be utilized in concreting of HRT, Surge shaft, pressure shaft, power house and TRT/TRC. Assuming the proposed quarry dimension of 300 m x 100 m and with 30 m height of excavation on a hill slope of 35^0, the quarry shall yield about 7.5 lakhs cum of blasted material.

10.9.3. *Environmental Impacts*

The environmental impacts of excavation of construction materials such as rock mass/boulder and sand for construction of hydroelectric projects depend on excavation process, local hydrological conditions, climate, rock types, size and type of operations and topography. Impacts also vary with stage of development at quarry sites e.g., development of working platforms has a less impact compared to the excavation of aggregates and sand. Physical changes in the soil, water and air associated with environment impacts would be due to excavation and degradation of land around the quarry and on biota around it. About 20% excavated material from the proposed underground works shall be utilized together with materials obtained from river bed shoal deposit quarry. The mining method for wining rock mass from rock-in-situ quarry shall be opencast semi-mechanize using wet drilling process, proper benches of height not more than 5m shall be developed with width of bench depending upon the equipment used for loading. The river bed quarry does not require any major restoration measures. The quarrying operation in the river bed shall be manual and the quarry pits shall not be dug more than 1.0-meter-deep and the hill side edge of the quarry line shall be at-least 5m away from the foot of the hill. Blasting shall not be allowed in the stream bed. Copious use of sprinkler shall be resorted to stock piles of aggregate and the washing of the aggregate shall be first allowed to settle in the setting tanks before disposing into river. As a dust arrester G.C sheet shield of adequate height shall be erected.

10.9.4. *Legal Provisions for Mining from Quarries*

In consonance with EIA Notification September, 2006 and Notification dated 9th September, 2013, read conjointly with O.M. No. J-13012/12/2013-IA-1I (I) dated 24th December, 2013 vide para 2-I-Mining of Minor Minerals (ii), both quarry sites which are located more than 500m of each other and with individual and consolidated area less than 25 ha shall be categorized as 'B2' for the purpose of granting EC. These projects will be appraised on the basis of documents viz. Form-1, PFR and Mining Plan approved by the authorized agency of the concerned state government.

In compliance of this mandatory requirement the project proponent shall have to act in accordance with the mandatory provision of the notification/office memorandum.

10.9.5. *Treatment Measures for Restoration*

The environment management plan for mining activity shall be prepared on the basis of impacts and shall be compatible with the eco-friendly management plan in case of the minor mineral. The plan shall have various ingredients like plantation in the area above thalweg line and also within 7.5-meter safety barrier along the hill side and also at such pockets of the river which are above the HFL and normally not affected due to floods.

10.9.6. *Cost Estimate for Restoration of Borrow Areas*

The details of the expenditure likely to be incurred on the implementation of biological and engineering measures to be adopted are placed in **Table 10.50**.

Table 10.50 : Cost Estimate for Restoration Plan for Quarry Sites

Sl. No.	Item of Work	Qty.	Unit	Rate (Rs.)	Amount (Rs. lakh)
1	Construction of drains	500	m	1000	5.00
2	Stone masonry (1:5) in retaining wall of 4 m height	600	cum	2510	15.00
3	Plantation in 3 ha. Including maintenance for 4 yr.	3.0	ha	200000	6.0
4	Watch and ward 2 No Chowkidars for 4 years	96	months	12000	11.52
5	Provision for Settling Tanks	Job		LS	3.00
6	For execution of management plan for quarry area	Job	LS		12.00
7	Sprinkling of water	Job	LS		5.00
				Total	**57.52**
				Say	**58.00**

10.9.7. *Landscaping Plan*

Umngot HEP encompassing dam, intake structure, underground water conductor system and surface powerhouse is located in the interior area of Makynrew block, East Khasi Hills Dist. The dam is located across Umngot river near Siangkhnai village in deep gorge and the surface power house about 20 km d/s of it on the right bank near village Syntung. Nevertheless, being in remote area and at a detour from District Headquarter Shillong, the dam site provides a great opportunity for landscaping for being aesthetically attractive. The water conductor system and appurtenant works are all underground structures and thus their landscaping is not warranted. Considering this the landscape plan is restrictive in nature being limited to dam and power house site, residential, and office complex areas. It is proposed to provide for landscaping the area around dam complex. The financial provision of landscape works is presented in **Table 10.51**.

Table 10.51 : Cost Estimate for Landscaping Plan

S.N.	Particular	Quantity	Amount (Rs lakh)
1	Providing one view point on road overlooking dam site	LS	2.00
2	Providing Channel fencing along approach road to dam	LS	4.00
3	Providing ornamental, avenue and flowering plants, lawn and flower beds in colony area, working areas	LS	5.00
4	Providing rest benches in colony /dam /powerhouse area	LS	2.00
5	Watch and ward @ Rs. 1.44 lakh/year for 4 years	LS	5.76
6	Provision for recurring cost on maintenance of items 1 through 4 @ 2.5% of cost per year for 4 years	LS	1.30
		Total	**20.06**
Say			**20.00**

10.9.8. *Cost Estimate for Restoration Plan for Quarry Sites and Landscaping*

The overall cost of restoration of quarry and of landscaping plan is shown in **Table 10.52.**

Table 10.52 : Total Cost Estimate for Restoration of Quarry Sites and Landscaping

S.N.	Particular	Amount (Rs lakh)
1	Cost of Restoration of Quarry Sites	58.00
2	Cost of Landscaping of colony areas, working areas and roads.	20.00
		78.00

10.10. Study of Design Earthquake Parameters

10.10.1. *Introduction*

The project is located at geographical coordinates (Latitude 25^0 21' 38" N and Longitude 92^0 6' 45" E) in East Kasi Hills district of Meghalaya on river Umngot. MSEB referred the study for site-specific earthquake parameters to the Department of Earthquake Engineering, Indian Institute of Technology Roorkee.

The proposed dam site in East Kasi Hills district of Meghalaya lies in Seismic Zone-V as per the seismic zoning map of India as incorporated in Indian Standard Criteria for Earthquake Resistant Design of Structures IS:1893-(Part-I)-2002 General Provisions and Buildings. As per this code, it is generally presumed that for design of normal structures adequate safety would be attained if structures are designed as per Codal recommendations. The probable intensity of earthquake in Seismic Zone-V corresponds to earthquake intensity IX on comprehensive intensity scale (MSK64). The structures designed as per the recommended design parameters for this zone would generally prevent loss of human life and only repairable damage can occur. However, the recommended design parameters in IS:1893-(Part-I)-2002 are for preliminary design of important structures and it is desirable to carry out dynamic analysis for final design of important hydraulic structures in order to estimate stresses and deformations during probable future earthquakes. IS code, therefore, recommends that for such structures detailed site-specific investigations be carried out for estimating the design Earthquake parameters.

10.10.2. *Summary of Recommendation*

The recommendations for the site-specific earthquake design parameters for the site are based on the studies carried out related to the tectonics, regional geology, local geology' around the site, earthquake occurrences in the region around the site and the seismotectonic setup of the area. Both approaches namely, Probabilistic seismic hazard assessment and deterministic approach for seismic hazard assessment were considered as per the 'Guidelines for the preparation and submission specific study report of River Valley project to National Committee on Seismic Design Parameters (NCSDP)" for arriving at the specific design earthquake parameters for the site (CWC, 2012).

The design seismic coefficient for dam i.e., evaluated horizontal seismic coefficient as αh=0.24 and vertical seismic coefficient as αv=0.16 respectively as per the value approved by NCSDP vide CWC letter No.2/2/2015(Vol-I) FE&SA/497, Dated 07.10.2016.

10.11. Disaster Management Plan

10.11.1. *Introduction*

Any hydroelectric project if not designed on sound principles of design after detail investigations in respect of hydrology, geology, seismicity etc. could spell a large-scale calamity. There are inherent risks to the project like improper investigation, planning, designing and construction which ultimately can lead to human catastrophe. Although through detailed field investigations it has been ensured that the dam is founded on firm foundation, designed for suitable seismic design parameters yet in view of that uncertain element of "Force Majeure" the eventuality of a disaster cannot be ruled out. Therefore, a rescue plan has to be devised for confronting such an exigency without being caught in the vast realm of unpreparedness.

A disaster is an unwarranted, untoward and emergent situation that culminates into heavy toll of life and property and is a calamity sometimes caused by "force majeure" and also by human error. The identification of all types of disasters in any proposed project scenario involves critical review of the project vis-à-vis the study of historical past incidents/disasters in similar situations. The evolution of disaster management plan dwells on various aspects such as provision of evacuation paths, setting up of alarms and warning systems, establishing communicating system besides delineating an Emergency Response Organization with an Effective Response System. Keeping in view the grievous affects a disaster can cause on human or animal population, property and environment in and around the areas of impact, it is essential to assess the possibility of such failures in the context to the present project and formulate a contingent plan.

The 362 m long dam comprising of 275.8m long non-overflow section and 86.2m long spillway section having 6 bays 8.70 m wide with radial gate of size 8.70m x 15 m to pass design flood (9760 cumecs). The FRL and MDDL have been fixed at El. 1040 masl and El 1010 masl respectively.

10.11.2. *Dam Break Inundation Analysis*

The outflow flood hydrograph from failure of a hydraulic structure is dependent upon many factors such as physical characteristics of the structure, volume of reservoir and the mode of failure. The parameters which control the magnitude of the peak discharge and the shape of outflow hydrograph include: the breach dimensions, the manner and length of time for the breach to develop, the depth and volume of water stored in the reservoir, and the inflow to the reservoir at the time of failure. The shape and size of the breach and the elapsed time of development of the breach are in turn dependent upon the geometry of the dam, construction materials and the causal agent for failure.

In the DAMBRK model, the dam break flood analysis is performed computationally be components, viz., (1) breaching of the dam, i.e. the temporal and geometrical description the breach; and (2) hydraulic computational algorithm for determining the time history

hydrograph) of the outflow through the breach as affected by breach description of reservoir, reservoir storage characteristics, spillway outflows, and downstream tail water stations; and for routing of the outflow hydrograph through the downstream valley in order to account for the changes in the hydrograph due to valley storage, frictional resistance, downstream bridges or dams. The model also determines the resulting water surface elevations and flood wave travel time.

10.11.2.1 Breaching of Dam

The breach is the opening formed in the dam during its failure. The incident hydrograph is due to the breaching of the dam. The physics of breaching of a dam is not well understood. For concrete arch dams, instantaneous and complete dam break is an appropriate assumption. Based on experimental studies and observations in field situations for other types of dam, the breaching of the dam (i.e., the shape and size of the opening) is evolved within a definite interval of time period. Generally, parametric approach using the time, width and side slope is employed to describe a trapezoidal breach shape. The side slope of the breach opening depends on the characteristics of the dam material. The model assumes the breach bottom width that starts from a value of zero and increases either at linear or non-linear rate over the failure time until the terminal bottom width is attained and the breach bottom has eroded to the prescribed elevation. If the failure time is less than one minute the breaching is considered to be instantaneous, and therefore, width of the breach bottom at the start is equal to the terminal bottom width. The breaching can be either by overtopping or by piping failure in the case of earthen dam. It begins when the water level in the reservoir exceeds a specified value. A piping failure may be simulated by specifying the initial center line elevation of the pipe.

10.11.2.2 Model for Dam Break Analysis

The DAMBRK model was first developed by Danny L Fread (1979) and was published by National Weather Service. The present study uses the latest version of the model that incorporates various modifications over the original one. The model has been used by many researchers, field engineers and scholars, and has wide applicability

For reasons of simplicity, generality, wide applicability and the uncertainty in the actual mechanism, the BOSS DAMBRK model has been used. The model uses failure time interval, terminal size and shape of the breach as the inputs. The possible shapes of the breach that can be accomplished by the model are rectangular, triangular and trapezoidal. The model is capable of adopting either storage routing or dynamic routing methods for routing floods through reservoirs depending on the nature of flood wave movement in reservoirs at the time of failure**.**

The model can work for special conditions in dam break floods. Such as the presence of mixed flows, routing losses, lateral flows, flood plain compartments, landslide generated waves, pressurized flow, and mud-debris flows. The model can also take into account the conveyance option, the sinuosity factor, the hydraulic radius option, reservoir cross- section option, selection of distance and time steps. Thus, the model is equipped with a higher degree of robustness against computational difficulties

The dynamic wave method based on the complete equations of unsteady flow is the appropriate technique to route the flood hydrograph through the downstream valley. The method is derived from the original equations developed by St. Venant. The model uses St. Venant's equations for routing dam break floods in channels.

10.11.3. *Methodology*

The U.S. National Weather Service's DAMBRK model developed by Dr. L. Fread has been used in the study. This model simulates the failure of dam, computes the resultant outflow hydrograph and also simulates movement of the dam break flood wave through the downstream river valley. The model is built around three major capabilities, which are reservoir routing, breach simulation and river routing. However, it does no rainfall-runoff analysis and storm inflow hydrographs to the upstream of reservoir must be developed external to the model. A brief description of the capabilities of the model is described in the following paragraphs.

10.11.3.1 Reservoir Routing

The storage routing is based on the law of conservation given as:

$I - Q = dS/dt$ ……. ….. (1)

in which, I is reservoir inflow. Q is the total reservoir outflow which includes the flow spillway, breach, overtopping flow and head independent discharge, and rate of change of reservoir storage volume. Equation (1) can be expressed in finite difference form as:

$(1 + I') 2 - (Q + Q')/2 = \Delta S/\Delta t$ -. -----(2)

in which the prime (') superscript denotes the values at the time t - Δt and the notation approximates the differential. The term ΔS may be expressed as:

$\Delta S = (As + A's) (h-h')/2$ …… (3)

in which, As is the reservoir surface area coincidental with the elevation (h) and is a function of h. The discharge Q which is to be evaluated from equation (2) is a function of h and this known h is evaluated using Newton–Raphson iteration technique and thus the estimation of discharge corresponding to h.

10.11.3.2 Dynamic Routing

The hydrologic storage routing technique, expressed by equation (2) implies that the water surface elevation within the reservoir is horizontal. This assumption is quite adequate for gradually occurring breaches with no substantial reservoir inflow hydrographs. However, when the breach is specified to form almost instantaneously so as to produce a negative wave within the reservoir, and/or the reservoir inflow hydrograph is significant enough to produce a positive wave progressing through the reservoir, a routing option which simulates the negative and /or positive wave occurring within the reservoir may be used in DAMBRK model. Such a technique is referred to as dynamic routing. The routing principle is same as dynamic routing in river reaches and it is performed using St. Venant's equation. The movement of the dam break flood wave through the downstream river channel is simulated using the complete

unsteady flow equations for one dimensional open channel flow, alternatively known as St. Venant's equations. These equations consist of the continuity equation

$$\frac{\partial Q}{\partial x} + \frac{\partial s (A + A0)}{\partial t} = q \quad \text{…… (4)}$$

And a conservation of momentum equation:

$$\frac{\partial(sQ)}{\partial t} + \frac{\partial(A2/ + A)}{\partial t} + g A \left(\text{---- + Sf + S e} \right) + Lc = 0 \text{ ……(5)}$$

where,

A = active cross – sectional flow area

A_0 = inactive (off-channel storage) cross – sectional area

s = a sinuosity factor which varies with h

x = distance the channel

t = time

q = lateral inflow or outflow per lineal distance along the channel

g = acceleration due to gravity

β = the momentum coefficient for velocity distribution

Q = discharge h = water surface elevation

Sf = boundary friction slope

Se = expansion – contraction slope

Lc = lateral inflow/outflow momentum effect due to assumed flow path of inflow being perpendicular to the main flow

The friction slope and expansion – contraction loss slope is evaluated by the following equation

$$Sf = \frac{n^3 Q^2}{2.21 A^2 R^{¾}} \quad \text{…….. (6)}$$

and,

$$Se = \frac{K\Delta(Q/A)^2}{\text{----------}} \quad \text{…….. (7)}$$

$2g \Delta X$

Where,

n = Manning's roughness coefficient

R = A/B where B is the top width of the active portion of the channel

K = Expansion – contraction coefficient varying from 0.1 to 0.3 for contraction and -0.1 to 1.0 expansion

$\Delta(Q/A)^2$ = Difference in (Q/A)2 for cross sections at their end of a reach

The non-linear partial differential equations (4) and (5) are represented by a corresponding set of non-linear finite difference algebraic equations and they are solved by the Newton – Raphson method using weighted four-point implicit scheme to evaluate Q and h. The initial conditions are given by known steady discharge at the dam, for which steady state non-uniform boundary flow equations are used. The outflow hydrograph from the reservoir is dependent upon the downstream boundary condition for the channel routing and the model is capable of dealing with fully subcritical flow or fully supercritical flow in the reach or the upstream reach having supercritical flow and downstream reach having subcritical flow. There is a choice of downstream boundary conditions such as internally calculated loop rating curve, user provided single valued rating curve, user provided time dependent water surface elevation, critical depth and discharge which may pass flow via spillways, overtopping and/ or breaching.

10.11.3.3 Statement of the problem

In the case of concrete gravity dams, removal of one or more of the monolithic sections by the escaping water leads to partial breaching of the dam. The time for breach formation is this case is of a few minutes. The judicious selection of the time of breach for an earthen dam is important due to the fact that most of the existing dams fall in this category. Breaching of an earthen dam takes place neither completely nor instantaneously, and therefore, breach width is generally much less than the total length of the dam. The time of breach for overtopping failure in an earthen dam is larger as compared to that of a concrete dam. It depends on the height of the dam, dam material as well as its compaction, and magnitude/duration of overtopping. The value may vary from a few minutes to a few hours. In case of piping failure, the breach time is considerably more as compared to that of an overtopping failure. Breach parameters are prescribed by the user, and, therefore, reasonable values need to be used in the input data set

The computation of flood wave resulting from a dam breach basically involves two scenarios which can be considered jointly or separately: (1) the outflow hydrograph from the reservoir (2) the routing of the flood wave downstream from the breached dam along the river valley and the flood plain. If breach outflow is independent of downstream conditions, or if their effect can be neglected, the reservoir outflow hydrograph is referred to as the free outflow hydrograph. In this case, the computation of the flood characteristics is divided into two distinct phases: (a) the determination of outflow hydrograph with or without the routing of the negative wave in the reservoir, and (b) the routing of flood wave downstream from the breached dam. In this study the problem of simulating the failure of "Dam" and computing

the free outflow hydrograph from the breached section using storage routing technique' with the aim of reproducing the maximum water level marks reached during the passage of flood wave is considered. The information regarding inflow hydrograph into the pond due to the storm at the time of failure, the structural and the hydraulic characteristics details of the Dam, the time of failure, the channel cross sections details, the maximum water level marks reached in the reservoir at the time of failure and those observed in the downstream reach of the Dam to the passage of flood wave etc. are available for the study.

10.11.3.4 Availability of Data

The input data required for the U.S. National Weather Service's BOSS DAMBRK model can be categorized into two groups. The first data group pertains to the dam and inflow hydrograph into the reservoir and the second group pertains to the routing of the outflow hydrograph through the downstream valley. These are described in the following paragraphs.

First Data Group

The first data group pertains to the dam, the breach spillways and physical characteristics of the reservoir. The required breach data are time of breach formation, final bottom breach width side slope of breach, final elevation of breach bottom, initial elevation of water level in the reservoir, elevation of water when breach begins to form and elevation of top of dam. The spillway data consist of elevation of uncontrolled spillway crest, coefficient of discharge of uncontrolled spillway, elevation of center of submerged gated spillway, coefficient of discharge of crest of dam and constant head independent discharge from dam. The reservoir data consist of table describing storage features of the reservoir, surface area (or volume) versus elevation of dam

Second Data Group

The second group of data pertaining to the routing of the outflow hydrograph through the downstream valley consists of a description of cross-sections, hydraulic resistance coefficients of the reach, steady state flow in the river at the beginning of the simulation and downstream boundary condition. The cross section is specified by location mileage, and tables of top width and corresponding elevation. In this study, eight cross sectionals have been used. Four cross-sections are located at 0, 0.2,3,6,9,12,15 and 20 km respectively from the dam. The breach time has been taken as 1.0 hour and breach width a 16m.

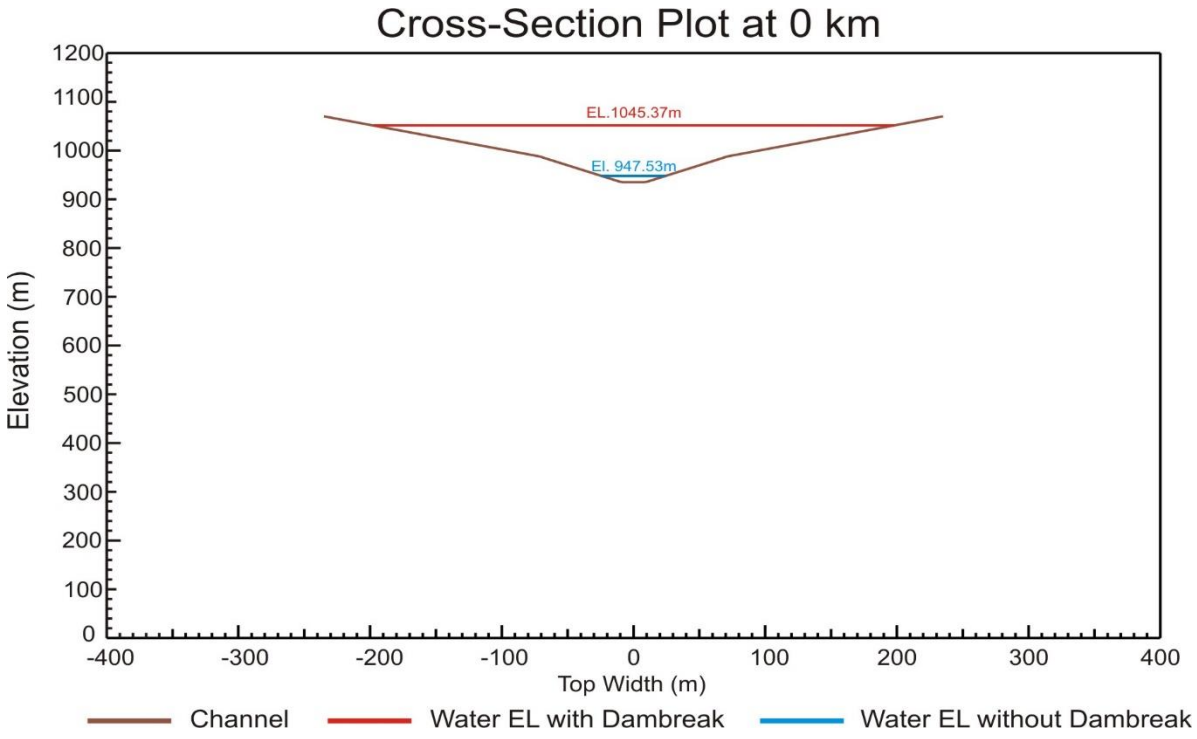
10.11.4. *Result and Conclusions*

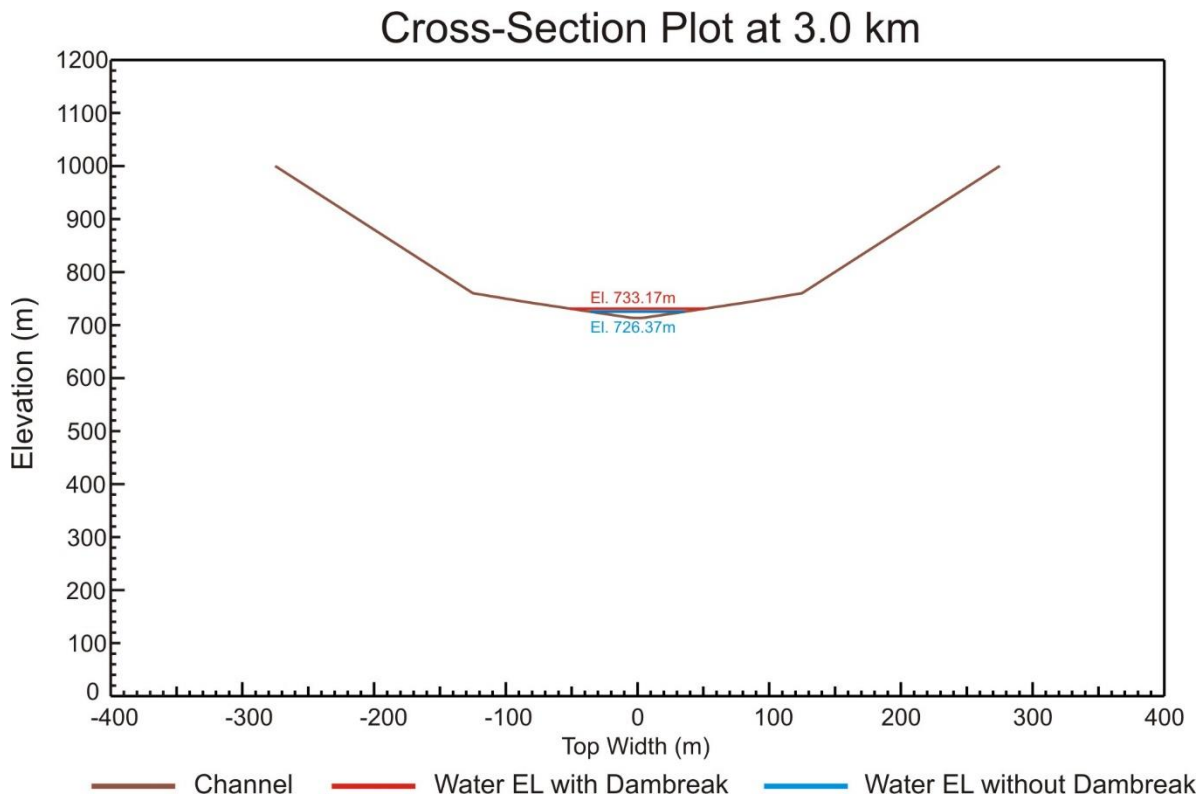
The routing of PMF through downstream channel reach up to 20 km was studied for no dam break scenario and also for the simulated dam break scenario in order to find out the maximum stage of elevation at different sections for both scenario which is shown in **Table10.53** and the plot of flood elevation in both cases is depicted in **Figure10.16.**

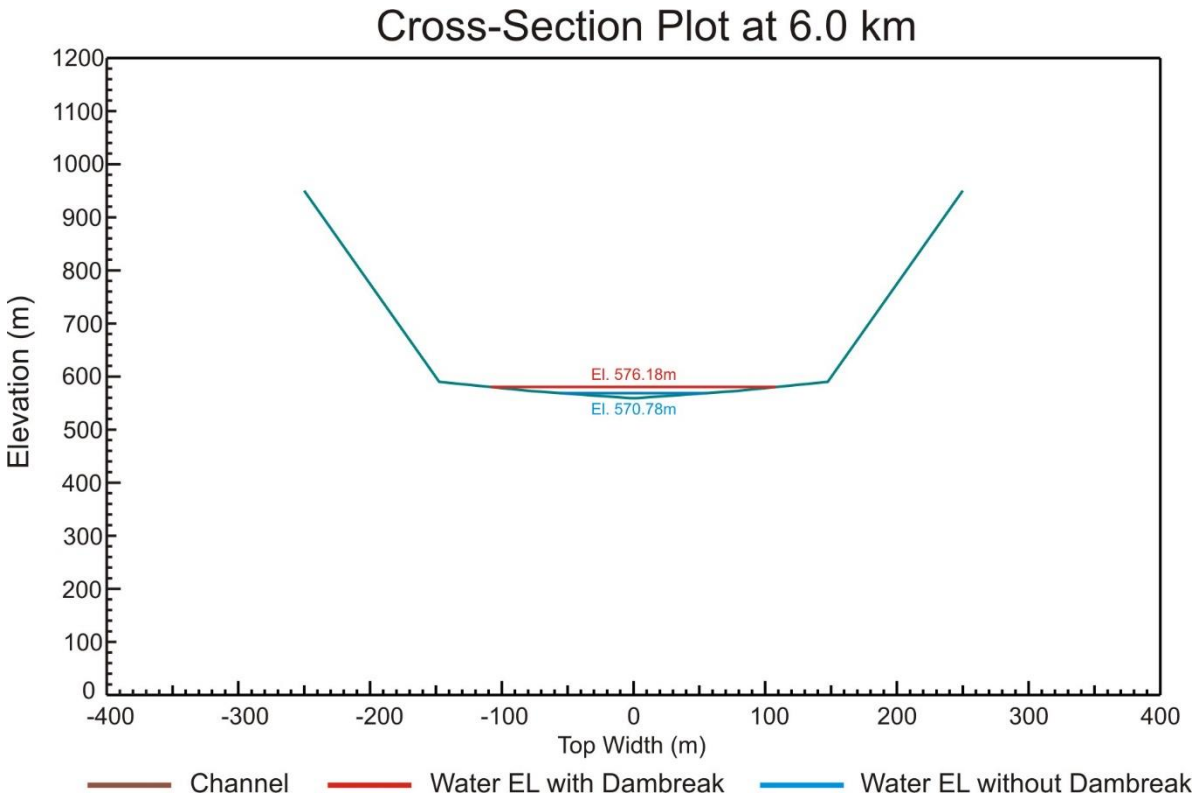
Table 10.53 : Flood Crest Summary

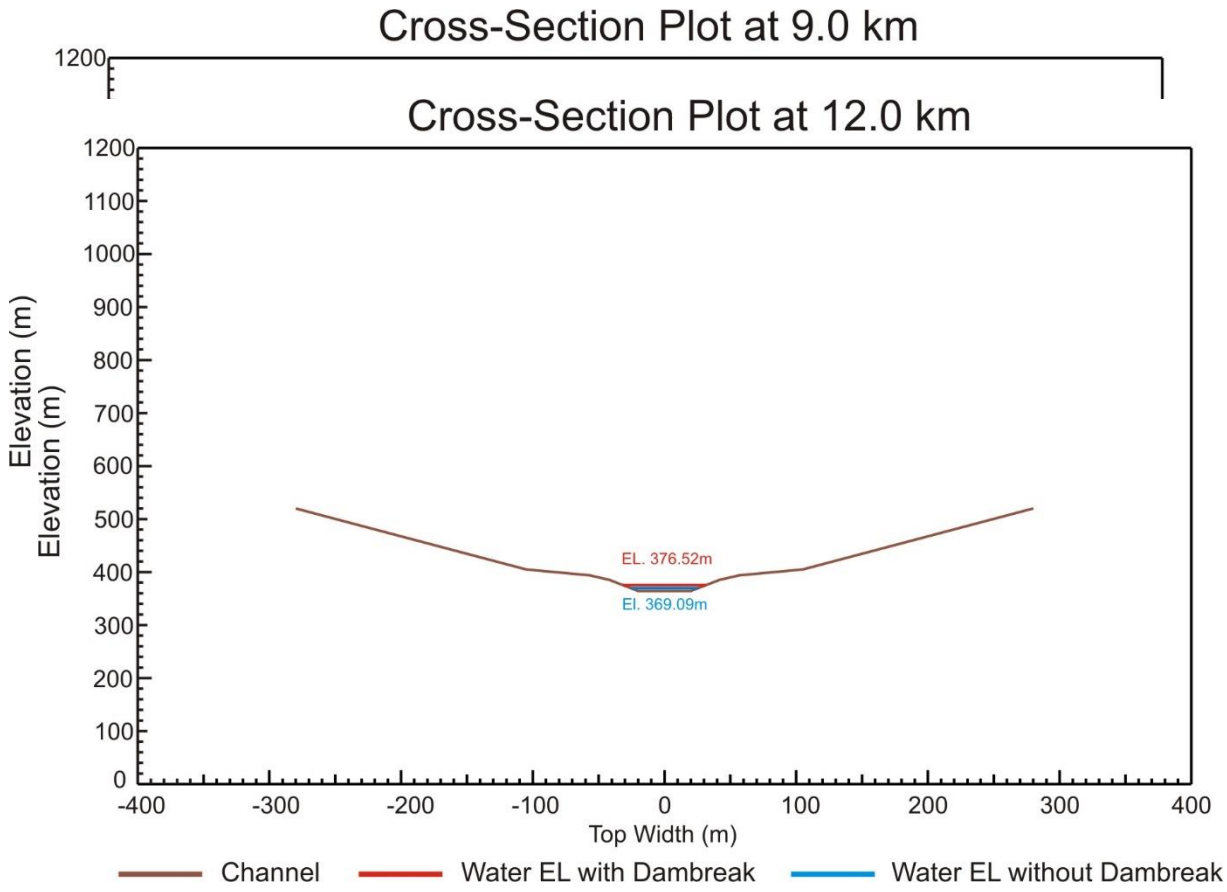
Cross Section Location (km)	Without Dam break		With Dam break	
	Maximum Stage Elevation (masl)	Maximum Flow (cumecs)	Maximum Stage Elevation (masl)	Maximum Flow (cumecs)

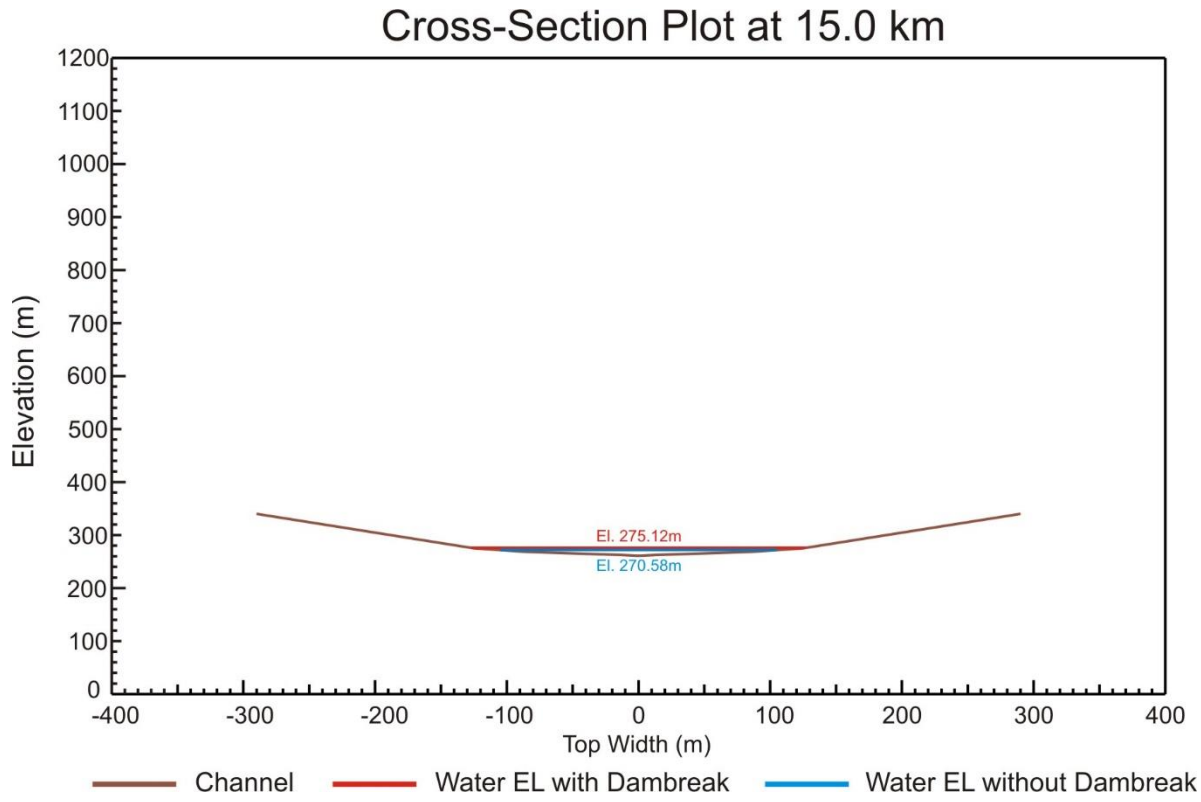
0.00	947.67	9760	1045.37	29255
0.455	917.07	9987	925.18	29118
3.00	726.37	10428	733.17	28779
5.0	622.84	10499	629.21	28581
7.0	536.77	10390	542.76	28389
9.0	467.16	10278	473.15	28249
10.0	440.59	10234	448.43	28154
12.00	376.52	10311	387.11	27950
15.00	263.24	10897	275.12	27815
18.00	212.93	10894	219.54	27625
20.00	173.52	11134	181.10	27426




Cross-Section Plot at 3.0 km
Elevation (m)
Top Width (m)
El. 733.17m
El. 726.37m
Channel
Water EL with Dambreak
Water EL without Dambreak


Cross-Section Plot at 6.0 km
Elevation (m)
Top Width (m)
El. 576.18m
El. 570.78m
Channel
Water EL with Dambreak
Water EL without Dambreak


Cross-Section Plot at 9.0 km
1200
Cross-Section Plot at 12.0 km
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Elevation (m)
Elevation (m)
EL. 376.52m
El. 369.09m
-400
-300
-200
-100
0
100
200
300
400
Top Width (m)
Channel
Water EL with Dambreak
Water EL without Dambreak


Cross-Section Plot at 15.0 km
Elevation (m)
Top Width (m)
El. 275.12m
El. 270.58m
Channel
Water EL with Dambreak
Water EL without Dambreak

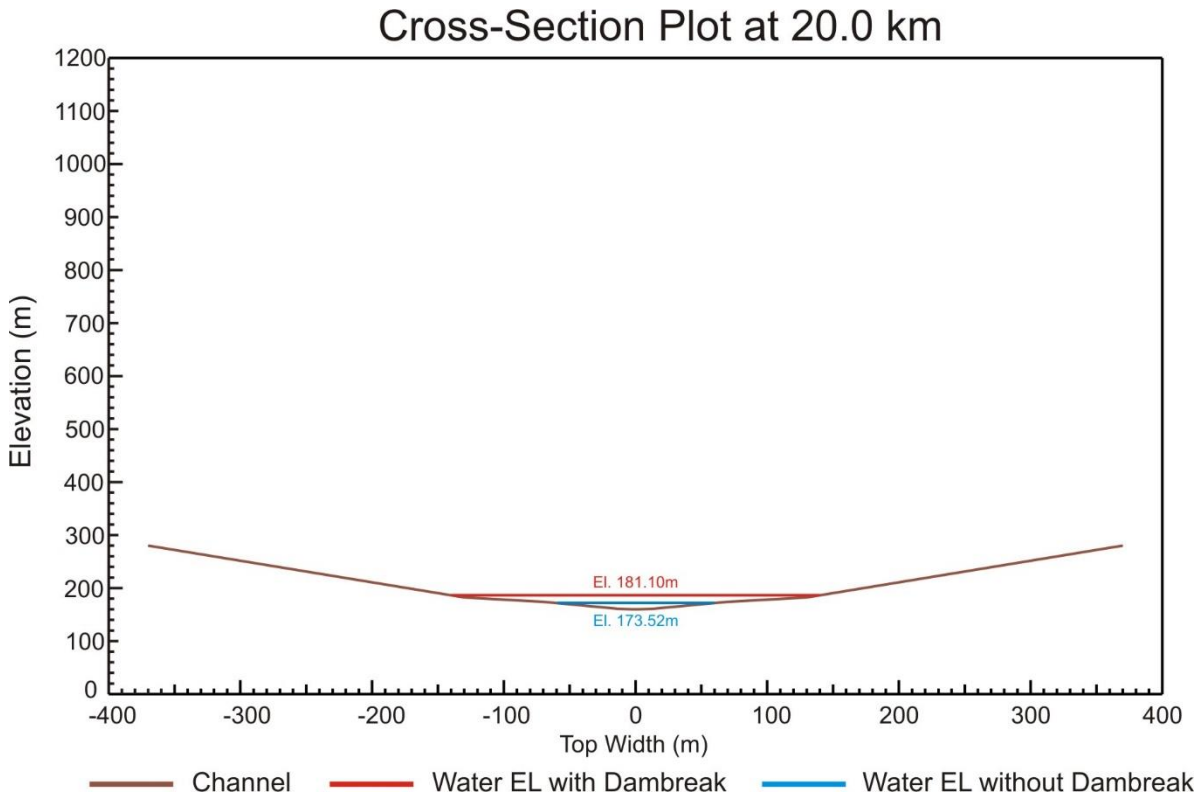

Cross-Section Plot at 20.0 km
Elevation (m)
Top Width (m)
El. 181.10m
El. 173.52m
Channel
Water EL with Dambreak
Water EL without Dambreak

Figure 10.16 :X-Sections at Different Location

The dam break study has been carried out assuming that one bay gets washed away in the entire length and also height from El 935 masl i.e., inspection gallery. The failure is also assumed to occur when the dam receives the PMF. The study involves determination of the flood flow from the dam due to its breach, and routing the same along the river valley on the downstream, to estimate the maximum flood levels at various locations on the downstream.

The maximum stage elevation and maximum flow at different cross-section at various distances downstream of the dam is shown in Table 13.1. It can be inferred from the result that maximum flow 29098 cumecs corresponding to maximum stage elevation 1045.37 masl has been achieved at RD 0.00 km due to breach of dam and thereafter the maximum flow has gradually attenuated to 27387 cumec corresponding to stage elevation 181.09 at RD 20km (**Table 10.54**). This is because for reaches further downstream, the flow wave characteristics may be predominantly influenced by channel geometry. The combined stage and discharge hydrograph are depicted in **Figure 10.17** and **Figure 10.18** respectively.

Table 10.54 : Flood Crest Summary

Cross Section Location (km)	Maximum Stage Elevation (masl)	Maximum Flow (cumecs)	Time to Maximum Stage (hr)	Maximum Flow Velocity (m/sec)	Flood wave arrival time (hr)
0.00	1045.37	29255	0.425	3.12	0.00
0.455	925.18	29118	1.000	25.55	0.05
3.00	733.17	28779	1.050	23.76	0.05
5.0	629.21	28581	1.075	18.27	0.10
7.0	542.76	28389	1.125	14.62	0.15
9.0	473.15	28249	1.150	17.65	0.20
10.0	448.43	28154	1.175	13.63	0.25
12.00	387.11	27950	1.225	19.73	0.30
15.00	275.12	27815	1.250	18.13	0.40
18.00	219.54	27625	1.325	10.98	0.45
20.00	181.10	27426	1.375	11.23	0.50

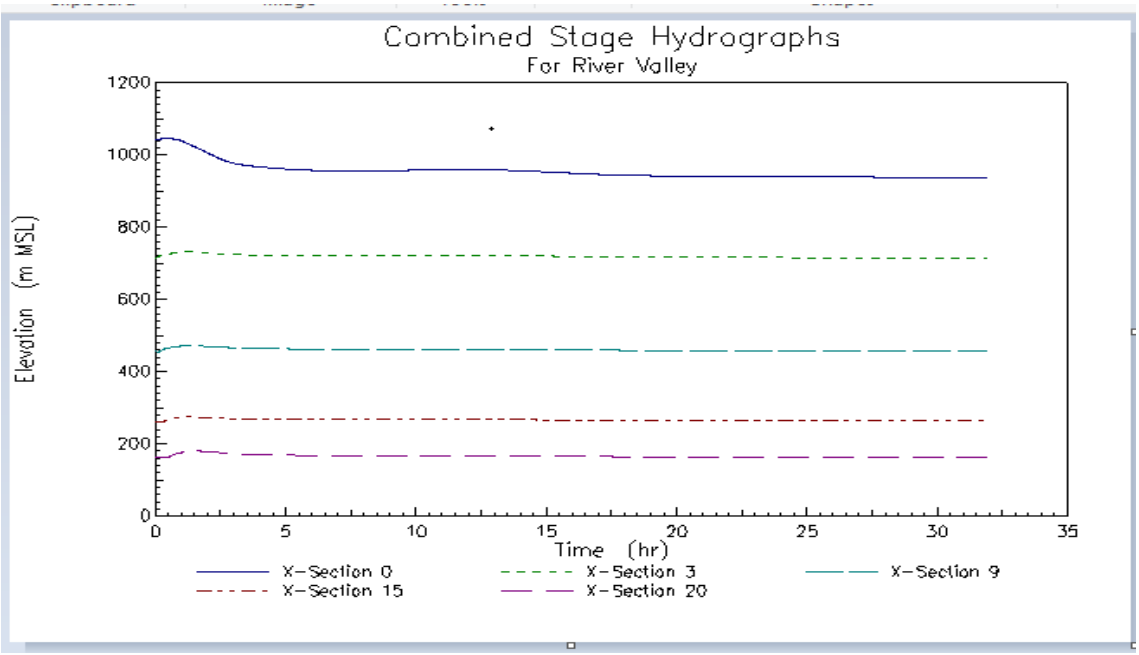


Figure 10.17 Combined Stage Hydrographs

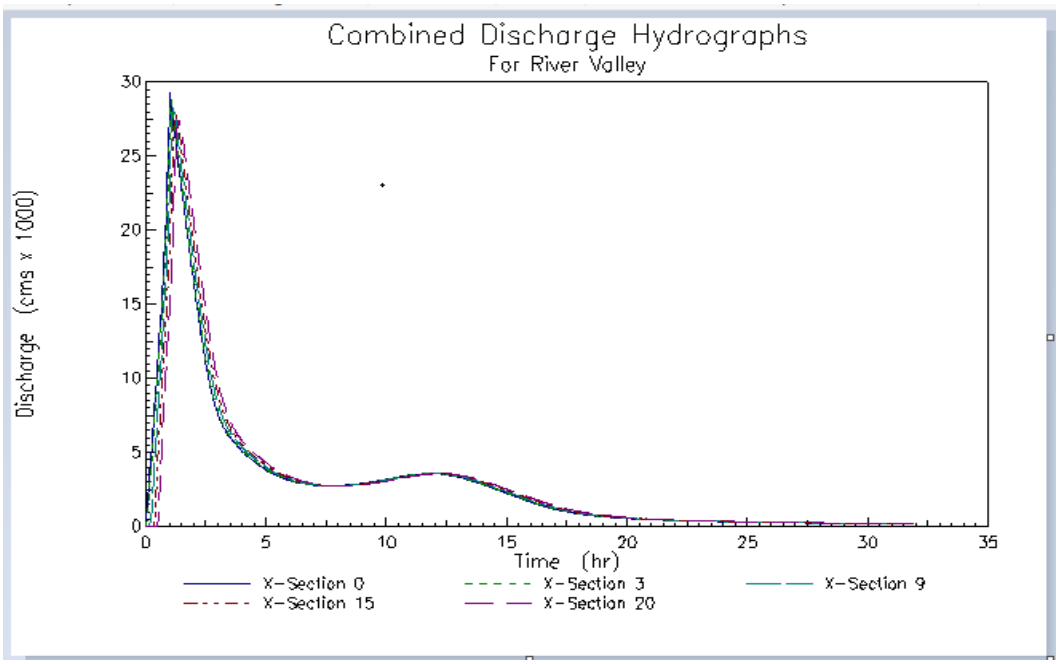


Figure 10.18 : Combined Discharge Hydrographs

The following conclusions could be drawn:

- Failure of the concrete dam which is designed to the present technical standards and built with adequate quality control, is a very-very remote possibility.

- The assumed condition that one bay gets washed away is only hypothetical.
- Even in the case of dam breach the outflow hydrograph shall remain within the river section and shall not inundate any settlement / village.

10.11.5. *Disaster Management Plan*

The emergency planning for dam break scenario is devised on the basis of results of break analysis mainly the travel time of flood wave to various locations in the downstream stretch of the river. It is inferred from the analysis that in case of dam break the flood peak discharge as it propgates through valley shall inundate downstream stretch of five km within 14.5 minutes. Owing to the breaking of the dam the major risk shall be to the persons who have for some reason or the other has entered the river bed / plain. The plan is, therefore, based on such measures, which are purely preventive in nature.

The flood period during monsoon generally is reckoned from June with the onset of monsoon and ends with withdrawal of south-west monsoon by the end of September. Before the onset of monsoon all hydro-mechanical equipment, electrical gadgets, captive power plant and public announcement and communication system should be kept in perfect readiness. The degree of alertness has to enhance during high stage of river manifested with sharp increase in discharge. Though there cannot be very sharp edge demarcation between different levels of emergency yet the following flood conditions have been contemplated and the preventive measures suggested against each as given in **Table 10.55.**

Table 10.55 : Status of Emergency

S. N.	Status of emergency	Water Level	Preventive measures
1.	Normal Flood	Below FRL i.e., EL 1040 masl and flood discharge below 9760 Cumec	Utmost vigil observed in regulation of spillway gates
2.	Level –1 Emergency	Rises above EL 1040 masl but discharge below 9760 cumec	(1) All gates fully operational (2) All the official should attend dam site. Local officials informed and warning system be kept on alert. Communication & public announcement system should be put into operation and flood warning issued to people
3.	Level –2 Emergency	Top of dam i.e.,1042 masl but discharge below 9760.	(1) All staff from dam site, power house & TRT outlets alerted to move to safer places (2) Possibility of dam failure should be flashed to District Administration.

4.	Disaster	Rising above EL 1042 masl and the breach appears in any form rises above	District Administration and Project authorities be intimated and only life saving measures should be resorted too

10.11.5.2 Dam Safety and Maintenance Manual

Based on standard recommended guidelines for the safety of dam a manual should be prepared by the project proponents in respect of dam safety surveillance and monitoring aspects. This should be updated with the availability of instrumentation data and observation data with periodical review. The need for greater vigil has to be emphasized during first reservoir impoundment and first few years of operation. The manual should also delve on the routine maintenance schedule of all hydro-mechanical and electrical instruments. It should be eloquent in respect of quantum of specific construction material needed for emergency repair along with delineation of the suitable locations for its stocking and also identify the much-needed machinery and equipment for executing emergency repair work and for accomplishing the evacuation plan.

10.11.5.3 Emergency Action Plan (EAP)

Dam safety programme as indicated above includes the formation of an Emergency Action Plan for the dam. An emergency is defined as a condition of serious nature which develops unexpectedly and endangers downstream property and human life and required immediate attention. Emergency Action Plan should include all potential indicators of likely failure of the dam, since the primary concern is for timely and reliable identification and evaluation of existing of potential emergency.

This EAP presents warning and notification procedures to follow during the monsoon season in case of failure or potential failure of the dam. The objective is to provide timely warning to nearby residents and alert key personnel responsible for taking action in case of emergency.

10.11.5.4 Administration and Procedural Aspects

The administrative and procedural aspects of the Emergency Action Plan consist of flow chart depicting the names and addresses of the responsible officials. In order of hierarchy, the following system will usually be appropriate. In the event that the failure is imminent or the failure has occurred or a potential emergency conditions is developing, the observer at the site is required to report it to the Junior Engineer / Assistant Engineer who will report to the Executive Engineer / Superintending Engineer for their reporting to the Chief Engineer through a wireless system or by any available fastest communication system. The Engineer-in-Charge is usually responsible for making cognizant with the developing situation to the Civil Administration viz. District Magistrate. Each personnel are to acknowledge his/her responsibilities under the EAP in an appropriate format at a priority.

The technical aspects of the EAP consist of preventive action to be taken with regards to the structural safety of the dam. The EAP is drawn at a priority for the regular inspection of the dam. For this purpose, providing an adequate and easy access to the dam site is a necessity. The dam, its sluices, overflows and non-overflow sections should be properly illuminated for

effective operations during night time. Whenever sinkholes, boils, increased leakages, movement of masonry rock, gate failure, rapid rise or fall of the level in the reservoir, rise in the level of reservoir beyond the maximum working level, or wave overrun of the dam crest are observed, the personnel on patrol is required to inform immediately to the Junior Engineer (JE)/Assistant Engineer (AE) for initiation of the execution of EAP. They are required to inform the Engineer-in-Charge and the local administrative authorities. It is desirable if the downstream inhabitants are warned using siren, if available, so as to make them aware the likely imminent danger.

The other preventive measures may include availability of sufficient number of sandbags at several selected downstream locations and logs (for holding and sandbags) and at the dam site, one tractor, two motor boats, gas lanterns, Manila ropes and life jackets. Areas from where the labor can be mobilized should be chalked out at a priority. In addition to these, public participation in the process of execution of the EAP may further help in amelioration of the adverse impacts of the likely disaster. For this, it is necessary that the public should be made aware of its responsibilities.

10.11.5.5 Preventive Action

Once the likelihood of an emergency situation is suspected, action has to be initiated to prevent a failure. The point at which each situation reaches an emergency status shall be specified and at that stage the vigilance and surveillance shall be upgraded both in respect of time and level. At this stage a thorough inspection of the dam should be carried out to locate any visible sign(s) of distress.

Engineers responsible for preventive action should identify sources of equipment needed for repair, materials, labour and expertise for use during an emergency. The amount and type of material required for emergency repairs should be determined for dam, depending upon its characteristics, design, construction history and past behavior. It is desirable to stockpile suitable construction materials at appropriate sites. The anticipated need of equipment should be evaluated and if these are not available at the dam site, the exact location and availability of these equipment should be determined and specified. The sources/agencies must have necessary instructions for assistance during emergency. Due to the inherent uncertainties about their effectiveness, preventive actions should usually be carried out simultaneously with the appropriate notification on alert situation or a warning situation. The flow chart of the responsibilities of Project Proponent and Civil Administration, District Dehradun is shown in **Figure-10.19**.

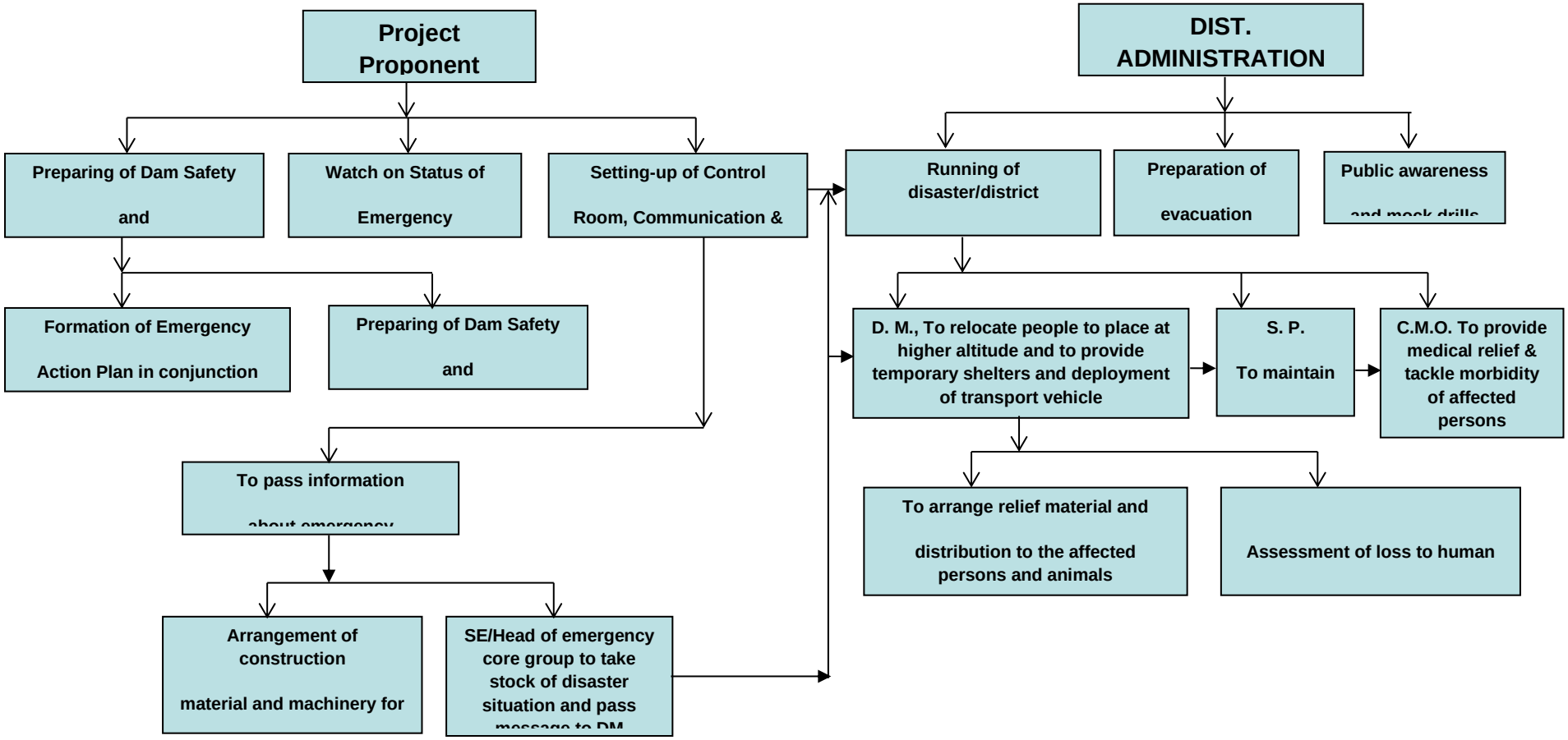


Figure 10.19 : Flow Chart of Responsibilities

10.11.5.6 Communication System

An effective communication system and a downstream warning system are absolutely essential for the success of an emergency preparedness plan. The difference between a high flood and dam-break situation must be made lucidly clear to the downstream population.

10.11.5.7 Evacuations Plans

Emergency Action Plan includes evacuation plans and procedures for implementation based on local needs. These could be:

- Demarcation / prioritization of areas to be evacuated.
- Notification procedures and evacuation instructions.
- Safe routes, transport and traffic control.
- Safe areas/shelters.
- Functions and responsibilities of members of evacuation team.

Any precarious situation during floods will be communicated either by an alert situation or by an alert situation followed by a warning situation. An alert situation would indicate that although failure of flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the dam. It would normally include an order for evacuation of delineated inundation areas.

10.11.5.8 Evacuation Team

It will comprise of following official / Representative:

- District Magistrate (D. M.)/his Nominated officer (To peacefully relocate the people to places at higher elevation with state administration).
- Engineer in charge of the project (Team Leader)
- Superintendent of Police (S. P.)/Nominated Police Officer (To maintain law and order)
- Chief Medical Officer (C. M. O.) of the area (To tackle morbidity of affected people)
- Sarpanch/Affected village Representative to execute the resettlement operation with the aid of state machinery and project proponents.
- Sub committees at village level

The Engineer-in-Charge will be responsible for the entire operation including prompt determination of the flood situation time to time. Once the red alert is declared the whole state machinery will come into swing and will start evacuating people in the inundation areas delineated in the inundation maps. For successful execution, annually demo exercise will be done. D. M. is to monitor the entire operation.

10.11.5.9 Public Awareness for Disaster Mitigation

In addition, guidelines that have to be followed by the inhabitants of flood prone areas, in the event of flood resulting from dam failure, which form part of public awareness for disaster mitigation may also include following:

1. Listen to the radio for advance information and advice.

2. Disconnect all electrical appliances and move all valuable personal and household goods beyond the reach of floodwater, if one is warned or if one suspects that flood waters may enter the house.
3. Move vehicles, farm animals and movables goods to the higher place nearby.
4. Keep sources of water pollution i.e., insecticides out of the reach of water.
5. Turn off electricity and LPG gas before one has to leave the house.
6. Lock all outside doors and windows if one has to leave the house.
7. Do not enter floodwaters.
8. Never wander around a flood area.

10.11.5.10 Notifications

Notification procedures are an integral part of any emergency action plan. Separate procedures should be established for slowly and rapidly developing situations and failure. Notifications would include communication of either an alert situation or an alert situation followed by a warning situation. An alert situation would indicate that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the dam. It would normally include an order for evacuation of delineated inundation areas.

10.11.5.11 Notification Procedures

Copies of the EAP that also include the above-described inundation map are displayed at prominent locations, in the rooms and locations of the personnel named in the notification chart. For a regular watch on the flood level situation, it is necessary that the flood cells be manned by two or more people so that an alternative person is always available for notification round the clock. For speedy and unhindered communication, a wireless system is a preferable mode of communication. Telephones may be kept for back up, wherever available. It is also preferred that the entire flood cells, if more than one, are tuned in the same wireless channel. It will ensure communication from the dam site to the control rooms. The communication can be established by messenger service in the absence of such modes of communication.

10.11.5.12 Management after receding of Flood Water

It is to be accepted that in the event of dam break, even with maximum efforts, the loss of human lives, livestock and property would be inevitable. Under such a scenario, a massive effort would be used by various government agencies to provide various relief measures to the evacuees. Formulation of a plan delineating such measures is beyond the scope of work of this document. However, some of the measures which need to be implemented are listed as below: -

- Provision of various food items and shelter to the evacuees.
- Provision of fuel for various evacuees.
- Provision of adequate fodder supply.
- Arrangements for potable water supply.
- Commissioning of low-cost sewage treatment and sanitation facilities, and disposal of treatment sewage.

- Expeditious disposal of dead bodies human and livestock.
- Immunization programmes for prevention of outbreak of epidemics of various water related diseases.
- Adequate stocks of medicines of various diseases, especially water-related diseases.

10.11.6. *Flood Forecasting*

The importance of flood forecasting is paramount in a dam break scenario, by overtopping, when little or no reaction time is left for the people to evacuate to safe places. Effective and accurate flood warning can facilitate the evacuation of people living in flood zone, their property and livestock, opportune maintenance and early alerting of emergency services besides exercising legitimate control by adjusting downstream releases from reservoir / ponds or achieving the balance reservoir. An advance warning of approaching flood allows suitable reservoir operation for moderating its intensity / peak and also helps in ensuring full storage and for flood relief purposes.

The catchment of Umngot river, up to the proposed dam site, extends approximately 304 sq km in area. River flows are constituted of two main natural components viz., run-off resulting from precipitation and base flow derived from spring flows. Due to mountains topography, the excessive bed slope causes rapid run-off from the contributing hill torrents to the main river. There is no extensive network of meteorological station, rain gauge; snow-gauge; gauge and discharge sites in the catchment area. Many of the sub-watersheds within the catchment are un-gauged. Currently flood warning relies on issuing of alerts when the river level at a few location reaches is within a few meters below the high flood levels observed in the past. Sometime these warnings may be accurate but due to very little lead time between the HFL being very fast approached and the commencement of flooding. Due to the existence of fertile agricultural land and its expansion along the river banks and concentration of population in the region of submergence area, there is a need for developing an operational flood forecasting system as a part of preparedness strategies for disastrous flood events by providing advance warning several days ahead such that the public and the district authorities have adequate time at their disposal without being panicky.

Due to morphological characteristics, the flood plains and the area near to the river / stream banks, classified under land use class agriculture and settlement, are more prone to the flood hazards. In such area's delineation of flood zone and its height besides detecting the characteristics of floods in different return periods is most significant. Thus, flood zonation is not only essential in respect of various development activities in the likely inundation area, but also for study of ecological and environment impacts. For the study of flood zonation, within the likely inundation area, for different time periods of 2, 5, 10, 25, 50 and 100 years, topography maps at 1:1000 scale shall have to be developed.

All forms of flood forecasting use some type of trigger mechanism to anticipate when the water level of the river at the flood risk area shall exceed the threshold. When the trigger reaches a predetermined level that is less than the threshold, a warning is triggered. In case of a small river, a rainfall-runoff based model may be adequate within reasonable limits of accuracy. In case of large rivers, forecasting of discharge by upstream stages, with a high degree of sophistication is involved. The main aim is to assess the future output at different time as accurately as possible, i.e., within narrow error bonds, starting with measurements of present and past input quantities. Interaction

between a comprehensive hydrological model and geographical information system (GIS) technique provides a better forecasting tool. The main requirement of a hydrological model is description of flow channel characteristics and land surface as input data to the watershed model. The flood zonation is actualizing, development and perfection of the applied engineering hydrology and its aim is to acquire a real time rainfall data and river flow by short wave, radio and satellite network, and using them tin rainfall runoff models to forecast.

For enabling GIS based flood forecasting using hydrological model, a network of meteorological station, rainfall and snowfall gauges, gauge and discharge sites equipped with latest state-of-the-art gadgets, meteorological radar shall have to be established. Some of the flood forecasting methods and models are described as under

10.11.6.1 State-of-the-art hydrological modelling

The development of hydrological models started in the 60s and was enhanced by the advance of high-speed computers and by the demand imposed by advanced water management engineering projects. Due to computer limitations and lack of spatial information, lumped models were initially applied. Spatial variability of the characterization of the landscape, hydro-meteorological forcing, or initial conditions were not explicitly accounted for in this type of formulation. To overcome these weaknesses, effective parameters were calibrated based on the hydrograph at the outlet of the basin. Parameter calibration guaranteed good fit and a correct overall mass balance but Sacramento Soil Moisture Accounting Model which is the main model used for river forecasting by the National Weather Service River Forecast Centers across the United States.

10.11.6.2 Stochastic models for real time flood forecasting

Several stochastic/time series models have been proposed for modeling hydrological time series and generating synthetic stream flows. The time series models are considered to be most suited for real time forecasting as on-line updating of model forecasts and parameters can be achieved using various updating algorithm. It has been observed that the dynamic stochastic time series models are most suitable for online forecasting of floods. These models also provide a means for the quantification of the forecast error, which may be used to calculate the risks involved in the decisions based upon these forecasts. Further, these models can be operated even with interrupted sequences of data and easy to implement on computer and other computing devices.

10.11.6.3 Artificial neural network models for real time flood forecasting

The ANN model has wide applicability in Civil Engineering applications and many research papers have been published on its application. The use of ANN in real time flood forecasting is of very recent origin and is still in the evolution stage. Recently Xiong and O'Connor (2002) studied four updating models for real time flood forecasting, in which the authors have shown that the use of ANN model as forecast error update model has in fact not improved the real time flow forecasting efficiencies over that of the standard AR model.

10.11.6.4 Fuzzy logic techniques for real time flood forecasting

Unlike mathematical models that require precise knowledge of all the contributing variables, fuzzy logic, on the other hand, offers a more flexible, less assumption dependent and self-adaptive approach to modelling flood processes, which by their nature are inherently complex, non-linear and dynamic. Fuzzy Logic based model can be used to model process behavior even with incomplete information. Fuzzy logic is widely regarded as a potentially effective approach for effectively handling non-linearity inherently present in the hydrological processes.

10.11.6.5 Use of remote sensing and GIS in flood forecasting

Ranaee et al. (2009) He had done flood routing in two branches of ZOSHK river using HECGeoHMS, HEC-HMS and MIKE 11 software. They used HEC-GeoHMS software to prepare required statistics for rainfall-runoff modelling in HEC-HMS. Later on, they used the output information of HEC-HMS model as input data for flood routing modeling in MIKE11 software. Finally, they calibrated computed statistics of MIKE 11 software in compare with observed data in hydrometric station which was located in that river outlet. They suggested a suitable procedure for flood routing in rivers with uncompleted initial and boundary condition. Survey of inundation area at 1:1000 scales with 1.0 meter shall have to be conducted. For meeting the cost of GIS based flood forecasting a sum of Rs. 20 Lakh is being earmarked.

10.11.7. *District Disaster Management Plan for East Khasi Hills District*

The District Disaster Management Authority (DDMA), East Khasi Hills District, Shillong is responsible for preparation of the District Disaster Management Plan (DDMP) as per Section 31 of the National Disaster Management Act, 2005. The DDMP is a document planned by the DDMA which will serve as a ready reckoner for the District Administration & stakeholders to take up both preparedness and response activities. This plan deals with Hazard, Vulnerability, Capacity and Risk Assessment; Institutional Arrangements; Prevention & Mitigation Measures; Preparedness Measures; Response (from Incident Response System) & Relief Measures; Standard Operating Procedures and Directory of key officials & institutions. The project is covered under East Khasi Hills District and Jaintia Hills District, therefore the management plan for these districts should form a guideline and blue book for the project proponent to strictly follow during the exigency of emergency resulting from disaster from different causes mentioned in the management plan.

10.11.7.1 District Disaster Management Authority

The District Disaster Management Authority (DDMA), shall ensure that the Guidelines for prevention, mitigation, preparedness and response measures laid down by NDMA / SDMA are followed by all Departments of the State Government and the Local Authorities in the District. The power and functions of DDMA are enshrined under section 30 of Disaster Management Act, 2005.

As per the State Policy on Disaster Management, 2013 of the Government of Meghalaya a District Crisis Management Group (DCMG) is constituted with the DC as Chairman with eleven members. The DPO/ADC in charge Crisis Management Group will be the Member Secretary of the DCMG. DDMA shall also constitute advisory committees or sub-committees to assist the DDMA and also enable it to make payment to any person associated as an expert with these committees.

10.11.7.2 Incident Response System (IRS)

The Incident Response System (IRS) is an effective mechanism for reducing the scope for ad-hoc measures in response. It incorporates all the tasks that may be performed during DM irrespective of their level of complexity. It envisages a composite team with various Sections to attend to all the possible response requirements. The IRS identifies and designates officers to perform various duties and get them trained in their respective roles. Incident Response Team (IRT) is constituted at the District level and will be instructed to constitute at Sub-Division & Block levels. Local Authorities include the District Council, Rang bah Shnong, Municipal Board, Cantonment Board and Town/Urban Planning Authorities. These bodies will prepare DM plans in accordance with the Guidelines of NDMA/SDMA/DDMA and will ensure capacity building of their officers and employees for managing disasters, carry out relief, rehabilitation and reconstruction activities in the affected areas.

10.11.7.3 District Emergency Operations Centre (DEOC)

The DEOC is the hub of activity in a disaster situation in the district. The EOC will have the flexibility to expand when demand increases and contract when the situation comes to normal. The DEOC is connected with the SEOC in the upstream which further connects to NEOC and other EOCs in the downstream including other field offices during emergencies. EOC has been set up in the office of the DC with requisite facilities. Similarly, at the Sub-Division and Blocks, Control Rooms are to be set up. Sub-Division Committees, BDMCs and the VDMCs headed by the respective Civil Sub-Divisional Officers, Block Development Officers and the Village Headmen are responsible for overall Disaster Management and to keep in close contact with the DEOC/DDMA.

10.11.7.4 Trigger Mechanism

Govt. of India/State Govt. has authorized agencies generating such early warning signals; in case the matter is very urgent needing action at Block/ Village levels, the alerts and action points will go directly to all concerned. In case the information starts from the place of incident through government agency or community and the institutional mechanism in such cases will be that the concerned village will report to the SDO/BDO/Police Station and the information should reach the DC/DDMA. The DDMA will assess the information and assess the level of disaster. The DEOC will be activated and if required the SEOC will be kept at alert if assistance needed; otherwise, information of the incident will be passed on to the SEOC. The DDMA will convene the meeting of IRT and plan the management of the disaster as Incident Action Plan (IAP). The respective Incident Response Teams (IRTs) will be rushed to the site for effective management.

10.11.7.5 Reporting- First Information Report & Daily Situation Report

DEOC shall send First Information Report immediately to SEOC and all designated authorities/agencies. FIR shall invariably give an account of the severity of the disaster, damage & loss caused, locally available capacities, priority. The First Information Report on occurrence of natural calamity shall be sent to SEOC, NEOC and MHA, Government of India within maximum 24 hours of occurrence of calamity.

10.11.7.6 Responsibility Matrix for Emergency Response Functions

The responsibility matrix of task/activity for emergency response functions during emergent breach situation is shown in **Table 10.56.**

Table 10.56 : Responsibility Matrix

Emergency Status	Task/Activity	Department/Agency
Normal Flood, Level -I, II Emergency	Convening a meeting of the DDMA official, ESFs, EOC and other concerned institutions to take stock of department wise preparations.	DEOC/DDMA
	Take stock of functioning of the EOC and Control Rooms	DEOC/DDMA
	Guarding of weak points	MePGCL
	Rain-recording and submission of rainfall reports	Water Resources Dept.
	Communication of gauge-readings	Water Resources Dept.
	Dissemination of weather reports and flood bulletins issued by the India Meteorological Centers & Central Water Commission	DEOC/DDMA

	Deployment of boats at strategic points, arrangement and use of power/motor boats	DEOC/DDMA
	Installation of temporary Police Wireless Stations and temporary telephones in flood-prone areas	DEOC/DDMA/Police
	Storage of food in interior, vulnerable strategic and key areas and arrangements for their safety	DEOC/DDMA/Food Supplies Dept.
	Arrangements of dry food stuff, essential medicines and other necessities of life	DEOC/DDMA/Food Supplies Dept.
	Appropriate measures for Health, Veterinary services etc.	Health & Animal Dept.
	Identification /Selection of flood shelters	DDMA/DEOC
Disaster	Report the occurrence of breech of dam / flood to DDMA, Heads of all line departments, ESFs, IRTs	DEOC
	Establish communication links by activating alternate communication equipment's i.e., satellite phone, HF/ VHF set, HAM radio, VSAT etc.	DEOC/DDMA, MPRO, NIC
	Deploy mobile emergency communication unites to affected areas for establishing communication link	DEOC, BSNL
	Verify the authenticity of the flood event from agencies like IMD, MePGCL, Water Resource Dept, block level officers, police and fire department etc.	DDMA/DEOC/ MePGCL
	Organize and dispatch the SAR teams to the affected areas	DEOC/DDMA
	Ask for SDRF/NDRF/Army assistance as per requirement	DEOC/DDMA
	Relief measures by non-official and voluntary organizations may be enlisted as far as possible.	DEOC/DDMA
	Organize relief camps and flood shelters	DEOC/DDMA
	Provision of safe drinking water to the affected communities	PHE Dept.
	Organize controlled kitchens to supply foods initially at least for 3 days.	Food supplies Dept., DDMA
	Provision of sanitation and hygiene facilities	PHE Dept, NGOs & Health dept.
	Provision of health assistance and medical service	Health dept.
	Grant of emergency relief to all the affected people	DEOC/DDMA, Food Supplies Dept, Health dept.
	Submissions of daily reports and disseminate correct information through mass media and district website to avoid rumors	DEOC/DDMA
	Repairs and reconstructions of infrastructural facilities such as roads, embankments, resettlement of flood prone areas.	Line Dept.
	Maintain constant communication with the onsite EOC	DEOC/DDMA

	Initiate relief distribution and recovery actions	DEOC/DDMA, Line Dept.

10.11.7.7 Equipment/Resources

The following resources/equipment shall be procured and maintained by the Project proponent **(Table 10.57**).

Table 10.57 : Inventory of Equipment

S. N.	Equipment/Resources	No/Specifications
1	Concrete Cutter	To Cut Angle Iron and Steel
2	Generator	4/Diesel (250KVA)
3	Search Light 2 km Range	2km 10 Hrs. Battery Backup
4	Public Announcement System	Speaker and Mike
5	Public Announcement System 16 Amp	Cordless System
6	Breaker Accessories	Different Sizes
7	Ladder	5 Number 15 Feet
8	Driller	2 No
9	Tarpaulin	10 No
10	JCB	2
11	Recovery Vehicle	1
12	Trucks	2
13	Tata Pick Up	2
14	Motor Boats	2
15	Manilla Ropes	10 X 100 Ft
16	Manual Digging Equipment	50
17	Tree Cutter	5

10.11.8. ***Cost Estimate***

The budget for different activities required to be carried out for mitigation and prevention of dam break hazard exclusively from the dam is given in **Table 10.58**.

Table 10.58 : Cost Estimate for Implementing DMP

S. N.	Particular	Cost (Rs. Lakh)
1.	Installation of alert system in control room	1.0
2.	Setting up of communication system between dam and d/s settlements	2.0
3.	Public information system	1.0
4.	Flood forecasting	20.0
5.	Setting up a seismic observatory	20.00
6.	Training and miscellaneous	1.00
7	Equipment	30.00
Total		**75.00**

10.12. Water & Air Quality Management Plan

10.12.1. *Control of Air Pollution*

10.12.1.1 Impacts on Air Quality

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

- Fuel combustion in various construction equipment, e.g., heavy earth movers, loaders, drillers, rock bolters, diesel generating sets, compressors etc.
- Fugitive emissions from stone aggregate crushers.
- Drilling and blasting
- Impacts due to vehicular movement

a. Pollution due to fuel combustion in various equipment's

The running operation of various construction equipment's involves combustion of fossil fuel for running the engine. Normally, diesel is used in such equipment. The major pollutant, which gets emitted as a result of diesel combustion, is SO2. The PM10 emissions are minimal due to low ash content. Based on past experience in similar projects, PM10 and SO2 are not expected to increase significantly. Thus, in the proposed project, no significant impact on ambient air quality is expected as a result of operation of various construction equipment's.

b. Emissions from various crushers

The operation of one crusher (200 tph) during the construction phase is likely to generate fugitive emissions, which can move even up to 1 km in predominant wind direction. During crushing operations, fugitive emissions comprising of the suspended particulate matter will be generated. There could be marginal impacts to settlements close to the site at which crushers are commissioned. However, based on past experience, adverse impacts on this account are not anticipated. The labour camps, colonies, etc. shall be located outside the impact zone (about 1.5 to 2 km) of the crusher plant.

c. Impacts due to vehicular movement

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

10.12.1.2 Mitigation Measures

a) Control of Emissions

Minor air quality impacts will be caused by emissions from construction vehicles, equipment and DG sets, and emissions from transportation traffic. Frequent truck trips will be required during the construction period for removal of excavated material and delivery of concrete mix and other equipment and materials. The following measures are recommended to control air pollution:

- The contractor will be responsible for maintaining properly functioning construction equipment to minimize exhaust.
- Construction equipment and vehicles will be switched off when not used for extended periods of

time.

- Unnecessary idle running of construction vehicles to be prohibited.
- Effective traffic management to be undertaken to avoid significant delays in and around the project area.
- Road damage caused by sub-project activities will be promptly attended to with proper road repair and maintenance work.

b) Air Pollution control due to DG sets

DG sets should be located from the consideration of prominent and first prominent wind direction so that on the downwind direction the human habitats are least impacted by the flue gas emissions. The norms prescribed by the CPCB in respect of fixing the minimum stack height for generator, should be strictly complied with. In no case, it should be lesser than the 20% of the under root of generator capacity in KVA added to the height of the building where it is installed. The emission norms in India cover CO, NOx, PM, and HC and are specified based on the number of grams of these compounds present in diesel exhaust when one kilowatt-hour of electricity is generated. These norms have been revised in December 2013 (G.S.R. 771 (E) / 11th Dec 2013 notification), its amendment vide GSR 232(E) dated 31st March,2014 and GSR(E) dated 7th March ,2016 and have come in force from 1st July 2016. These norms are presented in **Table 10.59.**

Table 10.59 : Emission limits for DG sets prescribed by CPCB

Power Category	Emission Limits (g/kWh)			Smoke Limit (Light absorption co-efficient per meter)
	NOx+THC or NOx+NMHC or RHC	CO	PM	
Up to 19 kW	≤ 7.5	≤ 3.5	≤ 0.3	≤ 0.7
More than 19 kW up to 75 kW	≤ 4.7	≤ 3.5	≤ 0.3	≤ 0.7
More than 75 kW up to 800 kW	≤ 4.0	≤ 3.5	≤ 0.2	≤ 0.7

c) Dust Control

The project authorities will work in close association with representatives from the community living in the vicinity of project area to identify areas of concern and to mitigate dust-related impacts effectively (e.g., through direct meetings, utilization of construction management and inspection program, and/or through the complaint response program). To minimize issues related to the generation of dust during the construction phase of the project, the following measures have been identified:

- Identification of construction limits (minimal area required for construction activities).
- When practical, excavated spoils will be removed as the contractor proceeds along the length of the activity.
- When necessary, stockpiling of excavated material will be covered or staged offsite location with muck being delivered as needed during the course of construction.
- Excessive soil on paved areas will be sprayed (wet) and/or swept and unpaved areas will be sprayed and/or mulched. The use of petroleum products or similar products for such activities will be strictly prohibited.
- Contractors will be required to cover stockpiled soils and trucks hauling soil, sand, and other loose materials (or require trucks to maintain at least two feet of freeboard).

- Contractor shall ensure that there is effective traffic management at site. The number of trucks/vehicles to move at various construction sites to be fixed.
- Dust sweeping - The construction area and vicinity (access roads, and working areas) shall be swept on a daily basis or as necessary to ensure there is no visible dust. Kutcha surface / earthen roads shall be sprinkled with water twice a day.
- Dust mufflers shall be provided at batching plants and stone aggregate crushers.

10.12.1.3 Implementing Agency

Various management measures required for control of air pollution need to be included in the Tender Document for the Contractor involved in construction activities. The same shall be monitored on a regular basis by the project proponents. Considering an expenditure of Rs. 2000/day for 240 working days annually (excluding rainy season of 4 months), a sum of Rs. 28.80 lakh has to be earmarked under air pollution control measures for copious sprinkling on roads for dust suppression. The cost for water has been assessed @ Rs 20/kid for construction purpose (Appendix-1, Meghalaya Water Supply Rules).

10.12.2. *Impacts on Noise Levels*

In a water resource project, the impacts on ambient air noise levels are expected only during the project construction phase, due to operation of heavy earth moving machinery, etc. Likewise, noise due to quarrying, blasting, vehicular movement will have some adverse impact on the ambient noise levels in the area.

10.12.2.1 Mitigation Measures

The contractors will be required to maintain proper functioning of equipment and comply with occupational safety and health standards. The construction equipment will be equipped with noise suppression devices and properly maintained mufflers.

- Vehicles to be equipped with mufflers recommended by the vehicle manufacturer.
- Staging of construction equipment and unnecessary idling of equipment within noise sensitive areas to be strictly avoided.
- Use of temporary sound fences or barriers with acoustic material at sensitive locations
- Notification shall be provided at a conspicuous place close to residential areas within 100 meter of major noise generating activities. The notification will describe the noise abatement measures that will be implemented.
- Monitoring of noise levels will be conducted during the construction phase of the project. In case of exceeding of pre-determined acceptable noise levels by the machinery will require the contractor(s) to halt work and remedy the situation prior to continuing construction.

The following Noise Standards for DG sets are recommended for the running of DG sets during the construction:

- The maximum permissible sound pressure level for new diesel generator sets with rated capacity up to 1000 KVA shall be 75 dB(A) at 1 m from the enclosure surface.
- Noise from the DG set should be controlled by providing an acoustic enclosure or by treating the enclosure acoustically

- The Acoustic Enclosure should be made of CRCA sheets of appropriate thickness and structural/ sheet metal base. The walls of the enclosure should be insulated with fire retardant foam so as to comply with the 75 dB(A) at 1m sound levels specified by CPCB, Ministry of Environment & Forests.
- The acoustic enclosure/acoustic treatment of the room should be designed for minimum 25 dB(A) insertion loss or for meeting the ambient noise standards, whichever is on the higher side.
- The DG set should also be provided with proper exhaust muffler with insertion loss of minimum 25 dB(A).
- Proper efforts to be made to bring down the noise levels due to the DG set, outside its premises, within the ambient air noise requirements by proper placing and control measures.
- A proper routine and preventive maintenance procedure for the DG set should be set and followed in consultation with the DG set manufacturer which would help prevent noise levels of the DG set from deteriorating with use.

10.12.2.2 Mitigation Measures of Noise from Crushers

Based on literature review, noise generated by crushers is in the range of 79-80 dB(A) at a distance of 80 m from the crusher. Thus, noise level at a distance of 160 m from the crusher shall be of the order of 74 dB(A). The exposure to labor operating in such high noise areas shall be restricted up to 30 minutes on a daily basis. Alternatively, the workers need to be provided with ear muffs or plugs, so as to attenuate the noise level near the crusher by at least 15 dB(A). The exposure to noise level in such a scenario is limited up to 4 hours per day.

It is known that continuous exposure to noise levels above 90 dB(A) affects the hearing of the workers/operators and hence has to be avoided. Other physiological and psychological effects have also been reported in literature, but the effect on hearing has been specially stressed. To prevent these effects, under OSHA Noise Exposure Standards vide Table G-16, has provided a 90 dB(A) criterion for an eight-hour time weighted average PEL and is measured using a 90 dB(A) threshold (i.e., noise below 90 dB(A) is not integrated into the TWA. The table reproduced as **Table 10.60** limits short- term noise exposure to a level not greater than 115 dB (A) for up to 15 minutes

Table 10.60 : Maximum Exposure Periods specified by OSHA

Maximum. equivalent continuous noise level dB(A)	Unprotected exposure period/day for 8hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	0.5
115	0.25 No exposure permitted at or above this level

The workers deployed at such locations where the noise levels are high shall be provided with earplugs. The cost of 400 earplugs including its one-time replacement @ Ra 150.00 each shall be Rs.1.20 lakh.

10.12.3. *Control of Water Pollution During Construction*

During project construction phase, sufficient measures need to be implemented to control the problem of water pollution from various sources. The sewage generated from various labour camps

is proposed to be treated in an oxidation ditch, prior to its disposal. However, efforts shall be made to discharge the treated effluent only in these water bodies, which are not used for meeting domestic water requirements. It is proposed to provide three 10KLD capacity STP for project colony and labour colonies for which an amount of Rs 30 lakh @ Rs10 lakh each has been earmarked. The rates are based on prices of Richa Environmental Service Pvt. Ltd(www.richaservices.com).

The construction activities would require a crusher to crush large lumps of rocks to the requisite size for coarse as well as fine aggregates. The effluent generated from these crushers will have high-suspended solids. The effluent needs to be treated before disposal. Settling tanks of appropriate size for treatment of effluent from various crushers should be provided.

During tunneling work the ground water flows into the tunnel along with construction water, which is used for various works like drilling, shortcreting, etc. The effluent thus generated in the tunnel contains high suspended solids. Normally, water is collected in the side drains and drained off into the nearest water body without treatment. It is recommended to construct a settling tank of adequate size to settle the suspended impurities. Effluents are expected to be generated from adit locations. The sludge from the various settling tanks can be collected once in 15 days and disposed at the site designed for disposal of municipal solid wastes from the labour camps. The sludge after drying could also be used as cover material for landfill disposal site. An amount of Rs.2.00 lakh has been earmarked for construction of settling tanks.

10.12.4. *Control of Water Pollution During Construction*

The cost of mitigative measures suggested for control of water, air and noise is given in **Table 10.61**.

Table 10.61 : Maximum Exposure Periods specified by OSHA

S. No.	Particulars	Amount (Rs. Lakh)
1.	Control of air pollution	28.80
2.	Control of noise pollution	1.20
3.	Control of water pollution	32.00
Total		**62.00**

10.13. Public Health Management Plan

10.13.1. *Introduction*

From the information collected, it has been revealed that no ethnic disease is associated with people of the region but acute dysentery, gastrointestinal problems, acute respiratory infection are common endemic diseases prevalent in the area.

The lung diseases, amoebiasis, diarrhea, bacillary dysentery and respiratory diseases are common diseases prevalent in the area. Acute bacterial and viral respiratory infections are affecting large number of the people in this zone, which requires advanced medical treatments to reduce the number of incidences. The nearby government run medical facilities available in the project area is PHC Mawkynrew

10.13.2. *Likely Impacts on Human Health Due to The Project*

Construction of the proposed project may cause the following impacts on the health of local residents and the workforce: -

(i) Fuel and dust emission may cause respiratory problems like asthma, for which mitigative measures like wet excavation of exposed surfaces, battery operated muck cars in underground excavation may be deployed. Frequent water sprinkling at least thrice a day shall be carried out on haul roads in the project activity area. All approach roads to site shall be metaled.

(ii) The scheme being storage type involving a dam, where the flowing discharge is made to impound upstream of the dam to be diverted through underground conveyance system for continuous generation of power. Thus, the pond level shall be subjected to fluctuation and the chances of water surface being still are not there. However, localized stagnation in borrow pit areas is expected during construction in some of areas. This may require sprinkling of antibacterial/insecticides to control propagation of bacteria related disease.

(iii) The influx of labour-force during construction warrants proper sanitation and hygiene facilities to avoid diseases related to sewage pollutants such as Typhoid, cholera & gastroenteritis.

10.13.3. *Proposed Health Management Plan*

Based on the impact evaluation following mitigation measures are proposed to be adopted for management of health environment: -

10.13.3.1 Awareness Programme

The project authorities should undertake various awareness programmes by organizing camps and poster presentation etc. in the directly affected areas to bring about awareness on prevention and control of various diseases such as Malaria, Dengue, Cholera, Gastroenteritis, STD, AIDS, and Cancer etc. Special emphasis should also be given to provide awareness on family planning to the local people. Special awareness programmes should be undertaken to explain to people about diseases like Tuberculosis (TB) and Asthma.

10.13.3.2 HIV / AIDS

A virus known as Human Immunodeficiency Virus (HIV) causes AIDS. This virus is what destroys the immune system. HIV can also invade the central nervous system causing severe neurological problems. HIV can also invade the central nervous system causing severe neurological problems. It can take up to 10 years after a person is infected with HIV to develop AIDS. An HIV-infected person can look perfectly normal and healthy. In addition, anyone infected with HIV can infect another person. HIV is spread through certain body fluids, mainly: · Blood, Semen, Vaginal secretions and breast milk. HIV is spread by certain behaviors and/or situations, which inter-alia include sexual contact (anal, vaginal, and oral) with infected person, sharing injection equipment, blood or its components and Infected mother to infant. The following measures are recommended for AIDS control:

Prevention

Awareness programme educating people to enable to make life saving need to be implemented. Intravenous drug users to be informed about the perils of sharing of needles. Use of various modes of media to educate people on AIDS, its nature, transmission and prevention. People in high-risk groups to be refrained from donating blood, body organ, etc. Strict sterilization practiced to be ensured in hospitals and dispensaries. Pre-sterilized or disposable syringes to be used as far as possible.

Anti-Retroviral Treatment

At present, there is no vaccine or cure for treatment of HIV infection/AIDS. However, drugs that suppress the HIV infection rather than its complications can be used for prolonging the life of terminally ill patients.

Primary Health Care

AIDS touches all aspects of primary health care, including mother and child, family planning and education. Thus, it is recommended that the AIDS control programme integrate various related issues into country's primary health care system. The AIDS control and awareness programs, developed by National Aids Control Organization (NACO) need to be strictly implemented in the project area as w ell. In addition to primary health care, it is also recommended that the workers should be made aware not to hurt the traditional cultural and regions customs and practices.

10.13.3.3 Asthma

Asthma is a long-term (chronic) disease of the airways which are involved in carrying air in and out of the lungs. Its symptoms are caused by inflammation, which makes the airways red, swollen, narrower and extra sensitive to irritants. This leads to recurrent attacks of wheezing, breathlessness, chest tightness and coughing. Asthma does not stay the same, but changes over time and every person with asthma has a good and bad days. However, if asthma is properly treated, one can enjoy long periods without symptoms or attacks. The causes of asthma are not fully understood. Asthma is usually caused by a mixture of hereditary (which a person is born with) and environmental factors.

Allergens from house dust mites and pets are the most common causes, but many other allergens, such as pollen and moulds, can cause asthma. Some patients with asthma have no obvious allergies.

Treatment of asthma requires two types of medicines, preventers and relievers. Preventers are medicines that prevent asthma attacks from starting. The most effective and most commonly used preventer medicines are inhaled glucocorticosteroids. Reliever medicines, like inhaled salbutamol, salmeterol etc., provide rapid relief from an asthma attack by quickly opening the narrowed airways (dilating the bronchi).

10.13.3.4 Tuberculosis (TB)

It is a communicable, but curable bacterial infection caused by Mycobacterium tuberculosis. The lungs are primarily involved, but the infection can spread to other organs.

TB is spread through the air when a person with TB in the lungs or throat coughs or sneezes, sending TB germs in the air. When other people breathe in these germs, they may become infected. The primary stage of the infection is usually asymptomatic (without symptoms). Pulmonary TB develops in the minority of people whose immune systems do not successfully contain the primary infection. In this case, the disease may occur within weeks after the primary infection. TB may also lie dormant for years and reappear after the initial infection is contained.

This TB infection becomes 'disease' when the body's defenses are weakened, due to aging, a serious illness, stressful event, drug or alcohol abuse, HIV infection (the virus that causes AIDS) or other conditions. When inactive TB germs become active, they multiply and damage the lungs or other parts of the body and the disease develops. Only about 10% of people infected with TB germs develop TB disease.

10.13.3.5 Malaria

Once adult mosquitoes have emerged, the ambient temperature, humidity and rains will determine their chances of survival. To transmit malaria successfully female anopheles must survive long enough after they have become infected (through a blood meal on an infected human) to allow the parasite they know harbour to complete their growth cycle. That cycle takes 9-21 days @ 250 C. Below a minimum ambient temperature (150 C for plasmodium vivax, 200 C for P falciparum) the cycle cannot be completed and malaria cannot be transmitted.

Spray Operation

There shall be regular fumigation, fogging, or sprays of insecticides in the areas where water is likely to be stagnant, to prevent the growth of malarial larvae. As per modified plan of operation SP is required to be sprayed in project area. The requirement of insecticide is as follows:

- SP 5%-37.5 M.T per million populations for two rounds
- SP 10%-18.75 M.T per million populations for two rounds

To undertake the spray operation field workers are required. One squad consisting of one superior field worker and five field workers each spraying squad need two stirrup pumps which will cover 25 t0 30 houses per day per pump

Reduce Exposure to Mosquitoes

Encourage prevention of mosquito-borne disease by helping people by reducing their exposure to mosquitoes during the day and at night. Work with the malaria control programme in the project area to:

- Popularize the use of bed net programme
- Conduct community education on the proper use of bed nets and how to avoid dawn to dusk mosquito bite. Regular spray of insecticides.
- Implementation of various management measures for vector control (drainage, filling, of breeding, sites) as outlined in the earlier section
- Vector Control is still one of the major measures to control malaria in endemic area.

Following measures are recommended:

Anti-Adult Measures

- Residual spraying with insecticides.
- Space application of insecticides in the form of a fog or mist. The method has proved economical due to ultra-low volume dispersion of pesticides in air.
- Prevention of man-vector contact by use of repellents, protective clothing, and bed nets.

Anti-Larvae Measures

- Use of larvicides at regular intervals
- Reduction of mosquitoes breeding sites by drainage or filling, deepening or flushing,
- Introduction of fish species in permanent water bodies which feed on mosquito larvae.

10.13.4. *Establishment of Project Dispensary*

The project proponent shall develop and maintain a dispensary within the project area, which shall have trained staff, equipment and medicines. Onsite first-aid facility should also be provided in the labour at all the working sites. The capital cost of establishing and development of dispensary at the project site has been covered under sub head "K-building" in the DPR. The hospital facilities would be available to the staff, workers and local people. Free medicines should be distributed to the identified project affected families who shall be provided with identity cards and to the locals. Provision for2 ambulances, which will function around the clock has been made in the DPR, under sub head "Q-Spl T & P". Free facilities of ambulance shall be made available to the project affected families (PAFs) and project labourers and for the people meeting accident on the state highway /district roads. Under subhead "O-Miscellaneous", provision has not been earmarked for O & M charges for ambulances has been included in the DPR. O & M charges for mobile health van have been included in the plan. The cost of providing free veterinary health services in the project-affected villages shall also be provided in the plan. The project authorities should undertake various health care programmes in consultation with State Health Department such as providing vaccination and other primary health care facilities. It is also proposed to provide for chlorination of drinking water in project-affected villages.

10.13.5. *Malaria Control and Vaccination Programme*

The borrow pits caused during construction activities, if not reclaimed, provide habitat ground for mosquito population increase and develop the risk of malaria & elephantiasis during rains. However, proper arrangements should be made and implemented for maintaining hygienic conditions in the area. Besides these, arrangements are proposed to distribute medicines and anti-malarial drugs as and when required. Various vaccination programmes shall be arranged periodically as and when required for the locals of the project area.

10.13.6. *Bio-Medical Wastes from Hospitals*

In view of proposed dispensary to be located at proposed permanent colony in the project area, the hospital waste management should be considered a priority. All kinds of hospital waste are considered as hazardous waste. Hospital waste is generated during the diagnosis, treatment or immunization of human beings. It may include waste like scrap, anatomical waste, culture media, discarded medicines, chemical waste, syringes, swabs, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be serious threat to human health if not managed in a scientific and discriminate manner. It is expected that generation of such hazardous waste will be very less. For management, special type of collection container and incinerator should be placed near the hospital for proper collection and disposal of hospital waste. Hospital waste should be incinerated or buried at isolated, identified sites, strictly in accordance with the provisions of the Biomedical Waste (Management & Handling) Rules2016 and amendment thereof. Any kind of hospital waste should not be either recycled or reused. It is proposed that the bio-medical waste generated in the hospital should be got treated at the nearest CBWTF. For this some annual arrangement for collection, transportation, storage and treatment needs to be made.

10.13.7. *Drinking Water Supply to Local People*

Out of fifteen project affected villages nine villages do not have tap water supply scheme. As per terms of reference the provision of drinking water supply shall be included in the Public Health Delivery Plan. In this backdrop, Jal Jeevan Mission (JJM) was launched on 15.8.2019 by the Prime Minister, in partnership with States, to enable every household in villages to have Functional

Household Tap Connection (FHTC) in the next 5 years. The per household average cost of Rs 7500 has been adopted to arrive at fund requirement under the mission. Under the mission the Centre-State fund sharing pattern shall be 90:10 for NE states. The cost of providing FHTC for each village has been arrived at **Table 10.62.**

Table 10.62 : Budget Estimate for Drinking Water Supply Scheme

S.N.	Name of Village	Number of HH	Cost (Rs lakh)
1	Moosakhia	88	13.20
2	Samanong	32	4.80
3	Sohmynting	526	78.90
4	Mawjatap	123	18.45
5	Mawlang	44	6.60
6	Mawsir	25	3.75
7	Jatah Nonglyer	105	15.75
8	Pashang	46	6.90
9	Umsawwar	71	10.65
Total		**1060**	**159.00**

10.13.8. *Cost Estimate for Health Management Plan*

The details of the expenditure likely to be incurred on the implementation of the Health Management Plan other than the cost of project dispensary are given in **Table 10.63.**

Table 10.63 : Budget Estimate of Health Management Plan

S.N.	Particulars	Amount (Rs. lakh)
1.	Free medicines for labourers, PAF, local people @ Rs. 4.50 lakh per year for 6 years	27.00
2.	O & M charges of mobile health van @ Rs 1.50 lakh/year for 6 years	9.00
3.	Spraying of insecticide @ Rs. 0.50 lakh/year for 6 years	3.00
4.	Health awareness / vaccination camps @ Rs. 1.50lakh/year for 6 years through Zonal Hospital	9.00
5.	Cost of one incinerator	8.50
6.	O & M charges for incinerator @ Rs. 0.50 lakh / year for 6 years	3.00
7.	Providing Veterinary health service for 6 years @ Rs 0.75 lakh/year.	4.50
8	Provision for salary of a doctor and para-medical staff (I compounder+1 nurse) @ 1.50 lakh/month for six years	108.00
9	Provision for Drinking Water Supply Schemes	159.00
10	Cost of collection, transport, storage and treatment through CBWTF	3.00
	Total	**334.00**

10.14. Labour Management Plan

10.14.1. *Introduction*

Construction projects, which invariably engaged large number of contract workers, are highly prone to hazards pertaining to site activities. Generally, the workers come from the rural areas and agricultural background and do not have adequate training in construction safety and some time

workers from varied trades are drawn into construction activities. Thus, workers are exposed to various risks and occupational diseases and health hazards which sometimes cause grave injuries and prolong illness. Therefore, it is incumbent upon the project proponent to have certain safety guidelines for site activities and create awareness among the workers, supervisors and engineers.

The project like any other construction project has significant impact on health and safety during project execution and its operational stage, which need to be managed systematically since the project inception. In construction project, the risk is involved to the labour in various activities like excavation on slope, excavation, quarrying operation, works related to Electrical and Mechanical components, various activities in workshop and machine halls. The project envisages deployment of workforce to the tune of 400 mainly comprising of skilled/semi-skilled/unskilled workers at the peak construction stage.

10.14.2. *Legal Framework for Health and Safety Management*

The following Indian standard listed below contains provision for managing Occupational health and Safety Management **(Table 10.64).**

Table 10.64 : International standards of Health & Safety

S. No	IS No	Title
1	15793:2007	Managing Environment, Occupation Health and Safety Legal Compliance – Requirement of good practices.
2	15883 (part-I) :2009	Guidelines for construction project management.
3	18001:2007	Occupational Health and Safety Management System
4	IS 15883 (Part 5)	Guidelines for construction project Management-Health and Safety Management

As per general requirement under OH&S management system the organization (project proponent) shall establish, document, implement, maintain and continually improve an OH&S management system, in accordance with the requirement of this standard. The organization shall define and document the scope of its OH&S management system.

10.14.3. *Health and management safety requirement*

The project proponent shall have a written statement prescribing the health and safety policy of the organization. The policy shall convey the management commitment and its intent towards health and safety, its implementing organization and arrangement to ensure that the set objectives are met. It shall also provide a framework for establishing, maintaining and periodically reviewing health and safety objectives and targets. The salient aspects which will be covered in the project health and safety plan are:

- Project specific health and safety objectives, targets and programmes in line with health and safety policy;
- Hazard identification and risk assessment;
- Health and safety organization;
- Resources, roles, responsibility and authority;
- General health and safety rules;
- Health and safety requirements to be followed by sub-contractors;

- Operation control procedure;
- Activities requiring work permit system and its procedure;
- Management of traffic safety inside the project;
- Access control of employees;
- Safety of visitors;
- Management of critical activities such as work a height, material handling and working with plant and machinery;
- Ensuring the competency and awareness of the workmen;
- Fire prevention and firefighting plan;
- Emergency preparedness and response plan;
- Traffic management plan;
- Training matrix; and
- Personal Protective Equipment Matrix.
- Health and safety performance monitoring measures such as Inspection, Audit Incident reporting and investigation procedure

10.14.3.1 Resource, Roles, Responsibility and Authority

Project manager shall define, document and communicate the roles, responsibilities and authorities of all personnel like health and safety officer and supervisor who manage, perform and verify activities having an effect on health and safety risks.

The line management personnel who are responsible for execution of activities is directly responsible for health and safety in the work under their control.

Health and safety officers shall administratively report to the project manager and functionally report to the senior health and safety representative of the organization.

Health and safety supervisors shall be engaged to assist the health and safety officers in performing their duties.

Management shall provide adequate resources essential to effectively manage the health and safety management system requirements of the project. The resources shall include human resources, organizational infrastructure, technology and financial resources.

10.14.3.2 Competence, Training and Awareness

It shall be ensured that all employees are competent to perform the assigned work safely on the basis of appropriate education, training or experience. Training needs of the different category of employees shall be identified at the beginning of the project and a training matrix and training plan shall be prepared for implementation. The objective of health and safety Training shall be

- to equip the employee with necessary knowledge and skill to perform the work assigned to him in a safe manner;

- to foster continual improvement; and
- to imbibe safety culture.

After completion of training due procedure shall be followed for obtaining the feedback from the participants on the effectiveness of the training.

10.14.3.3 Health and Safety Reporting

Procedures shall be established for timely recording and reporting of information required for continual improvement of health and safety performance. Reporting procedures shall cover:

- Incident reporting
- Non-conformance reporting

Health and safety performance reporting

- Hazard Identification reporting
- Statutory reporting requirements
- Stakeholder reporting

The recording of reporting of health and safety performance shall be clearly documented in the project health and safety plan

10.14.3.4 Permit to Work Systems

Activities requiring permit to work shall be decided before starting the construction and shall be suitably documented in the project health and safety plan. Some of the activities which may require permit to work are:

- Excavation
- Entry into confined spaces
- Electrical work (HV/LV)
- Opening manholes, covers and grills
- Blasting operation
- Hot work
- Work on plant, machinery and other power-driven equipment.
- Working at height
- Working at night

The project team may establish a permit to work system for any other hazardous activity which they feel need to be controlled administratively for safe execution

10.14.3.5 Certification of Plant and Machinery, Lifting

Tools and Tackles Lifting appliance such as crane, hoist, derrick, winch, gin pole, sheer legs, jack, pulley block and other equipment used for lifting materials, objects or building worker; lifting gear such as ropes, chains, hooks and slings; and other accessories of a lifting appliance shall be tested and

examined by a competent person for the first time. These shall thereafter be tested and examined by a competent person once every year as per the provision of Building and other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 and other relevant central and state rules and regulations. Apart from the above statutory testing and examination, project specific procedures shall be established to ensure the fitness of machinery and equipment being deployed at the project for the first time. Regular Inspections shall be carried out to ensure that machinery and equipment continue to be in safe condition.

10.14.3.6 Fire Prevention and Control

Fire prevention measures such as controlling the ignition source and segregation of flammable materials shall be implemented to prevent fire.

Adequate firefighting facilities such as portable first aid fire extinguishers, fire buckets filled with water and sand, water pipelines and hoses shall be established and maintained regularly.

Firefighting arrangements provided shall be suitable to fight the possible type of fire that may occur depending on the type of flammable material. Fire facilities shall be placed strategically such that they are accessible from any location of the site without travelling for long distances. Employees shall be trained on fire prevention and firefighting measures on a regular basis.

10.14.3.7 Access Control

It is advisable to establish access control measures at the construction project to control movement of workmen and visitors. Access control may be achieved by entry pass, bar-coded cards and biometric systems or other suitable means.

10.14.3.8 Safety of Visitors

Visitors for the project shall be given health and safety induction before they are allowed in to the construction project. It shall include the minimum PPE to be used, hazards and risks at the work area, restricted areas of entry, emergency response arrangements, etc.

10.14.3.9 Traffic and Logistics Management

Traffic management plan shall be prepared as a part of the project health and safety plan at the initial stage of the project to manage the traffic inside the project site. Traffic management plan shall include:

- Measures for segregating pedestrian and vehicle traffic;
- Establish project specific traffic rules such as speed limit and one-way etc.;
- Managing the flow of traffic such that blind zones and hazardous junctions are not present;
- Managing the flow of traffic such that reversing can be avoided as far as possible; and
- Use of traffic control devices such as road humps, convex mirrors, delineators traffic signals and barriers. It shall be planned to deploy flag man, security personnel and traffic marshals at critical areas to regulate traffic.

10.14.4. *Occupational Health Management Plan*

10.14.4.1 Potential Risk of Project Activities

The excavation for the project, by the nature of the activities involved, are accompanied with risk of medium to high degree involving blasting. The risks associated with the project are not hazardous, but if any, they are only accidents and incidents, associated with construction machinery or transportation activity, if adequate controls or safety systems are not adopted. The rock excavation by deploying excavators / JCB/loaders/ rock-breakers besides drilling and blasting and loading on to the trucks by backhoe can have risks of accidents if human failure or errors are not taken care of. The accidents, if any, may not be fatal, but are potential to cause temporary or permanent disabilities. Thus, the need for adequate safety at work places is needed. Some minor incidents like exhaustion, sun-strokes, or other health related incidents may take place, which can be avoided with adequate safety regulations and measures. Transportation of construction material, excavated muck for disposal and crushed stone aggregates to various construction sites are some of the activates associated with accidents on road and at the project site. However, with effective safety measures the accidents can be avoided and prevented.

10.14.4.2 Safety of Machine Use at Project Site

The major machinery to be deployed at site shall be excavators/JCB, Backhoe and loaders which can excavate earth mix with boulders / rock mass and load on to vehicles. The area where machinery shall be operated will be under supervision of trained operators and helpers besides technically qualified foreman to ensure that the machinery is operated as per specified design parameters of the manufacturer. Before the work is initiated every day, the routine check-up especially with regard to its hydraulic systems, mechanical conditions, and other operating systems shall be performed. The movement of trucks/trippers/tractors for loading /transportation of material within the project area and haul road area shall be regulated by a trained supervisor who shall be responsible for the safety of vehicle movement and prevention of accidents or incidents associated with the vehicular movement. All staff working with the construction machinery shall be trained in first-aid and other safety measures, accident or incident prevention and reporting and communication mechanisms.

10.14.4.3 Occupational Health & Safety (OHS)

The excavated material and construction material do not contain any toxic element. Therefore, the likelihood of any health hazard does not arise due to their handling per se. However, the process of excavation / quarrying leads to some health hazards. The dust generated due to excavation loading and movement on Kutcha/riverbed haul road creates air borne dust which has silica contents. The dust is the main pollutant of concern for the workers engaged in the mining activities. The most significant occupational health impacts are Noise Induced Hearing Loss (NIHL) and Occupational Lung Disease (OLD) like allergic rhinitis and asthma due to inhalation of dust. Working in open during summer can expose workers to the direct sun rays causing heat strokes, cramps and burns besides leading to exhaustion. In extreme windy conditions, the dust particles forcing way into the eyes can create itching as well as allergic conjunctivitis of eye. Medical examination of employees at the initial stage and periodically, shall be done by a team of qualified medical officers provided by the project proponent.

The initial medical examination of every person employed in the mine within a period of five years of the date so notified and the said examination shall be so arranged over a period of five years that one fifth of the persons employed at the mine undergo the examination every year. The periodical medical examination thereafter of every person employed in the mine shall be conducted at intervals of not more than five years. In the present case since the lease is only for five years. It is suggested that the

initial medical examination for all workers must be arranged during the first year of appointment and the periodical check-up during fourth and fifth year after the appointment.

Regular medical check-up camps shall also be arranged for detection of occupational diseases and minor disease in the nearby rural population. Free check-up and medicine for treatment for their acute and chronic illness shall be provided. The medical examination schedule is provided in **Table 10.65.**

Table 10.65 : Schedule of Medical Check-up

S. N.	Particular	1- Y	2- Y	3-Y	4-Y	5-Y	Total
1	Initial medical check-up of employees for lung function, audiometric test, tuberculosis and pulmonary disease at the time of appointment	1000	-	-			1000
2	Periodical Medical Check-up of the employees (Audiometric Test, Eye – Check-up, Lung function and respiratory test)	-		400	300	300	1000

10.14.4.4 Occupational Health & Safety Measures to Control Dust Inhalation

- Providing a working environment that is conducive to safety and health.
- The management of occupational safety and health is the prime responsibility of mine management.
- Employee involvement and commitment in the implementation of health and safety guidelines.
- Periodical health check-ups
- Implementing safety and health management system and assessing the effectiveness through periodic audits.
- Monitoring the effects of mining activities on safety and health and conducting regular performance reviews.
- Provision of necessary personal protective equipment.
- Establishing and maintaining a system of medical surveillance for employees
- Ensuring employees at all levels receive appropriate training and are competent to carry out their duties and responsibilities.

All the above precautions would be adopted to prevent dust generation at site and to be dispersed in the outside environment. However, for the safety of workers at site, engaged at strategic locations / dust generation points like loading and unloading points, screening sieve, dust masks would be provided. Dust masks would prevent inhalation of PM10/PM2.5 thereby reducing the risk of lung diseases and other respiratory disorders. Regular health monitoring of workers will be carried out.

10.14.4.5 Noise Induced Hearing Loss (NIHL)

Blasting causes intermittent high level of noises whereas the continuous running of construction machinery / compressors / wagon drills / rock breakers leads to high noise level in the immediate vicinity of the point of noise emission. Hearing conservation programmes exists at all operations. Baseline audiogram forms the basis for future assessment of employees in terms of hearing loss.

Using engineering initiatives to reduce noise at source is the priority management tool. The hearing conservation programme includes the provision of Hearing Protection Devises (HPDs) and annual audiometry examination of all employees. Apart from provision of HPDs emphasis is also laid on training the employees' responsibility to protect his / her hearing.

10.14.4.6 Occupational Lung Diseases (OLD)

There will be regular health camps for all the workers and nearby rural people. Lung function tests, chest X-rays etc. shall be carried out and any health disorders will be evaluated. The budget shall be earmarked for the necessary protective devices and training needs.

10.14.4.7 Cost Estimate

For initial and periodical medical check-up of employee, who are engaged at the active construction site, budgetary provision of Rs. 1000 employee/year shall be made. The provision at this stage is being made for 1000 skilled/semi-skilled / unskilled workers. The cost estimate is provided in **Table 10.66.**

Table 10.66 : Cost Estimate

S. No.	Particular	Quantity	Unit	Rate	Amount (Rs. lakh)
1.	Initial medical check-up of employees for lung function (Rs 250/-), audiometric test (Rs150/-), tuberculosis (Rs450/-) and pulmonary disease (Rs150/-) at the time of appointment	1000	Man	1000	10.00
2.	Periodical Medical of employees for lung function (Rs250/-), audiometric test (Rs 150/-), tuberculosis (Rs450/-) and pulmonary disease (Rs150/-).	1000	Man	1000	10.00
3.	Provision for free medicines for all workers @ Rs. 500/year	1000	Man	500	5.00
4.	Provision for personal protection equipment like helmets (Rs 200/-), ear plug (Rs150/-), dust mask (Rs125/-), shoes (Rs400/-), goggles (Rs125/-) etc., for workers	1000	No.	1000	10.00
Total					**35.00**

10.14.5. ***Safe Working Procedure:***

10.14.5.1 Demolition:

Before any demolition work is commenced and also during the progress of the work:

- Appropriate warning signs shall be displayed for cautioning persons approaching the demolition area. The area shall be cordoned off properly.

- Before demolition operations begin, the Contractor shall ensure that the power on all electric service lines is shut off and the lines are cut or disconnected at or outside the demolition site. If it is necessary to maintain electric power during demolition operation, the required service lines shall be adequately protected against damage.
- Persons handling heavy materials /equipment shall wear safety shoes.

10.14.5.2 Earthwork in excavation and backfilling:

The Contractor shall take all safety precautions during the execution of awarded work and shall maintain and leave the site safe at all times.

- The Contractor shall ensure the stability and safety of the excavation, adjacent structures, existing services and the works of other agencies.
- Open excavations shall be cordoned off by suitable railing/barricading and photo-luminescent warning signals installed so as to prevent persons slipping or falling into the excavations. Warning signals shall be visible at night also and the area shall be well illuminated during the work.
- All blasting operations, if permitted by Engineer-in-charge, shall be carried out on the basis of procedures approved by Inspector of Explosives. All works in this connection shall be carried out as per I.S Code of Practice. Barricades, photo-luminescent warning signs, etc. shall be placed on the roads/open area. Prior approval of such operation shall be obtained from Safety Officer/Engineer-In-Charge of Works.
- Contractor shall arrange adequate and efficient mechanical dewatering system as recommended by Engineer-in-charge. These pumps shall be inspected and maintained in proper working condition. The electrically operated pumps shall be connected to ELCB of proper rating for safety of the person operating/shifting them.
- Contractor shall wash the wheels, of the transport vehicles carrying excavated soil, with water jet before moving out of the site premises so that there is no spillover of soil on the existing roads. In case there is any such spill over on the roads, the same shall be cleaned by the contractor by manual / mechanical means immediately at no extra cost.

10.14.5.3 Reinforcement and Concrete works:

Concreting:

- Proper exhaust ventilation shall be available at the cement store and during casting work in confined places. PPE for protection of workers viz. respirators, hand gloves, gumboots, etc. shall be provided by the contractor to the workers handling cement bags and concrete manually.
- The contractor shall provide ear-muffs to the operator / worker exposed to continuous high-level of noise and ear-plugs to all workers involved in the concreting work.
- Wheels of concrete pump / concrete mixer shall be placed on firm ground / platform. Pump accessories shall be checked for its safe working pressure considering maximum pipe line height. A pressure release valve shall be attached to the pump to release the excess pressure.
- The pipeline for transporting the concrete shall have the shortest route with minimum bends and shall be installed on firm supports at suitable intervals. Pipeline shall be properly joined with clamps and securely tied to nearby support and checked in advance before starting the

concreting. Pipe segments shall be cleaned in advance to avoid choking of concrete during casting.

- All mechanical equipment/tools used in concreting activity like batching plant/concrete mixer, concrete pumps, vibrators, etc. shall be operated by trained person only.

Reinforcement:

- Bar bending and cutting yard shall be properly cordoned / barricaded and entry shall be restricted.
- Re-bar bending and cutting machines shall be handled by trained operator / skilled workers.
- Shifting of cut re-bars shall be done by mechanical means as far as possible. When re-bars are shifted manually, it shall be done with proper care and proper balance shall be maintained. Clear access shall be provided for shifting of re-bars.
- Proper support shall be given to the column bars by means of rings / props against undesirable sway.
- Free ends of the binding wires shall be bent inside to avoid injuries.
- Proper PPE viz. leather / cotton hand gloves, goggles, etc., for the people handling / shifting and cutting / tying of re-bar, shall be used for protection from injury and other occupational diseases.

Formwork for concreting:

- Shuttering and supporting members viz. props, tie rods, etc. shall be of adequate strength to support the load / pressure of concrete and the formwork scheme shall be approved by Engineer-In-Charge in advance. The procedure approved by Engineer-In-
- Charge shall be followed for mixing, transporting and pouring of concrete.
- While removing formwork from vertical surfaces, the shuttering board shall be adequately supported by props, in order to prevent the same from toppling / slipping, until it is lowered on ground safely. Same support with props shall be provided during erection of formwork too until the plywood is secured in desired place with tie rods.

10.14.5.4 Scaffolding and Working at Height:

General:

- All the workers, supervisors and engineers of the contractor, who will work at height, shall have valid height passes issued by the Safety Officer.
- The scaffold to be erected for working at height shall be designed for the estimated load.
- The erected scaffold shall be inspected and cleared by the safety officer of the contractor.
- The scaffold shall be checked for its condition i.e., it shall be free from bends, cuts, rust, etc. All vertical members shall be in plumb and correctly spaced. The joints of vertical and horizontal members shall be properly connected with couplers, lock pins, etc. The scaffold shall be securely tied with permanent structure as per the requirement of IS:3696 – 1991 (Part 1) (Reaffirmed in 2002).
- The working platform and the access to the scaffold shall be free from all debris and loose materials.

- Contractor shall provide necessary PPEs as per relevant I.S. Codes for the workers working at height viz. full harness safety belt, fall arrestor, kinetic shock absorber, safety helmet, gloves, etc.

Working platform:

- The quality of wooden planks or MS grill plates for decking of working platform shall be made of good quality material and free from any defects, etc. The load carrying capacity of the working platform shall be designed in consultation with Engineer-in-charge. Working platform, gangways and stairways shall be so constructed that they shall not sag unduly or unequally.
- All working platforms shall have guard rails at 1.0 m height with middle rails at 0.5 m height from the platform and 15 cm high toe boards securely tied with the vertical posts.
- The spacing of vertical posts shall not exceed 2.0 m Centre to Centre.
- The contractor shall provide grab rope / life line all around the working platform/level, at height, which will provide tying / anchoring facility for the safety belt / fall arrestor.
- Contractor shall provide safety net under all working platform/level at height to protect fall of men and materials from above and such safety nets shall conform to IS:11057-1984.
- Adequate precautions shall be taken to prevent danger from electrical lines and equipment. Scaffolding, ladder, working platform, gangways, etc. shall not exist within 5m of any un-insulated electric wire. Whenever electric power and lighting cables are required to run through (pass on) the scaffolding or electrical equipment's are used, such scaffolding structures shall have minimum two earth connections with earth continuity conforming to relevant IS Code of Practice.

Ladder:

- Safe means of access shall be provided to all working platforms and other elevated working places with the help of ladders.
- Ladder shall be placed in an inclination not steeper than 1 in 4 (1horizontal and 4 vertical).
- Every ladder shall be securely fixed at bottom from sliding/slipping.

10.14.5.5 Construction machinery and Tools:

The operation and maintenance of any construction machinery shall be as per manufacturer's guidelines & checklists and by trained personnel only.

Earth moving machinery:

The contractor shall ensure the stability of the equipment, while working, depending on the load bearing capacity of the ground; which may reduce due to presence of moisture and due to vibration effect. The contractor shall provide bearing plates, packing, etc. to strengthen the ground below outriggers or wheel or crawler of the equipment. All earth moving equipment shall have Roll Over Protective Structures, sound suppressers, seat belts, reverse alarms, warning horns, windshield wipers and easily approachable control and lever for brake system and emergency stop. They shall be checked at the time of delivery and they shall be properly maintained. Contractor shall display warning sign for keeping away from the moving parts of such equipment and the area of operation of such machinery shall be properly cordoned. The shovel / bucket of the earth moving equipment shall be rested on ground when the equipment is not working. Operation of such equipment shall always be carried out by trained operator accompanied by the designated helper.

- Bulldozers: The blade of Bulldozer shall be inspected at least once in a week. The blade shall not be used as a brake except in emergency. The position of the blade shall be adjusted while travelling up or down the gradient. The Bulldozer shall be parked on levelled ground, by applying hand brakes and by lowering blade.

Lifting and hoisting machinery:

Lifting machines and tackles shall be of good mechanical construction, sound material and adequate strength and free from any defects and shall be kept in good repair and in good working condition. Every rope used in hoisting or lowering materials or as the means of suspension shall be as per manufacturer's guidelines, of good quality and adequate strength and dimension and free from any defect. Test certificates of such ropes, D-shackles, etc. shall be submitted in advance by the contractor.

- Every crane operator or lifting appliance operator shall be properly qualified. No person under the age of 18 years shall be in charge of any hoisting machine or to give signal to operator of such machine.
- The base of such hoisting equipment shall be kept in perfect horizontal condition since any tilt would reduce the load carrying capacity of the equipment. The foundation shall be firm enough to support the equipment. The level shall be checked every day before starting the work in case of mobile hoisting equipment.
- Thorough inspection and load testing of lifting machines and tackles shall be done by a third party, at least once in every 12 months and the records of such inspection and testing shall be maintained and a copy shall be submitted by the contractor to the departmental representative at site. Motors, transmission, couplings, belts, chain drives and other moving parts of hoisting appliances shall be provided with adequate safeguards. Hoisting appliances shall be provided with such means as it shall minimize the risk of any part of a suspended load becoming accidentally displaced or lowered.

Tower Cranes: Erection & Commissioning

The type of the tower crane to be used shall be selected based on the load to be lifted, the reach of the boom and the height at which the material is to be shifted. The contractor shall follow all the safety instructions given in the manufacturer's manual for erection, dismantling or extension (jumping) of tower cranes. The contractor shall submit the operation manual, provided by the manufacturer, to the departmental representative before erection of the same at site. For both movable and fixed tower cranes, the adequacy of the counterweight shall be ensured. The base of the tower crane shall be in perfect horizontal level. Base shall be capable of bearing the loads during the operation of tower crane.

Operation – The crane shall never be used to pick the loads which are out of the crane's reach or to do skew pulls of any sort. The load (to be lifted by the crane) shall be free from any sticky characteristic which may cause sudden jerk while lifting. No worker / person shall be lifted by tower crane. Any kind of swinging of lifted load, to put them out of crane's reach, shall not be tried. The operator shall not reverse the motor in order to achieve quicker stop to save time. He shall execute one operation at a time only and shall never combine horizontal movement of trolley with vertical movement of lifting hook. Tower crane shall be protected from sway due to wind load, etc. during operation. Precautions in high wind load shall be taken as per manufacturer's guide. Various components and parts of the

tower crane like wire ropes, pulleys, structural members of the tower and boom, etc. shall be periodically checked and properly maintained by the mechanical engineer of the contractor. Proper lighting arrangement with the boom and the tower of the crane shall be provided as safety arrangements for clear visibility during night. The tower crane shall be provided with the siren / horn facility in order to caution the workers in vicinity during operation of the crane. The operator shall take "START" and "HOISTING" signal from the designated helper / supervisor only; however, "STOP" signal can be taken from anyone.

Maintenance- The balancing rope, trolley rope, hoisting rope and erection rope shall be checked as per maintenance guidelines given by the manufacturer and they shall be replaced immediately as and when required. For regular maintenance, the manufacturer's manual shall be followed.

Mobile Cranes:

The contractor shall take care that, the engine of the crane shall be kept running with the gear engaged and maintain a slow speed, while moving down the hill. While travelling uphill or downhill, the boom shall always be kept downhill in order to prevent the boom from falling back. The soil of working area, movement area and parking area of the mobile crane shall be well compacted and shall have proper drainage arrangement. The area shall be dry, levelled and firm enough to hold the load of the mobile crane. The lifting hook shall be tied / anchored while the crane is moving or not operational. Before starting operation at the beginning of day's work, the capacity load shall be picked up to 0.3 m above the ground to test the drift, if any, due to faulty brakes. The brakes shall be 'ON' when a rubber tyre crane is operated. The operator shall always avoid any jerky start or a fast swing during operation of the crane since it increases the risk of overturning of the crane. The pressure in the pneumatic tyre shall be maintained correctly in all wheeled machines.

Transporting Machinery:

Trucks, tippers, dumpers used in transportation of excavated earth or other materials; which are loaded with mechanical excavators, shovels / loaders shall have strong canopies over the driver's cabin to protect them from injuries while loading. The driver's cabin for all the vehicles at construction site shall have a system of sound and vibration suppression, seat belts, reverse horn/alarm, rear view mirror, wide windshield, triplex glass, wiper, sun visor, etc. Brakes and control shall be designed so as to get locked when the vehicle is parked. While going down the gradient, the speed of the vehicle should be controlled. Hydraulic retarder shall be used for big dumpers. Persons holding valid driving licenses for heavy motor vehicle shall be engaged as drivers of the respective type of vehicles. Every dumper, tipper, truck, etc. shall be accompanied by helper and driver shall take all signals from his helper only. The access road of such transport vehicle shall be firm and levelled as far as practicable and shall be free from any obstacle.

Batching plants:

The batching plants shall be calibrated by the contractor at least once in a month and such records shall be made available to the departmental staff for record.

The installation, operation, maintenance and decommissioning of batching plant shall be done as per manufacturer's guidelines and manuals. All electrical works and connections shall be done by a licensed electrician under supervision of electrical engineer of the contractor. The DG requirement (in case of power cuts) shall be of at least 150% of the overload capacity. The operations of hopper, scrapper and pan mixer shall be smooth and periodic inspection shall be done as per manufacturer's guidelines. The material bins shall be checked periodically for presence of any boulders, lumps, etc.

which may choke in the hopper causing disruption of operation of the batching plant. Proper care shall be taken during feeding cement silo from the bulker for any loose joints in the feeder pipe and pump of the silo. The silo shall have a guarded monkey ladder for access to the top. The person accessing the top of silo shall seek work permit in advance and shall use proper PPE while climbing. The outer surface of the silo shall be properly painted and maintained against weathering effects. The contractor shall make available at least one fire extinguisher near the operator cabin of the batching plant and the same shall be maintained in good condition always. The operator cabin and the scrapper cabin shall be well ventilated and dust proof. The underground water tank/Vat of the batching plant shall be covered with suitable protective cover and shall be cordoned all around.

Hydraulic machines:

Hydraulic operated machines like mechanical excavators, jacks, or any other hydraulically operated parts, etc. shall be handled carefully. The pressure relief valves mounted on the Hydraulic construction equipment shall not be tampered. These machines shall be equipped with the foam-based fire extinguisher. These machines shall be maintained at regular intervals as per the manufacturer's manual, to avoid failure of brakes, hydraulic system, etc. Regular checking shall be done for such equipment for any leakage, condition of the hoses and connections, etc. Contractor shall give proper training to the operator, mechanic, etc. before they handle the equipment.

10.14.5.6 Dewatering pumps, Concrete pumps, Boom placer pumps:

- The rotating parts of the dewatering pump shall be well guarded. Only authorized operator / mechanic shall operate the pump on requirement. He shall not wear any loose clothes while operating the pump. The exhaust of the smoke shall be away from the workers working in the surrounding area. The pump shall be operated and maintained as per the manufacturer's guidelines.
- For electrically operated dewatering pumps including submersible pumps, special care shall be taken while operating them. Such pumps shall be fitted with ELCB of proper rating. The power shall be put off before shifting or removal of the submersible pumps.
- Only authorized operator / electrician shall be allowed to operate the same.

Stationery Concrete Pumps and Boom Placer pumps:

- The commissioning, operation and maintenance of concrete pumps (both stationery and boom placer type) shall be done as per manufacturer's guidelines or manual provided along with the equipment. The safety procedure and tips as mentioned in these guidelines shall not be violated. A copy of such manuals shall be submitted to the department before installing the equipment at site. Apart from manufacturer's manual, the following guidelines shall be followed for operation and maintenance of the concrete pumps:
- The operation, maintenance and signaling of concrete pumps shall be done by trained and authorized personnel having minimum 18 years of age.
- Place of work shall be so selected that the visibility of batching plant operator/transit mixer driver, concrete pump operator, signal man/supervisor and hose man (at the pouring point) is ensured all at a time. In case such visibility between all the above people cannot be ensured, then at least the pump operator shall be able to see the batching plant operator and signal man separately. The pump operator shall play most key role in pouring and he shall be properly trained by the

safety officer/site Engineer of the contractor to understand the signaling process properly in order to ensure smooth concreting activity at site.

- When the concrete is being placed in the hopper of the pump (either from batching plant chute or transit mixer chute), no person shall climb on the hopper of the pump.
- The danger zones (within working area) like hose end position, beneath the placing boom, moving parts of the concrete pump and its hopper, its support legs and the area of the concrete pipe line, etc. shall be identified by the safety officer/ mechanical engineer in advance. Accordingly, these areas shall be cordoned and restricted movement shall be ensured as practicable as possible.
- The concrete pipeline (delivery system) for stationary pumps shall be checked by the mechanical engineer before he seeks work permit for concreting activity, for proper clamping of the pipe joints, supports for pipe line, etc. The pipe line shall have minimum number of bends and shall be straight as far as possible. In case pipe line needs to change the direction, then there shall be at least 5 m straight portion just after the concrete pump. The bends in the pipe line shall be as smooth as possible.
- Inspection interval shall be decided based on manufacturer's guide line, age of the concrete pump, quantity of the operating hours and output of concrete.
- Personal protective equipment like helmet, safety shoes, ear defenders (ear muff/ ear plug), protective gloves and goggles, face mask/respiratory protector, etc. shall be arranged by the contractor for all the workers working on concrete pump.
- Concrete pump shall have suitable pressure relief valve, set at a predetermined pressure level, in order to ensure safety of the workers as well as the pump.

10.14.5.7 Structural Steel Fabrication:

Welding and Gas Cutting:

- Welding and gas cutting operations shall be done only by qualified and authorized persons and as per IS: 818-1968 (Reaffirmed in 2008). No hot job shall be done without approved work permit.
- Welding and gas cutting shall not be carried out in places where flammable/any materials such as combustible/flammable chemicals, dyes, hessian cloth, wooden pieces, cylinders, etc. are kept within 10 m from the spot of fabrication or gas cutting.

Electric Arc Welding:

For Electric Arc welding the following additional safety precautions shall be taken:

- All power connections shall be routed through ELCB of proper rating and machine connections shall be through MCB. Double earthing shall be provided to the welding machine. A provision of a separate return path shall be ensured. ii) The cable to be used shall be of adequate capacity corresponding to output of the welding transformer / generator and shall be routed through dry isolated path. Welding cable terminals shall be provided with lugs and connected properly. Proper insulation of cable with insulation tape of approved quality shall be ensured and only double insulated cable shall be used. Extension of welding cables shall be done using standard connectors. iii) Pipe lines carrying flammables shall not be used as part of earth conductor, but a separate earth conductor shall be connected to the machine directly from the job. Painting and

Dye Penetration testing shall not be done near electric arc welding. iv) Personal contact with the electrode or other live parts of electric welding equipment shall be avoided. Wires and cables shall not be hung from any metal hook.

- Accidental contact of electrodes with ground shall be prevented.
- The welding cables shall not be allowed to get entangled with power cables. It shall be ensured that the cables are not damaged by movement of materials. Dragging and coiling of cable shall be avoided. vii) For Dye Penetration test, necessary care shall be taken so that there is no hot job going on nearby. Place of the test shall be well ventilated.

Erection:

Only trained operators and workers shall be engaged for the erection of structural fabricated members. For erection by mechanical means, the safety procedures shall be followed in addition to the following guidelines:

- The heavy materials shall not be manually handled. They shall be handled and shifted by mechanical means like crane, hydra, trolley, etc. of adequate capacity.
- All mechanical transport devices and erection equipment shall be operated with the assistance of a helper / supervisor exclusively for proper signaling.
- While erecting fabricated members, suitable guy rope arrangement shall be made to avoid sudden toppling of derrick.
- Chain pulley block, D-shackles and wire ropes (lifting appliances) shall be of rated capacity at least 2.0 times more than the maximum desired load to be lifted. Hooks, jigs and fixtures used shall be marked with their capacities.
- Two or more slings shall be used for lifting the loads and they shall be tied as per the center of gravity of the load to be lifted.

10.14.5.8 Electrical Safety:

Guide lines for providing temporary power supply at the site and general safety procedures for using electricity are given as under. Following safety requirements shall be complied with before the Contractor uses the power supply.

The Contractor shall submit a list of licensed electrical staff to be posted at site. It shall be the responsibility of the Contractor to provide and maintain complete installation on the load side of the supply point about the safety requirements at site. All cabling and installation shall comply with the appropriate statutory requirements given below and shall be subject to approval of the Departmental Engineer-in-charge/ Electrical Engineer.

- The Electricity Act, 1910 (as amended in 2003)
- Electricity (Supply) Act, 1948
- Indian Electricity Rules, 1956 (as amended in 2005)
- National Electric Code 1985 (as amended in 2005)
- Other relevant rules of Local Bodies and Electricity Boards

10.14.5.9 Fire Safety:

The contractor shall take all necessary precautions to prevent outbreak of fires at the construction site. Adequate provisions shall be made to extinguish fires should they still break out.

- Quantities of combustible materials like timber, coal, paints, etc. shall be the minimum required in order to avoid unnecessary accumulation of combustibles at site.
- Containers of paints, thinners and allied materials shall be stored in a separate room which shall be well ventilated and free from excessive heat, sparks, flame or direct rays of the sun. The containers of paint shall be kept covered or properly fitted with lid and shall not be kept open except while using.
- Fire extinguishers suitable for the different classes of fire such as Class A, B, C & D as per IS: 2190-1992 (Reaffirmed in 2010) shall be made available at the appropriate places in the construction site. The date of last maintenance of fire extinguisher shall be displayed properly on the same by using maintenance tag. The fire extinguishers shall be sent for maintenance/refilling at least once in 6 months or whenever exhausted. The safety officer shall inspect the condition of the plunger, safety pin, switch grip, hose tube, etc. at least once in a month and
- report shall be submitted to the departmental representative as per the format enclosed as Annexure 14.
- Adequate number of contractor's workmen and supervisors shall be given training in firefighting and extinguishing methods.
- The safety officer of the contractor shall plan for site evacuation in fire emergency in order to facilitate to easy and safe exits for entire site work force and supervisory staff. He shall identify and train the designated staff or supervisor for specific role in site evacuation plan.
- The telephone number of the nearest fire station shall be displayed at suitable locations (near telephone, main entrance of the site, first aid canter, stores, etc.) in bold distinct font.

Housekeeping:

- The Contractor shall promote and upkeep the practice of good housekeeping throughout the contact period in order to create a safe and hygienic working environment at site. The contractor shall maintain a separate housekeeping team of workers and supervisors who shall maintain the hygienic conditions at site. He shall at all times, keep his work spot, site office, labour toilets and surroundings and roads clean and tidy from rubbish, scrap, surplus materials and unwanted materials, tools and equipment. The contractor shall follow the recommendation of IS: 4082-1996 (Reaffirmed in 2003) for stacking and storage of construction materials and components at site.
- After the completion of the work, the contractor shall have removed from the work premises all scaffoldings, surplus materials, scrap, rubbish and all temporary structures, huts and sanitary arrangements used/installed for his workmen at site. The contractor shall stack all undesirable materials and debris to the designated area at his own cost, as directed by Engineer-in-charge.

Common Hazards:

- Barricading and Sign Boards: All work areas around excavated pits, trenches, openings, scaffolding, vehicle movement areas, etc. shall be well cordoned / barricaded with the help of

railing, safety tapes (photo luminescent), etc. Photo luminescent sign boards and warnings shall be displayed at required locations and they shall be clearly visible from a distance even at low or no illumination.

- Noise: Suitable ear protection (ear muff) shall be provided to the workers, who are exposed to high noise levels (85dBA and above), e.g., concrete pump operator, vibrator operator, batching plant operator, air compressor operator, grinding machine operator, breaking rocks with pavement breaker, etc. The exposure duration in case of these workers shall be restricted. Other workers and staff who are in the close vicinity of high noise level such as unskilled worker engaged in concreting works, etc. shall be provided with ear plugs.
- Area Illumination: Adequate lighting facilities such as flood lights, halogen lamps, hand lights and area lighting shall be provided by the contractor at the site of work, storage area of materials and equipment and temporary access roads within his working area. The intensity of illumination shall depend on the nature of work and the same shall be planned by the contractor in advance based on the recommendations of Hand Book on Functional Requirements of Industrial Buildings (Lighting & Ventilation: SP32-1986).
- Dust and fumes: Adequate measure like dust extractor/arresters shall be available for use to prevent spread of dust to nearby areas during open area operations. Workers shall be rested for sufficient time after everyone hour of continuous working in dust. The same worker shall not be engaged for many days continuously and they shall be engaged/kept on job rotation. All necessary PPEs like dust respirators, safety goggles, hand gloves, ear plugs, protective clothes, etc. shall be provided. Any illness due to continuous work in dust or fume shall be immediately reported to the First Aid Centre.

The cost components for ensuring certain measures for safety of labour during construction have been enumerated in **Table 10.67.**

Table 10.67 : Cost Estimate

S. No.	Particular	Amount (Rs. lakh)
1.	Cost of Barricading work areas around excavated pits, quarry area/muck disposal sites	4.00
2.	Cost of Caution and Sign Boards	1.00
3.	Cost of Fire extinguishers	2.00
4.	Implements for housekeeping in site offices and work site	6.00
5.	Illumination facilities in work area	7.00
	Total	**20.00**

10.14.6. *Cost Estimate for Occupational Health and Safety Management*

The cost components for ensuring occupational health and measures for safety of labour during construction have been enumerated in **Table 10.68**.

Table 10.68 : Cost Estimate

S. No.	Particular	Amount (Rs. lakh)
1.	Cost estimate for Occupational Health Management (Table 10.66)	35.00
2.	Cost of Safety management during construction (Table 10.67)	20.00
	Total	**55.00**

10.15. Sanitation & Solid Waste Management Plan

10.15.1. *Introduction*

During the construction phase of the project, there will be an influx of technical staff, laborers and other service providers into the project area. The proposed project has also envisaged four colonies to house project employees including personnel for other utility services with their families. Sewage and solid waste will be generated from the colonies. It is very essential that from the planning stage, sewerage management and solid waste disposal facilities should be conceptualized to maintain the health of the people and the environment. The main sources of wastes in case of the proposed project can be divided into following categories:

- Municipal waste from residential areas
- Solid wastes from labour camps
- Bio-medical wastes from Dispensary

Since most of the dam operations shall be automated or mechanized, very few people shall be staying in the project during the operation phase. The solid waste is primary problem during the construction phase of the project. Solid waste generated from temporary and permanent colonies in construction as well as operation phase requires special management to dispose of as warranted under the new Solid Wastes Management Rules, 2016.

10.15.2. *Responsibility of Project Authority*

The project authority, as principal waste generator, shall, within the territorial area of the project complex/ colony, be responsible for the implementation of the provisions of Solid Wastes Management Rules, 2016, issued by MOEF vide S.O.1357 (E) dated 8th, April 2016, and for any infrastructure development for collection, storage, segregation, transportation, processing and disposal of municipal solid wastes.

Any municipal solid waste generated in the project complex/ project colony/ labour colony, shall be managed and handled in accordance with the duties set forth under clause 4 (1) through 4(3) and clause 20 in respect of landfill. The management plan has, therefore, been framed taking into consideration compliance criteria against each parameter as set out under Schedule-II, some of which are described in the foregoing paragraphs.

10.15.2.1 Collection of Municipal Solid Wastes

The project authorities shall prohibit littering of solid wastes in the area under their control by resorting to following: -

- Organizing house-to-house collection of solid waste on regular pre-informed timing and

scheduling through any of the methods, like community bin collection (Central bin).

- Devising collection of wastes from office complexes, hotels and commercial areas.
- Avoiding mixing of Bio-medical wastes with municipal solid wastes.
- Collected waste from residential areas shall be transferred to community bin by hand-driven containerized carts or another small vehicle. Horticulture and construction / demolition wastes or debris shall be separately collected and disposed of.
- Waste like dry leaves shall not be burnt.
- Collection of wastes from vegetable and fruit shops and meat shops and also dry leaves collected from avenues/ parks, which are biodegradable in nature to be finally disposed of through aerobic composting in composting units of size 8 m x 2.5 m built from bricks. The compost thus obtained shall be used for development of flower beds and avenue plantation around colonies and office areas and also in biological measures to be adopted in respect of soil tips developed at muck disposal sites.

10.15.2.2 Segregation of Municipal Solid Wastes

The project authority shall organize awareness programmes to encourage the generators of wastes and to ensure community participation in waste segregation. For this purpose, regular meeting at quarterly intervals shall be arranged with representatives of resident of colonies.

10.15.2.3 Storage of Municipal Solid Wastes

The project authority shall establish and maintain storage facilities in such a manner as they do not create unhygienic and insanitary conditions around it. Following criteria shall be considered while establishing and maintaining storage facilities.

- Storage facilities of bins shall have 'easy to operate 'design for handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be painted white and those for storage of other wastes shall be painted black.
- Manual handling of waste shall be prohibited. If unavoidable due to constraints, manual handling shall be carried out under proper precaution with due care for safety of workers.

10.15.2.4 Transportation of Municipal Solid Wastes

Vehicles used for transportation of wastes shall be covered. Wastes should not be visible to public, nor exposed to open environment preventing their scattering. Transportation vehicles shall be so designed that multiple handling of waste, prior to final disposal, is avoided.

10.15.2.5 Processing of Solid Wastes

The project authorities shall adopt suitable technology or combination of such technologies to make use of wastes to minimize burden on landfill. Following criteria shall be adopted: -

- The biodegradable wastes shall be processed by composting, vermin-composting, anaerobic digestion for stabilization of wastes in terms of Schedule II
- Mixed waste containing recoverable resources shall follow the route to recycling. Incineration can also be used for processing wastes.

10.15.2.6 Disposal of Municipal Solid Wastes

Land filling shall be restricted to non-biodegradable inert waste and other waste that are not suitable for recycling or for biological processing. Three landfill sites shall be selected as per criteria mentioned under Schedule I (A) and (I) of rules. In terms of clause 21of the rules any-recyclable waste having calorific value of 1500K/Cal/kg or more shall not be disposed on landfills and shall be used for generating energy by giving away as feed stock for preparing refuse derived oil. Before establishing any land fill site ground water quality within 50m of its periphery should be monitored covering pre-monsoon, monsoon and post-monsoon

10.15.2.7 Municipal Waste from Residential Areas

Permanent/temporary project colonies for staff (350) shall be created. The colony will have family accommodations. The total expected population in the project colony would be 1400 persons. In the colony, use of plastic bags be discouraged and use of biodegradable cotton and jute bags be encouraged. The average solid waste generated in the colony has been assumed to be approx. 0.75 kg [dry-weight]/ per person/day. Thus, the solid waste generated by 1400 persons in the project colony on average daily, weekly, monthly and annual basis is given in the **Table 10.69.**

All households need to be instructed to sort their wastes and store the food, biodegradable and non-biodegradable wastes viz. bottles, cans etc. in separate containers. Two numbers of doorstep waste collectors per house will be arranged and given to each family. A handcart shall be deployed to collect the wastes from the doorsteps daily.

Table 10.69 : Solid Waste Generated from Project Colony

Garbage Generation	Per Day(kg)	Per Month(kg)	Per Year(kg)
Per Person	0.75	22.5	270.00
By 1400 persons	1050	31500	378000

The collected biodegradable wastes will be disposed of at a suitable landfill site, to be developed. The area will be properly fenced to avoid animals to feed on the wastes. The organic waste collected will be suitably processed to form compost. The compost thus produced shall be utilized in parks and plantation area around colony. The recyclable (non- biodegradable) wastes can be collected at a place and can be incinerated at regular interval of time. Apart from this, there will be provision for cleaning the streets of the colony to keep the surrounding area clean.

Considering water requirement of about 70 liter / head / day and on an average a person generates about 56 lit. of sewage per day and therefore, about 78400 lit. /day of domestic sewage along with other waste are expected to be generated from the colony. In the light of the fact that conventional septic tank system, which is too expensive and requires a large volume of water for flushing and is also riddled with problems like periodic cleaning and disposal of sludge, flush compost toilet which requires only 1.5-2.0 liters of water for flushing as against 12 to 14 liters in case of former shall be resorted to. Flush toilet is eco-friendly, technically appropriate, socio-culturally acceptable and economically affordable. Flush compost toilet shall be adopted in residential area. For inspection houses / office areas Thermophilic Aerobic Composter which requires only 6 to 10 days to make compost from any biodegradable waste, without any manual handing during composting shall be adopted. Adequate provision shall have to be earmarked under the sub-head “O-Miscellaneous” as the capital cost of sewerage disposal and storm water drainage and O & M charges respectively.

10.15.3. *Solid Waste from Labour Colony*

About 1000 workers (labour and staff) would be engaged temporarily during peak construction period. It is expected that 80% of the total work force shall be locally available from adjacent areas and thus labour colony shall be designed to house 200 workforces. It is proposed to provide family residences to 40 workers while the balance shall remain in bachelor accommodation. Proper care has to be taken to manage the solid waste generated from the labour colony for a population of 360 residential persons and 10 floating population i.e., for 370 persons.

It is estimated that total solid waste generation per day by labour population residing in the labour colony would be approximately 277.5 kg dry weight. This would be to 8325 kg dry weight, and 99900 kg dry weight per month and per annum respectively. For maintaining the cleanliness of the labour colony and to restrict from disposing the solid waste into the river, this solid waste management plan has been formulated. No dumping of solid waste should be allowed near any water body or drain. For solid waste collection 6 iron storage vats, each of 5 cum capacity, will be located at convenient dumping locations in the colonies. Each vat will have the capacity of holding 500 kg dry weight of garbage, which will be emptied at regular time intervals and the biodegradable waste will be transported to the landfill sites. Use of plastic bags need to be totally banned in the labour colony. Periodical awareness should also be provided to avoid use of plastic bags.

Proper sanitary facilities would also be provided at the labour colonies. The standard municipal designs for community sanitation facilities in hill areas have been taken into consideration while formulating the sanitation scheme for the labour colony. Flush compost toilets shall be provided for 40 residences of workforce besides 5 community latrines of five-seated unit each with three bathrooms constructed at appropriate locations.

10.15.4. *Treatment of Wastes*

Various waste minimization techniques like Bio-methanation, microbial composting, vermin-composting, anaerobic digestion or any other appropriate processing for bio-stabilization of biodegradable wastes to be adopted are described in following sub-sections: -

10.15.4.1 Landfill

Only the non-usable, non-recyclable, non-biodegradable, non-combustible and non-reactive inert waste shall be sent to sanitary landfill. Generally, from sanitary landfill, there is negligible risk for generation of methane, due to the decay of vegetable matters, as it slowly diffuses at low concentration through the covering material. The most serious risk from sanitary landfill is that of pollution from leachates. Hence, the bed of the disposal sites should be covered with an impervious material to ensure that leachate does not lead to soil and water pollution. During long dry periods the surface of a sanitary landfill can become dusty, causing discomfort to locals in and around such sites. Covering of the disposed material would prevent entrainment of fugitive emissions as well. Paper and other material also flies off the landfill area due to wind currents. This often creates a nuisance in the immediate vicinity of the landfill site. The landfill site, therefore, needs to be skirted with wire fence of about 3 m high with paper catchers to avoid fly of papers. Once the landfill operation is complete, the entire landfill site is to be suitably capped by an impervious material like clay. To ward off entries of dogs and monkeys, the landfill site shall have welded wire fencing all

10.15.4.2 Composting

Processing of solid waste by resorting to aerobic/anaerobic composting yields organic manure along with macro/ micro nutrients for plants. The segregated biodegradable waste is the feedstock for a composting unit. Based on the quantum of solid waste likely to be generated, simple windrow composting has been preferred. The process involves placing of sorted feedstock in long narrow piles called windrows which are periodically turned/agitated for ensuring aeration. Each day's waste shall be placed in a window which are rectangular. Several windrows shall be put to use. After a fixed periodical interval, the windrow shall be turned from outside to middle to destroy harmful insects/larvae. After 21 days windrow shall be broken and screened through 25mm mesh to screen out oversized materials. The compost thus screened shall be stored for a month to ensure that it is fully stabilized before being used in green belt.

10.15.4.3 Vermin Composting

Vermicomposting provides the nutrients and growth enhancing hormones necessary for plant growth. The fruits, flowers and vegetables and other plant products grown using vermicompost are reported to have better keeping quality. The process of composting crop residues/ kitchen garbage using earthworms comprise spreading the agricultural wastes and cow dung in layers as 1.5 m wide and 0.9 m high beds of required length. Earthworms are introduced in between the layers @ 350 worms per m3 of bed volume. The beds are maintained at about 40 - 50% moisture content and a temperature of 200 - 30o C by sprinkling water over the beds. The earthworms being voracious eaters consume the biodegradable matter and give out a part of the matter as excreta or vermin castings. The vermin casting containing nutrients is rich manure for the healthy growing of plants. Eisenia fetida, Eudrilus eugeniae, Perionyx excavatius are some of the species for rearing to convert organic wastes into manure. The worms feed on any biodegradable matter ranging from kitchen garbage and vermicomposting units are ideally suited to locations / units with generation of considerable quantities of organic wastes.

A small Vermicomposting unit can be located in project colony. The unit shall have vermin 3 beds under open shed. The dimension of beds could be 10m(L)x1.0 m (W)x 0.75m (H)and it shall be laid above ground level.

The beds have always to be kept moist with about 50% moisture content. Since it shall near the project colony no separate watering arrangement shall be required. Worms @ 350 worms per cubic meter of bed space should be adequate to start with and to build up the required population in about two cycles or three without unduly affecting the estimated production. The area has to be fenced to prevent trespass by animals and other unwanted elements. The work of shredding raw material, loosening of beds for aeration, shifting of compost and packing shall be done manually.

10.15.4.4 Incineration

The combustible component of waste is made to burn inside a furnace, when the waste combines with oxygen releasing mostly carbon monoxide and water vapors and heat energy. Incineration can reduce the volume of uncompacted waste in excess of 90% leaving the inert residue of ash, glass, metal and other solid materials called bottom ash. The gaseous by-products along with particulate matter are removed through emission control devices like baghouse filters and electrostatic precipitators. Bottom ash if not hazardous is disposed in landfill. For energy recovery a water tube wall furnace can be put to use for energy recovery. Waste to energy systems is more expensive to build and operate as compared to plain incinerators

10.15.4.5 Bio-methanation

Bio-degradable waste (wet organic waste/cooked food water) undergoes decomposition due to microbial activity as a result of which biogas which chiefly contains methane and carbon dioxide are released. Wet solid waste from kitchens from project colony, mess of officer's field hostel and canteen are proposed to be treated by this process. The biogas produced can be used for cooking in kitchen of various mess of field hostels besides water heating.

10.15.4.6 Recycling

Apart from the municipal solid waste in labour colony of project area, a lot of waste is expected to be generated on account of construction activities mainly consisting of cement bags, iron scrap, packing material, etc. It is expected that most of the iron scrap and packing material would be recycled since it has reuse value apart from monetary values and hence, it is proposed that stipulations should be imposed on suppliers and contractors to take away the scrap and packing materials. Apart from above, substantial cement will be required for constructional works. Since cement is supplied in 50 Kg plastic bags, many plastic bags would require proper disposal through annual public auction with a provision of monthly disposal of such bags. Iron scraps have a resale value and therefore these shall be auctioned to steel re-rollers.

10.15.5. *Hazardous Waste Management*

Hazardous waste inter alia includes burnt mobile oil from vehicles and construction machinery and equipment, batteries and like items specified in column (3) of Schedule-I of Hazardous and other Wastes (Management &Transboundary Movement) Rules, 2016.These will be disposed of by auctioning them to the recycling vendors approved by the CPCB or State Pollution Control Board in consonance with Hazardous and other Wastes (Management &Transboundary Movement) Rules,2016. Under the rules, certain responsivities have been rested on the occupier of hazardous and other wastes generator for safe and environmentally sound management of hazardous wastes staring from pollution prevention to safe disposal. Hazardous waste shall be sent or sold by the occupier to an authorized actual user or disposed in an authorized disposal facility only. Occupier shall transport wastes through an authorized or certified transporter to an authorized actual user or to an authorized disposal facility as per the provisions of these rules.

Under the rules, the occupiers of facilities generating hazardous & other wastes may store for a period of not more than ninety (90) days and a maximum quant of ten (10) tons. An area shall be designated as a storage area known as Central Hazardous Waste accumulation area. This is an area where hazardous wastes are accumulated prior to being picked up for treatment, recycling or disposal. A sum of Rs 2.50 lakh has been earmarked for storage and handling of the waste.

10.15.6. *E- Waste Management*

E-Waste (Management) Rules, 2016, applies to consumer electrical and electronic equipment listed in Schedule I, including their components, consumables, parts and spares which make the product operational. Electrical equipment (LED/LCD TV sets, refrigerators, air conditioners, fluorescent and mercury lamps) and electronic equipment (Telex, Telephones, Computers, Printers, Cartridges) including their components, consumables, parts and spares mentioned under Schedule-I are covered under the rules.

Under clause 9 (1) of E-Waste (Management) Rules, 2016, consumers or bulk consumers of electrical and electronic equipment listed in Schedule I shall ensure that e-waste generated by them is

channelized through collection center or dealer of authorized producer or dismantler or recycler or through the designated take back service provider of the producer to authorized dismantler or recycler. The collection, storage, transportation, segregation, refurbishment, dismantling, recycling and disposal of e-waste shall be in accordance with the procedures prescribed in the guidelines published by the Central Pollution Control Board from time to time. Implementation of e-waste (Management and Handling) Amendment Rules, 2016 shall be in accordance with the guidelines prescribed by the Central Pollution Control Board from time to time. For properly storage of e-waste before its disposal, as sum of Rs.0.50 lakh has been earmarked.

10.15.7. *Cost Estimate for Waste Management*

The overall cost estimates for the waste management plan are shown in **Table 10.70.**

Table 10.70 : Cost Estimate for Solid and other Waste Management Plan

S.N.	Description	Qty.	Unit	Rate (Rs lakh)	Amount (Rs. lakh)
A	**Sanitary and Solid Waste Management**				
1.	Flush composite toilets for labour colony	40	No	0.30	12.00
2.	Community toilet with 5 seats with ETS	8	No	15.00	120.00
3.	Cleaning worker for 6 years (3 x 12 x 6)	216	months	0.10	21.60
4.	Door step plastic dustbin 40-liter capacity @ 2 No/family including one-time replacement	800	No	0.01	8.00
5.	Waste collection handcarts including one-time replacement	20	No	0.05	1.00
6.	Landfill R&M	1	Job	LS	30.00
7.	Implements such as. Brooms, spade etc.	1	Job	LS	1.00
8.	Anti-malarial and anti-insecticides equipment and spraying material	1	Job	LS	3.00
9.	Iron storage vat (3.1 m x 1.25 m x 1.25 m)	8	No	1.0	8.00
10.	Maintenance of 1 Truck @ Rs 3.0 lakh / Yr	6	Yr	3.0	18.00
11.	O& M charges of incinerator @ Rs. 0.50 lakh / year	6	No.	0.50	3.00
12.	Developing simple composting unit with size 3.75 m x 2.2 m, three chambered build from brick	4	No.	0.75	3.00
13.	Contingency	LS			0.40
Total Sanitary and Solid Waste Management (A)					229.00
B	**Hazardous Waste Management**	1	Job	LS	2.50
C	**E-waste Management**	1	Job	LS	0.50
Grand Total					**232.00**

10.16. Local Area Development Plan

10.16.1. *Introduction*

The project developer would aim at the improvement in the living standards of inhabitants in the project area not only by being a catalyst for development but also by developing infrastructure in the area. The infrastructure development will be in addition to the rightful compensation to the project affected families. Besides meeting the mandatory requirement, certain works relating to social welfare and community development are also considered in consultation with local authorities and representatives of Gram Panchayats of project-affected area where in the project area is covered, so that more acceptability for implementation of the plan is achieved

As large-scale investment is being made in the area by way of construction of project, benefits should reach to the local population so that there is remarkable improvement in their quality of life. Provisions will be made by the project proponent for the infrastructure development programme in the project area as per the needs of the local population. Thus, the proposed strategy should be formulated by keeping in view the existing facilities and giving due consideration to the views of the local people.

The activities proposed under plan shall be worked out based on the issues raised during the public hearing and social need assessment. The proposed activities shall be restricted to the affected area around the project.

10.16.2. *Activities Proposed Under Plan*

As per provision under O.M. F.No.22-65/2017-IA.III, dated 30th September,2020, such concerns raised during public hearing which were committed for addressal by the project proponent, after deliberation on the commitment and prescribed as a specific condition while recommending of EC, shall be addressed/undertaken for implementation by the project proponent under Local area Development Plan. Therefore, work activities shall be based on the issues likely to be raised and suggestion made during the course of public hearings.

10.16.3. *Cost Under Human Resource and Local Area Development Plan*

Since no expenditure can be incurred, without an approved budget for it, the tentative cost likely to be debited to project has been assessed @0.5% of the direct and indirect charges of basic project cost (Rs. INR 2567.80 Crore) i.e., INR 1284.00 lakh.

10.17. Environmental Safeguard During Construction

10.17.1. *Introduction*

The project construction would entail significant vehicular movement for transportation of construction machinery, construction material, Muck Disposal. Some of the existing roads in the project area would require widening. To execute the various civil works, roads would be made for linking the work site to other sites and to job facility areas. The details of identified roads are given in **Table 10.71**.

Table 10.71 : Project Roads to the Different Work Sites

S. N.	Description of Roads	Length (Km)
1.	5/7 m wide approach road to right bank of dam	6.50
2.	5/7 m wide approach road to left bank of dam	11.00
3.	5/7 m wide approach road to Surge shaft and HRT Adit Portal	10.50
4.	5/7 m wide approach road to Power House and Pressure shaft adit from right bank	10.40
5.	5/7 m wide approach road to Power House and Pressure shaft adit from left bank	20.40
	Total Length (Km)	**58.80**

10.17.2. *Impacts Due to Construction of Roads*

The construction of roads can lead to the following impacts:

- The topography of the project area has steep to precipitous slope, which descends rapidly into valleys. The conditions can give rise to erosion hazards due to net downhill movement of soil aggregates.
- Construction of new roads increases the accessibility of a hitherto undisturbed areas resulting in greater human interferences and subsequent adverse impacts on the ecosystem.
- Increased air pollution during construction phase.

10.17.3. *Management Measures*

The approach roads will have to be constructed as a part of the access to the construction site. Road construction may result in loosening of soil/rock at places and give rise to landslides particularly due to seepage water.

Landslides on steeply sloping bank can largely be controlled by provision of suitable drainage. The basic principle is to intercept and divert as much water as possible, before it arrives at a point, where it becomes a nuisance. The other erosion hazard is that of surface erosion of the bank, which is best controlled by vegetation. For such terrain of the project area which does not support vegetation, engineering solutions such as surface drainage, sub-surface drainage, toe protection and rock bolting can be used. The cost required for implementation of various measures has already been incorporated in the overall budget earmarked for construction of roads.

Road construction will generate muck due to the stripping / blasting of the rocks. The stripped material would be collected (to the maximum extent) and dumped in the designated muck disposal area, which will have retaining wall to prevent the muck to flow down into the river. After disposal

operation is complete at the dumpsite, the dump yard shall be stabilized by terracing and overlain with geo-textile and seeded with suitable grass species.

The various aspects to be considered while making the project roads are briefly described in the following paragraphs.

10.17.3.1 Construction

- The clearing area shall be properly demarcated. Where erosion is likely to be a problem, operations shall be so scheduled and performed that grading operations and permanent erosion control of features can follow immediately thereafter, if the project conditions permit; otherwise, temporary erosion control measures shall be provided between successive construction stages.

- The method of balanced cut and fill formation shall be adopted to avoid large difference in cut and fill quantities.

The cut slopes shall be suitably protected by breast walls, provision of flat stable slopes, construction of catch water and intercepting drains, treatment of slopes and unstable areas above and underneath the road, etc.

Excavated material shall not be thrown haphazardly but dumped at designated dumping sites which shall be stabilized by terracing and overlain with geo-textile and seeded with suitable grass species.

10.17.3.2 Drainage

- All artificial drains shall be linked with the existing natural drainage system.

- Surface drains shall have gentle slopes. Where falls in levels are to be negotiated, check dams with silting basins shall be constructed and that soil is not eroded and carried away by high velocity flows.

- Location and alignment of culverts shall also be so chosen as to avoid severe erosion at outlets and siltation at inlets.

10.17.3.3 Grassing and Planting

- Tree felling for road construction/works shall be avoided wherever possible. However, compensatory afforestation shall be carried out for forest land used for the purpose.

- Afforestation with suitable species will be attempted and sustained along the roadside to a sufficient distance on either side of the road.

10.17.3.4 Other measures

- Water will be sprayed regularly during construction phase of the roads to prevent entrainment of dust.

- Regular compaction of temporary roads shall also be carried out

10.17.4. *Budget*

An amount of Rs 150 lakh has been earmarked for implementation of measures to mitigate adverse impacts due to construction of roads. The details are given in **Table 10.72**.

Table 10.72 : Details of expenditure for implementation of measures

S. N.	Item	Cost (Rs lakh)
1.	Clearing and grubbing @ Rs.0.2 lakh /km/year for 58.80 km for 6 years	70.80
2.	Provision of water for spray @ Rs. 750/tanker for 5 tankers per day for a construction period of 240 days/year for 6 years	54.00
3.	Providing Revetments and Breast walls	25.00
	Total	**149.80**
	Say	**150.00**

10.18. Energy Conservation Measures

10.18.1. *Introduction*

The execution of Umngot HEP and appurtenant works there under have been proposed to be carried out contractually to be completed in 60-month time. Infrastructure facilities shall be developed *pari passu* with the construction activities. With the commencement of construction activities, the deployment of labour force comprising of skilled/semi-skilled/unskilled will take place and at peak of the works about 1000 workforce shall be engaged. It is expected that 80% of the total work force shall be locally available and manpower to the tune of 200 persons shall be imported from other parts of the country. The temporary labour camps will be established at suitable location in the project area. The fuel need of the labourers/ workers has to be attended in an organized manner otherwise the labour may resort to indiscriminate felling of trees and shrubs owing to their cost free and easy availability at leisure. Consequent deforestation if continued shall adversely affect the ecosystem; therefore, pre-emptive action plan has to be devised to meet the fuel needs of workers especially those residing in the labour camps. These objects can be best accomplished by mandatory banning of the use of fuel wood in the labour camps besides complying with the following obligatory steps:

- In every contract document mandatory clause should be made for the contractors to provide community kitchen facilities to labourers who reside without family and also to ensure supply of LPG fuel to the laborers living with families in camps failing which the contractor shall solely be held responsible and liable for penalty and or remedial action.
- Establishing an LPG go-down and a state-owned kerosene oil depot within the township of project complex.
- Providing free electricity for domestic purpose to the labourers residing in labour camps.

10.18.2. *Alternate to Fuelwood*

The fuel shall be required by the labour for cooking purpose, warming the rooms during cold months and also for warming water. In natural course, if the workforce is allowed to manage these at their will, the first choice shall be the free and readily available natural and conventional resources i.e., fuel wood. Thus, pressure due to immigrating labour using fuel-wood extracted free from the local forest shall increase in alarming proportion which may lead to complete denudation of forest in nearby

pockets. Therefore, to avoid immediate pressure for fuel-wood in the adjoining forest and consequential increased production of carbon emission it is proposed to use LPG for cooking and electricity for heating in the camps and kerosene stoves at site.

10.18.3. *Scheme for Substitute Fuel to Labourers*

Under this scheme a practical work plan has been prepared for implementing the subsidized fuel scheme for the work force of the project. It is proposed to provide LPG connection for cooking, kerosene and electricity for heating purposes. The supply of LPG and kerosene can be ensured on regular basis through written arrangement with local LPG/kerosene suppliers for supply of the same.

10.18.3.1 Provision for LPG

Each worker family can refill 1 (one) cylinder after every 30 or more days depending on actual consumption. About 1200 work force (skilled/unskilled) would be engaged temporarily during peak construction period, of which 80% shall be from bona fide residents of the state. It is expected that 80% of the work force shall be locally available from the adjacent areas and shall manage to work at site by making back and forth journey from their home. Thus, out of balance 200 numbers, about 40 workmen shall reside in colonies with their families and rest 160 in bachelor accommodations like dormitories/ field camps. The requirement of gas cylinder per month has been worked out based on one cylinder per month for workmen living in family accommodations and one cylinder for a group of 3 workers living in dormitories/ labour camps. The total requirement of LPG cylinders for stipulated 6-year project period @ 95 cylinder / month works to 6840 numbers

10.18.3.2 Provision for Kerosene

Kerosene is an easily available fuel having less operational hazards. With the help of the state Government, a kerosene depot shall be opened for the distribution of kerosene oil to labourers. The requirement of Kerosene has been worked out @ 0.25 l/family/day as 10 liters /day for 40 labour family, who shall reside in family accommodation and@ 0.15 l/labour/day as 24 liters/day for 160 labours, who shall reside in bachelor accommodation. Thus, the total requirement shall be to the tune of 74460 liters for the entire project execution period.

10.18.3.3 Provision for Electricity

Electricity supply should be arranged for lighting purpose to the tune of two 100 W bulbs per family and provision of street light should be made in the labour colony at the contractor's cost. However, use of CFL should be encouraged from the consideration of saving of power and economy. The electricity for heating purposes shall be provided at one (01) unit/day for each of 160 workers residing in bachelor's accommodation and two (02) unit/day for each of 40 workers residing in family accommodations. Thus, the total consumption per day on this count shall be 240 units and about 10 units for street lights, the overall consumption during 72 months shall be 540000 units.

10.18.3.4 Energy Conservation Devices

With a view to conserve electrical energy, wherever possible, it is proposed to resort to solar lighting system for street lighting / park lighting etc. Besides this the workers shall be discouraged for using conventional electric bulb/florescent tube lights which consume more wattage. For this the workers shall be encouraged to use energy saving lighting devices like CFL/LED Bulbs which shall be provided at subsidized rates to the workers.

10.18.4. *Debit able Cost of Providing Fuelwood Substitute*

The difference in cost of using fuel wood and other suggested substitutes which the contractors shall be loading in their tendered rates and which finally shall be debited to the cost of project has been assessed to the tune of **Rs. 60.00 lakh** as is shown in **Table 10.73.**

Table 10.73 : Cost of providing fuel wood substitute

S. N.	Item	Unit	Estimated Consumption		Rate (Rs.)	Cost (Rs. lakh)
			Per month	Project period		
1	Conventional Fuel wood @ 1.5 kg/person/day	Quintal	144	10368	600	62.21
2	Alternate fuel					
(i)	LPG	Cylinder	95	6840	900	61.56
(ii)	Kerosene stores.	Liter	34	74460	16.00	11.75
(iii)	Electricity (heating)	Unit	7500	540000	6.00	32.40
Sub Total (B)						105.71
3	Difference between conventional and alternate cost	-	-	-	-	43.50
4	Providing CFL/LED Bulbs at 50% subsidy to workers	Job	-	-	L.S.	4.00
5	Providing Solar Street Lighting (SL7- 15 Watts Solar Street Light)	Nos.	-	40	25000	10.00
6	Providing Solar Water heater (200-liter capacity) complete with erecting cost	Nos		10	40000	4.00
Total						**61.50**
Say						**62.00**

It is thus eloquent from the table that the additional cost due to application of alternate fuel to fuel wood due to environmental constraint shall be attributed to the environment management of the project under provision for substituted fuel. The cost is inconsequential when compared to the loss of 3300 trees which would have been cut for meeting the fuel wood requirement. The assessment is based on very conservative approach by adopting conversion factor of 3.6 Qtl/cum and the cubical content of a tree as 3 cum. per tree. This implies that on the assumed average stock density of 200 trees per ha, in all 6-ha forest area would have to be sacrificed for this purpose.

10.19. Summary of Cost

The summary of cost estimate of various environment management plans as contained in this report is enumerated in **Table 10.74**.

Table 10.74 : Summary of Cost Estimate

S. No.	Plans	Cost (Rs. Lakh)
1.	Catchment Area Treatment Plan	2917.00
2.	Compensatory Afforestation Scheme	2308.00

3.	Wildlife and Bio-diversity Management plan	100.00
4.	Resettlement & Rehabilitation Plan	30417.00
5.	Green Belt Development Plan	76.00
6.	Reservoir Rim Treatment Plan	85.00
7.	Landscape and Restoration Plan	18.00
8.	Fisheries Management Plan	192.00
9	Muck Management Plan	912.00
10.	Restoration Plan for Quarry Sites and Landscaping	60.00
11.	Disaster Management Plan	75.00
12.	Water, Air and Noise Management Plan	62.00
13.	Public Health Delivery Plan	334.00
14.	Labour Management Plan	55.00
15.	Sanitation and Solid Waste Management Plan	232.00
16.	Local Area Development Plan	1284.00
17.	Environmental Safeguards During Construction Activities	150.00
18.	Energy Conservation Measures	62.00
19.	Environmental Monitoring Plan	60.00
Grand Total		**39399.00**

Chapter 11. SUMMARY AND CONCLUSION

11.1. Background

Considering the vast and untapped potential and availability, of the hydro resources in India, the development of hydropower projects is required to be explored fully. Power generation from such projects is also comparatively less damaging for the environment.

As per CEA, the total installed capacity from all sources in India as on 31.10.2018, stands at 3,46,048 MW of which the installed capacity of Hydropower stands at 45,487MW (13.1%). This implies that so far only 30.6% of the feasible hydro potential of 148700 MW could be harnessed

11.2. Need for The Project

The need for Umngot HEP in Umngot Basin, has therefore been considered in context of power shortage in the country as whole. The project has been conceptualized as storage scheme. Umngot H.E.P. (3 x 70MW) alone would be able to supplement 210 MW of peaking power to the requirements of the state and provide an annual design energy (90% dependability) of 708.98 GWh.

11.3. Location and Approach

From Shillong, the project is accessible by road on the left bank through the NH-44 E which runs through the neighbouring Jaintia Hills District of Meghalaya to Tamabil, a dry port on the Bangladesh border. On the right bank the Project is also accessible from N.H-44 via a District/village road in East Khasi Hills District where most of the hydraulic structures will be located.

11.4. Project Features

The proposed Hydro Electric Project comprises the following structures:

- 362m long and 111 metres high concrete dam across river Umngot to impound 71.31 MCM. of water.
- 3.40m diameter head race tunnel of length 5.646 Km,
- A restricted orifice surge shaft of 12m diameter and 68.1m height at the junction of HRT and pressure shaft opens into the atmosphere at the top.
- 2.50m diameter steel lined pressure shaft of length 2.209Km,
- Surface Power House of length 107.5m and width 22m for generation of 210 MW of peak power.
- Three tail race tunnels of41m length and 3.78m diameter.
- Tail Race channel of cross-section 6.60mx2.80m.

11.5. Environment Impact Assessment

M/s. EQMS India Pvt. Ltd, Karkardooma, Delhi, has conducted the Environment Impact study, as per ToR issued by the MoEF&CC vide letter No. J-12011/1/2016-IA-I dated 12-04-2016.

11.6. Methodology

The methodology and techniques used for studying the various parameters of the environment viz. land, air, noise, water, flora, fauna and socio-economics in the study area are described as follows:

11.7. Land Environment Study

- The Digital Satellite data IRS P6 LISS-III of project area was acquired from NRSA and evaluated on ERDAS Imagine Software.

- Toposheets on 1:50,000 scale of the directly draining catchment area were used for the study.
- Detailed field survey was conducted for study of soil characteristics of erosion prone areas and landslides in the reservoir area.

11.7.1. *Air Quality Assessment*

To generate, a database on the existing status of the pollutants, the study area was evaluated for setting up six locations to conduct air quality monitoring in respect of PM10, SO2 and NOx.

11.7.2. *Sound Level Measurement*

The sound level was measured at six locations by sound level meter

11.7.3. *Soil Quality Assessment*

Physical and chemical characteristics of the soil were studied in respect of six samples taken from the study area.

11.7.4. *Water Environment Assessment*

For evaluating physical, chemical and biological characteristics of surface and ground water samples were taken from seven locations.

11.7.5. *Aquatic Environment*

Evaluation of the parameters related to aquatic environment has been done in respect of biological characteristics of river water.

11.7.6. *Floral Study*

It is based on extensive field survey of the area. In this the phytosociology of plants and diversity of the forest vegetation was determined.

11.7.7. *Faunal Study*

Various transects were identified along the villages to carry out faunal studies as the village trails were the best options to cover-up the complete area. Observer walked at a constant pace for their observation.

11.7.8. *Socio-economic Study*

The data on socio economic and dependency aspects were collected. The process involved assessment of the study area to obtain an overall perspective of the project affected villages that were located in the submergence zone / 10 km radius from the dam including command area. In order to gather information on public perception of the proposed project the attitude/psychology survey was carried out which depicts the prevailing awareness and acceptance/no-acceptance about the project. Data collection from secondary sources has also been made to validate some of the information and to supplement the data on demographic aspects.

11.8. Existing Status of Environment

11.8.1. *Land use/Land Cover*

The dominating classes are dense forest (34.61%), open forest (28.27%), settlement (24.08%), Open Scrub Land/Rocky area (22.24%), Barren Land/Stony waste area (8.59%) and water body (1.37%).

11.8.2. *Land Requirement for Construction of the Project*

For execution of the project 390.50 ha land shall be required of which the apportionment between, Forest land and private land shall be 93.53 ha and 296.97 ha respectively.

11.8.3. *ARCHAEOLOGICAL / HISTORICAL MONUMENTS/SENSITIVE AREA*

No archaeological monument of national importance, Defence Establishments, lies either in the project area or in its submergence area.

11.8.4. *SOIL QUALITY*

Texturally the soils of study area are observed as Sandy Loam and Silty Clay soils. The Bulk Density of the soils was found in the range of 1.38 to 1.65 g/cc. Porosity was observed in the range of 38.2 to 47.9% in the soils of the study area. Water holding capacity of study area soils was observed as 28.2 to 31.4Soil pH ranges from 6.51 to 7.45, thereby indicating the soils are slightly acidic to slightly alkaline in nature. The low EC values indicate low salt content. The organic carbon content of soil varied from 0.51 to 0.82% (0.88 to 1.41% as organic matter) thereby implying that soils are medium and high organic content. Available nitrogen content in the surface soils ranges between 271.8 & 302.6 kg/ha, thereby indicating that soils are low to medium in available nitrogen content. Available phosphorus content ranges between 6.2 & 12.6 kg/ha, thereby indicating that soils are low to medium in available phosphorus content. Available potassium content in these soils ranges between 144.2 & 172.5 kg/ha, thereby is indicating that the soils are medium in potassium content.

11.8.5. *AIR AND NOISE ENVIRONMENT*

The pollutants concentration in the air is well below the permissible limit, the maximum concentration monitored for PM_{10}, $PM_{2.5}$, NOx and SO_2 was 52.0µg/m^3, 25.0µg/m^3, 9.8µg/m^3 and 6.3µg/m^3respectively. there are no industries in the area and the density of vehicular traffic is not alarming. The noise monitoring shows day and night time noise levels are higher at dam site and near power house site due to flow of river. The noise levels for the rest of stations are within the prescribed limits. As regards the total ADT at traffic enumeration point on MDR Mawkynrew were 656 in terms of number which translates into 689 in terms of PCU.

11.8.6. *WATER ENVIRONMENT*

The pH values of all analysed samples ranged between 7.52 – 7.66 and are within the acceptable limit (6.5-8.5). Total hardness levels ranged from 8 to 20 mg/l and were well below the acceptable limit of 200 mg/l. The dissolved oxygen values ranged between 7.0-8.0 mg/l and were within the acceptable limit of 6mg/chlorides level in surface water samples ranged from 4 -7 mg/l and were within the acceptable limit of 250 mg/l. The sulphates level ranged from 0.2 to 1.2 mg/l and were within the acceptable limit of 200 mg/l. The nitrate was not detected in an of samples. The concentration of various heavy metals was below the detectable limits, indicating the suitability of water for meeting domestic requirements. The BOD values ranged between 1.0 to 1.6mg/l and were within the CPCB criteria of less than 2mg/l for Class A water. The Total Coliform level were less than 50 MPN/100ml, the limits specified for Class A water under CPCB Water Quality Criteria for designated best use. The water is suitable for meeting drinking water requirements after conventional treatment and disinfection. All physical and general parameters for ground water were observed within the desirable limit as per IS10500:2012 (Second Revision).

11.8.7. *STATUS OF BIOLOGICAL ENVIRONMENT*

11.8.7.1 Flora of the Project Area

- The study area has 190 plant species which include 68 tree species,66 species of shrubs ,37 species of herbs and 19 species of climbers.
- About 5 economically important plant species were recorded from the study area.
- About 16 important medicinal/ethnobotanical importance plant species were recorded
- 8 RET species falling under IUCN Red list was recorded/reported from study area.

11.8.7.2 Fauna

- 28 mammalian species were recorded /reported during the survey of which one (Hoolock gibbon) belongs to Schedule-1 of WPA, 1972.
- 98 bird species were observed /reported during the survey of which one (White throated brown Hornbill) belongs to Schedule-1 of WPA, 1972.
- As many as 16 species of herpetofauna were recorded /reported, of which four (Monitor lizard, Yellow Monitor, Water Monitor, Rock Python) belong to Schedule-1 of WPA, 1972.
- 28 species of insects and butterflies were recorded/reported
- 17 species of fish were recorded/reported

11.8.8. *SOCIAL AND CULTURAL BACKGROUND OF THE AREA*

11.8.8.1 Demography of Project Affected Villages

As per the Census of India 2011, the total population of the project affected villages comprising of 1338 households' aggregates to 7946 of which male and female population is 4076 and 3870 respectively. The overall sex ratio is 950 females per thousand males. The Literate male and female in the study are 1655 and 2122 which implies that the literacy rate is 62.62%. The main workers are 2846 (35.82%) and marginal workers are 676(8.50%) respectively of the total workers population.

11.8.8.2 Demography of Project Affected Villages

The village-wise details of project affected families and assets to be acquired is shown in **Table 11.1**

Table 11.1 : Village wise details of Land to be Acquired

S. No.	Name of Village	No. of PAF	Arable Land (ha)	Non-arable Land (ha)	Total Land (ha)
1	Moosakhia	37	16.51	13.34	29.85
2	Samanong	27	10.85	34.79	45.64
3	Sohmynting	20	14.85	3.25	18.1
4	Ksanrngi	32	8.62	4.69	13.31
5	Mawdulop	40	4.94	3.28	8.22
6	Mawjatap	8	4.98	1.97	6.95
7	Mawlang	22	5.59	4.56	10.15
8	Mawsir	38	13.51	21.3	34.81
9	Syntung	38	25.2	16.5	41.7
10	Jatah Nonglyer	23	3.84	1.74	5.58
11	Pashang	28	9.23	4.5	13.73
12	Siangkhnai	35	23.45	29.04	52.49
13	Umsawwar	30	10.86	5.58	16.44
Total		**378**	**152.43**	**144.54**	**296.97**

11.9. Identification, Prediction and Evaluation of Impacts

11.9.1. *Impacts on the Micro-Climate of the Area*

Due to construction activities, there shall be temporary and nominal effect on the ambient temperature and humidity. The operation stage project may not create any impact on the meteorology and climatology of the area. Due to submergence, the increase in water surface area due to creation of reservoir will result in increased evapo-transpiration and humidity.

11.9.2. *Change in Land use / Land Cover*

11.9.2.1 Construction Phase

- The land use class of 253.75 ha land involved in submergence shall change into waterbody. The change shall be permanent and irreversible. The forest land cover within the submergence area shall reduce due to project during construction.
- The land use class of forest land and arable land required for project components and internal roads shall have land use class changed to built-up area.
- The land use class of forest land required for quarry sites shall remain unchanged as the quarry sites shall later on developed with vegetal cover.
- The present land use of land involved in quarry sites/muck sites shall permanently change into forest land use after completion of the work and creation of vegetal canopy by way of plantation over the spoil tips.
- The land use category of arable land acquired for construction of buildings shall change to land use category settlement.
- The land use class forest in respect of forestland required for underground components will not cause any change in the present land use.

11.9.2.2 Operational Phase

During the operation phase no change in land use is expected. Many of the redundant areas having no further usage will be brought under plantation.

11.9.3. *Soil Erosion and Siltation*

11.9.3.1 Construction Phase

Soil erosion due to excavation of different components of the project, construction of roads will accelerate soil erosion.

11.9.3.2 Operational Phase

Soil erosion due to project activities will not exist in the operation phase as the construction would be completed and landscape restoration work would also be implemented

11.9.4. *Impact on Geology*

The intensity of anticipated environmental impact on geology of the area will be weak and extent of anticipated impact will be local. No impact is anticipated on the geology of the area during the operation phase.

11.9.5. *Impact on Hydrology*

Since, the quantity of the water abstracted from the river for non-consumptive use of power generation is again returned to the system without any consumption, there shall not be any remarkable change in hydrological cycle in context to the project absolutely.

11.9.6. ***Environmental Degradation due to Labour Immigration***

During the construction phase congregation of approximately 1000 workers is likely to take place in the project area, which will increase pressure on land and water resource. Conflict between the migrants and the local population may occur for employment. Labour engaged in construction activity will also move away once the project work is completed; therefore, no additional impact is expected.

11.9.7. ***Impacts on Air Environment***

Temporary changes in air quality during construction phase are expected due to emission of hydrocarbons from vehicles and gases from blasting operations. Inside dam complex excavation area, the maximum GLC of pollutants PM10, PM2.5, NOx and SO2 was found to be 17.85 µg/m^3, 1.55 µg/m^3 ,9.52 µg/m^3 and 1.19 µg/m3 respectively. At the nearest settlement viz. Moosokhiai, the predicted GLC for PM10, PM2.5, NOx and SO2 would be 1.66 µg/m^3, 0.10 µg/m3, 0.90 µg/m3 and 0.11 µg/m3 respectively. At Siangkhnai, the predicted GLC for PM10, PM2.5, NOx and SO2 would be 0.66 µg/m3, 0.10 µg/m3, 0.90 µg/m3 and 0.11 µg/m3 respectively.

Due to increased transportation during construction phase at 25 m, predicted concentration for PM10 is 11.6 µg/m3 which reduces to 7.3 µg/m^3, 3.2 µg/m3 and 1.3 µg/m3 at 50m, 150m and 500m respectively. Thus, the impact on the pollutant level (PM10) due to increased traffic due to transportation of material shall be minimal. The increased GLC in respect of NOx were insignificant being 0.13 µg/m3 up to 25m and 0.11 µg/m3 up to 50m and 0.10 µg/m3 up to 1km.

11.9.8. ***Impacts on Noise Environment***

Temporary increase in noise levels is expected during construction phase only. It is evident from the modelling results that due to running of construction machinery the estimated noise levels at Barrage complex shall be 71 dB(A),whereas at two receptors i.e. ,Siangkhnai and Moosakhai shall be 34 dB(A) and 33 dB(A) respectively and the resultant levels (estimated +background level) at these receptors shall be 50 dB(A) and 50 dB(A) respectively which are less than the standard values 55 dB(A) for day time for Siangkhnai and Moosakhai but at night time these marginally exceeds the standard limit by 5 dB(A) and are not much perceptible. An increase of about 8 −10 dB(A) is required before the sound subjectively appears to be significantly louder.

11.9.9. ***Impacts due to Ground Vibration and Air-overpressure***

Due to blasting, the resulting PPV shall be 0.67 mm/sec and 0.53 mm/sec at Siangkhnai and Moosakhia village which shall be considerably lower than the limiting values 5.0 mm/sec for excitation frequency less than 8 Hz, in case of temporary structures. Predicted air over pressure due to blasting at Siangkhnai and Moosakhai shall be 105.2 dB(A) and 103.3 dB(A) respectively.

11.9.10. ***Impacts on Water Environment***

- During the construction phase, the river water on d/s of dam is supposed to catch considerable amount of sediment from the surface and underground works for which the water coming out from such area will be dislodged of sediment in the silt trapping tanks before being released to river.
- The discharge coming out of batching and crushing plants would also bring considerable sediments in water due to washing of plants and aggregate material.
- The sewage generated at the labour camps and other residential areas may also bring considerable pollutants to river sections, if disposed of in the river section without treatment.

- In the operation phase of the proposed project the water environment in general will not deteriorate as the water will be continuously used for power generation and will be released simultaneously.
- Problems due to eutrophication are not anticipated in the proposed project
- For downstream usages of river course will have a minimum environmental flow of 0.37 cumec released downstream of dam site for downstream riparian use of d/s 20 km length, during lean months (January-April). During non-monsoon and monsoon season the ecological flow requirement of 3.43 cumec and 10.33 cumec respectively shall be released d/s of barrage.

11.9.11. ***Impact due to Acidification of Reservoir***

There will be no acidification of reservoir due to the alkaline nature of the river water at dam site and upstream having pH vary between as 7.52 to 7.66.

11.9.12. ***Impacts on Flora***

It is evident from the study that the vegetation composition of the submergence zone is also widely distributed in the influence zone in abundance and there will be no significant loss to the habitat. However, any loss of riverine vegetation during the project activity period will be restored in the reservoir periphery in due course of time.

The floral abundance of the project area in post construction phase will increase by many folds as the plantation under catchment area treatment, reservoir rim treatment, green belt, restoration and landscaping will be completed.

11.9.13. *Impacts on Fauna*

As the project activity is not going to submerge all the major habitats, there is little concern for these niche birds. There will be no alteration to the existing habitat of endangered and threatened species. There is also no wildlife sanctuary, national park and biosphere reserve near the project area. As the project is having its submergence mostly along the deep gorge, the project is not likely to be a threat to any of the recorded butterfly species. Increase in temporary stress levels of wildlife during construction phase due to noise, human interference and reduction in present habitat. Threat due to poaching might increase. Due to reservoir creation, there will be improvement in the habitat for mainly water birds, reptiles, mammals, amphibians and plankton and Improvement in food chain of some reptiles, birds and carnivorous mammals due to creation of reservoir and increase in humidity level. The butterfly diversity in the area would be enhanced, as scrub habitat around the submergence will receive substantial amount of moisture, which will help in natural regeneration of forest canopy.

11.9.14. *Summary of Positive and Negative Impacts*

The positive impacts are-

- Additional annual generation of 708.98 MU of energy in a 90 % dependable year
- Better living Standards.
- Employment opportunities/fisheries.
- Benefits to economy and commerce.
- Access to improved infrastructure facilities.
- Recreation and tourism potential
- Improvement in environment through implementation of CAT, Compensatory Afforestation, Green belt Development and different other plans.

The negative impacts are -

- Land of 13 Villages shall be partially affected due to acquisition of land for project purpose.
- 378 families shall be impacted due to land acquisition.
- The loss of agriculture land (152.43 ha) and agriculture produce.
- Loss of livelihood and income.
- Loss of homestead and other assets over which the PAFs have developed affinity
- The change of river status from riverine to lacustrine regime
- The loss of forest due to construction of dam, reservoir and appurtenant works
- Disturbance to the fauna of the study area during construction
- Pressure on the existing provincial / state road will increase.

11.10. Impact Management

To ameliorate the negative effects of the project construction and overall improvement of the environment following management plans are formulated for implementation concurrent to the project construction. The cost of the management plans is shown in **Table 11.2.**

Table 11.2 : Summary of Total Cost Estimate of EMP

S. No.	Plans	Cost (Rs. Lakh)
1.	Catchment Area Treatment Plan	2917.00
2.	Compensatory Afforestation Scheme	2308.00
3.	Wildlife and Bio-diversity Management plan	100.00
4.	Resettlement & Rehabilitation Plan	30417.00
5.	Green Belt Development Plan	76.00
6.	Reservoir Rim Treatment Plan	85.00
7.	Landscape and Restoration Plan	18.00
8.	Fisheries Management Plan	192.00
9	Muck Management Plan	912.00
10.	Restoration Plan for Quarry Sites and Landscaping	60.00
11.	Disaster Management Plan	75.00
12.	Water, Air and Noise Management Plan	62.00
13.	Public Health Delivery Plan	334.00
14.	Labour Management Plan	55.00
15.	Sanitation and Solid Waste Management Plan	232.00
16.	Local Area Development Plan	1284.00
17.	Environmental Safeguards During Construction Activities	150.00
18.	Energy Conservation Measures	62.00
19.	Environmental Monitoring Plan	60.00
Grand Total		**39399.00**

Chapter 12. DISCLOSURE OF CONSULTANTS

12.1. Brief Profile of Company

EQMS India Pvt. Ltd., is a leading ISO 9001: 2008 complied and NABET/QCI consulting company constantly striving towards newer heights since its inception in 1998. EQMS is accredited in 17 sectors including 1 (c) River Valley Projects, 7 (c) (Industrial estates/park/complexes/areas, export processing zones (EPZs), Special Economic Zones (SEZs), Biotech Park, Leather Complexes) and 8 (b) (Area Development and Township Projects). EQMS has experience of about 20 years in field of EIA and is one of the pioneer company to get QCI/NABET Accreditation. NABET/QCI Accreditation Certificate is attached as **Annexure I.** EQMS is providing consulting services in almost all states in India and also in Sri Lanka, Nepal, Bangladesh, Bhutan, Saudi Arabia and Abu Dhabi. EQMS has experiences of carrying out EIA study as per regulatory requirements (MoEF&CC) guidelines and as per policy requirement of International Funding Agencies like World Bank, Asian Development Bank, IFC, USAID, UNDP etc. EQMS has carried out EIA study for various Hydro Power, Thermal Power, Solar Power, Wind Power, Industrial Estate/Economic Zone Projects located in India and Bangladesh.

The company has huge clientele comprising of Government Agencies (IWAI, MPPWD, JKSPDCL, UJVNL, UPDCC, MEPGCL, MMRDA, NMRC, Govt of Maharashtra, UPPWD etc.), PSUs (GAIL, TCIL etc.) and Private Clients. Our company is dedicated to providing strategic services in the areas of Environmental Impact study, Risk Assessment study, Environmental Audits, Due Diligence Assessments, Policy Trainings, Quality, Occupational Health & Safety, Social Accountability Management Systems; Enterprise level Behavioral Based Safety (BBS) Management; EHS Performance Benchmarking and Post Project Management.

EQMS has already experience of working in PAN India. EQMS has worked on some of the major projects in state, i.e. development of EIA, EMP, EMP implementation monitoring and Environmental monitoring for Navi Mumbai Airport Project: Package II, III and IV proposed by CIDCO, EIA /SIA/RAP study for conversion of overhead electricity network to underground system for three coastal towns (Alibag, Ratnagiri and Satpati) and for development of 8 nos of Saline embankments under NCRMP-II Project of Government of Maharashtra and SIA/RAP study for metro line project 2B and 4 of MMRDA, EIA Study for the Kerala Power Sector Reform Project, EIA study for development of the electricity transmission system for Turkmenistan, ESIA study for various hydro-electric power plants, Thermal power plants, solar power plants, wind power plants and transmission of electricity to the nearest substation as per IFC guidelines. Other than this there are various industrial projects in different states wherein EQMS has conducted environmental impact assessment study and obtained environmental clearance.

EQMS has worked on various projects which are funded by bilateral and multilateral funding agencies like World Bank, ADB, IFC etc. EQMS has experts from all the fields and has experience of working on river valley, water sector, irrigation and water supply projects

12.2. Team of Professional

EQMS has team of highly talented and experienced professionals including all required NABET approved Environmental Coordinators and Functional Area experts who work in sync with each other & clients ensuring that the defined assessment, survey or reporting is executed with high level of efficiency. Our experts team consists of Environment engineers, Environment specialist, Policy analysts, geologists, chemists, Safety Experts, civil engineers, Chemical Engineers, hydro geologists, Bio-diversity experts, industrial hygienists, technicians, research associates, sociologists and others

with expertise in various niche areas. They undergo various training sessions at regular intervals to keep themselves updated with new ideas, techniques and tools.

Table 12.1 : Qualification and Area of Expertise of Professional

Name	Experience	Key Qualifications	Areas of Expertise
Mr. S.K. Jain	30	B. Tech (Chemical) M.Tech (Chemical)	• Environment Impact Assessment • Due Diligence • Education, Capacity Building & Training • Air Pollution Monitoring and Control • Water Pollution Monitoring & Control. • Solid & Hazardous Waste Mgt • Risk & Hazard Analysis & Mgt. • Designing of STP, ETP & WTP • Consent Management
Mr. A.K. Chaturvedi	30	BE (Civil.) ME Env. Engg.	• Environment Impact Assessment • Air Pollution Monitoring and Control • Air Quality Modeling & Prediction • Noise & Vibration • EHS Legislations. • Health & Safety Audits • Energy Audits • Environmental Audits • Training on Behavioral Based Safety • Training & education
Mr. T.G. Ekande	30	B.A. Economics M.A. Economics PG Dip. Development Planning.	• Social Impact Assessment • Resettlement & Rehabilitation • Public Consultation • Land Acquisition • Monitoring & Evaluation • Institutional Development • Institutional Strengthening, Capacity
Mr. Yamesh Sharma	50	B.Sc. (Civil Engg.)	• Environment Impact Assessment • Hydrology & Hydro-Geology • Ground Water Estimation & Modeling • Water optimization & conservation • Land Use and Cover Study • Noise modelling & Vibration • Soil Conservation & Quality Analysis • RWH & Storm Water Management • Catchment Area Treatment • Dam Break Analysis

Mr. P. K. Srivastava	51	B. Tech (Chemical Engg.)	• Environment Impact Assessment • Air Pollution Monitoring and Control • Water Pollution Monitoring & Control. • Risk & Hazard Analysis & Mgt. • Consent Management
Mr. Sanjeev Sharma	22	B. Tech (Civil) M.Tech (Env.Sc.&Engg.))	• Air pollution prevention and control • Air quality modeling and prediction • Meteorology • Noise & Vibration
Mr. Hardik Pramodbhai Patel	11	M.Sc. (Geology) B.Sc. (Geology)	• Geology • Hydrogeology • Ground water Estimations and modeling • Rain water harvesting
Mr. Ratnesh Kotiyal	14	M.Sc. Botany	• Ecological & Biodiversity Study • Ecological Impact Assessment • Socio Economics Survey
Mr. Manoj Kumar Sharma	25	M.Sc. (Agriculture)	• Environment Impact Assessment • Laboratory Monitoring & Analysis • Soil Quality Analysis. • Ecology & Biodiversity Studies. • Agriculture
Mr. Anil Kumar	8	M.Sc. (Geography) P.G. Diploma (Remote Sensing & GIS)	• Land Use & Land Cover • Mapping (Remote Sensing &GIS Software) • Change in Land Use /Land cover • Socio Economy
Ms. Shweta Gupta	3	B.Tech. Bio-Technology M.Tech Environment Engineering	• Environment Impact Assessment • Noise & Vibration Studies • Water Pollution & Control
Mr. Kaleem Qureashi	6	M.A. (Geography) Certification Course (GIS)	• Land Use & Land Cover • Mapping (Remote Sensing & GIS Software) • Change in Land Use /Land cover • Socio Economy

Annexure – I: Certificate of Accreditation

Quality Council of India

National Accreditation Board for Education & Training

Certificate of Accreditation

EQMS India Private Limited

304-305, Plot No.16, Rishabh Corporate Tower, Karkardooma Community Centre, Karkardooma, Delhi-110092

Accredited as Category - A *organization under the QCI-NABET Scheme for Accreditation of EIA Consultant Organizations: Version 3 for preparing EIA-EMP reports in the following Sectors:*

Sl.No	Sector Description	Sector (as per)		Cat.
		NABET	MoEFCC	
1	Mining of minerals including Open cast/ Underground mining	1	1 (a) (i)	A
2	River Valley projects	3	1 (c)	A
3	Thermal power plants	4	1 (d)	A
4	Metallurgical industries (ferrous & nonferrous) - both primary & secondary	8	3 (a)	B
5	Cement plants	9	3 (b)	A
6	Chemical Fertilizers	16	5 (a)	A
7	Pesticides industry and pesticide specific intermediates (excluding formulations)	17	5 (b)	A
8	Synthetic organic chemicals industry (dyes & dye intermediates; bulk drugs and intermediates excluding drug formulations; synthetic rubbers; basic organic chemicals, other synthetic organic chemicals and chemical intermediates)	21	5 (f)	A
9	Pulp & paper industry excluding manufacturing of paper from wastepaper and manufacture of paper from ready pulp without bleaching	24	5 (i)	A
10	Isolated storage & handling of hazardous chemicals (As per threshold planning quantity indicated in column 3 of Schedule 2 & 3 of MSIHC Rules 1989 amended 2000)	28	6 (b)	B
11	Air ports	29	7 (a)	A
12	Industrial estates/ parks/ complexes/ Areas, export processing zones (EPZs), Special economic zones (SEZs), Biotech parks, Leather complexes	31	7 (c)	A
13	Ports, harbours, break waters and dredging	33	7 (e)	A
14	Highways	34	7 (f)	A
15	Common Municipal Solid Waste Management Facility (CMSWMF)	37	7 (i)	B
16	Building and construction projects	38	8 (b)	B
17	Townships and Area development	39	8 (b)	A

Note: Names of approved EIA Coordinators and Functional Area Experts are mentioned in SA AC minute dated May 11, 2018 posted on QCI-NABET website.

The Accreditation shall remain in force subject to continued compliance to the terms and conditions mentioned in QCI-NABET's letter of accreditation bearing no. QCI/NABET/ENV/ACO/18/0701 dated July 17, 2018.The accreditation needs to be renewed before the expiry date by EQMS India Private Limited, following due process of assessment

Sr. Director, NABET
Dated: July 17, 2018

Certificate No.
NABET/EIA/1619/ SA 070

Valid up to
May 23, 2019

For the updated List of Accredited EIA Consultant Organizations with approved Sectors please refer to QCI-NABET

National Accreditation Board for Education and Training
(Member - International Accreditation Forum & Pacific Accreditation Cooperation)

May 10, 2019

QCI/NABET/EIA/ACO/19/0969
EQMS India Pvt. Ltd.
304 & 305, 3rd Floor, Plot No. 16,
Rishabh Towers, Community Centre,
Karkardooma, Delhi – 110 092
(Kind Attention: **Dr. S. K. Jain**)

Sub: Validity of Accreditation

Dear Sir,

This has reference to the accreditation of your organization under QCI-NABET EIA Scheme, the validity of **EQMS India Pvt. Ltd.** is hereby extended till November 23, 2019 or completion of assessment process, whichever is earlier.

The above extension is subject to the submission of required information/documents related to assessment on time to NABET.

You are requested not to use this letter after expiry of the above stated date.

With best regards,

10/05/2019

A.K Jha
Senior Director| NABET

Institute of Town Planners India, 6th Floor, 4-A, Ring Road, I.P Estate, New Delhi-110 002, India
Tel. : +91-11-233 23 416, 417, 418, 419, 420, 421, 423 E-mail : ceo.nabet@qcin.org Website : www.qcin.org

National Accreditation Board
for Education and Training
(Member - International Accreditation Forum & Pacific Accreditation Cooperation)

NABET

November 19, 2019

QCI/NABET/EIA/ACO/19/1125
EQMS India Private Limited
304-305, Plot No.16, Rishabh Corporate Tower,
Karkardooma Community Centre, New Delhi - 110092
(Kind Attention: **Mr. Sanjay Kumar Jain**)

Sub: Validity of Accreditation

Dear Sir,

This has reference to the accreditation of your organization under QCI-NABET EIA Scheme, the validity of **EQMS India Private Limited, New Delhi** is hereby extended till February 18, 2020 or completion of assessment process, whichever is earlier.

The above extension is subject to the submission of required information/documents related to assessment on time to NABET.

You are requested not to use this letter after expiry of the above stated date.

With best regards,

19/11/2019

A.K Jha
Senior Director| NABET

Institute of Town Planners India, 6th Floor, 4-A, Ring Road, I.P Estate, New Delhi-110 002, India
Tel. : +91-11-233 23 416, 417, 418, 419, 420, 421, 423 E-mail : ceo.nabet@qcin.org Website : www.qcin.org

National Accreditation Board
for Education and Training
(Member - International Accreditation Forum & Pacific Accreditation Cooperation)

NABET

QCI/NABET/ENV/ACO/19/1230

10 February 2020

EQMS India Private Limited.,
304-305, Plot No.16, Rishabh Corporate Tower,
Karkardooma Community Centre,
Delhi- 110092
(Kind Attention: Mr. Sanjay Kumar Jain)

Sub: Validity of Accreditation

Dear Sir,

This has reference to the accreditation of your organization under QCI-NABET EIA Scheme, the validity of **EQMS India Private Limited**, is hereby extended till May 09, 2020 or completion of assessment process, whichever is earlier.

The above extension is subject to the submission of required information/documents related to assessment on time to NABET.

You are requested not to use this letter after expiry of the above stated date.

With best regards,

10/02/2020

A.K Jha
Senior Director| NABET

Institute of Town Planners India, 6th Floor, 4-A, Ring Road, I.P Estate, New Delhi-110 002, India
Tel. : +91-11-233 23 416, 417, 418, 419, 420, 421, 423 E-mail : ceo.nabet@qcin.org Website : www.qcin.org

National Accreditation Board
for Education and Training
(Member - International Accreditation Forum & Pacific Accreditation Cooperation)

Oct 28, 2020

QCI/NABET/EIA/ACO/20/1513

EQMS India Pvt Ltd
305, 3rd Floor, Plot No. 16, Rishabh Towers,
Community Centre, Karkardooma, Delhi – 110 092

Sub.: Extension of Validity of Accreditation till Jan 27, 2021 - regarding

Dear Sir/Madam

In view of the outbreak of Corona Virus (COVID-19) and subsequent lockdown declared for its control vide order dated 24th March 2020, issued by Ministry of Home Affairs, Govt. of India, NABET hereby extends the Validity of your Accreditation till Jan 27, 2021.

As soon as, NABET office opens/resumes its operation necessary action regarding issuance of certificate/extension of validity letters / other may be initiated, therefore, ACO to ensure their complete application with NABET, if applicable.

Meanwhile, you may enclose this with your EIA reports along with the certificate/validity letter. The EAC/SEIAA/SEAC/Other are hereby requested to consider the same as a valid document for the preparation of EIA/EMP report.

With best regards.

(A K Jha)
Sr. Director, NABET

National Accreditation Board
for Education and Training
(Member - International Accreditation Forum & Pacific Accreditation Cooperation)

QCI/NABET/ENV/ACO/21/1607 Jan 25, 2021

To

EQMS India Pvt Ltd.
305, 3rd Floor, Plot No. 16, Rishabh Towers,
Community Centre, Karkardooma, Delhi – 110 092

Sub.: Extension of Validity of Accreditation till April 24, 2021 - regarding

Dear Sir/Madam

In view of the outbreak of Corona Virus (COVID-19) and subsequent lockdown declared for its control vide order dated 24th March 2020, issued by Ministry of Home Affairs, Govt. of India, NABET hereby extends the Validity of your Accreditation till 24 April, 2021.

Meanwhile, you may enclose this with your EIA reports along with the certificate/validity letter. The EAC/SEIAA/SEAC/Other are hereby requested to consider the same as a valid document for the preparation of EIA/EMP report.

With best regards.

(A K Jha)
Sr. Director, NABET

Institute of Town Planners India, 6th Floor, 4-A, Ring Road, I.P Estate, New Delhi-1 10 002, India
Tel. • +9 11 -233 23 4 1 6, 417, 18, 419, 420, 421 ,423 E-mail : ceo.nabet@qcin.org Website : www.qcin.org

Annexure – II: Certificate of Accreditation of Laboratory Engaged

National Accreditation Board for Testing and Calibration Laboratories
(A Constituent Board of Quality Council of India)

CERTIFICATE OF ACCREDITATION

J.P. TEST & RESEARCH CENTRE

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2005

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

4/54, Site IV, Sahibabad Industrial Area, Sahibabad, Ghaziabad, Uttar Pradesh

in the field of

TESTING

Certificate Number TC-8047 *(in lieu of T-4182 & T-4181)*

Issue Date 10/10/2018 Valid Until 09/10/2020

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.

(To see the scope of accreditation of this laboratory, you may also visit NABL website www.nabl-india.org)

Signed for and on behalf of NABL

8907697010003000232O

Anil Relia
Chief Executive Officer

ilac-MRA NABL

National Accreditation Board for Testing and Calibration Laboratories

(A Constituent Board of Quality Council of India)

QCI

26.06.2020

Extension in Validity of Accreditation

NABL Policy: It is decided to extend the validity of accreditation for a period of one year to all conformity assessment bodies (CABs) where renewal of accreditation is to take place and accreditation validity date is between 01.01.2020 and 30.06.2022 **subject to the following**:

1. Providing satisfactory documents based on NABL-218 wrt compliance to the requirements of the relevant Standard and NABL requirements.
2. The CABs are required to conduct additional internal audit to ensure compliance with the standard requirements (by increasing the existing frequency of their audit plan) and submit the document.
3. The CABs are required to provide control charts and trends for assuring the validity of results.
4. CABs are required to provide an undertaking to undergo unannounced assessment (onsite and/or remotely, depending on the situation) and actions as per NABL-216 thereof, at any point of time during the validity period.
5. Making payment of **annual accreditation fee** for the extended period.

Examples:

- Accredited CABs with date of issue 15.01.2018 and valid till 14.01.2020, then their Accreditation validity will be extended till 14.01.2021.
- Accredited CABs with date of issue 15.02.2019 and valid till 14.02.2021, then their Accreditation validity will be extended till 14.02.2022.
- Accredited CABs with date of issue 15.06.2020 and valid till 14.06.2022, then their Accreditation validity will be extended till 14.06.2023

NOTE:

1. The above will be applicable to the laboratories for which transition to ISO/IEC 17025:2017 version has been completed. For the laboratories which are accredited as per ISO/IEC 17025:2005 version, they have to undergo transition assessment (onsite and/or remotely, depending on the situation) and follow transition plan defined.
2. The above is not applicable to CABs where there will be a change in name of CAB and/or legal identity change and/or Premises change.
3. Also, **the above is not applicable to the CABs which are not registered in portal** (exemption- International accredited CABs).
4. Routine assessments will take place for any scope extension /addition.
5. Payment due to NABL can be deferred (postpone the payment) upto a period of Six (6) months. There will be no waive-off of any fee for any CABs. If payments are not made, then action as per procedure (NABL-216) will be initiated. There will be no relaxations wrt payment from 01.01.2021.

Director

N.Venkateswaran
CEO, NABL

NABL House, Plot 45, Sector 44, Gurugram 122 002, Haryana, India
Tel. No.: +91-124-4679700 (30 lines) • Fax: +91-124-4679799 • Website: www.nabl-india.org