Draft Final Report

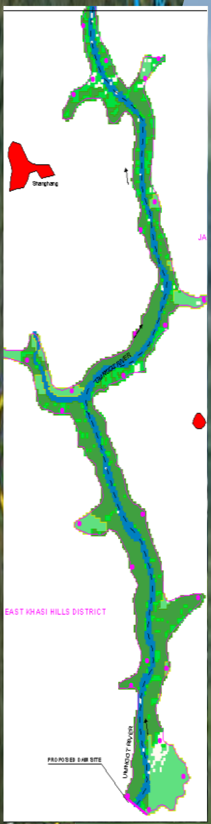
INDIA

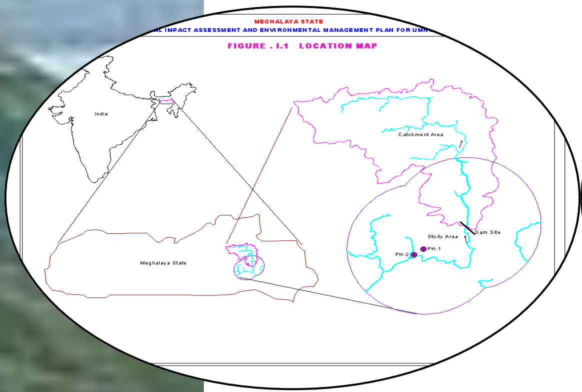
MEGHALAYA

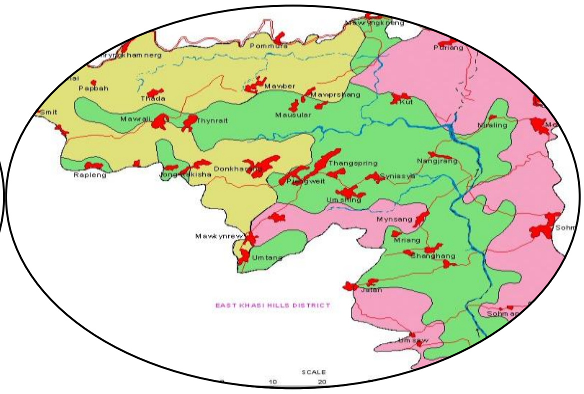
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

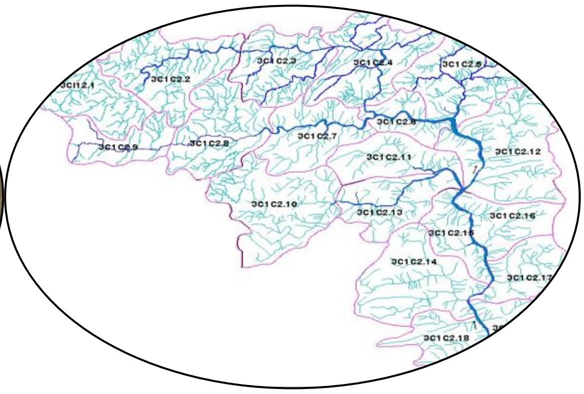
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT OF

UMNGOT HYDRO-ELECTRIC PROJECT
(3 X 80 MW)









Submitted to

MEGHALAYA ENERGY CORPORATION LTD

AFC

AGRICULTURAL FINANCE CORPORATION LTD
GUWAHATI
November 2010

INDIA
MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

CONTENTS

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EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - I

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Chapter - I

INTRODUCTION

INDIA
MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT
(3 X 80 MW)

PART - I
ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

I
INTRODUCTION

Backdrop

1.01 There has been a global rise in growth of population over years, necessitating the urgent need for rapid development in all fields to meet the requirements of the growing population. As a sequel to this situation there has been an all-round development in industrialisation/urbanisation both in the developed and the developing countries. This rapid development is causing a serious concern in providing and maintaining pollution free environment. An analysis of the present situation has brought to light that industrialisation and urbanisation, particularly in the developing Countries has been creating more stress on the natural resources with over exploitation and associated depletion of plant and animal wealth. Keeping in view the biotic stress in the recent past, protection of natural environment has been gaining highest priority while planning for any developmental projects like Thermal and Hydro Power Generation units, Irrigation projects, road projects, industrialisation, etc.

1.02 It is an established fact that nature's stability is dependent on bio-diversity and environmental sustenance. Therefore, during the last couple of decades there has been a spurt in the awareness on the need for environmental protection and environmental management for improving the global ecology. Serious efforts are, therefore, being made to conserve and regenerate the nature because of the fact that the poor live in by 'Gross Nature Product' and the bio-mass developed in various forms in different regions along the hills, plains, rural areas and in other parts with dense human habitation. To meet the challenges of environmental pollution, the developed countries in the world have taken concrete steps and have established separate Departments/Ministries exclusively for this purpose. Falling in line with the developed countries, the Government of India has established an exclusive Ministry of Environment and Forests (MOEF) for taking care of environmental protection needs. Safeguarding the interests of environment is done through suitable identification of Environmental Impacts and preparing suitable Environmental Management Plans while sanctioning establishment of industries, reservoirs/dams, railways, thermal power plants, etc to mitigate the impact. In other words, any project interfering with the environment is governed by the Environmental Protection Act enacted by the Government of India. The Ministry of Environment and Forests (MOEF), Government of India, therefore, is the nodal agency for sanctioning the Environmental Clearance for developmental projects. While clearing the projects, the MOEF is taking care of the environmental needs within and around the areas of different developmental projects/schemes in the Country. As per the notification dated 14th September 2006 issued by the Ministry of Environment and Forests the following are the stages prior to Environmental Clearance (EC) process for the new projects in sequential order.

- Stage – 1 - Screening
- State – 2 - Scoping
- Stage – 3 - Public consultation
- Stage – 4 - Appraisals

1.03 Out of the above the first two stages are over and the present report is prepared for the other two stages.

The Project and its Objectives

1.04 In view of wide gap between the availability of demand for power in the State, the Meghalaya Energy Corporation Limited (MeECL) is in search of avenues to establish power generation units. As a part of this search exercise, the MeECL identified the Umngot hydropower generation as an ideal choice for establishing one hydro-electric power generation project. The two main resources available for power generation in the country as well as in the state of Meghalaya are hydro potential available along the river drops and fossil fuels. There are severe limitations on the availability of fossil fuels for power generation. Also, the existing ratio of hydro and thermal power generation at the National level is 25:75 whereas the ideal economic ratio should be at least 40:60. A review of utilisation of available hydro resources in the state for power generation indicated that there is tremendous scope for developing hydro power sector and this is imperative to develop hydro power in the state. Meghalaya is endowed with numerous river systems originating and flowing towards north as well as south. The north flowing rivers ultimately join Brahmaputra River. The major rivers flowing towards south into Bangladesh which ultimately join Barak – Meghana river systems are Myntdu, Umngot, Umngi, Kynshi, Umiew and Someswari. Most of these rivers and distributaries have a good hydro power generation potential of over 3000 MW.

1.05 The state has proposed Umngot Hydro-Electric project with an installed capacity of (3 x 80) 240 MW which would bridge the gap between demand for and the supply of power as well as the ratio of hydro and thermal power generation. Thus, the project is proposed to be implemented with a dual objective of narrowing down the gap between demand and supply of power as well as the adverse ratio of hydro and thermal / fossil fuel power generation.

1.06 The liberalized industrial policy of Meghalaya has triggered an unprecedented load growth in the industrial sector coupled with identical growth in other sectors due to the accelerated power development and reform process. The state has a generating capacity of only 185.2 MW and central share of approximately 100 MW is unable to cater to the present requirement of power and future increase in demand.

1.07 The Peak Load Demand for 2006-07 was around 240 MW and it is expected that with the present trend, the anticipated Peak Demand of Meghalaya by the end of the 11th Plan would be of the order of 430 MW. The commissioning of the 126 MW Myntdu Leshka HEP by December 2010, the 40 MW New Umtrew HEP by 2011 and the 25 MW Ganol HEP also by 2012 would still not cater to these demands. Therefore, it is proposed to develop a mega project which would adequately meet the projected demand. The Umngot basin in the near vicinity which is adjacent to the Myntdu basin and offers a scope to generate power with map of the proposed Umngot HEP is shown in Fig. I .1 an installed capacity of 240 MW.

Objectives of the EIA and EMP study

1.08 The basic objective of the study is to assess the environmental impact of the proposed hydro-electric power generation project on land, water, air, climate, flora and fauna, public health, etc., and formulate a suitable environmental management plan for minimising or avoiding the negative impacts that are likely to occur due to construction of the project in the area.

Scope of the study

1.09 The scope of the study is as follows:

i) Assess the impact of the project on land environment and propose suitable CAT plan;
ii) Assess the impact of the project on water environment;
iii) Assess the impact of the project on biological environment comprising flora and fauna, migratory birds, endangered species of both flora and fauna;
iv) Assess the impact of the scheme on climate;
v) Assess possible health hazards during pre and post project stages;
vii) Formulate a detailed Environmental Management Plan for maintaining healthy environmental cover in the project area;
viii) Assess the impact of the project due to acquisition of land, morbidity etc. of the population in the area;
ix) Conduct a detailed household survey of the Project Affected Families (PAFs) and formulate Economic Rehabilitation Plan for the affected families to ensure the pre-project economic living standards to the identified PAFs;
x) Study the feasibility of compensating land for land nearer to the project area especially to the tradition bound tribals, if any, affected under the project;
xi) Identify suitable locations for the resettlement of the displaced families, if any, in the nearby areas and assess the infrastructural needs in the resettlement colony for education, health, drinking water, etc.;
xii) Assess the training needs and provide suitable training modules for human resources development;
xiii) Suggest suitable organisation for implementation of the EMP; and
xiv) Estimate the Project Cost for implementation of the Environmental Management Plan.

Recommendations

1.10 The following aspects need to be detailed as a part of EIA Impact due to acquisition of forest land, Impact on the migratory fish species as a result of construction of dam, Impact on ethnographic aspects, proper stabilization of quarries and muck disposal sites, Management of pollution sources from labour camps and Formulation of resettlement & rehabilitation plan for project affected families.

Team Composition

1.11 The Agricultural Finance Corporation Ltd. constituted a high level Technical Team of Experts drawn from various disciplines supported by Technical Supervisors and Computer Operators. The team of experts is as follows:

1.12 The team constituted by Agricultural Finance Corporation Ltd (AFC) comprises specialists drawn from Environmental Engineers, Agronomists, Hydrologists, Irrigation and water management specialists, Hydro geologists, Forestry, Fisheries, RS and GIS specialists supported by a large number of field level technical professionals for collection of both primary and secondary data and also computerization, processing and generation of relevant reports.

THE TEAM		
Sl.no	**Name**	**Designation**
I.	**CORE TEAM**	
1	Shri M. Dharma Reddy	Team Leader and Project Coordinator
2	Dr. K.B. Reddy	Environmental Sciences, Bio Diversity Expert
3	Shri A. Srinivasa Rao	Hydrologist and Irrigation Expert
4	Dr. Alex Thomas	Command Area Development and Dam Break Expert
5	B.R.Syiemlieh	Manager and Incharge, Guwahati AFCL
6	Shri. U.M. Lal	Socio-Economic and R & R Expert
7	Shri V K Malleswar	Agricultural Engineer
8	Mr. M. Satya Bhanu	Remote Sensing & GIS Expert
II. MIDDLE LEVEL TEAM		
9	Ms. K. Padma	Project Officer, RS and GIS Specialist
10	Shri C. Manohara	Project Officer, & R &R
11	Miss Malakhi Deuri	Associate Environmentalist
12	Mr. N. Suresh	Project Associate
13	Mr. J. Goswami	Assistant Project Officer, R &R
III. SUPPORTING STAFF		
14	Md. Nazeeruddin	CAD & GIS Engineer
15	Mr. M. Ashish	CAD & GIS
16	Ms. Sunitha	CAD & GIS
17	Ms. I. Manjulatha	Computer Programmer
18	Ms. G. Rajyalaxmi	Computer Operator

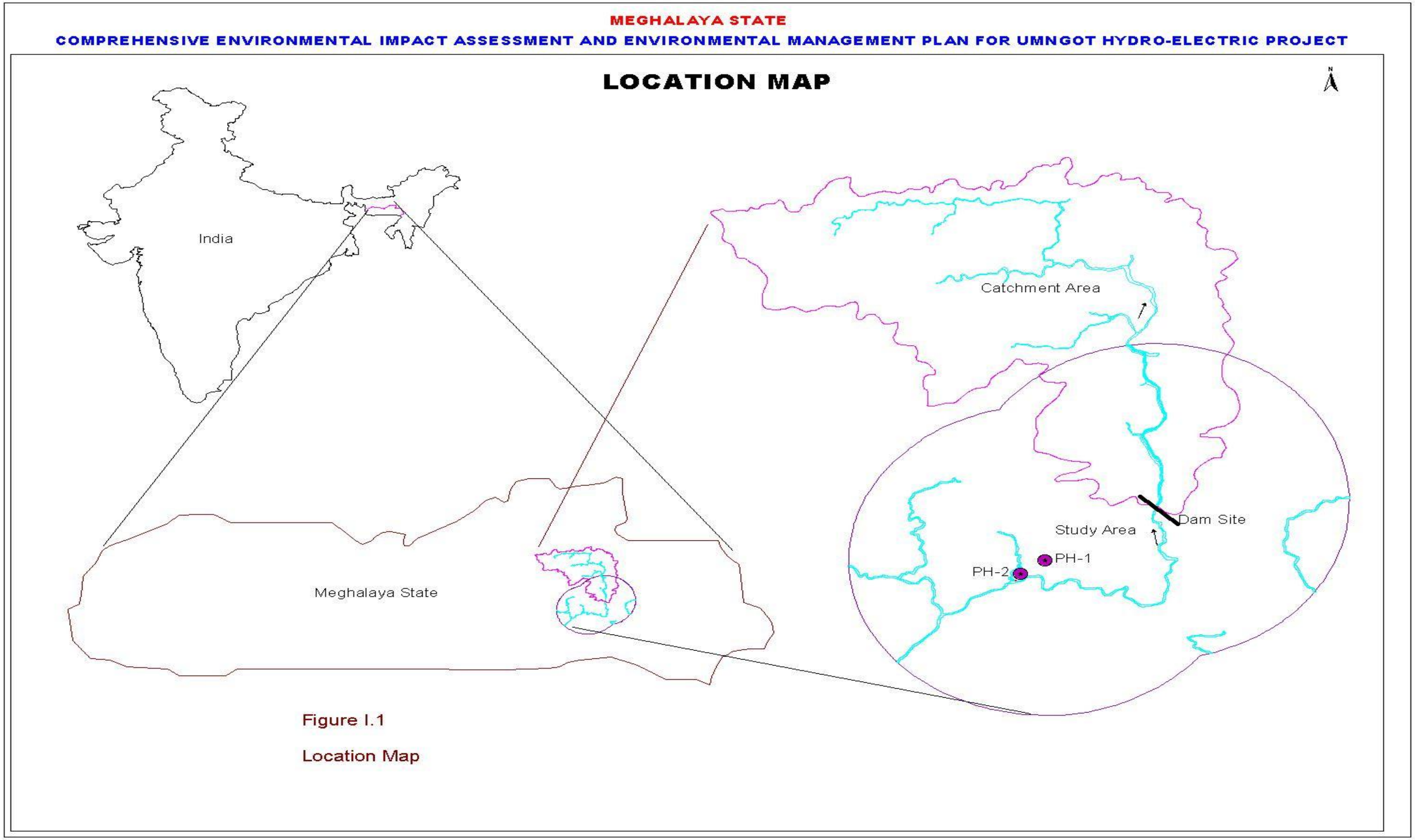

Figure I.1

Location Map

1.13 The report is divided into two parts and they are as follows:

Part - I: Environmental Impact Assessment (EIA),
Part - II: Environmental Management Plan (EMP)

History of Power Generation

1.14 The North Eastern Region comprises the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. This region of India has been consistently suffering from shortages in meeting peak energy demand during the last decade. The shortfall of energy has become more aggravated since 1991. During the last few years, Meghalaya has been contributing about 100 MW of power by coordinating its operations and maximizing power generation during the peak load hours. At the same time the state is drawing maximum power during peak hours. This situation might prevail for some more years till some new hydro power stations come up in the region. Any power project contributing towards supply of peak power will give inputs to the industrial and financial growth of Meghalaya state.

1.15 In recent years power crisis in North-Eastern Region has become severe and fatal. The supply side approach infact turned off the bend and crashed noisily against ecological limits. Large dams particularly have been singled out for causing catastrophic environmental damage. This rapid development is causing a serious concern in providing and maintaining pollution free environment. Keeping in view the biotic stress in the recent past, protection of natural environment has been gaining highest priority while planning for any developmental projects like thermal and hydro power generation units, irrigation projects, road projects and industrialization, etc.

Assessment of Alternative Sites

General

1.16 The Umngot HEP is the first of the two stage planned developed of the Umngot river basin for the generation of hydroelectric power. The concrete gravity dam for this project is proposed to be located near the Siangkhnai village at 92°00°38°E; 25°21°31°N bordering East Khasi Hills District and Jaintia Hills District of Meghalaya. The HRT of modified horse shoe shape with 3.6 m diameter will take off from an Intake in just 75 m away from the dam on the right banks which will be driven through a granite-gneiss formation for 5588 m. The Surge Shaft at the end of this tunnel is 79.90 m high with a diameter of 10 m. Due to the topographical conditions and the high head involved, and Underground High Pressure Shaft lined Shaft, 2.75 m diameter, having an inclined limb of 970.00 m and a horizontal limb of 1230.00 m, is proposed to be constructed right from the Surge Shaft to be connected to the Surface Powerhouse of size house (107.5 m x 31 m x 20 m) . The underground shaft will accommodate a butterfly valve in its initial reach and it will be trifurcated just before the power house to feed the 3(three) units of 80 MW capacity each fitted with a Pelton

Turbine. The water from the powerhouse would be discharged through a common channel of size 6.60 m x 2.80 m back into the Umngot River.

1.17 The proposed layout has been chosen on the basis of the best possible choice from several alternatives considered which are discussed in the following paragraphs. The preliminary designs of major hydraulic structures were carried out as per relevant I.S. Codes and are included in a separate volume. This section discusses only the planning and design aspects of these works.

Alternative Studies of Project Components

Dam Site

1.18 Two alternative dam sites were chosen on the basis of the site specific topographical conditions. The sites were chosen in close proximity to the location from where the profile of the river bed upstream follows a mild slope which is suitable for impoundment of the river flows and from where the river downstream suddenly drops down through waterfalls and rapids making it amenable for power development.

1.19 The river bed at the upstream site is at an elevation of EL.955.00 m. At this section, the height of the dam would be 87 m with the top length reaching about 380 m with the maximum FRL of 1040 m considered for DPR studies. The river is quite wide at this section where it stretches to about 80 m. The geological features exposed at this site suggest fresh rocks of migmatised granite gneiss dipping upstream. Both the abutments slopes at 45°-60° with rocks exposed up to 10 m from the river bed. The bed rock appears intact with no indication of failure along joints. However, there is a presence of intrusive basic bodies which would render a non-homogenous foundation for the dam body.

1.20 The other dam site alternative is located at 92°6°38° E; 25°21°31° N approximately 1.0 km downstream of the previous site where the river bed is at EL 935.0 m. The width of the river is very narrow at this point which only 45 m at HFL is. The height of the dam would reach 107 m with an FRL of 1040 m and the length of the dam would extend to about 360 m at the top. During preliminary investigations, moderately jointed granite gneiss is seen to be exposed in the river bed as well as on both the abutments and shallow overburden comprising slope wash supporting thick vegetation has been observed on the abutments at higher elevations. This site appears feasible from the geological point of view.

Intake and HRT

1.21 Three intake sites on the right bank were examined for consideration in the planning of the layout of the HRT.

1.22 Alternative – I: The first alternative for the intake was chosen at the location marked ‘A’ which is close to a perennial nala at a distance of about 170 m from the dam axis. The HRT from this point is initially aligned in S85° W direction for 1.50 km upto bend point B from which the HRT is aligned in S52° W for the rest of its length. There is however apprehension of low cover for the HRT near the proposed intake, both vertically and laterally, which could result in chimney formation and loose fall from sides and crown and heavy ingress of ground water may pose problem during tunneling. The length of the HRT along this alignment shall be 5.90 km.

1.23 **Alternative-II:** A second alternative for the intake is therefore examined at a location of about 300 m away from the dam axis. The HRT from this point is aligned initially in S75° W for a length of 1.16 km upto point ‘R’ where it is then aligned in a S53° W for the rest of its length. The intake site at this location is covered by thick vegetation and soil/slope wash followed by moderately to highly weathered jointed granite gneiss. The HRT with this alignment follows higher elevation of ridge to have maximum cover which is composed of Archaean biotite-gneiss capped by Teritary sandstone. The cover in most of its reaches is more than 300 m and it is apprehensive that this excess cover may create high stress conditions and cause stress related problems. The length of the HRT along this alignment shall be 5910.00 m.

1.24 Alternative-III: A third alternative for place the intake is therefore examined for a location quite close to the dam axis, at just 70 m away, after avoiding a nala nearby. Loose boulders and thin overburden are observed in the area. Moderately jointed and weathered granite with occasional partings of schist is exposed in the intake area. The site appears feasible and would only require removal of thin overburden and some loose rock mass for placing the intake structure. The new HRT alignment would now follow a straight course in S62° W up to the surge shaft location. The length of the HRT along this alignment shall be 5588.00 m. The length of the HRT in this case would hence, get reduced by about 1.0 km as compared to other two alignments. This alignment appears feasible on topographical conditions and would have sufficient but lesser vertical cover than the 2nd alternative and thereby reduce the excessive stress conditions of the rock mass.

Surge Shaft

1.25 Preliminary topographical studies and a reconnoitre of the area around 92°03’40”E; 25°20’10”N between EL.1000 m to EL.1075 m suggest a site feasible for locating a surge shaft on topographical conditions. The topography is comparatively milder and the ridge on this section has a much wider reach for getting sufficient side cover for the shaft. The location is also strategically positioned for examining three possible alternative sites of placing the power house. A borehole drilled at EL.1025 m indicates that fresh hand and compact granite is available at 61-62 m below the ground surface.

Penstock and Powerhouse

1.26 Three possible alternatives were considered for placing of the powerhouse identified as PP1, PP2 and PP3 in the order of the sequence of the locations starting from the downstream towards the upstream sites.

1.27 Alternative PP1: The alignment of the proposed surface penstock for this alternative follows a course in S43° W from the surge shaft location with a few bends and the surface powerhouse site is selected just upstream of the confluence of the Umsot stream and the river Umngot at about 90°02'38" E and 25°19'05"N where the level of the river at this section is EL.200 m. The penstock length is estimated at this site to be 3400 m. A drill hole drilled at EL 600 m mid-way through the penstock alignment suggests that thick overburden and highly weathered rock mass is likely to be encountered in this alignment. The powerhouse site appears feasible which could be founded on granite after the removal of 5-10 m overburden and weathered rock.

1.28 Alternative PP2: The alignment in this case follows in S26° W from the surge shaft. The topography through this course is not suitable for a surface penstock as the alignment is criss-crossed by a number of streams and saddles except for the lower most reaches where a surface penstock could also be placed. Through this alignment, two powerhouse alternatives area considered. One alternative **(PP2(U))** is for an underground powerhouse located at the bottom of an included shaft of 1100 m along with a tail race tunnel and an access tunnel each of 1200 m long. A ventilation-cum-emergency exit tunnel, 600 m long, is also proposed to be provided. The other alternative **PP2(S)**, is proposed to have a surface powerhouse either with an underground shaft throughout with inclined limb, 1035 m long and horizontal limb of 1265 m long, hereby name **PP2(S-1)**, or a combination of an underground shaft with an inclined limb and a horizontal limb of 600 m long and 840 m long respectively, and a surface penstock of 860 m long, hereby namely **PP2(S-2)**.

1.29 The river bed in this section is at an elevation of about 214 m. From the exposed features along the many streams criss-crossing this alignment it is anticipated that the underground hydraulic system from the surge shaft up to the tail race end would be contained in a homogenous granite basement rock.

1.30 **Alternative PP3:** This alternative follows an alignment in S10°E from the surge shaft. The alignment traverses through a ridge line contained within a narrow strip between two deep perennial steams. The topography appears feasible for a surface penstock but there is very limited scope for locating a surface powerhouse and switchyard due to the steep terrain in the area. The river bed in this section is about EL.280 m. The length of the surface penstock would be about 2600 m.

1.31 With a view to provide power facilities in the backward areas and towns in Meghalaya state and thereby improve the socio economic conditions of the citizens, Meghalaya Energy Corporation

Limited has proposed for construction of Umngot HE project as a diversion scheme on Umngot river to tap the hydropower potential by construction of a concrete dam at Saida near the village of Siangkhnai in the East Khasi hills district of Meghalaya. The project envisages to divert the water of Umngot river from the right bank into a 5.6 km long Head Race Tunnel of 3.6 m diameter, and 79.90 m high surge shaft of 10 m diameter and a pressure shaft of 2200 m long and 2.75 m diameter to feed three Peltron units of 80 MW each housed in an over ground or surface power house. A 146 m long Tail Race discharges the water back into the river in a very deep gorge just beyond the village of Syntung.

1.32 During review of the preliminary feasibility report with the above proposals, it was optimized the utilization for power generation based on water availability of 71.32 Mcum at FRL of 1040. The zero elevation after 75 years of siltation in the reservoirs is worked out in hydrological studies as EL 995.8 m.

Environmental Impact Studies

1.33 The change in the environment may be because of submergence of land, displacement of population including Flora and Fauna and resettlement in the surrounding catchment, denudation of Forest, water logging, salinity and alkalinity of soils, water quality and ground water fluctuations etc. Different types of environmental and ecological impacts may be observed in the areas due to this project. It is, therefore, essential to assess the possible adverse impacts along with positive impacts from the relevant areas of the project, so as to formulate a suitable environmental management plan to eliminate or minimize the negative impacts. Thus, the basic objective of the study is to assess the environmental impacts of the proposed Umngot H.E project on land, water, climate, including air and noise, flora and fauna, public health, submergence of habitations, etc., and suggest a suitable Environmental Management plan with necessary mitigative measures.

1.34 The river Umngot is set in very deep gorge along the stretches of the proposed development of the Umngot HEP. The elevation difference from the hill top to the river varies considerably from 400m to 1100m. The reservoir and other project components are, therefore, set to be confined on the gorge itself. Although the migration of construction labourers during the construction period would increase many fold, however, no adverse impact on the socio-economic aspect is expected as the local people have strong traditional values which are not easily influenced by outside forces.

Scope of the Study

1.35 The broad scope of the work is to carry out comprehensive Environment Impact Assessment of the proposed Umngot H.E project. This includes assessment of positive and negative impacts likely to occur with its economic evaluation, and preparation of EMP. The scope further includes study of Socio-Economic aspects and preparation of R& R plan for the project affected people. The scope also includes Disaster Management plan along with Dam Break analysis besides formulation of implementation plan. In brief, the following aspects will be covered under the Comprehensive Environment Impact Study of the project.

- Land Environment
- Water Resources and Water Quality
- Aquatic Ecology
- Terrestrial Ecology
- Socio-economics
- Air Pollution
- Noise Pollution
- Public Health
- Risks and Hazards
- Preparation of Environmental Monitoring Plan (EMP)

1.36 The following chapterisation is adopted for the preparation of the report duly covering various aspects related to Environmental impacts and Environmental Management Plan.

Chapterisation

Part I : **Environmental ImpactAssessment**

i. Introduction
ii. Project area and Baseline Features
iii. Land Environment
iv. Water Environment
v. Biological Environment
vi. Climate and Mateorology
vii. Public Health.

Part II: Environment Management Plan

viii. Catchment Area Treatment
ix. Land Management Plan
x. Bio – Diversity Management plan
xi. Public Health Management plan
xii. Environment Monitoring plan
xiii. Dam Break Analysis and Disaster management plan
xiv. Rehabilitation and Resettlement Plan
xv. EMP Implementation plan
xvi. EMP Project cost.

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EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - I

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Chapter - II

THE PROJECT AREA AND BASELINE FEATURES

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PART - I
ENVIRONMENTAL IMPACT ASSESSMENT (EIA)
II
THE PROJECT AREA AND BASELINE FEATURES

General Features of Meghalaya State

2.01 Meghalaya State is situated in the North–Eastern Region of India, between the Brahmaputra Valley in the North and Bangladesh in the South. Meghalaya State was carved out of former State of Assam as an autonomous State on April 2, 1970. It was declared as a State of the Indian Union on January 21, 1972. The State is one of the seven sister states of North Eastern Region bordered by Assam in the north and Bangladesh in the south. The State of Meghalaya or "the abode of clouds" is geographically known as the Meghalaya Plateau or the Shillong Plateau", is known for its scenic beauty. Above all, Cherrapunji the place receiving the highest rainfall in the world offers flora unique to India with the wealth of pine, firs, orchids and tropical vegetation. It is one of the most picturesque states of India and its people are part of a matriarchal society.

2.02 Meghalaya has a geographical area of 22,429 sq km with Shillong as capital and consists of Garo, Khasi and Jaintia hills along with their outline formed by the Assam ranges. The State is divided into seven administrative districts namely Jaintia hills, East, West and South Garo hills, East and West Khasi hills and Ri-Bhoi. The plateau is highly dissected and has irregular terrain in the western and northern side. The southern side is marked by a continuous escarpment with steep slopes. The central land and eastern part of the plateau or The Khasi and Jaintia Hills districts plays prominent serrile topography. The Shillong plateau is incised by numerous river valleys. Shillong peak is the highest in the entire state with EL 1965 m above MSL. The southern flowing rivers are Umiew, Kulpi, Umiam, Umngot and Myntdu. The Umngot HEP is located in the southern face of the State which is manned by deep gorges, spurs and abrupt slopes.

2.03 The Umngot basin which lies in the mid-central upland is geologically formed mainly by the Jaintia Groups of rocks, overlaying over the Archean Gneissic rocks, substantial part of Granite, Quartzite, schist, sills and dykes are found in these formations. The soil thickness is usually very thin in most parts. Red loamy soil occupies the northern portion whereas the southern is comprised mainly of Red, Yellow soil. The natural vegetation ranges from coniferous trees in the upper region to temperate forests and sub-tropical forests in the middle and lower hills. Stony wastelands and grasslands occupy most of the drainage basin. The density of the population per sq. km in the whole area is very low. It is 72 in Jaintia hills district and 138 in the East Khasi hills district in the rural areas. The main occupation is marginal farming and developmental activities are at very slow pace. Irrigation is usually not practicable and almost absent and therefore cultivation is dependent on rain. Only about 2% of the land is under cultivation and except for land with forests, the rest is waste and fallow land.

Location of the Project

2.04 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 river length from this place of origin upto the dam site is about 51 km. in a slope of 1:55. The Umngot HE project has been identified as a diversion project with pondage on the Umngot River in East Khasi hills district for hydro power generation. The Umngot HE scheme is located near Siangkhanai village of East Khasi Hills district. The catchment area and pondage lies in the districts of East Khasi hills and Jaintia hills.

2.05 Short stretch of about 20 km. between the proposed Dam site and the Powerhouse site is encountered by a numbers of rapids and falls to drop from an elevation of 940 to 210 m, offering a good scope for harnessing Hydro power potential from the river. The drop between the proposed dam site and power house is about 749 m. The dam site is located at a longitude of $92^0$6' 45" and latitude $25^0$21'38". The catchment area at the proposed dam site is about 304 sq.km.

2.06 The Gross and Live storage of the Umngot storage reservoir is 38.59 MCM and 32.95 MCM at FRL / MWL El 1042.0 m and MDDL at EL 995.0 m respectively. With the construction of a 111 m. high diversion dam the water will be diverted from the right bank through a 5588 m long Head Race Tunnel (low pressure tunnel) upto the Surge Shaft. An underground High pressure Shaft of length 2200 m long would then connect it to a surface Power house which is located inside the mountain formation at a place near the village of Syntung. The water would be discharged back into the river through a 140 m. long Tail Race . The installed capacity is proposed as 240 MW to be generated through 3 Nos. of Pelton Turbines of 80 MW each.

2.07 The Umngot Hydro-Electric Project is expected to generate 240 MW in a dependable year. The power from this project would be very much useful in mitigating the hardships of power crisis in the state as well as in the region besides providing employment in two districts of East Khasi hills and Jaintia hills.

2.08 The Umngot Hydro Electric Power project envisages the following main components.

1. Concrete gravity dam in the gorge portion across Umngot River of 111 m high and 394 m long to impound on effective storage of 32.95 MCM.
2. Intake and Head Race Tunnel (HRT) of 5588 m long and 3.6 m diameter modified horse shoe low pressure tunnel.
3. High pressure shaft 2200 m long and 2.75 m diameter. High pressure shaft.
4. Surface power house (107.5 m x 31 m x 20 m) and Gas Insulated Switchyard (107.5 m x 34 m x 24 m).
5. Free Flowing Tail Race 140 m long to lead the effluents back to Umngot River.
6. Surge shaft with a chamber of 79.90 m high and 10 m diameter between low pressure tunnel and high pressure tank.

2.09 Besides the above, minor components such as approach roads, temporary and permanent colonies, switch yard etc. are also proposed. A base map showing general layout of different major components is appended as **Fig- II.1.** Salient features of the project are presented in **Annexure – II.1.**

Study Area

2.10 The study area considered as per TOR approved by Expert Appraisal Committee (EAC) of MoEF for the preparation of EIA and EMP study comprise the following:

- Area covered within 10 km radius from the periphery of the project. This is taken duly covering the components such as main dam and point of confluence of the tail race tunnel with the Umngot River.
- Catchment area at the proposed site.
- Area of submergence.

The general details of the above indicated study area is discussed in the foregoing paragraphs.

2.11 The study area pertaining to the Umngot HEP fall in two districts namely East Khasi hills and Jaintiahills district. The following blocks of the above districts are covered.

I.	East Khasi Hills district	:	1	Mawkynrew
			2	Mawryngkneng
II.	JaintiaHills district	:	3	Amlarem
			4	Thadlaskein

The general features of the project area districts are narrated below:

East Khasi Hills District

2.12 East Khasi Hills district has a geographical area of 2820sq.km and is situated in the south central part of Meghalaya State capital Shillong. The total population is about 6,60,923 (2001) out of which 3,33,553 are males and 327370 are females. The sex ratio is 981 females for 1000 males. Urban population is 42.97 per cent of the total population. The district is mainly inhabited by aboriginal tribes called Khasis. They are about 75.91 per cent of the population. The district comprises of 7 blocks and 854 inhabited villages. The main two urban areas are Shillong and Cherrapunji.

2.13 The district is an imposing plateau with rolling grass land, hills and river valleys. Deep gorges and abrupt slopes are seen in the southern face of the plateau. The proposed Umngot HEP is located near the south east corner of the district on Umngot River. The district occupies highest part of the State and Shillong peak is at a height of 1963 m above MSL. Major part of the district is composed of igneous rocks, mainly basalt. Also granite, granodiorite and pegmatite are seen at some of the central and southern portions of the district. Limestone, shale and sandstone are also found on the south eastern and south western parts of the districts. Total area under forest is 37.74 per cent of the total geographical area of the district. Sal, teak and Khasi pine are the important forest products.

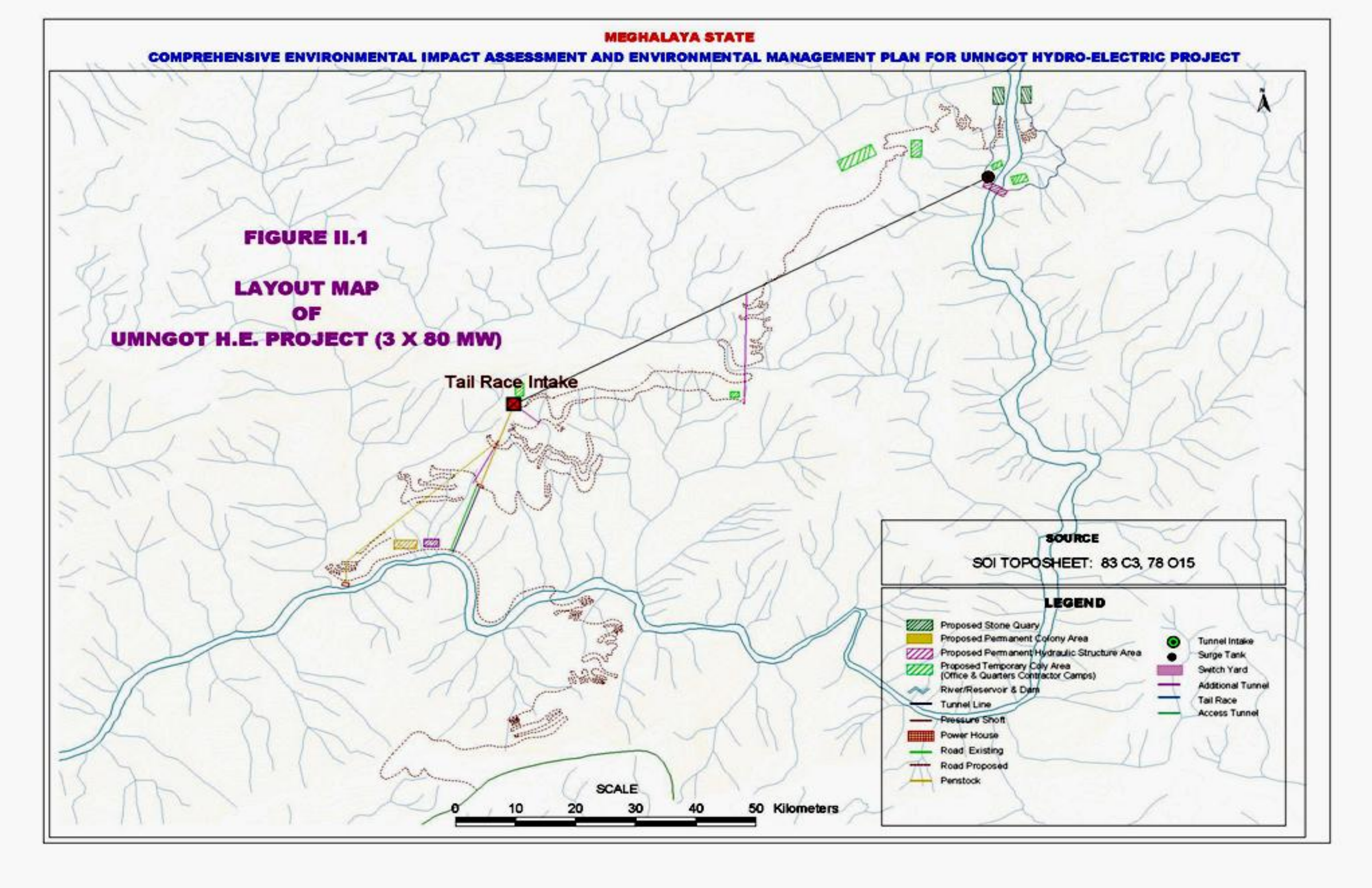
2.14 Red gravelly soils cover a large area in the central part of the district. Red loamy and red sandy soils are seen on the southern and northern parts of the district. The groundwater potential is very low and is less than 10 lit/sec. The climate of the district is directly influenced by south west monsoon and north east winter winds. Pleasant summer and very cold winter prevail in the area. Heavy rainfall over Cherrapunji and Mawsynram is one of the characteristics of the district. The average annual rainfall of the district is 12000 mm.

2.15 The total cropped area in the district is about 14.00 per cent only. The important crops are gram, rice, maize, potato and vegetables. Besides, plantation crops like beetle nut, pan leaf and pepper are also grown. Horticultural crops like orange, jack fruit and pineapple are also grown. Agriculture is the main important activity of the people. Industries play a minor role. Unemployment in the region is as larger as 61.92 per cent of the total population which stresses the need for development projects.

2.16 The district is devoid of railway lines. But it is connected by good arterial roads. NH40 from Guwahati to Dawki and NH44 from Shillong passes through the district.

2.17 The district has 2 main hospitals, 23 PHCs and 10 dispensaries. The district has got literacy percentage of 64.58 which is in the urban areas i.e., Shillong and Cherrapunji where there are two higher educational centres. North eastern hill university is located in Shillong town.

2.18 The district serves as an interesting place for the tourists. There are ideal peaks like Shillong peak. Deep gorges and roaring water falls beautify the landscape of Cherrapunji


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
FIGURE II.1
LAYOUT MAP
OF
UMNGOT H.E. PROJECT (3 X 80 MW)
Tail Race Intake
SOURCE
SOI TOPOSHEET: 83 C3, 78 O15
LEGEND
Proposed Stone Quary
Proposed Permanent Colony Area
Proposed Permanent Hydraulic Structure Area
Proposed Temporary Coly Area (Office & Quarters Contractor Camps)
River/Reservoir & Dam
Tunnel Line
Pressure Shaft
Power House
Road Existing
Road Proposed
Penstock
Tunnel Intake
Surge Tank
Switch Yard
Additional Tunnel
Tail Race
Access Tunnel
SCALE
0 10 20 30 40 50 Kilometers

Jaintia Hills district

2.19 Umngot River is the border for East Khasi Hills district and Jaintia hills district. The study area pertaining to Umngot HEP extends over this district also. The general features of the Jaintia hills district are presented below:

2.20 The district lies on the eastern part of Meghalaya state. It shares common international boundary with Bangladesh in south. It is surrounded by Assam state in the north and east and Khasi hills district in the west. The district was formed as sub division with head quarters at Jowai and declared as a district on 21.2.1972.

2.21 The district has a geographical area of 3819 sq.km and has four community development blocks with ASO inhabited villages. The district head quarter is Jowai and is the the only town of the district. The district occupies 37.92 per cent of forest area and 8.71 per cent cropped areas.

2.22 The district is characterized by hilly area with undulated terrain having a general height varying from 30 m to 600 m. The highest peak is Marangkisih with an elevation of 1627 m above MSL. The district also comprises plains and valleys. Important valleys are Sung and Letein. Maximum portion of the district is covered with red loamy soil. Only a narrow strip of red sandy soil is found along the Bangladesh border. In the forest areas (39.92%) the prominent species are teak, sal and pine. The district has got richest forest resource.

2.23 The climate of the district is moderate. Maximum temperature reaches 24^{0}C during September and the minimum reaches 10^{0}C during February. Rainfall occurs during south west monsoon period from May to October. Maximum rainfall is received in June and July months. Jaintia hills district possess a total population of 2,95,692 persons (2001) out of which 149376 are males and 146316 are females. Schedule tribes share a maximum of 95.50 per cent.

2.24 Groundwater potential in the district is very poor. The irrigation facilities are also meager. Thus the district has little area under irrigation (8.71 %). Potato and rice are the main crops of the district while other crops include vegetables, maize, Beetle nut, pan leaf, ginger, etc. Agriculture is the main source of livelihood. 74.39 per cent of the working force is engaged in agricultural activities. Only 1.34 per cent of the working force is in industrial sector.

2.25 The entire district is devoid of railway line. National highway 44 linking Shillong and Silchar passes through the district head quarters Jowai. Other roads are limited due to undulating terrain. Only four settlements including Jowai town have educational facilities providing higher secondary and above level education. Medical facilities such as dispensaries and PHCs are limited.

2.26 The district has immense potential for the development of tourism. Natural and scenic beauty water falls, lakes tribal culture are the major motivating factors for tourists' attraction. The important tourists' centres are Thadlaskein, Nartiang, Jowai, Bataw, Sutnga, Dawki.

2.27 The district is economically backward and the present project may improve the status of the local inhabitants duly providing employment to a considerable extent. Study area within 10 km radius from the periphery of the main dam site and confluence of the Tail Race Channel with Umngot River has been considered. Catchment area is also one of the components of the study area and hence considered for detailed study. The study areas fall in East Khasi Hills and Jaintia Hills districts. General features relating to the above are furnished in the Table – 2.1.

Table – 2.1
GENERAL DETAILS OF STUDY AREA

Sl. No.	Details	Area	Details	
			East Khasi hills district	Jaintia hills district
1	Blocks covered	Study area	i) Mawkynrew ii) Mawryngkneng	Amlarem Thadlaskein
2	Climate a) Rainfall	Study area	<4000 mm to 8000mm	<4000mm to 8000mm
	b) Temperature Maximum c) Minimum	Catchment area	30.5°C 7.5°C	30.5°C 7.5°C
3	Relief and slope	Study area	80 m to 60m /km	<110C
		Catchment area	80m to 600m/km	80 to 600m/km
	Relief	Study area	300m to 1800m elevation	300m to 1200m elevation
4	Soils	Study area	Red gravelly soils (60%), Red sandy soils (20%), Red loamy soils (20%)	Red sandy soils (25%) and red loamy soils (75%)
		Catchment area	Red sandy soils (10%), Red gravelly soils (40%), Red loams (50%)	Red sandy soils (15%), Red loamy soils (25%)
5	Hydrogeological status (Groundwater)	Study area	Wells yield < 10 lit /sec (aquifers with inter granular paracity)	Wells yield <10 lit/ sec, (primary inter granular paracity) in 60% area 1-5 lit/sec 40% (secondary)
		Catchment area	Wells yield < 10 lit/sec (Aquifers with intergrannular poracity and fractures)	<10 lit/sec (70% area) 1-5lit/ec (30% area)
6	Rocks	Study area	Granite, granodolomite, pegmatite, gneisses, schists, quartzites	Sand stone, shales limestone, schists , gneisses , quartzites, granite and grano dolomites.

Table – 2.1 GENERAL DETAILS OF STUDY AREA				
Sl. No.	Details	Area	Details	
			East Khasi hills district	Jaintia hills district
		Catchment area	Gneisses, schists, quartzitews	Sand stone, shales limestone, schists , gneisses , quartzites, granite and grano dolomites and unclassified crystallines (mainly gneisses)
7	Minerals	Study and Catchment areas	No minerals	No minerals
8	Industries	Study area	No industries	No industries
		Catchment area	Food and food processing units at Sohryngkham	Food processing forest based units, bricks at Jowai near catchment border.

Study Area Land use / Land cover

2.28 The study area is considered as 10 km radius from the periphery of the project location. The land use/ land cover status in the study area is analysed and shown in Table 2.2.

Table 2.2 Land use/ Land cover in the study area.			
Sl No.	**Classification**	**Area (ha)**	**Per centage**
1	Shifting cultivation	2134	5.09
2	Arable lands (current fallows)	8628	20.59
3	Dense forest	15340	36.60
4	Open forest	8607	20.54
5	Tree clod / Scrubland	6003	14.32
6	Built up lands (settlements)	583	1.39
7	Water bodies	617	1.47
Total		**41912**	**100.00**

The table infers that the fallow and cultivated lands are about 25.68 per cent whereas forest lands account for about 57.14 per cent. Map showing land use / land cover in the study area is shown in Fig II.2.

General Geology of the Catchment Area

2.29 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.

2.30 The plateau top land is occupied by sedimentary sequence of Jaintia Group of Tertiary Age, which is mainly comprised of low dipping in sub horizontally bedded, medium to coarse grained sandstone with intervening minor shale and coal bands. The Jaintia groups of rocks are unconformably underlain by crystalline rocks of the Archaean basement complex which are exposed at lower elevations along the valley. The Crystallines comprise granite gneiss,megabits , granites, biotite-schists, and also intruded at the places by basic dykes(doleritic) and pegmatite's, quartz veins. Lithologically the Crystalline primarily represent a very complex granitoid association with evidence of deformation at some places. Micro floods (ptygmatic floods), faults (axial planar) have been observed within this rock.

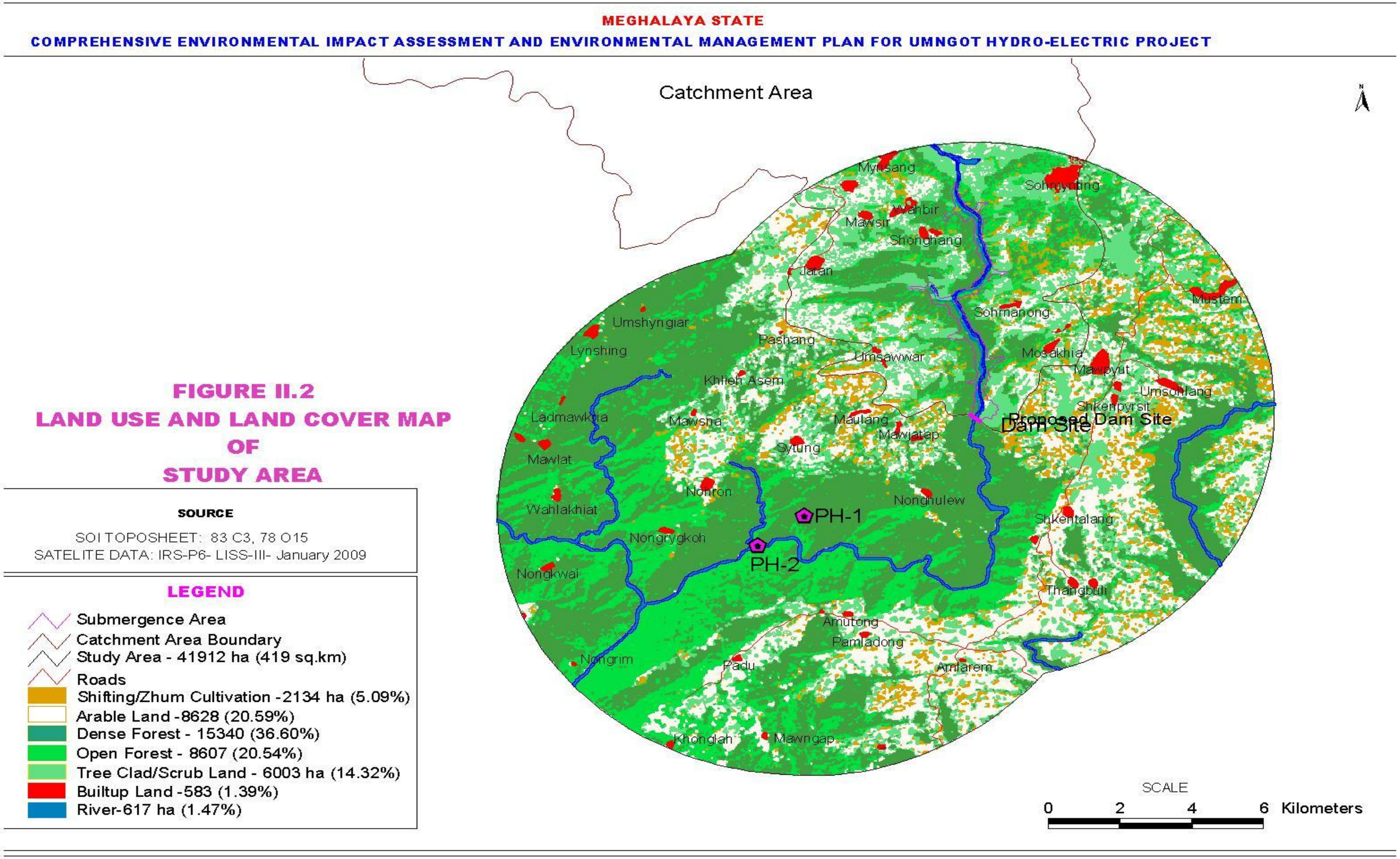
2.31 The contact between the sedimentary sequences of Jaintia Group and the Achaean Crystalline is represented by an angular unconformity, which shows a moderate slope towards south. The unconformable contact is observed at around EL.1210 m near the dam site area and near bend point it has been observed at around EL.1100 m indicating a southward inclination near the Tertiary basinal surface. Near bend point and surge shaft ridge area, the sedimentation sequences are found to be much thicker than that the northern part. All the structural sites of the project are housed within the Crystallines.

Topography of Catchment Area

2.32 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.

Meteorology

2.33 **Climate:** The climate in the catchment is determined by the altitude of the land surface and 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 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.


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
Catchment Area
FIGURE II.2
LAND USE AND LAND COVER MAP
OF
STUDY AREA
SOURCE
SOI TOPOSHEET: 83 C3, 78 O15
SATELITE DATA: IRS-P6- LISS-III- January 2009
LEGEND
Submergence Area
Catchment Area Boundary
Study Area - 41912 ha (419 sq.km)
Roads
Shifting/Zhum Cultivation -2134 ha (5.09%)
Arable Land -8628 (20.59%)
Dense Forest - 15340 (36.60%)
Open Forest - 8607 (20.54%)
Tree Clad/Scrub Land - 6003 ha (14.32%)
Builtup Land -583 (1.39%)
River-617 ha (1.47%)
Proposed Dam Site
Dam Site
PH-1
PH-2
Umshyngiar
Lynshing
Pashang
Umsawwar
Khlieh Asem
Ladmawkria
Mawsna
Maulang
Mawlat
Sytung
Nonron
Wahlakhiat
Nongrygkoh
Nonghulew
Nongkwai
Amutong
Pamladong
Nongrim
Padu
Amlarem
Khonglah
Mawngap
Thangbuli
Shkentalang
Sohmanong
Mosakhia
Mawpyut
Umsohlang
Shkenpyrsit
Mustem
Jalan
Shonghang
Mawsir
Wahbir
Sohmynting
SCALE
0 2 4 6 Kilometers

Three distinct seasons in the year are as below:

* Pre-monsoon : March & April
* Monsoon : May to October
* Post-monsoon : November to February

2.34 The average Maximum& Minimum temperatures are 27.3^0 C and 16.4^0 C respectively in the catchment and the maximum and minimum temperature recorded are 30.5^{0}C & 7.5^{0}C respectively in the catchment area.

Demography of District and Project Area

2.35 The geographical area of East Khasi Hills district is 2820 sq.km and with a low population density of 234 persons per sq.km. The total population as per 2001 census district was 660923. As per the census there were 981 females for every 1000 males in the district. This indicates a low level of female population in the district. The literacy rate among males was 77.3 per cent where as in females it was 74.8 per cent. The average literacy rate was 76.1 per cent. Work force constituted 32.64 per cent of the total population in the state. Among the total main workers; cultivators, agricultural labourers, workers in household industries and other workers account for to 32.64 per cent. About 41.84 per cent of the total population was marginal workers. Thus there is adequate work force available to participate in the project construction activity locally.

2.36 The land use land cover relating to the catchment area of Umngot HEP is presented in Table – 2.3.

Table – 2.3
Land use land cover relating to the catchment area of Umngot HEP

Sl.No.	Classification	Area in ha	Per centage to total areas
1	Shifting cultivation	1611	5.29
2	Arable area	6245	20.52
3	Dense Forest (Dense mixed jungle (UR)	3963	13.02
4	Open Forest (Mixed jungle) UR	6475	21.27
5	Scrub lands / grass land	10058	33.05
6	Built up land (settlements)	1216	4.00
7	River, Water channel (water bodies)	865	2.84
	Total	**30433**	**100.00**

2.37 No reserve forests are available in the project area. As per RS imageries only community forests having dense mixed and mixed jungles are encountered to an extent of 34.29 per cent. Scrub lands including grass lands account for to 33.05 per cent. Arable lands' including shifting cultivations accounted for 25.81 per cent of total study area. Slope analysis has been carried out with the help of RS imageries and the results are tabulated in Table – 2.4.

Table – 2.4
Slope Classification of the Catchment Area

Sl.No.	Slope Classification	Area in ha	Per centage
1	Gentle to moderate (0-5 per cent)	2238	7.35
2	Gentle steep (5-10 per cent)	2503	8.22
3	Moderate steep (10-15 per cent)	2509	8.24
4	Steep (15-35 per cent)	9328	30.65
5	Very steep (>35 per cent)	13855	45.54
	Total	**30433**	**100.00**

2.38 The table infers that about 76.19 per cent of the catchment area comprises slopes under steep and very steep category, indicating possibility of severe soil erosion in the area except in the areas of 34.29 per cent of dense and green forest areas.

Environmental Baseline Status

2.39 Before start of any Environmental Impact Assessment study, it is necessary to identify the baseline levels of relevant environmental parameters which are likely to be affected as a result of the construction and operation of the proposed project. A similar approach has been adopted for conducting the EIA study for the proposed Umngot Hydro-electric Project. A Scoping Matrix was formulated to identify various parameters likely to be affected as a result of the proposed project. Based on the specific inputs likely to accrue in the proposed project, aspects to be covered in the EIA study were identified. The other issues as outlined in the scoping matrix were then discarded. Thus, planning of a baseline survey commenced with the short-listing of impacts and identification of parameters for which the data needs to be collected. The scoping matrix adopted for the EIA study for the proposed Umngot Hydro-Electric project is given in Table – 2.5. The project area does not have national parks or wild life sanctuaries in the submergence area to be protected. Significant adverse long-term impact on the environment is not expected in the area .However, every precaution will be taken during the construction phase of the project so as to minimize the effects on environment.

- There is no reserve forest area in the project area and hence no National parks or wild life sanctuaries are getting affected due to the project.
- Biosphere reserves and Bird Sanctuaries are also not available in the project area.
- There are no significant monuments in the area. Also no places of archeological, historical, cultural importance are available in the study area..

- No defense installations are noticed in the area.
- No significant inundation noticed in the area even due to maximum floods, in view of the location of the project in deep gorge portion of the river.
- No Endangered flora and fauna species within the project area and no species require special management.

Table - 2.5
SCOPING MATRIX FOR EIA STUDY FOR THE PROPOSED UMNGOT HE PROJECT

Aspect of Environment	Likely Impacts
A. Land Environment	
Construction phase	➢ Increase in soil erosion ➢ Pollution by construction spoils ➢ Use of land for labour colonies ➢ Problems due to muck disposal ➢ Solid waste from labour colonies ➢ Acquisition of land for various project appurtenances
B. Water resources and water quality	
Construction phase	➢ Increase in turbidity of nearby receiving water bodies ➢ Degradation of water quality due to disposal of wastes from labour colonies and construction sites
Operation phase	➢ Disruption of hydraulic regime ➢ Sedimentation & siltation risks ➢ Eutrophication risks
C. Aquatic Ecology	
Construction phase	➢ Increased pressure on aquatic ecology as a result of indiscriminate fishing. ➢ Reduced productivity due to increase in turbidity
Operation phase	➢ Impacts on migratory fish species ➢ Impacts on spawning & breeding grounds ➢ Degradation of reverine ecology ➢ Increased potential for reservoir fisheries
D. Terrestrial Ecology	
Construction phase	➢ Increased pressure on nearby flora due to labour force to meet their fuel wood & timber requirements. ➢ adverse impacts due to migration of labour population ➢ Impacts on terrestrial flora ➢ Impacts on wildlife movement ➢ Impacts on wildlife habitats ➢ Impacts on diversity and productivity of flora ➢ Impacts on economically/ genetically/ biologically important plant species

Table - 2.5
SCOPING MATRIX FOR EIA STUDY FOR THE PROPOSED UMNGOT HE PROJECT

Aspect of Environment	Likely Impacts
E. Socio-Economics	
Construction phase	Acquisition of land and private properties ➢ Impacts on archaeological & cultural monuments ➢ Impacts on mineral reserves ➢ Improved employment potential during the project construction phase
Construction phase	➢ Development of allied sectors leading to greater employment ➢ Pressure on existing infrastructure facilities ➢ Development of infrastructure communication facilities ➢ Reduction of Agriculture/ Forest land ➢ Loss of private properties
	➢ Impacts on archaeological and cultural monuments if any
Operation phase	➢ Increased revenue from power generation
F. Air Pollution	
Construction phase	➢ Impacts due to emissions generated by crushers and other equipment ➢ Impacts due to increased vehicular movement ➢ Fugitive emissions from various sources
G. Noise Pollution	
Construction Phase	➢ Noise due to operation of various equipment ➢ Noise due to increased vehicular movement ➢ Noise due to blasting activities
H. Public Health	
Construction phase	➢ Increased incidence of water related diseases ➢ Transmission of diseases by immigrant labour population
Operation phase	➢ Increased incidence of vector borne diseases

2.40 As mentioned earlier, relevant environmental impacts out of the entire gamut of issues outlined in the Scoping Matrix were identified. For these impacts or aspects, environmental baseline data had been collected from secondary as well as primary data sources.

2.41 Most of the submergence area falls in the deep gorge area and therefore, submergence area is restricted longitudinally and there would be no major submergence laterally. Mostly, submergence is restricted to river margins. In such conditions, the impacts likely to accrue as a result of project construction and operation are not expected to be significant. As a part of the study, detailed field studies on various aspects were conducted. Baseline status has been ascertained for the following aspects on the basis of secondary as well as primary sources of data.

Water Environment	i)	Water resources
	ii)	Water use
	iii)	Water Quality
	iv)	Hydrology
Climate and Weather	i)	Meteorology
	ii)	Ambient air quality
	iii)	Noise
Land Environment	i)	Land use
	ii)	Geology
	iii)	Seismology
	iv)	Soils
	v)	Catchment area
Biological Environment	i)	Terrestrial Ecology
	ii)	Aquatic Ecology
Socio-Economic & Cultural Environment	-	Demography & Socio-economics
	-	Public Health

All the above aspects have been covered separately under relevant chapters.

2.42 The information presented in these chapters had been collected by the consultant through field studies, interaction with various government departments and from available literature with various institutions and organizations. The summary of data collected from various sources as a part of the EIA study is outlined in Table - 2.6.

Table - 2.6
SUMMARY OF DATA COLLECTION FROM VARIOUS SOURCES FOR THE STUDY

Aspect	Mode of Data Collection	Parameters Monitored	Frequency	Source(s)
Meteorology	Secondary	Temperature, relative humidity, rainfall, wind velocity, direction.	-	Indian Meteorological Department, Pune
Water Resources	Secondary	Flow, design flood and system details	-	Hydrological Report of DPR
Water Quality	Primary	Physico-chemical and biological parameters like pH,	Three seasons	Field studies

Table - 2.6
SUMMARY OF DATA COLLECTION FROM VARIOUS SOURCES FOR THE STUDY

Aspect	Mode of Data Collection	Parameters Monitored	Frequency	Source(s)
		temperature, TDS, TSS, Turbidity, Hardness, Ca, NA, K, DO, Fe, Mg, Zinc etc.		
Ambient Air Quality	Primary	RPM, SPM, SO_2 & NO_x	Three seasons	Field studies
Noise	Primary	Maximum, Minimum	Three seasons	Field studies
Land use	Primary and Secondary	Land use pattern and others like archaeological historical, cultural and ecological sensitive areas	-	RS, GIS & Ground truth studies
Geology	Primary and Secondary	-	-	Geological survey conducted for the project as a part of DPR preparation
Soils	-	Physio-chemical parameters like Sp. Gravity , soil classification, pH, conductivity NPK contents		Field studies
Terrestrial Ecology	Primary and secondary survey	Floral & Fauna, bio-diversity, wet lands, historical monuments.		Field studies, Forest Department and literature
Aquatic ecology	Primary and Secondary	Aquatic ecology		Field studies Fishery Dept. and literature review
Biological Resources	Primary and Secondary	Flora, fauna, impact on animal distribution & migration, routes, avi fauna, conservation areas and study of endangered species-	-	Field studies , forest department and literature
Socio-economic aspects	Primary and secondary	Demography Ethnography, economy, agricultural practices, cultural and aesthetics , infrastructure, details of PAPs	-	Field studies, Statistics, Public health Department and literature review.

Project Benefits

2.43 The direct benefits that are expected to be accrued from the implementation of the Umngot HEP are the generation of about 856.35 Million units in a 90 per cent dependable year. For assessing the tariff, design energy generation of 838.73 Million units, calculated with 95 per cent capacity availability in a 90 per cent dependable year, has been adopted. The project would provide 240 MW of peaking capacity benefits. The First Year Tariff and Levellised Tariff have been worked out as Rs.3.11 and Rs.3.03 per KWH respectively at 2010 price level.

2.44 The people around the project area are expected to reap many indirect benefits that would bring about a transformation in the upliftment of their socio-economic conditions from the implementation of this project. Road communication, Health facilities, School facilities and various other social programmes will be undertaken by project authorities. Besides these, employment will be generated in the short term through various construction works that could be carried out by the local people. In the long term, the pondage in the reservoir would boost tourism, fisheries, water sports, etc and roads would make transporting of agricultural produce faster and cheaper.

Annexure – II.1

SALIENT FEATURES OF UMNGOT H.E.PROJECT (STAGE-I)

Sl.no	Name	Umngot Hydro Electric Project (Stage-I)
1	Location	Latitude : 25^0 - 21'- 38" Logitude : 92^0 - 06' - 45"
2	State	Meghalaya
3	District	East Khasi Hills
4	River	Umngot
5	Catchment area	304.00 sq.km
6	Installed capacity	3 x 80 MW
7	Annual Energy /Potential –Design Energy 90% dependable year	838.73 MU 856.35 MU
8	Firm Power	34.05 MW
9	Dam type i) Max Height (m) ii) FRL/ MWL (m) iii) M.D.D.L (m) iv) Deepest Bed Level (m) v) Deepest Foundation Level (m)	Concrete gravity 111.00 1040.00 1010.00 933.00 931.00
10	**Dam** i) Overflow Section(m) ii) Non- overflow Section(m) iii) Total Length (m) Deepest Foundation Level (m) Crest level (m) Max. Height (m) Top Level of Dam (RL-m) **Dam** Design flood, cumec Spillway capacity, cumec Number and Size of Spillways Radial Gates Stop Log Gates	 93.0 269.0 362.0 931.0 995.0 111.0 1042.0 8969.0 9009.5 6 Nos X 8.50 m X 12.70 m 6 No X 8.5 m X 13.50 m 1 No X 9.70 m X 23.90 m
11	**HRT Intake** Type Control Invert Level, m Vertical Lift Fixed Wheel Gates	 Semicircular with trash rack. Fixed wheel gate operated through Intake Shaft 997.80 1 No x 5.0 m x 4.76 m

Sl.no	Name	Umngot Hydro Electric Project (Stage-I)
12	**Reservoir**	
	Type	Type II or Foothill
	New zero elevation :-	
	50 years sedimentation	981.30 m
	75 years sedimentation	995.80 m
	Storage Capacity	
	At MDDL	5.63 Mcum
	At FRL/MWL	38.59 Mcum
	Live Storage	32.95 Mcum
	Sedimentation	
	50 years	4.65 Mcum
	75 years	11.18 Mcum
13	**Low Pressure Tunnel**	
	i) Shape	Modified Horse Shoe
	ii) Length	5588.00 m
	iii) Diameter	3.60 m
	iv) Capacity	35.17 cumec
	v) Gradient	1 in 230
14	**Surge Shaft**	
	i) Type	Restricted type
	ii) Diameter	10.00 m
	iii) Top elevation	1057.00 m
	iv) Bottom elevation	980.25 m
	v) Height upto GL	79.90 m
	vi) Diameter. of Orifice	1.82 m
15	**Pressure Shaft (1 No)**	
	Type	Steel lined with concrete backfill
	Number	One
	Internal Diameter	2.75 m trifurcating to 1.80 m
	Length	2200.0 m
	Angle of inclination	50^0
	Max. Discharge capacity	39.16 cumec
16	**Power House**	
	Type and Arrangement	Surface
	Capacity	3 X 80 MW
	Type and Turbine	6-Jet Pelton (Vert.Shaft)
	Machine Hall	77.50 m x 22.00 m
	Service/Erection Bay	30.00 m x 22.00 m
	Auxiliary Bay	107.50 m x 9.00 m
	GIS Hall	107.50 m x 16.00 m

Sl.no	Name	Umngot Hydro Electric Project (Stage-I)
	Pot Head Yard Maximum Gross Head Minimum Gross Head Maximum Net Head Minimum Net Head Maximum Height from Turbine Floor Jet Nozzle Level Machine Hall Floor/ Service Bay Level Crane Beam Level Roof Level At Eaves Control Bay Level	81.75 m x 18.00 m 808.60 m 788.60 m 774.13 m 744.13 m 20.0 m 231.40 m 244.00 m 258.00 m 264.00 m 244.00 m
17	**Annual Energy** Total Design	 856.35 Million Units 838.73 Million Units

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - I

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Chapter - III

LAND ENVIRONMENT

INDIA
MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS
UMNGOT HYDRO-ELECTRIC PROJECT
(3 X 80 MW)

PART - I
ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

III

LAND ENVIRONMENT

Introduction

3.01 The Meghalaya Energy Corporation Limited is contemplating to set up the Umngot Hydro Electric project which will necessitate the construction of a 111 m high and 362 m long concrete gravity dam across the river Umngot at a place called Saida near the Siangkhanai village from which water will be drawn through a 3.6 m dia. and 5588 m long Low pressure Tunnel, 79.90 m deep Surge Shaft, 2200 m long High Pressure Shaft and Powerhouse to generate 240 MW of power by utilizing a gross head of 808.60 m. Various reconnoitory geological traverses and mapping by the Geological Survey of India from limited sub-surface explorations have helped in the selection of suitable locations for Dam, Intake, HRT alignment, Pressure Shaft alignment and Powerhouse.

3.02 The prediction of impacts relating to the land environment due to the project had the following five main dimensions:

- Physical Geography or topography;
- Stratigraphy
- Regional geology of the catchment area
- Tectonics and seismicity
- Land slide zones or area prone to land slides along the periphery of reservoir
- Presence of economic mineral deposits
- Soil classification, physical & chemical characteristics

3.03 These dimensions of impact on land environment due to the project are discussed in the following paragraphs

Physical Geography and Topography

3.04 Meghalaya state is situated on the North Eastern Region of India between Brahmaputra valley in the North and Bangladesh in the south. The State is one of the seven sister states of the North Eastern Region. The State is geographically known as the Meghalaya plateau or the Shillong plateau. It is one of the most picturesque states of India. The geographical area of the state is 22,429 sq km. comprising of seven administrative districts. The project area lies in East Khasi hills and Jaintia hills district. These two districts are located in the central and eastern part of the plateau. The Shillong plateau is incised by numerous river valleys. The whole Meghalaya is a plateau interspersed with high hills and deep valleys. The Umngot hydro electric 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. Surface drainage map of the catchment area is shown in Fig. III.1

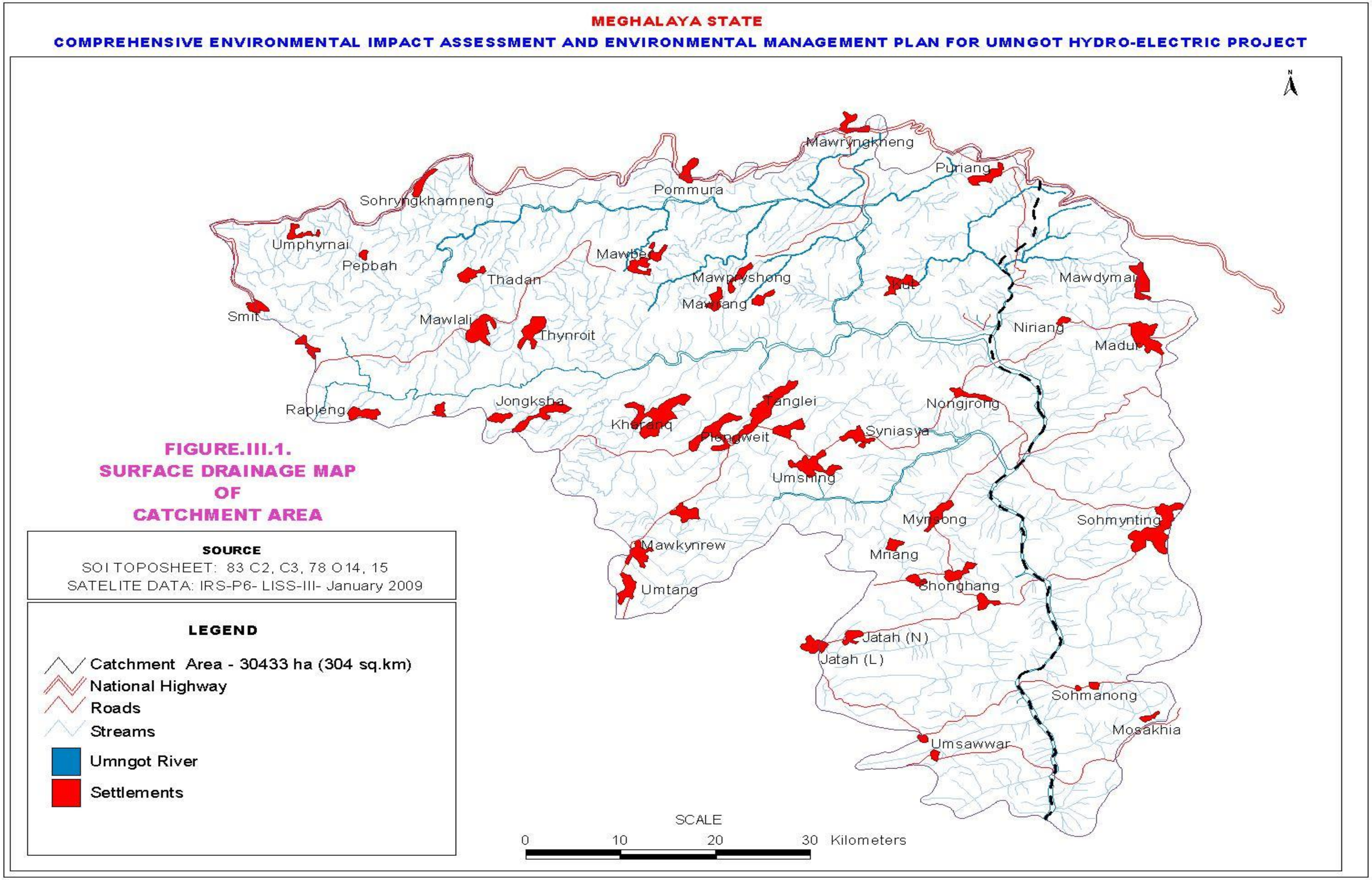
Slope in the Catchments area

3.05 The catchments area up to Umngot HEP is worked out as 304 sq.km (30433 ha). The catchment is of undulating nature. The slopes analysis was carried out with the help of GIS applications on the basis of information available in relevant SOI toposheets and RS imagery the distribution of catchment area according to slope category is presented in Table - 3.2. This slope categorization is based on IMSD methodology.

Table 3.2: Slope analysis of the catchments area of Umngot HEP.

S.I No	Slope range %	Slope category	Are in (ha)	Percentages to total area
1	0 – 5	Gentle to Moderate	2238	7.35
2	5 – 10	Gentle Steep	2503	8.23
3	10 – 15	Moderate Steep	2509	8.24
4	15 – 35	Steep	9328	30.65
5	> 35	Very Steep	13855	45.53
TOTAL			30433	100.00
Source: Computed on the basis of SOI toposheets and RS imagery Analysis				

3.06 As per the analysis shown in the above table, steep to very steep slopes occupy about 76.18 per cent of the total area.


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
Mawryngkneng
Puriang
Pommura
Sohryngkhamneng
Umphyrnai
Pepbah
Thadan
Mawdymai
Smit
Mawlali
Thynroit
Niriang
Madur
Rapleng
Jongksha
Tanglei
Nongjrong
Syniasya
Umshing
Mynsong
Sohmynting
Mawkynrew
Mriang
Umtang
Shonghang
Jatah (N)
Jatah (L)
Sohmanong
Mosakhia
Umsawwar
FIGURE.III.1.
SURFACE DRAINAGE MAP
OF
CATCHMENT AREA
SOURCE
SOI TOPOSHEET: 83 C2, C3, 78 O14, 15
SATELITE DATA: IRS-P6- LISS-III- January 2009
LEGEND
Catchment Area - 30433 ha (304 sq.km)
National Highway
Roads
Streams
Umngot River
Settlements
SCALE
0 10 20 30 Kilometers

Land Use and Land Cover

3.07 Baseline data relating to land use / land cover in the study area, extending up to 10 km radius of various components has been ascertained with the help of GIS applications, RS imageries and the analysis is presented in the following Table - 3.3.

Table - 3.3 Land use and Land cover of the study area around various components.

S.I NO	Classification	Area in (ha)	Percentage to total area
1	Shifting cultivation	2134	5.09
2	Arable areas	8628	20.59
3	Dense forests (UR)	15340	36.60
4	Open forests (UR)	8607	20.54
5	Scrub land / Grass lands	6003	14.32
6	Built-up land (Settlements)	583	1.39
7	Water bodies	617	1.47
	Total	**41912**	**100.00**

Source: Computed by AFC on the basis of RS imagery and toposheets.

3.08 Land use / Land cover in respect of the catchments area of the Umngot HEP was also analyzed with the help of R.S imageries and the results are tabulated in Table - 3.4.

Table - 3.4 Land use / Land cover of the catchments area.

S.I NO	Classification	Area in (ha)	Percentage to total area
1	Shifting cultivation	1611	5.29
2	Arable areas	6245	20.52
3	Dense forests (UR)	3963	13.02
4	Open forests (UR)	6475	21.28
5	Scrub land / Grass lands	10058	33.05
6	Built-up land (Settlements)	1216	4.00
7	Water bodies	865	2.84
TOTAL		**30433**	**100.00**

Source: Computed by AFC on the basis of RS imagery and toposheets.

3.09 The analysis indicates arable land is only 20.52 %, land under shifting cultivation is 5.29 %, forest lands 34.30 % and scrubs or grass lands (fallow) is 33.05 %. The forest is community forest land comprising dense mixed jungle and mixed jungles.

Regional Geology

3.10 The Northeastern India and the adjoining region constitute a complex geological province with convergence of two Tertiary mobile belts, the EW eastern Himalaya and the N-S Patkai-Naga-Manipur-Chin-Arakan Yoma Hill ranges (Indo-Burmese origin), developed as inconsequence collision /subduction between India and Asia. These two belts are truncated to the north east by the NW trending diorite-granodiorite complex of the Mishmi massif. In the core of these mutually orthogonally disposed mobile belts lies the Archaean-Proterozoic Cratonic elements of Meghalaya Plateau and the Mikir Hills (now Karbi Anglong) with Cretaceous to Recent shelf-platform sedimentary cover sediments on the southern margin of the Meghalaya Plateau.

3.11 The Shillong (Meghalaya) Massif is the oldest northeastern promontory of the Indian shield which occupies a crucial tectonic position between the Himalaya in the north and the Indo-Burmese Arc to the East. This Massif is only landmass, which existed in the region before the break up of the Gondwana land in Jurassic time (Powell et al,1988).The Plateau consist of high grade gneissic complex, overlain by mildly deformed Proterozoic intra-cratonic sediments of Shillong Group with meta –volcanic Khasi greenstones both indented by Upper Proterozoic / Late Precambrain granite plutons.

3.12 By the end of Jurassic, the southern margin of Shillong Massif experienced eruption of Sylhet Traps through E-W trending fissures (Murthy, 1970-1974). Around 150 million years ago, carbonalite complex was emplaced along an N-S trending fault in the eastern part of the Massif (Sarkar et al, 1992). Cretaceous sediments were deposited along the subsiding southern margin. Towards the Paleocene –Eocene, the Plateau attained a stable shelf condition due to lower subsidence till mid –Eocene when down sinking was experienced and resulted in deposition of coal bearing sandstone (GIS, 1974).

Geological Formations in the Project Area

3.13 The Umngot Hydro-electric Project is located within a typical plateau land of Meghalaya characterized by flat undulatory table top land deep gorges. The river Umngot flows along such a deep gorge towards almost southerly direction starting from near Smit (V), in the East Khasi Hills District through a very steep "V" shaped valley within the plateau land.

3.14 The plateau top land is occupied by sedimentary sequence of Jaintia Group of Tertiary Age, which is 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 the cross stratification and thus, this sedimentary sequence shoe varying attitudes at places. The Jaintia groups of rocks are unconformable underlain by crystalline rocks of the Archaean basement complex which are exposed at lower elevations along the valley. The Crystal lines comprise granite gneiss, migmatites, granites, biotite-schists, and also intruded at the places by basic dykes (doleritic) and pegmatite's, quartz veins. Lithologically the

Crystallines 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.

3.15 The contact between the sedimentary sequences of Jaintia Group and the Achaean Crystalline is represented by an angular unconformity, which shows a moderate slope towards south. The unconformable contact is observed at around EL.1210 m near the dam site area and near bend point it has been observed at around EL.1100 m indicating a southward inclination of near the Tertiary basinal surface. Near bend point and surge shaft ridge area, the sedimentation sequences are found to be much thicker than that in the northern part. All the structural sites of the project are housed within the Crystalines. The prominent foliation within Gneisses trends in N55^0-70^0 E-S55^0-70^{0}W with dips of 45^0-70^0 SE with minor variations at some places.

3.16 Evidences of macroscopic folding within gneiss are also noticed with different dipping attitudes of the foliation. It was also 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 granite country, (J.S.Rawat, F.S2003-04). 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.

Geotechnical Assessment of the project appurtenances:

3.17 The Geological survey of India had geologically mapped the project area and put forth recommendations / suggestions of the geology of the foundation material at various structures.

Dam site

3.18 The most prominent and persistent points dissecting the bed rock at the dam site is given below:

J_1 = N15ºW – S15ºE strike with 75º to 85º dip towards S75ºW continuity 200 – 1000 cm spacing 50 – 200 cm planar / rough altered on the surface dipping towards right bank.

J_2 = N65º - 70ºE – S65º - 70ºW strike with 30º - 80º dip towards S20º - 25ºE continuity 500 – 1000 cm spacing 50 – 300cm, planar, rough, iron stained on the surface dipping towards left bank.

J_3 = N55ºE – S55ºW strike with 30º to 40º south easterly dip, continuity 100 – 200 cm spacing few cm to 100 cm planar, rough, dipping towards left bank .

3.19 The GS1 has observed the proposed dam axis trending N60ºW – S60ºE with right abutment sloping at 55º (Between E L 936m & 960m) and 40º (Between E L ≠ 960M & dam top) and the left abutment sloping at about 55º to 75º between E L ≠ 936 and 960m and about 40º between EL 960m and dam top appears to be feasible.

Intake and Head race tunnel

3.20 Moderately joined and weathered granite with occasional partings of sehist is exposed in the proposed intake area. Intake structure proposed at E L ≠ 1002 m appears feasible. The HRT alignment from the intake site to near surge shaft following a straight course in S62ºW direction appears feasible on topographical conditions.

Surge shaft

3.21 As per the recovery from the bore hole, it has gone through weathered biotitic gneiss followed by fresh gneiss. The hole was entering into fresh rock at 49.5m depth.

High pressure tunnel

3.22 The structure is likely to pass through moderately weathered granite. Exploratory hole drilled indicates passing through thick overburden (0.0 m – 32.0 m) and highly weathered rock mass (quartzite 32.0 m to 44.5 m) followed perhaps by fresh gneiss (44.5 m – 54.0 m)

Power house

3.23 Based on the topographical conditions, erratic weathering pattern and overburden thickness, an under ground power house complex is proposed from geotechnical considerations. The power house will be founded on granite after removal over burden and weathered rock. The water conveyance system will be placed under ground right from the surge shaft up to the tail race tunnel exit which will be entirely founded on sound granite.

Stratigraphy along the dam axis

3.24 Six bore holes were drilled along the proposed dam axis alignment and the Stratigraphy of the geological formations are given below in Table - 3.5.

Table – 3.5 BOREHOLE DATA ALONG DAM AXIS					
Hole No	**Location**	**Ground elevation (m)**	**Depth drilled (m)**	**Inclin-ation**	**Logging details**
BH-1	Left Bank	997.50	30.71	90^0	0-6m – Overburden 6-14m=Slightly to highly weathered granite gneiss 14-30.71m = Fresh granite gneiss
BH-2	Right Bank	996.00	64.99	90^0	0-17m overburden 17-24m = Slightly to highly weathered bed rock granite gneiss 24-64.00 m= Fresh granite gneiss
BH-3	River Bed	940.50	16.41	90^0	0-3 m= River born materials 3-5 m = Slightly weathered bed rock granite gneiss 5-16 m = Fresh granite gneiss
BH-4	Left Bank	975.00	53.00	90^0	0-4.5m = overburden 4.5-14m = Slightly to highly weathered granite gneiss with basic rock between 9.9-10.5m 14-53m = Fresh granite gneiss
BH-5	Right Bank	970.00	54.40	90^0	0-2 m= Over burden 2-21m = Weathered granite gneiss21-54m fresh with basic rock between 43.3-45.5 and48-48.7
BH-10	Bucket	939.275	22.00	90^0	0-6m = Over burden 6-8.29m = Weathered meta-basic rock and quartz biotitic gneiss 8.29-22 m = Fresh quartz biotite gneiss intruded by pegmatite, quartz vein.
BH-6	River bed centre	933.305	24.90	90^0	0-3m = Over burden 0.3-24.90m= Fresh, hard, competent migmatite gneiss
BH-8	30 m d/s of dam axis (left bank)	1010.00	30.00	90^0	0-9 m = Over burden 9-12 m = Fine grained residual soil mixed with broken core pieces of biotite gneiss 12-30 m = Fine grained fresh, hard biotite gneiss with vein quartz between 27.21 m and 27.48 m and ultra basic body between 27.99 m and 28.92 m.

Source: MeECL

Geological map between intake and HRT is shown in Fig.III.1 (a) Stratigraphy map across proposed dam area is shown in Fig.III.1 (b), also the Geological map of Dam site area and Geological section along dam axis is furnished in Fig.III.1 (c) and Fig. III.1(d) respectively.

Tectonics and Seismicity

3.25 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, 1996). Geological Survey of India (2000) has published Seismo-tectonic Atlas of India and Sheet 14 of the same includes the area of Meghalaya Massif, Surma Basin and the Himalayan Tectonic Belt in the North. Micro seismicity map of the Shillong platean – Mikir hills (now Karbi Anglong)– Assam valley is shown in Fig.III.2 Modified seismicity map (modified from kayal) is shown in Fig.III.3

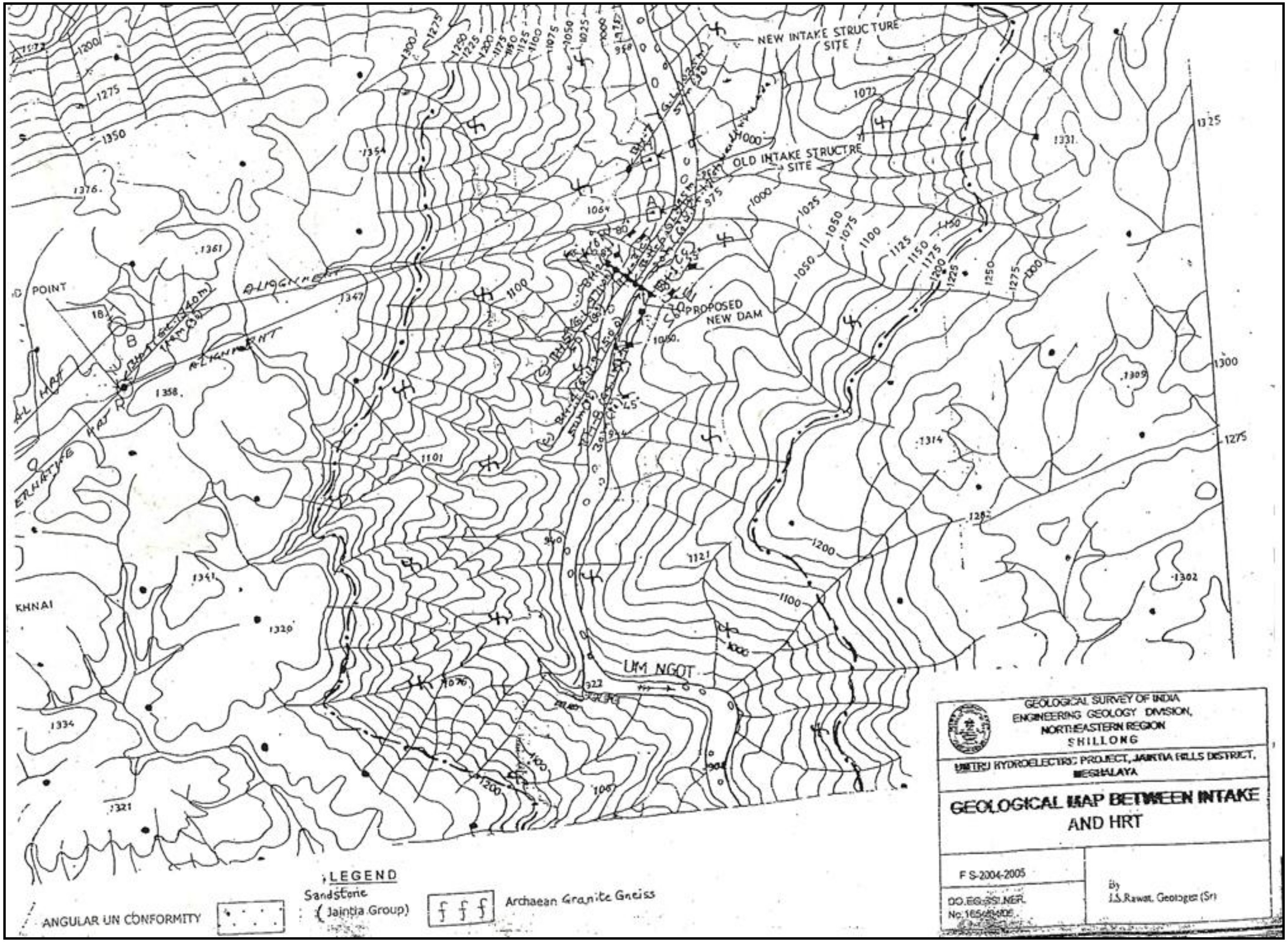
3.26 In the last 100 years as many as eighteen large earthquakes have been recorded from this seismo-tectonic domain, out of which two were the Great Earthquakes- one of 1897 and the other of 1950. List of events of damaging nature is included in Table 3.6.

Table – 3.6

CHRONOLOGICAL LISTING OF EARTHQUAKES OF MAGNITUDE>5.0

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

Figure 1II.1 (a) Geological Map between Intake and HRT



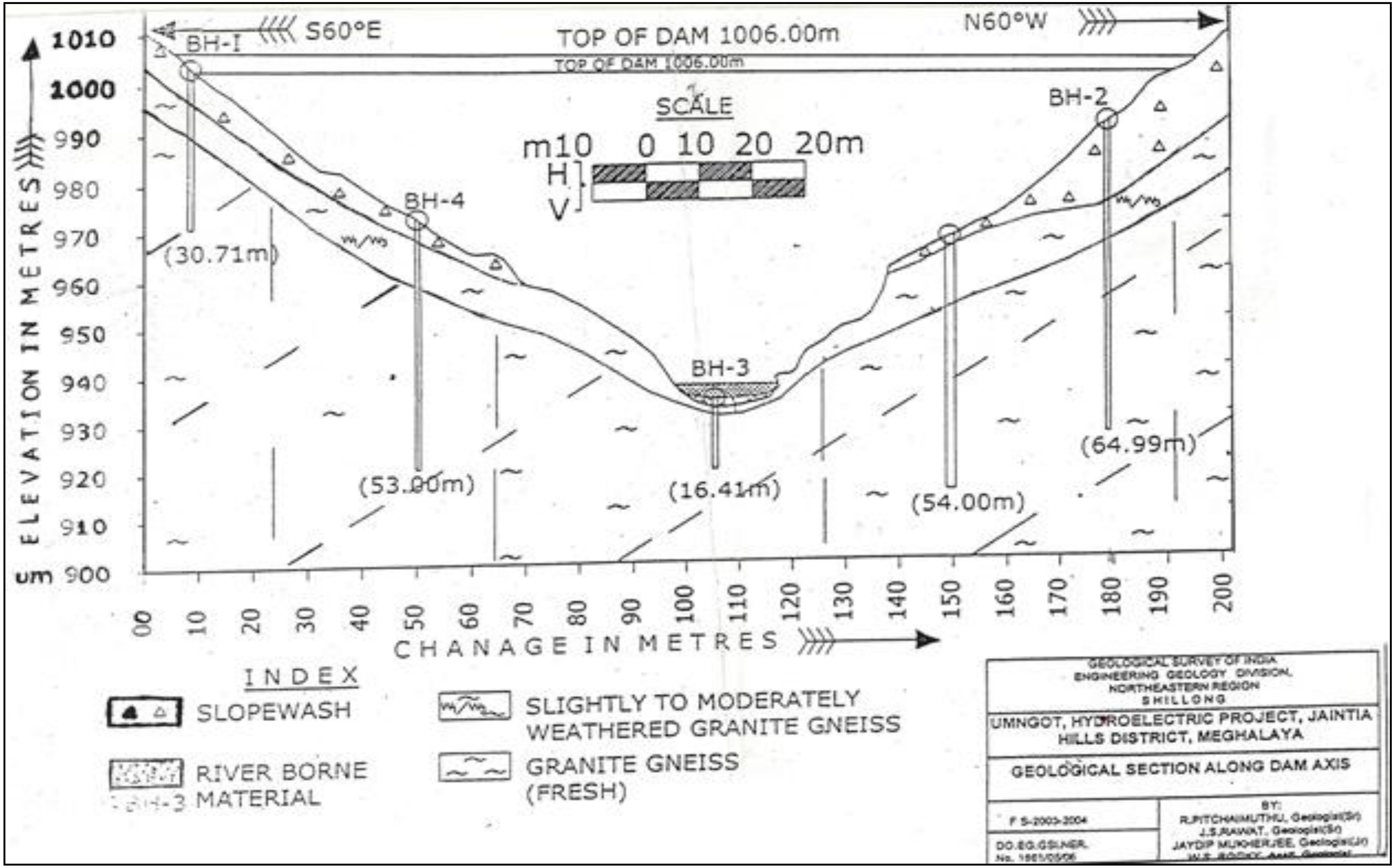

S60°E
N60°W
TOP OF DAM 1006.00m
BH-I
BH-2
BH-3
BH-4
SCALE
m10 0 10 20 20m
H
V
(30.71m)
(53.00m)
(16.41m)
(54.00m)
(64.99m)
ELEVATION IN METRES
1010
1000
990
980
970
960
950
940
930
920
910
900
00 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
CHANAGE IN METRES
INDEX
SLOPEWASH
RIVER BORNE MATERIAL
SLIGHTLY TO MODERATELY WEATHERED GRANITE GNEISS
GRANITE GNEISS (FRESH)
GEOLOGICAL SURVEY OF INDIA
ENGINEERING GEOLOGY DIVISION,
NORTHEASTERN REGION
SHILLONG
UMNGOT, HYDROELECTRIC PROJECT, JAINTIA HILLS DISTRICT, MEGHALAYA
GEOLOGICAL SECTION ALONG DAM AXIS
BY:
J.S.RAWAT, Geologist(Sr)
JAYDIP MUKHERJEE, Geologist(Jr)

Fig III.1 (c) :GEOLOGICAL MAP OF DAM SITE AREA

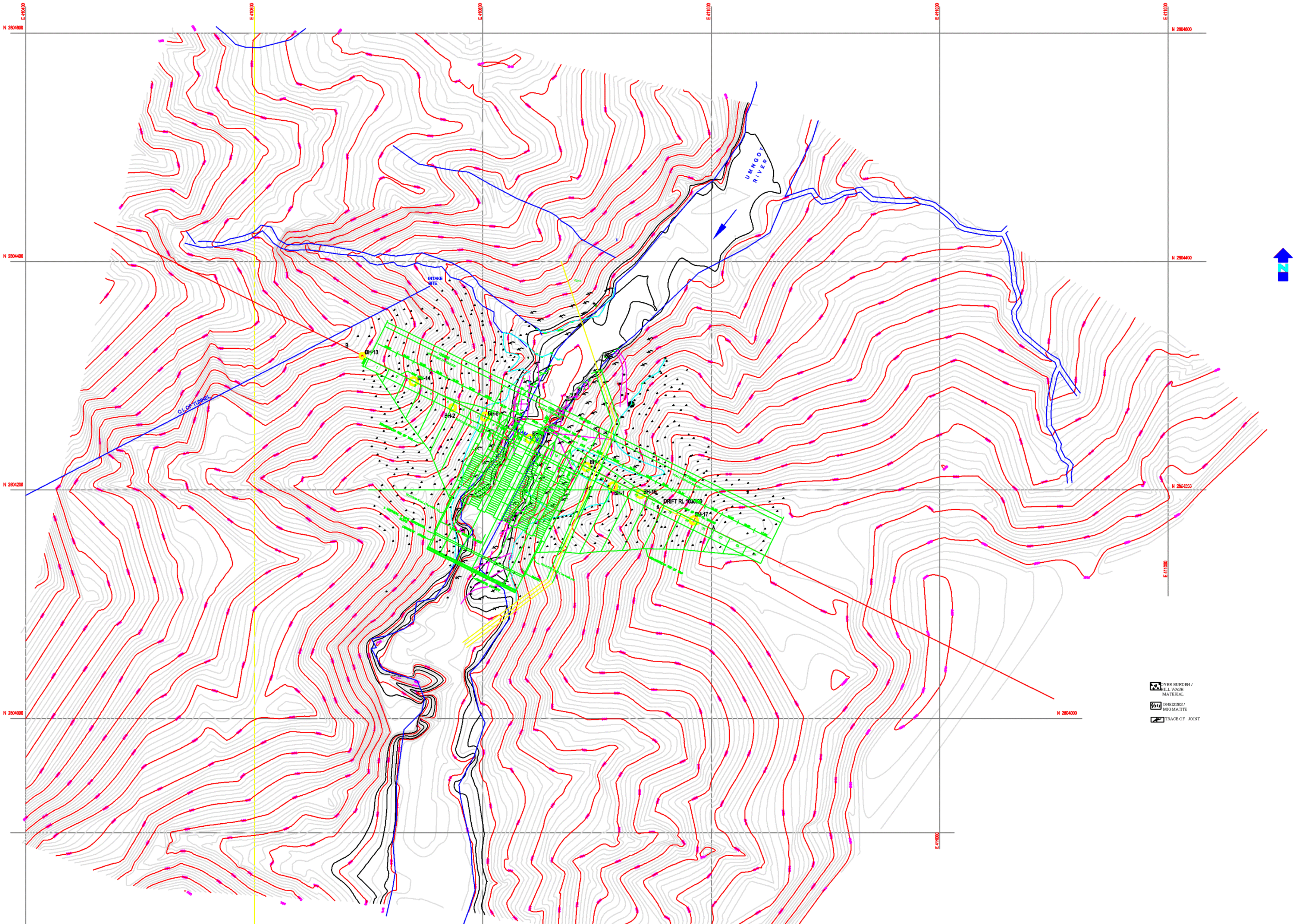
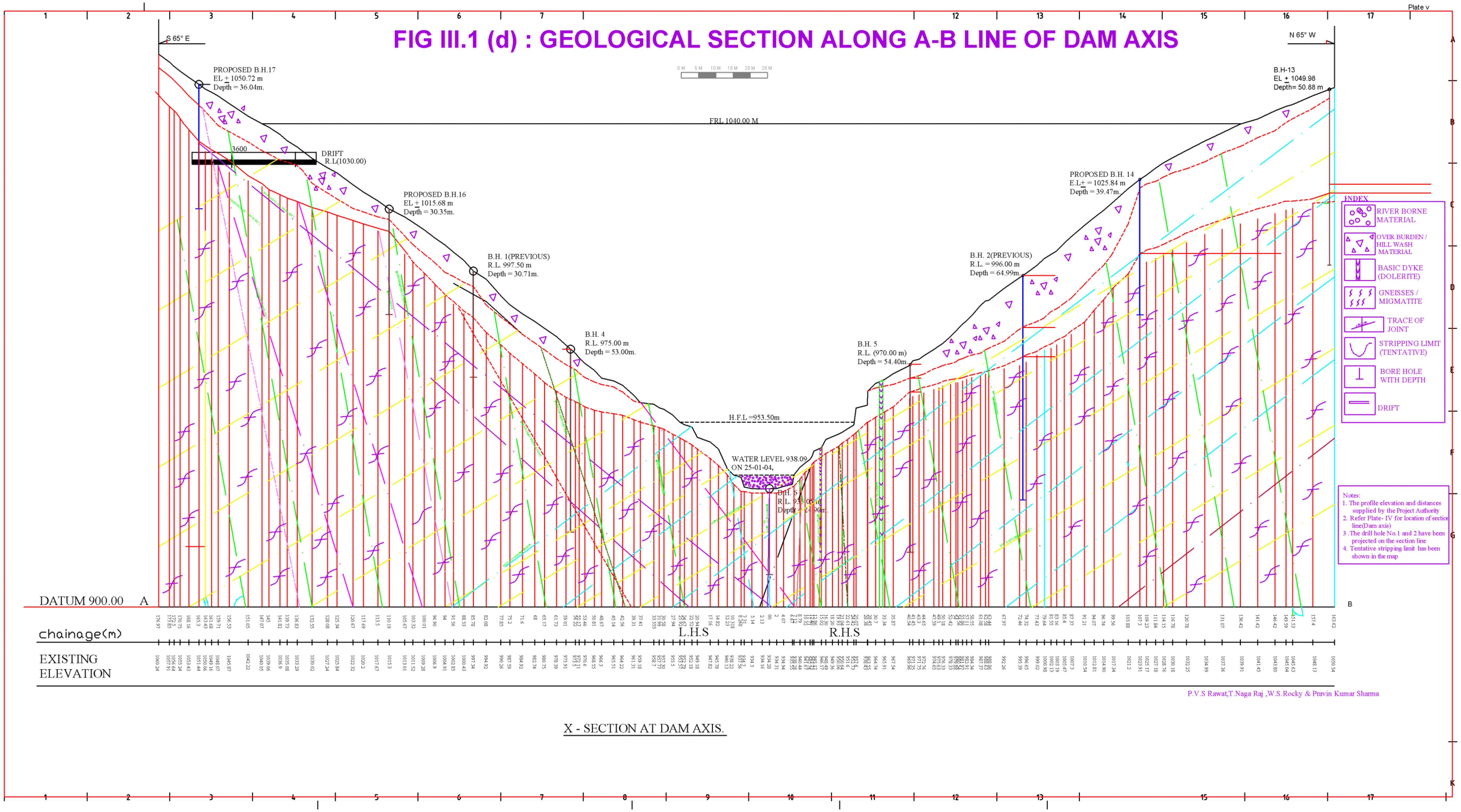


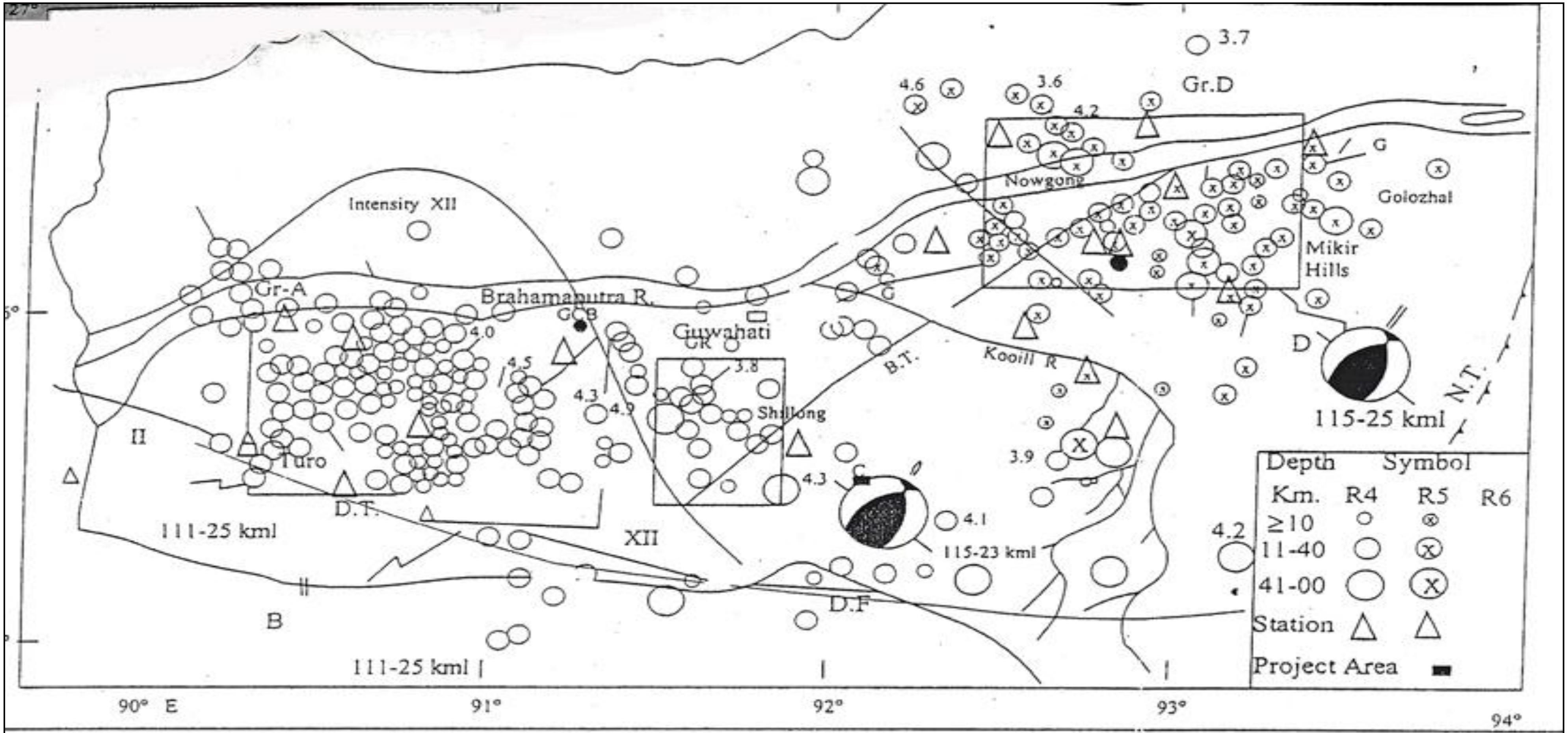
FIG III.1 (d) : GEOLOGICAL SECTION ALONG A-B LINE OF DAM AXIS



P.V.S Rawat,T.Naga Raj ,W.S.Rocky & Pravin Kumar Sharma

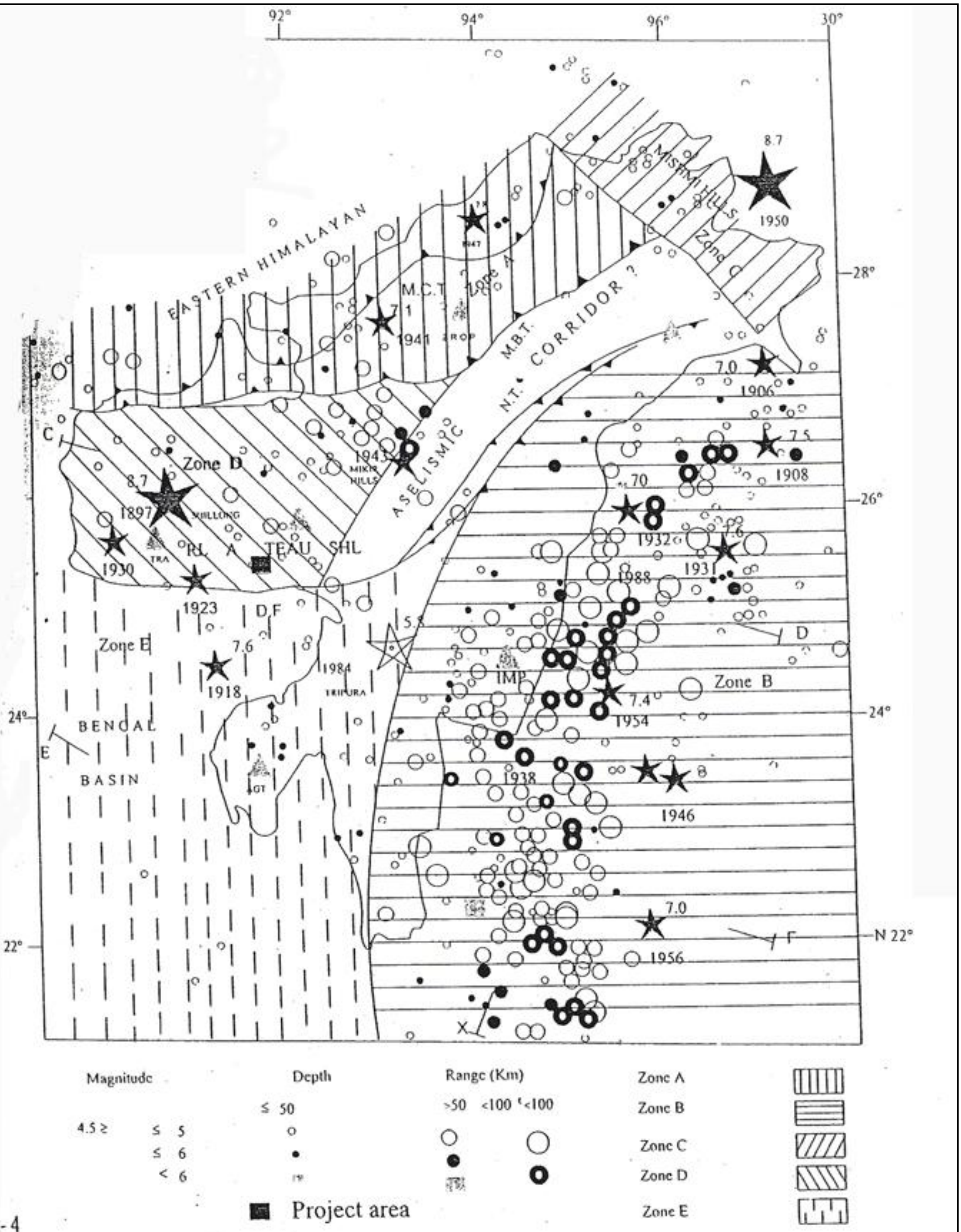
X - SECTION AT DAM AXIS.

Figure III.2 Micro Seismicity map of the Shillong plateau



Microseismicity map of the Shillong Plateau-Mikir Hills-Assam Valley area after Kayal and De , 1991)The high intensity (XII)zone of the 1897 great earthquake is shown by the curved line .The earthquakes of magnitude (Md) more than 3.5 are annotated. Composite focal-mechanisms (upper hemisphere) are shown for each selected group of earthquakes ,shaded area indicates zone of compression and open area indicates zone of dilatation ,small bars shown the direction of compressional stress (P-axis).Strike -slip movement area shown by small arrows Major fault / thrust, and lineaments are shown by broken lines; D.T.: Dapsi Thrust, D.F.: Dauki Fault, N.T.: Naga Thrust, B.T.: Barapani Thrust, G.G.: Guwahati Golaghat lineament .

Figure III.3 Modified Seismicity map (modified from Kayal)



g :- 4

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.

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

50	1989	4	13	7	25	33.0	24.40	92.43	5.1	5.0	29	ISC
51	1990	9	2	6	29	26.1	26.58	92.67		5.2	47	ISC
52	1991	2	2	0	15	40.0	25.51	91.17	3.9	5.0	24	ISC
53	1992	12	12	14	20	56.8	25.48	91.39	4.2	5.0	41	ISC

3.27 The Seismicity Map reveals concentrations of events in different techonic domains, with contrastic deformation styles, focal depths and different Stress fields. These tectonic domains are the Himalaya Region, the Mishmi Block, the Indo –Burmese Tectogenme the Meghalaya and Mikir hills (now Karbi Anglong) Massif area, the Bengal Basin and Tripura Folded Belt.

Zone A, The Himalayan Collision Zone, resultant of Collision of Indian Plate with Eurasian Plate, demonstrates north- south compressional stress field with thrust type faults with isolated events along N-S trending faults. Kayal, from micro-earthquake studies, has inferred that in the Arunachal area the NW-SE compressional stress is dominant and the activity with N-S compressional field and related to Himalayan Thrust sheets is less prominent. Elsewhere, in the Himalaya, large magnitude earthquakes have been related to a low angle northward verging detachment surface, but in this part, has pro-graded further south involving even the Meghalaya Massif (Narula & Sharda, 1997).

Zone B, is the Indo-Burmese Tectonic Belt which demonstrates activity of Plate Boundary as well as Benioff-zone intermediate focal events with normal as well as strike slip focal mechanism. These events are located away from the Meghalaya Massif.

Zone C, is the Syntaxial domain where the Himalayan Folded Belt and the Arakan Yoma Folded Belt have been overlapped by NW-SE trending Mishmi Thrust. This domain also demonstrates high level of Seismicity and the 1950 Assam Earthquake was located in this zone.

Zone D, The seismo- tectonic domain which includes the Meghalaya – Mikir hills (now Karbi Anglong) massifs, demonstrates high seismicity near the plate boundary and very high micro-seismic. The 1897 Great Indian Earthquake was located in this domain. This tectonic domain is of significance because the project site is located in this domain.

Zone E, is the domain of Indian plate which lies below the Bengal Basin and demonstrates seismic activity along discrete tectonic surfaces. From the above, it is apparent that for evaluating the Seismic Hazard for the site in the near vicinity, seismogenic sources as well as larger distance sources have to be considered.

Effect of Past events in the Project Area

3.28 Macro-seismic surveys have been conducted by the Geological Survey of India for delineating the intensity isoseismals based on the damage patterns as well as terrain changes and the observations made are briefly discussed below.

The Great Indian Earthquake of 1897

3.29 This event, located in the Meghalaya massif, rocked the Indian subcontinent at 1715 hours of 12th June 1897 caused extensive damage in the northeastern region and took a toll of more than 1500 human lives (loss of lives was comparatively low because of sparse population and the time of occurrence of the event). This earthquake was assigned a magnitude of 8.7. The meiso-seismal area of this event defines the boundaries of the Meghalaya Plateau. Narula & Sharda (1997) have assigned Intensity XI (Modified Mercalli) to the Epicentral Tract. From the observations made in the area, ground accelerations in the vicinity of 0.5 g have been interpreted by Oldham (1899) in the Memoirs VOL.XXIX of the Geological Survey of India.

3.30 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-centre of this quake was 140 km N60^0 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 Great Assam Earthquake of 1950

3.31 This event with an assigned Magnitude of 8.6 rocked the northeastern corner of the country on 15th August. 1950. The Epicenter of this event was located at 28.5^0 N and 97^0 E with Focal Depth of 20 km. The re-worked focal mechanism solutions for this event give different mechanism as well as nodal plane orientations; Molnar (1990) estimated that the NNW-SSE trending fault could be the source Fault. It may, however, be pointed out that the isoseismal trends for this event are oriented in the ENE-WSW direction which is across the regional tectonic trends prevailing in the area. The project area lies in the Isoseist VII of this event.

Monitoring of the area by Micro-Earthquake Studies

3.32 A few micro earthquake surveys have been conducted in the Meghalaya Plateau and Assam Valley between 1982 -1986 and various research workers have published the results obtained. Kayal and De re-analysed the data of the closely spaced network which were better constrained and a total of 5000 events of Magnitude 1.0 and above have been located. It is interesting to note that the maximum micro –earthquake activity has been observed in meiso-seismal area of 1897 earthquake. Kayal (1997). Hypo central cross section and fault plane solutions, however, suggest that northeast dipping fault (probably Dapsi Thrust) is seismically active in the western part of the Shillong Massif. In the eastern part of the Plateau, the seismic activity has been correlated with Barapani Shear Zone. In Mikir Hills (now Karbi Anglong)- Nagaon area (Assam Valley) activity along the Guwahati – Golaghat lineament as well as Kopili lineament has been interpreted.

Palaeoseismological studies

3.33 As historical records for large magnitude events are rather limited, the recurrence intervals of these events cannot be well constrained for adoption in the designs. For this purpose geological route of studying the deformational structures preserved in the Geological Recent (Holocene) period sediments, defined as palaeoseismicity, is used. Sukhija et al (1997) carried out palaeoseismological studies by trenching in the vicinity of Chidrang Fault, recognized the seismites and dated the same by radiocarbon dating method. They have interpreted that during last 1500 years including the Great Earthquake of 1897, four similar events have taken place in the 500+_ 150 years, 1100+_ years and 1500+_ 150 years and the events of 1897, thus suggesting a recurrence interval of about 500 years for 8+ Magnitude events in the Shillong Massif.

Earthquake Sources for Aseismic Design

3.34 From the above discussions it is evident that 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.

3.35 Detachment surface below the Meghalaya Plateau, the most conservative depth for this feature would be 15 km and the Magnitude of the event ± 8.5. This is the same source as of the 1897 Great Indian Earthquake.

3.36 Kulsi Fault- This 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.

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.

3.37 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.

Dhansiri – Kopili Fault

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

Dawki Fault

3.39 Which 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 neotectonic activity along this fault has been recorded.

3.40 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.

Earthquake Motions for Aseismic Design

3.41 Based on the seimo- 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 seimogenic 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.

3.42 The MCE and DBE values considered in the design of structures of Umngot HE project aera 0.36 g and 0.18 g respectively.

The Soils

3.43 Broadly, the soils met within the study area or in the catchment area are red loamy soils, red gravelly soils and red sandy soils. Mostly they are red loamy soils. Soil mapping, notwithstanding whether it is based on traditional field traversing procedure or by remote sensing application involves soil profile studies which have to be necessarily carried out in the field. However, the number of soil profiles to be studied in remote sensing based approach is comparatively less than those required for conventional system of study. The major aspects of methodology followed in this project are image interpretation..

3.44 The reliability of remote sensing application in soil mapping is largely dependent on appropriate selection of satellite data and accurate interpretation of imagery. Soils have characteristic spectral response in visible and infra-red range of electromagnetic spectrum which is a function of their physico-chemical properties. The variations in surficial features like colour, texture, moisture content, land use and vegetation which are partly diagnostic of soils classes are registered on the imagery. A correlative approach involving image elements and physiography is, therefore, necessary for systematic visual interpretation and soil identification. Based on the subtle differences in image elements, various mapping units are delineated. Observation points are identified and marked on the map for field checking. The exact relationship between a taxonomic class, its expression on the imagery and its spread defined the boundary and was established in the field.

3.45 Considering the genetic factors and based on differentiating morphological and morphometric characteristics, soil units have been identified and mapped in the area (Fig.VIII.3). The descriptions of mapping units are presented in the following paras:

Soil Unit – 01: Deep, excessively drained, fine soils on moderately sloping side-slopes of hills having loamy surface with moderate erosion hazard associated with: Moderately deep, excessively drained, coarse-loamy soils on gently sloping hill tops with very severe erosion hazard and strong stoniness.

Soil Unit - 05 Deep, excessively drained, fine soils on moderately sloping side-slopes of hills having loamy surface with moderate erosion hazard associated with: Moderately deep, excessively drained, fine-loamy soils on gently sloping hill tops with very severe erosion hazard and strong stoniness.

Soil Unit – 06 Moderately shallow, excessively drained, fine-loamy soils on moderately steep side slopes of hills having loamy surface with severe erosion hazard and strong stoniness associated with: Moderately shallow, excessively drained, loamy – skeletal soils on gently sloping hill tops with very severe erosion hazard and slight stoniness.

Soil Unit – 07 Moderately deep, excessively drained,coarse-loamy soils on very steeply sloping hill escarpment having sandy surface with very severe erosion hazard and strong stoniness associated with: Deep, excessively drained, coarse- loamy soils on steeply sloping hill tops with very severe erosion hazard and slight stoniness.

3.46 The area of soils under the different units in the catchment area is given in the following Table – 3.7.

Table 3.7 Soil Classification.

S.I NO	Soil Unit no.	Soil Classification.	Area in ha.	Percent age
1	01	Moderately deep excessively drained, coarse loamy soils on gently sloping hill tops with very severe erosion hazard and strong stoniness.	9018	29.63
2	05	Moderately deep excessively drained, fine loamy soils on gently sloping hill tops with very severe erosion.	8590	28.23
3	07	Deep excessively drained, fine loamy soils on steep sloping hill tops with severe erosion hazard and strong stoniness.	12455	40.93
4	08	Shallow, excessively drained loamy skeletal soils on moderately steep side slopes of hills with very severe erosion hazard and strong stoniness.	370	1.22
		TOTAL	**30433**	**100.00**

Environmental Impacts

3.47 Construction of a dam on a river for water poundage produces both negative and positive impacts on various environmental parameters. However, the impacts of a dam on land environment are mostly negative. Excavation of soils, rocks, sand etc and their transportation pollute land environment. Wastes and refuse generated during construction likely to pose environmental problems through their disposals. Land topography may register changes due to excavations while planning the projects. Impacts on land environment are both due to pre project and post project activities. During the construction stage, secondary impacts relating to pollution due to dust and other construction materials, soil erosion, increased in flow of traffic etc, may come into existence.

3.48 However during the post impoundment period the above said secondary impacts would gradually be reduced, but the impact due to impoundment sets in. There are two types. The first is immediate submergence of area resulting in total loss of eco-system and effect on socio-economic system. The second will be gradual one relating to the surrounding area in the immediate vicinity of the area coming under submergence.

Impact on land use / land cover – Quarrying Operation:

3.49 Any excavation work is bound to bring about changes on the face of earth. Quarries are proposed for extraction of coarse aggregates, soil, sand, rubble, rock. Extraction of material from different quarries produces depressions and will naturally change the micro topography of the area to a limited extent.

3.50 Part of the stone material required for the construction of the dam will be met with from the muck generated during exploration of foundations, tunnel excavations etc. Stone quarries are proposed in the nearby vicinity on the flanks of Umngot River on the upstream areas which are likely to be submerged. The rock in the quarry area is hard and compact and hence the erosion intensity will be very low. Quarries will be proposed in lands acquired for submergence. No major impact is anticipated from these excavations. However treatment of slopes is proposed as suggested under EMP to avoid any land slides.

3.51 Sand is proposed to be transported from sand quarries at Karkhana from Myntdu River in Jaintia hills district which is about 55 km. The sand is already being quarried from that river for other projects. Hence no treatment measures need be suggested.

Sites for construction equipment

3.52 During construction phase, various types of equipment will be brought to the site. These include crushers, batching plant, drillers, earthmovers, etc. The setting of construction equipment would require significant amount of space. Similarly space will be required for storing of various construction materials as well. In addition, land will also be temporarily acquired, i. e. for the duration of project construction for storing the quarried materials before crushing, crushed material, cement, rubble etc. The storage sites need to be so selected that it is away from human habitation and fauna population and cause least damage to the vegetation.

Muck Disposal

3.53 A large quantity of muck is expected to be generated as a result of excavation of foundations for dam, over ground power house, tunneling operations, etc. Normally, muck disposal sites are cleared of vegetation before disposing materials. Trees are cut before muck disposal, however, shrubs, grass or other types of undergrowth on which muck is disposed perishes. The approximate quantities of muck likely to be generated based on the line estimates is assessed as shown in the Table - 3.8.

Table – 3.8 MUCK GENERATION			
Sl.No	**Different Project Sites of Umngot HEP**	**Quantity of Muck, m^3**	
		Soils	**Rock**
1	Low pressure Tunnel	-	126900
2	Adit Tunnels	9000	28000
3	Surge Shaft	4800	7200
4	Pressure Shaft	-	7500
5	Access tunnel	4000	79200
6	Dam	635000	36000
7	Power House and Trail Race	10000	73500
8	Tail race tunnels	4000	47500
9	Intake Structure	5640	8420
10	Diversion tunnel	500	3100
	Total	**672940**	**417320**

3.54 About 50 percent of rock generated from different components can be utilized for construction works like masonry and concrete. Balance 50 per cent of the rock and soil material requires management measures. Thus management measures are required for the disposal of muck to a tune of 8.82 lakh cum

3.55 In many projects, it has been observed that the muck generated by various sources is disposed along river valleys. The boulders are stacked along the river bank, and during the next monsoon, the boulders slip along with runoff, and ultimately find their way into the river and finally in to the plains. This can affect the river flow and aquatic ecology. Hence, in the proposed project adequate measures, such as retaining walls, etc. need to be implemented to ameliorate the likely adverse impacts. Appropriate management measures need to be implemented for amelioration of adverse impacts, which have been outlined in Environmental Management Plan report

Construction of roads

3.56 The project is proposed to be connected from both the banks of the river Umngot through the National Highway 40E, from Jowai to Dawki which passes through Amlarem, on the left bank and the Lad Smit- Mawkynrew- Syntung /Siangkhnai road connecting the National Highway -44 on the right bank. On the left bank, the proposed approach road from the Dam site to the National Highway is essential for carrying the heavy machinery required for the project, and is about 5 kms. The major approach roads to be constructed are towards the power house. The one on the right bank is of 15 kms from Syntung towards the powerhouse. Several small approach roads to Surge Shaft, Adit Tunnel, colonies etc would also be required from this road. Another approach road from the left bank is essential to carry the Electro-mechanical equipment to the power house. This road would be diverted from the NH40E near Maulang village and road distance upto the power house is approximately 17 km. A bridge of about 70 m width is also proposed to be constructed upstream of the Tail race exit across Umngot river. Several small bridges and culverts are also required to be constructed across many streams and nallahs.

3.57 The project construction would entail significant vehicular movement for transportation of large construction material and heavy construction equipment. Most of the roads in the project area would require widening. Many new roads would have to be constructed. The construction of roads can lead to following impacts. Removal of vegetation on slopes and re-working of the slopes in the immediate vicinity of roads can encourage landslides, erosion, gullies etc. With the removal of vegetal cover, erosive action of water gets pronounced and accelerates the processes of soil erosion and formation of deep gullies. Consequently, the hill faces are barred of soil and vegetal cover and enormous quantities of soil and rock will move down the rivers and in some cases, the road itself may get washed out. Construction of new roads increases the accessibility of a hitherto undisturbed area resulting in greater human interference and subsequently adverse impacts on the eco-system.

3.58 The loss of natural flora shall be compensated suitably as suggested under EMP.

Submergence of land

3.59 The main component for the diversion of water for generating Hydro electric power is dam across Umngot River. The creation of storage by construction of huge dam of 111 m high involves moderate submersion of land and consequently change in land use and land cover besides adverse impacts on social environment, Since the river flow is in deep gorge, the submergence is limited to an extent of 253.85 ha (including water bodies) and no villages are going to be submerged fully. But cultivated lands pertaining to some of the villages (12) are likely to be affected.

3.60 The total area proposed for acquisition towards the submersion of private cultivated lands and for other appurtenance are 420 ha. The land use and land cover of the area required for project submergence and other appurtenance works is shown in Table - 3.9. The submergence area map showing the land use and land cover is exhibited in Fig VIII.6. The land area mainly comprises of Open forests (43.3%) and water bodies (24.0%) besides arable lands (2.3%) and broom stick lands(12.2%). Thus, there is no need for diverting either reserved or projected forest lands for the project purposes.

Table 3.9 Land use / Land cover of submergence and other appurtenance works.

Area in ha

Sl No	Classifications	Reservoir Submergence	Other appurtenance works	Total	Percentage
1	Arable lands	8.85		8.85	2.3
2	Broom Land	47.75		47.75	12.2
3	Dense forest	8.28	19.13	27.41	7.0
4	Open forest	51.72	117.54	169.26	43.3

Table 3.9 Land use / Land cover of submergence and other appurtenance works. *Area in ha*					
Sl No	**Classifications**	**Reservoir Submergence**	**Other appurtenance works**	**Total**	**Percentage**
5	Scrub land / Tree clad	8.96		8.96	2.3
6	Barren Land	34.74		34.74	8.9
7	River/Water bodies	93.55		93.55	24.0
	Total	**253.85**	**136.67**	**390.52**	**100.0**

Land degradation due to excessive irrigation and due to excessive use of fertilizers and insecticides

3.61 The proposed hydro electric project is located on Umngot River. The population density in the area is moderate in the catchment area intercepted at project site. Mainly traditional form of agriculture characterized by low agro chemical dosing and absence of mechanization ensures that the degradation of soils and pollution loading due to agro chemicals is quite low.

Land subsidence

3.62 Land subsidence is not apprehended in any part of the submergences area and impact zone, as all the quarries will be open except the tunnels. Ample precautionary measures have to be taken in design of the structures to avoid any risk of subsidence. Latest technologies have proposed for excavation of tunnels etc.

Reservoir induced Seismicity (RIS)

3.63 The proposed dam across Umngot River is situated in heavy seismic zone. The project area lies under the influence zone of the Great Indian earth quake of 1897 with a magnitude of 8.7 occurred in Meghalaya plateau with ground acceleration of 0.5g. The project lies with in the ISO-seismals VIII and IX. The project area also lies in the ISO seist VII of the great Assam earth- quake of 1950 which was assigned a magnitude of 8.6 occurred on 15th August 1950. Several other earthquakes occurred in the area were detailed before in the relevant paragraphs. From the observations made in the area, ground acceleration in the vicinity of 0.5g has been interpreted by Oldham (1899). The MCE and DBE values of 0.36 g and 0.18 g respectively are adopted in the design of structures of Umngot HE Project.

3.64 Significant reservoir induced earthquakes are usually related to large dams of height more than 100m. The height of the proposed Umngot dam is 112m and hence prone to induced earthquakes. The factors influencing earthquake frequency and magnitude include the rate of increase of water level, duration of loading, maximum water level reached and duration for which the high water level is retained. Reservoir induced Seismicity is generally noticed low to moderate seismic area line of the project site. In highly seismic active areas the normal stress changes may be larger than the incremental changes in frequency pattern of the natural seismicity. It is to be noted that in thrust type of environment, trigging effects involve a greater amount of increase in pre-pressure as compared to the strike slip normal environment.

3.65 The borehole data along the axis of the proposed dam line indicate the availability of sound rock. Since the bed of the proposed reservoir would be on quality rock below the over burden, Reservoir induced Seismicity would be negligible.

Impact due to inundation of mineral sources

3.66 No minerals which may change the water quality of the reservoir are available in the submergence area which may be harmful to the inundated water used for hydropower and down stream domestic purposes.

Impact on Soil Erosion

3.67 Soils in the catchments area are red loamy, red sandy, and red gravely soils (Algisoils) formed by parental material like Gneisses, sand stone & shale's. The catchments area is undulating with gentle to very steep slopes. The area is already under severe to very severe erosion category. No further impact is predicted. The present erosion status is likely to be reduced in view of the catchment area treatment proposed under EMP. It is notified that there is severe erosion through the side drains of existing roads. Preventive measures proposed by avenue plantation, other vegetation treatment besides structures for existing as well as proposed roads.

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - I

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Chapter - IV

WATER ENVIRONMENT

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MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

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(3 X 80 MW)

PART - I
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IV
WATER ENVIRONMENT

Introduction

4.01 The base line study of water environment is focused on water quality relating to surface water of Umngot River in various seasons. Most of the precipitation is received from south – west monsoon. Rainy season commences from May and continues till September. The other three seasons are spring, (March/April), autumn (October & November) and winter (December to February). Surface water samples were collected during monsoon period 7/2008 and during winter 12/2008.

4.02 Water is the most primary requirement for sustenance of flora, fauna, aquatic and above all human lives on the earth. Therefore the hydro power project plays an important role in the development of the region. The storage scheme indirectly benefits by way of drinking water to the population in the vicinity due to improvement in ground water tables, in addition to contemplated power generation of 240 MW. Such projects though beneficial and useful for a variety of purposes creating positive and beneficial impacts but they also contribute towards negative impacts which have to be taken care of by adopting suitable mitigative measures. The present study is therefore focused on the overall impact of the project on water environment.

Umngot River Basin

4.03 Umngot is one of the major southwardly flowing river 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 tributary. 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 criss-crossing 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 749 m.

4.04 The Umngot river basin is covered in the district of East Khasi hills and Jaintia hills of Meghalaya state under two blocks in each of the districts.

Hydrology

4.05 The Meghalaya state predominantly is mountainous and is drained by tributaries of Brahmaputra. The major tributaries are Kulsi, Jadukata, Myntdu, Mawblei, Kynshi and Umngot. All these tributaries except Kulsi drain to Bangladesh. The Umngot River is a tributary of Surma River in Bangladesh. The Umngot HE scheme is identified near Siangkhnai village and intercepts an area of 304sqkm of Umngot River basin.

4.06 The various rain gauge stations in the catchment area considered for rainfall observations are

- Sohmynting w. e. f 08-06-1991
- Kharang w. e. f 01-09-1991
- Jatah w. e. f 01-09-1991
- Umngot dam site w. e. f 08-04-1994
- Smit/Umphyrn ai w. e. f 17-06-1994
- Pommura w. e. f 01-03-2002
- Puriang w. e. f 01-03-2002
- Nongjrong w. e. f 01-03-2002

Discharge observations of Umngot River at CWC site Dawki with effect from 1975-2003 were taken for hydrological workings.

4.07 Monthly rainfall of all the station calculated from the observed daily rainfall. Isohyetal method has been used to estimate the mean catchments rainfall (monthly). Table 4.1 presents the same to assess the order of runoff that can be reasonably expected and to serve as a basis for checking the consistency of the observed flow series the formula evolved by Khosla (1960) is adopted. The assessment was made for the period from 1994 to 2006 and the observed runoff is considered reasonable when compared with the runoff by Khosla's formula. **Table - 4.1**

Table – 4.1 Observed Runoff

MEAN MONTHLY RAINFALL IN MM **CATCHMENT AREA 304 SQ.KM.**

Month / Year	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
JUN		790.82	1302.53	1021.40	1513.09	943.08	1003.36	928.93	768.63	1379.85	728.68	1465.61	1252.80	584.94	544.56
JUL		879.14	870.01	360.77	1118.95	1155.76	998.45	998.45	1161.22	459.36	966.68	1085.22	958.92	1990.33	581.59
AUG		364.48	735.58	488.39	847.64	424.95	481.59	454.45	553.63	766.41	450.34	481.89	305.76	378.17	804.84
SEP	966.38	378.19	380.72	200.63	528.79	284.85	371.33	388.45	168.43	376.24	535.40	405.44	194.83	416.49	154.02
OCT	542.93	195.92	246.21	276.86	102.82	755.47	63.89	50.60	431.57	298.41	313.15	48.32	400.95	737.90	308.84
NOV	0.33	14.09	20.24	29.31	228.93	0.00	12.05	8.79	25.98	0.00	21.73	230.00	18.13	1.05	8.57
DEC	49.23	12.81	2.91	3.21	4.34	0.00	21.61	14.70	2.15	0.00	0.00	0.00	11.59	3.30	0.07
JAN	3.47	71.22	16.85	11.99	7.72	6.47	8.45	8.45	10.09	1.50	38.31	3.80	1.36	5.09	0.00
FEB	25.32	16.39	49.60	36.37	36.15	27.34	5.82	5.82	8.65	34.34	6.90	9.56	5.84	7.89	4.03
MAR	28.16	198.02	143.33	9.42	56.63	63.33	157.58	135.56	78.60	31.80	56.95	119.00	58.67	194.20	23.51
APR	165.35	196.29	99.09	62.62	127.39	207.47	180.36	182.85	203.08	162.64	342.79	125.67	271.68	188.95	190.85
MAY	254.75	351.94	570.46	389.20	332.07	273.04	388.48	353.58	695.98	237.81	333.09	145.85	295.64	298.37	615.85
ANNUAL TOTAL	**2035.92**	**3469.30**	**4437.53**	**2890.16**	**4904.52**	**4141.75**	**3692.96**	**3530.63**	**4108.02**	**3748.36**	**3794.01**	**4120.36**	**3776.15**	**4806.67**	**3236.73**

4.08 The discharge gauging site of CWC at Dawki, located downstream of the project discharge site is drained by catchments area of 815 sq.km. The annual discharges at the two stations are seen to follow a similar trend. The trend conforms with the normal distribution of rainfall in the region which gradually decreases from the southern to the northern reaches of the catchments. The distribution of rainfall in the observed stations follows the same pattern as the normal distribution pattern provided by IMD. The monthly discharge data pertaining to the period from 1989 to 2006 on a ten daily and monthly basis are given in Tables -4.2 and 4.3 Overleaf

4.09 Annual maximum floods shown as peak discharges and levels are given tabular farm in Table - 4.4. Flood hydrographs on an hourly basis for few very large events are shown in Tables - 4.5 to 4.8

Table – 4.4
ANNUAL MAXIMUM FLOODS

Year	Month	Date	Discharge (Cumecs)	Reduced Water Level(m)
1989	July	6	444.0	943.16
1990	June	8	239.1	941.81
1992	September	2	239.1	941.81
1992	September	29	292.6	942.21
1993	August	7	462.0	943.26
1994	August	13	720.3	944.51
1995	June	19	2913.0	950.55
1996	July	16	854.2	945.06
1997	July	9	1402.0	946.92
1998	August	17	932.5	945.36
1999	July	9	1071.6	945.86
2000	August	1	1130.2	946.06
2001	July	29	1930.0	948.36
2002	June	14	1368.7	946.82
2003	June	30	1930.3	948.36
2004	July	10	2821.1	950.36
2005	August	24	2821.1	950.36
2006	May	30	816.4	944.91

Table – 4.2
AVERAGE 10 DAILY DISCHARGE IN CUMECS

Catchment area 304 sq.km

Month	Year																
	1989-90	1990-91	1991-92	1992-93	1993-91	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
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	48.50	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*	70.60	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	81.26
	74.89	62.76	9.24	32.04	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	29.80
	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	367.57	38.08	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	33.98	18.48	22.39	26.79	13.22	37.79	15.67	17.36	38.75	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	11.40
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	28.85	23.62	33.14	11.48	7.04	12.23	10.48	35.55

Table – 4.2
AVERAGE 10 DAILY DISCHARGE IN CUMECS

Catchment area 304 sq.km

Month	Year																
	1989-90	1990-91	1991-92	1992-93	1993-91	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
November	10.08	8.14	7.10	6.45	7.92	5.70	22.85	19.91	5.70	8.61	10.68	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	4.896	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	2.80	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
February	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	2.56	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	2.80	2.39	2.29	1.70	1.7
	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	6.32	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	3.87	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	111.10
Total	874.16	595.63	515.29	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	780.20

Table – 4.3

MONTHLY DISCHARGE IN CUMECS

Month	Year															
	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
June	1327.84	1198.76	1378.50	1521.23	2646.54	2028.56	4837.76	1223.09	1582.50	1101.91	1382.73	3404.62	1162.37	3655.79	2824.71	1031.28	985.64
July	2883.25	1572.29	493.80	1975.68	2145.30	806.00	2307.07	3142.26	2980.51	2850.52	3203.79	865.15	2261.77	2774.05	2355.31	6161.06	1374.60
August	584.56	526.46	633.52	2005.28	1931.18	1189.76	2182.13	885.48	1151.91	2944.41	1589.73	2396.27	1369.09	1076.38	950.15	834.42	2687.83
September	1065.28	853.93	1343.32	1383.20	1041.45	442.09	1327.18	472.50	1093.59	1064.96	621.73	1011.84	1383.36	789.38	533.92	1075.50	387.60
October	702.10	665.01	385.59	556.46	226.50	746.07	398.24	1174.63	320.88	537.49	1063.01	734.55	818.10	342.71	845.44	2976.13	689.22
November	210.16	185.54	162.61	157.37	182.74	138.56	518.47	363.76	143.45	340.26	238.85	298.99	214.58	390.61	216.02	173.96	205.37
December	105.49	96.41	83.23	103.97	97.96	83.88	155.78	138.31	98.51	191.56	139.91	146.24	130.20	165.22	139.79	106.20	115.49
January	56.31	66.82	70.12	122.20	70.45	68.49	104.28	94.50	76.04	119.26	108.27	111.13	113.98	111.92	107.79	77.90	85.52
February	70.09	41.51	71.60	83.36	68.89	53.29	78.81	72.02	51.75	76.55	89.65	84.11	88.65	81.22	80.59	55.69	62.75
March	111.13	40.39	54.03	90.58	252.76	40.35	73.78	78.86	84.65	219.76	79.44	85.80	83.72	99.10	102.15	139.45	51.44
April	1152.70	36.15	56.64	150.71	93.68	38.70	82.53	186.76	161.54	79.11	63.41	133.18	271.18	88.07	425.61	202.71	126.25
May	802.30	719.00	448.31	620.43	630.49	601.80	319.84	199.71	422.84	1034.31	1049.79	224.96	637.35	106.54	1067.63	310.73	1332.69
Total	**9071.21**	**6002.27**	**5181.27**	**8770.47**	**9387.94**	**6237.55**	**12385.87**	**8031.88**	**8168.17**	**10560.10**	**9630.31**	**9496.84**	**8534.35**	**9680.99**	**9649.11**	**13145.03**	**8104.40**

ESTIMATION OF UNIT HYDROGRAPH OF FLOOD ON 2.5.99/3.5.99 **TABLE -4.4**

Date	Time	Gauge	Reduced W/L	Stage (m)	Discharge	Time	Base Flow	Direct Runoff	Volume of DRH	Drainage Area	ER Depth	Ordinates of UH	Smoothened UH
		(m)	(m)	(m)	(cumecs)	(hrs)	(cumecs)	(cumecs)	(cum)	(sq.m)	(cms)		UH
2.5.99	6PM	3.18	938.24	0.64	3.61	**0.00**	3.61	0.00				0.00	0.00
	7PM	3.25	938.31	0.71	4.55	1.00	3.61	0.94				0.22	3.00
	8PM	3.40	938.46	0.86	6.97	2.00	3.61	3.36				0.79	8.00
	9PM	5.60	940.66	3.06	117.52	3.00	3.61	113.91				26.93	27.00
	10PM	7.20	942.26	4.66	299.70	4.00	3.61	296.09				70.01	70.00
	11PM	9.50	944.56	6.96	731.96	5.00	3.61	728.35				172.21	172.00
	12MN	**10.20**	**945.26**	**7.66**	**905.99**	6.00	**3.61**	**902.38**				**213.36**	**206.00**
3.5.99	1AM	9.40	944.46	6.86	708.75	7.00	4.46	704.30	12857488.64	304000000.00	4.23	166.52	165.00
	2AM	7.50	942.56	4.96	344.35	8.00	5.30	339.05				80.16	80.00
	3AM	6.20	941.26	3.66	175.06	9.00	6.15	168.91				39.94	40.00
	4AM	5.40	940.46	2.86	101.10	10.00	7.00	94.10				22.25	22.00
	5AM	4.85	939.91	2.31	62.85	11.00	7.85	55.00				13.01	13.00
	6AM	4.60	939.66	2.06	48.71	12.00	8.69	40.01				9.46	9.50
	7AM	4.45	939.51	1.91	41.16	13.00	9.54	31.62				7.48	7.50
	8AM	4.35	939.41	1.81	36.52	14.00	10.39	26.13				6.18	6.00
	9AM	4.25	939.31	1.71	32.18	15.00	11.23	20.95				4.95	5.00
	10AM	4.18	939.24	1.64	29.32	16.00	12.08	17.24				4.08	4.00
	11AM	4.10	939.16	1.56	26.23	17.00	12.93	13.30				3.15	3.00
	12NOON	4.00	939.06	1.46	22.63	18.00	13.77	8.86				2.10	2.00
	1PM	3.90	938.96	1.36	19.33	19.00	14.62	4.71				1.11	1.00
	2PM	3.85	938.91	1.31	17.78	20.00	15.47	2.31				0.55	0.40
	3PM	3.80	938.86	1.26	16.31	21.00	16.31	0.00				0.00	0.00
	4PM	3.75	938.81	1.21	14.90	22.00						844.44	844.40
	5PM	3.70	938.76	1.16	13.57	23.00							
	6PM	3.68	938.74	1.14	13.05	24.00							
	7PM	3.68	938.74	1.14	13.05	25.00							
	8PM	3.66	938.72	1.12	12.55	26.00							
	9PM	3.66	938.72	1.12	12.55	27.00							
	10PM	3.65	938.71	1.11	12.30	28.00							
	11PM	3.65	938.71	1.11	12.30	29.00							

ESTIMATION OF UNIT HYDROGRAPH OF FLOOD ON 29.7.01/30.7.01 table – 4.5

Date	Time	Gauge	Reduced W/L	Stage (m)	Discharge	Time	Base Flow	Direct Runoff	Volume of DRH	Drainage Area	ER Depth	Ordinates of UH	Smoothened UH
		(m)	(m)	(m)	(cumecs)	(hrs)	(cumecs)	(cumecs)	(cum)	(sq.m)	(cms)		UH
	8PM	6.76	941.82	4.22	240.33	**0**							
	9PM	6.75	941.81	4.21	239.07	1							
	10PM	6.70	941.76	4.16	232.79	2							
	11PM	6.65	941.71	4.11	226.61	3							
	12MN	6.60	941.66	4.06	220.52	4							
29/7/2001	1AM	6.60	941.66	4.06	220.52	5							
	2AM	6.55	941.61	4.01	214.52	6	214.52	0				0	
	3AM	6.60	941.66	4.06	220.52	7	220.52	0				0	0
	4AM	6.75	941.81	4.21	239.07	8	220.52	18.55				1.26	1.3
	5AM	6.85	941.91	4.31	251.89	9	220.52	31.37				2.12	10
	6AM	9.20	944.26	6.66	663.58	10	220.52	443.06				30.01	30.01
	7AM	10.00	945.06	7.46	854.18	11	220.52	633.66				42.91	55
	8AM	13.30	948.36	10.76	1930.31	12	220.52	1709.79				115.79	116
	9AM	**15.20**	**950.26**	**12.66**	**2772.17**	13	**220.52**	**2551.65**	**44887821.57**	**304000000**	**14.77**	**172.81**	**180**
	10AM	13.70	948.76	11.16	2093.68	14	241.67	1852.01				125.43	125
	11AM	12.20	947.26	9.66	1518.37	15	262.82	1255.55				85.03	84
	12NN	11.50	946.56	8.96	1284.28	16	283.97	1000.31				67.75	60
	1PM	10.60	945.66	8.06	1014.68	17	305.12	709.56				48.05	44
	2PM	10.00	945.06	7.46	854.18	18	326.27	527.91				35.75	32
	3PM	9.70	944.76	7.16	779.60	19	347.42	432.18				29.27	26
	4PM	9.50	944.56	6.96	731.96	20	368.57	363.39				24.61	21
	5PM	9.10	944.16	6.56	641.61	21	389.72	251.89				17.06	16
	6PM	9.00	944.06	6.46	620.04	22	410.87	209.17				14.17	13
	7PM	8.90	943.96	6.36	598.88	23	432.02	166.86				11.30	11
	8PM	8.80	943.86	6.26	578.12	24	453.17	124.95				8.46	9
	9PM	8.75	943.81	6.21	567.89	25	474.32	93.57				6.34	6
	10PM	8.70	943.76	6.16	557.77	26	495.47	62.30				4.22	3.5
	11PM	8.65	943.71	6.11	547.74	27	516.62	31.12				2.11	1.5
	12MN	8.60	943.66	6.06	537.81	28	537.81	0				0	0
30/7/2001	1AM	8.50	943.56	5.96	518.26	29	518.26	0				844.44	844.31
	2AM	8.40	943.46	5.86	499.10	30	499.10	0					
	3AM	8.25	943.31	5.71	471.11	31	471.11	0					
	4AM	8.10	943.16	5.56	444.00	32							
	5AM	7.00	942.06	4.46	271.82	33							
	6AM	7.20	942.26	4.66	299.70	34							
	7AM	7.25	942.31	4.71	306.91	35							
	8AM	7.60	942.66	5.06	359.99	36							
	9AM	7.40	942.46	4.86	329.09	37							
	10AM	7.30	942.36	4.76	314.21	38							
	11AM	7.45	942.51	4.91	336.67	39							
	12NN	7.65	942.71	5.11	367.96	40							
	1PM	7.50	942.56	4.96	344.35	41							
	2PM	7.40	942.46	4.86	329.09	42							

	3PM	7.00	942.06	4.46	271.82	43							

ESTIMATION OF UNIT HYDROGRAPH OF FLOOD ON 11.7.03/12.7.03 **TABLE 4.6**

Date	Time	Gauge	Reduced W/L	Stage (m)	Discharge	Time	Base Flow	Direct Runoff	Volume of DRH	Drainage Area	ER Depth	Ordinates of UH	Smoothened
		(m)	(m)	(m)	(cumecs)	(hrs)	(cumecs)	(cumecs)	(cum)	(sq.m)	(cms)		UH
	4PM	6.30	941.36	3.76	185.88	0							
	5PM	6.25	941.31	3.71	180.43	1							
	6PM	6.20	941.26	3.66	175.06	2							
	7PM	6.15	941.21	3.61	169.78	3							
	8PM	6.10	941.16	3.56	164.59	4							
	9PM	6.08	941.14	3.54	162.54	5	**4.93**						
	10PM	6.05	941.11	3.51	159.49	6	159.49	0				0	0
	11PM	6.20	941.26	3.66	175.06	7	154.56	20.50				3.452	3.45
	12M/N	6.25	941.31	3.71	180.43	8	149.63	30.80				5.187	5.19
12/07/03	1AM	7.00	942.06	4.46	271.82	9	144.70	127.12				21.409	21.41
	2AM	8.00	943.06	5.46	426.43	10	139.77	286.66				48.276	48.28
	3AM	9.00	944.06	6.46	620.04	11	134.84	485.20				81.713	81.71
	4AM	10.20	945.26	7.66	905.99	12	129.91	776.08				130.701	130.70
	5AM	11.00	946.06	8.46	1130.19	13	125.00	1005.19	18051052.99	304000000	**5.94**	169.286	185.00
	6AM	10.10	945.16	7.56	879.88	14	125.61	754.27				127.027	127.03
	7AM	9.50	944.56	6.96	731.96	15	126.22	605.74				102.013	86.50
	8AM	7.70	942.76	5.16	376.02	16	126.83	249.19				41.967	41.97
	9AM	7.10	942.16	4.56	285.57	17	127.44	158.13				26.632	26.63
	10AM	6.90	941.96	4.36	258.44	18	128.05	130.39				21.959	21.96
	11AM	6.70	941.76	4.16	232.79	19	128.66	104.13				17.537	17.54
	12NN	6.45	941.51	3.91	202.80	20	129.27	73.53				12.382	12.38
	1PM	6.30	941.36	3.76	185.88	21	129.88	56.00				9.432	9.43
	2PM	6.15	941.21	3.61	169.78	22	130.49	39.29				6.617	6.62
	3PM	6.05	941.11	3.51	159.49	23	131.10	28.39				4.781	4.78
	4PM	6.00	941.06	3.46	154.48	24	131.71	22.77				3.834	3.83
	5PM	5.95	941.01	3.41	149.55	25	132.32	17.23				2.902	2.90
	6PM	5.95	941.01	3.41	149.55	26	132.93	16.62				2.799	2.80
	7PM	5.90	940.96	3.36	144.71	27	133.54	11.17				1.882	1.88
	8PM	5.90	940.96	3.36	144.71	28	134.15	10.56				1.779	1.78
	9PM	5.85	940.91	3.31	139.96	29	134.76	5.20				0.877	0.88
	10PM	5.80	940.86	3.26	135.30	30	135.30	0				0	0
	11PM	6.00	941.06	3.46	154.48	31						844.44	844.65
	12M/N	6.05	941.11	3.51	159.49	32							
13/7/2003	1AM	6.10	941.16	3.56	164.59	33							
	2AM	6.15	941.21	3.61	169.78	34							
	3AM	6.20	941.26	3.66	175.06	35							
	4AM	6.30	941.36	3.76	185.88	36							
	5AM	6.35	941.41	3.81	191.43	37							
	6AM	6.40	941.46	3.86	197.07	38							
	7AM	6.20	941.26	3.66	175.06	39							
	8AM	6.15	941.21	3.61	169.78	40							

	9AM	6.30	941.36	3.76	185.88	41							
	10AM	7.40	942.46	4.86	329.09	42							

ESTIMATION OF UNIT HYDROGRAPH BY COLLIN'S METHOD OF FLOOD ON 14.05.04/15.05.04 **TABLE -4.7**

Time (hr)	Direct Runoff Hydrograph	Deduced UG ordinates, mm	Deduced UG ordinates, cm	Smoothened UG ordinates, cm
1	2	3	4	5
0	0	0	0	0
1	20.500	0.5980	5.980	4
2	30.797	2.8470	28.470	18
3	127.122	6.6719	66.719	50
4	286.656	11.2217	112.217	93
5	485.201	17.8218	178.218	154
6	776.085	23.0013	230.013	215
7	1005.193	14.4670	144.670	145
8	754.268	7.7412	77.412	80
9	605.738	0.0246	0.246	35
10	249.192	0.0159	0.159	18
11	158.134	0.0098	0.098	9
12	130.392	0.0066	0.066	6
13	104.133	0.0049	0.049	4.5
14	73.525	0.0034	0.034	3.5
15	56.004	0.0023	0.023	2.75
16	39.290	0.0018	0.018	2
17	28.389	0.0015	0.015	1.5
18	22.766	0.0012	0.012	1.2
19	17.232	0.0010	0.010	0.9
20	16.622	0.0007	0.007	0.7
21	11.174	0.0005	0.005	0.5
22	10.564	0.0002	0.002	0.3
23	5.205	0.0000	0.000	0.1
24	0	0	0	0
			844.44	844.95

Water availability

4.10 All the inflows worked out are historical sequence based on actual observations. These inflows through the development of a rating curve have averaged on a daily basis from these observations. Based on the average ten daily discharge data of Umngot River at dam site from April 1989 to May 2006, a flow duration curve was drawn using Weibulls distribution method. Even though the data computed from the mean 10 daily flows during monsoon season are approximate, the flows available being more than the requirement of the power house, the error involved is not important. The ten daily average discharge of water availability assessed for the average year, the 50% dependable year and the 90% dependable year are shown in Table - 4.9.

Table – 4.09

COMPUTATIONS OF FLOW DURATION SERIES FOR 50 PERCENT (1989-1990)

Month	Average 10-daily discharge	Discharge in descending order	No. of times discharge exceeded	Percent of time equaled or exceeded
June	40.38	155.52	1	2.70
	65.02	74.89	2	5.41
	32.58	65.02	3	8.11
July	155.52	53.77	4	10.81
	36.10	51.10	5	13.51
	74.89	40.38	6	16.22
August	23.60	37.93	7	18.92
	27.65	36.10	8	21.62
	7.93	35.58	9	24.32
September	19.74	34.76	10	27.03
	24.56	33.97	11	29.73
	53.77	32.58	12	32.43
October	25.28	27.65	13	35.14
	35.58	25.28	14	37.84
	7.79	24.56	15	40.54
November	10.08	23.60	16	43.24
	6.03	21.44	17	45.95
	4.96	19.74	18	48.65
December	4.16	10.08	19	51.35
	3.47	8.95	20	54.05
	2.72	7.93	21	56.76
January	2.11	7.79	22	59.46
	1.80	6.03	23	62.16
	1.58	4.96	24	64.86
February	1.44	4.89	25	67.57
	1.48	4.69	26	70.27
	4.89	4.16	27	72.97
March	4.69	3.47	28	75.68
	3.29	3.29	29	78.38
	291	2.91	30	81.08
April	34.76	2.72	31	83.78
	21.44	2.11	32	86.49

Table – 4.09 COMPUTATIONS OF FLOW DURATION SERIES FOR 50 PERCENT (1989-1990)				
Month	**Average 10-daily discharge**	**Discharge in descending order**	**No. of times discharge exceeded**	**Percent of time equaled or exceeded**
	51.10	1.80	33	89.19
May	8.95	1.58	34	91.89
	33.97	1.48	35	94.59
	37.93	1.44	36	97.30
COMPUTATIONS OF FLOW DURATION SERIES FOR 90 PERCENT (1990-1991)				
	77.47	77.47	1	2.70
June	18.97	62.76	2	5.41
	22.23	50.49	3	8.11
	50.49	42.35	4	10.81
July	42.35	37.33	5	13.51
	62.76	34.93	6	16.22
	16.89	33.99	7	18.92
August	11.19	32.93	8	21.62
	23.46	23.46	9	24.32
	14.93	23.18	10	27.03
September	34.93	22.81	11	29.73
	37.33	22.23	12	32.43
	23.18	18.97	13	35.14
October	33.99	16.89	14	37.84
	8.55	15.40	15	40.54
	8.14	14.93	16	43.24
November	5.80	11.19	17	45.95
	4.57	8.55	18	48.65
	3.66	8.14	19	51.35
December	3.09	5.80	20	54.05
	2.60	4.57	21	56.76
	1.83	3.66	22	59.46
January	2.56	3.09	23	62.16
	2.05	2.60	24	64.86
	1.73	2.56	25	67.57
February	1.44	2.05	26	70.27
	1.21	1.83	27	72.97
	1.12	1.73	28	75.68
March	1.44	1.44	29	78.38
	1.35	1.44	30	81.08
	1.31	1.35	31	83.78
April	0.90	1.31	32	86.49
	0.95	1.12	33	89.19
	32.93	1.21	34	91.89
May	22.81	0.95	35	94.59
	15.40	0.90	36	97.30

Design flood

4.11 IMD has given the one day maximum precipitation value as 140cms for the Umngot catchments up to the dam site and is distributed in two bells for convolution purpose as follows

Time	1	2	3	4	5	6	7	8	9	10	11	12
I Bell (cm)	17.84	13.64	12.24	10.84	9.44	8.04	6.64	6.64	3.84	5.24	3.84	2.44
II Bell (cm)	6.29	5.52	4.54	2.86	2.58	1.74	1.46	1.46	1.32	0.97	0.97	0.97

4.12 The above PMP with two bells were evaluated against the average unit hydrograph to estimate the direct runoff hydrograph. The base flow is then added to get the flood hydrograph. The peak discharge is estimated at 9760.68 cumec. Table -4.10 shows the peak flood details.

Table – 4.10
Flood Hydrograph of 14.5.04 / 15.5.04

Date	Time	Gauge (m)	Reduced W/L (m)	Stage (m)	Discharge (cumec)	Time (hrs)
14.5.04	12 NOON	4.00	939.08	1.48	22.63	0
	2.00 PM	3.97	939.03	1.43	21.61	2
	4.00 PM	3.92	939.01	1.41	20.95	4
	5.00 PM	3.89	938.95	1.35	19.01	5
	6.00 PM	3.79	938.85	1.25	16.02	6
	7.00 PM	3.71	938.85	1.17	13.83	7
	8.00 PM	3.64	938.77	1.10	12.05	8
	9.00 PM	6.06	938.70	3.52	160.50	9
	10.00 PM	8.91	941.12	6.37	600.98	10
	11.00 PM	9.50	944.56	6.96	731.96	11
	12 M/N	11.80	946.86	9.26	1381.96	12
15.5.04	1.00 AM	12.70	947.76	10.16	1698.87	13
	2.00 AM	11.00	946.06	8.46	1130.19	14
	3.00 AM	10.50	945.56	7.96	986.88	15
	4.00 AM	9.70	944.76	7.16	779.60	16
	5.00 AM	8.50	943.56	5.96	518.26	17
	6.00 AM	7.40	942.46	4.86	329.09	18
	7.00 AM	6.55	941.61	4.01	214.52	19
	8.00 AM	5.40	940.46	2.86	101.10	20
	10.00 AM	5.25	940.31	2.71	89.68	21
	12.00 NOON	4.95	940.01	2.41	69.07	22
	2.00 PM	4.75	939.81	2.21	56.95	23
	4.00 PM	4.55	939.61	2.01	46.11	24

Table – 4.10
Flood Hydrograph of 14.5.04 / 15.5.04

Date	Time	Gauge (m)	Reduced W/L (m)	Stage (m)	Discharge (cumec)	Time (hrs)
	5.00 PM	4.50	939.56	1.96	43.60	25
16.5.04	8.00 AM	3.90	938.96	1.36	19.33	26
	10.00 AM	3.89	938.95	1.35	19.01	27
	12.00 NOON	3.88	938.94	1.34	18.70	28
	2.00 PM	3.87	938.93	1.33	18.39	29
	4.00 PM	3.85	938.91	1.31	17.78	30
17.5.04	8.00 AM	3.65	938.71	1.11	12.30	31
	10.00 AM	3.63	938.69	1.09	11.81	32
	12.00 NOON	3.88	938.94	1.34	18.70	33
	2.00 PM	3.87	938.93	1.33	18.39	34
	4.00 PM	3.85	938.91	1.31	17.78	35
	8.00 AM	3.65	938.71	1.11	12.30	36
	10.00 AM	3.65	938.71	1.11	12.30	37
	12 NOON	3.61	938.67	1.07	11.33	38
	2.00 PM	3.60	938.66	1.06	11.10	39
	4.00 PM	6.30	941.36	3.76	185.88	0
	5.00 PM	6.25	941.31	3.71	180.43	1
	6.00 PM	6.20	941.26	3.66	175.08	2
	7.00 PM	6.15	941.21	3.61	169.78	3
	8.00 PM	6.10	941.16	3.56	164.59	4
	9.00 PM	6.08	941.14	3.54	162.54	5

4.13 The designed flood at power house site is calculated on a proportionate catchments area basis from the designed flood arrived at dam site (8969 cumec). Additional catchment area involved is 60 sq km, near the proposed power house site and the flood for this is worked out to 2040 cumec. Therefore, the total designed flood at the power house site is estimated as 11009 cumec.

Sedimentation rate

4.14 As is prevalent throughout the Shillong plateau, the land in the Umngot catchment area is always covered with vegetation or grass. Human population is thin and development activities involving earth work is negligible. The soil report status indicates that the area is prone to severe to very severe erosion and this may be due to high precipitation and flashy nature of the river flows. But during normal flows in the river it is observed that no considerable sediment is carried.

4.15 Sediment studies of the nearby catchments of Umiam river, where there are greater developmental activities, indicates a sediment rate of about 23.95 ha-m/100 sq.km/yr from its catchment area, average rate of 17.65 ha-m/100 sq.km/yr is found adequate and is adopted for sedimentation calculations of the proposed Umngot reservoir.

Sedimentation assessment

Gross capacity of Umngot reservoir at proposed FRL of 1040m	71.32 Mm^3
Annual inflow	800 Mm^3
Catchment Area	304 sq km
Rate of Sedimentation adapted	1.76 mm/yr
Capacity in flow ratio 71.32/800	0.089
From Brunes median curve, Trap efficiency	84%

Actual sediment volume = $304*1.76*0.84*10^3$

= 0.449 M cum.

R = 0.449/71.32*100 = 0.63.

4.16 The volume of sediment deposits for various periods are worked out with the help of the Brune trap efficiency curves and the sediment distribution worked out by using Empirical Area reduction method where the new zero elevations for 25yrs, 50yrs and 75yrs are found out. Based on the sediment distribution, revised area capacity curves are drawn to arrive at the new values. The MDDL has been fixed at 1010.00m where the capacity has been worked out to 22.41 M cum. The new zero elevations are as below.

- ✓ 50 years sedimentation is 981.30 m
- ✓ 100 years sedimentation is 995.80 m

4.17 The quantity of sedimentation after 50 years would be 4.65 Mm^3, and after 100 years it would be 11.18 Mm^3.

Surface Water Quality

4.18 As a part of the field studies, surface water samples were collected from Umngot River at dam site and at power house site during monsoon season and post monsoon seasons. The samples have been analyzed for physical, chemical and bacteriological parameters. In general the surface water quality is good and fresh as per drinking water standards. The analysis reports are appended here in Tables - 4.11 to 4.14. Sample 1 has been collected at the proposed dam site location near Siangkhanai village, Sample 2 between dam site and power house location and Sample 3 near the proposed power house location near Syntung village. Samples were collected for different seasons.

Table –4.11 UMNGOT H.E PROJECT SURFACE WATER QUALITY (24 /7/2008) IN MONSOON				
Sl.No	**Parameter**	**Units**	**Sample 1**	**Drinking water standard**
1	Temperature	^0C	20^0	20
2	pH	-	7.0	6.50-8.50
3	Electrical Conductivity	Micro mhos/cm	12.3	-
4	Dissolved Solids	mg/l	11.0	500
5	Total Solids	mg/l	65.0	500
6	Total suspended Solids	mg/l	55.0	500
7	Dissolved oxygen(DO)	Mg/l	8.4	
8	Turbidity	NTU	7.3	05
9	Alkalinity	mg/l	14.0	200
10	Total Hardness as C_aCO_3	Mgl	2.0	300
11	Calcium as Ca	mg/l	0.1	75
12	Magnesium as Mg	mg/l	0.36	30
13	Chlorides as Cl	mg/l	3.0	250
14	Sulphates as SO_4	mg/l	28.8	200
15	Nitrate -Nitrogen	mg/l	4.1	45
16	Nitrite Nitrogen	mg/l	Nil	45
17	Ammonia Nitrogen	mg/l	Nil	45
18	Organic Nitrogen	mg/l	Nil	45
19	Fluorides as F	Mg/l	0.04	1.00-1.50
20	Iron as Fe	mg/l	0.23	0.3
21	Phosphates	Mg/l	Nil	
22	Sulphates	mg/l	28.8	200
23	Sulphides	mg/l	Nil	
24	Lead	mg/l	Nil	0.1
25	Chromium	mg/l	Nil	
26	Zinc	mg/l	Nil	5.0
27	COD	mg/l	14.4	
28	BOD	mg/l	1.0	
29	Feacal Coliforms	MPN/100ml	7	
30	Total Coliforms	MPN/100ml	>_ 2400	Less Than 10

Table –4.12 UMNGOT H.E PROJECT SURFACE WATER QUALITY (10.12.2008) IN WINTER				
Sl. No	Parameter	Units	Sample 2	Drinking water standard
1	Temperature	^0C	15.0	20
2	pH	-	7.1	6.50-8.50
3	Electrical Conductivity	Micro mhos/cm	26.0	-
4	Dissolved Solids	mg/l	10.0	500
5	Total Solids	mg/l	22.0	500
6	Total suspended Solids	mg/l	12.0	500
7	Turbidity	NTU	0.3	05
8	Dissolved oxygen(DO)	Mg/l	7.8	
9	Alkalinity	mg/l	20.0	200
10	Total Hardness as C_aCO_3	Mgl	14.0	300
11	Calcium as Ca	mg/l	2.0	75
12	Magnesium as Mg	mg/l	0.9	30
13	Chlorides as Cl	mg/l	7.0	250
14	Nitrate -Nitrogen	mg/l	3.8	45
15	Nitrite Nitrogen	mg/l	Nil	45
16	Ammonia Nitrogen	mg/l	Nil	45
17	Organic Nitrogen	mg/l	Nil	45
18	Fluorides as F	Mg/l	0.04	1.00-1.50
19	Iron as Fe	mg/l	0.09	0.3
20	Phosphates	Mg/l	BDL	
21	Sulphates	mg/l	0.2	200
22	Sulphides	mg/l	BDL	
23	Lead	mg/l	0.006	0.1
24	Chromium	mg/l	BDL	
25	Zinc	mg/l	0.08	5.0
26	Copper	Mg/l	BDI	
27	COD	mg/l	18.7	
28	BOD	mg/l	Nil	
29	Feacal Coliforms	MPN/100ml	4	
30	Total Coliforms	MPN/100ml	17	< than 10

Table –4.13 SURFACE WATER QUALITY (10.12.2008) IN WINTER				
Sl.No	**Parameter**	**Units**	**Sample 3**	**Drinking water standard**
1	Temperature	^0C	15.0	20
2	pH	-	7.6	6.50-8.50
3	Electrical Conductivity	Micro mhos/cm	30.0	-
4	Dissolved Solids	Mg/l	15	500
5	Total Solids	Mg/l	23	500
6	Total suspended Solids	mg/l	8	500
7	Turbidity	NTU	0.3	05
8	Dissolved oxygen(DO)	Mg/l	6.8	
9	Alkalinity	Mg/l	18.0	200
10	Total Hardness as C_aCO_3	mgl	12.0	300
11	Calcium as Ca	Mg/l	2.0	75
12	Magnesium as Mg	Mg/l	1.7	30
13	Chlorides as Cl	Mg/l	7.0	250
14	Sulphates as SO_4	Mg/l	0.4	200
15	Nitrate -Nitrogen	Mg/l	2.8	45
16	Nitrite Nitrogen	Mg/l	Nil	45
17	Ammonia Nitrogen	Mg/l	Nil	45
18	Organic Nitrogen	Mg/l	Nil	45
19	Fluorides as F	Mg/l	0.03	1.00-1.50
20	Iron as Fe	Mg/l	0.09	0.3
21	Phosphates	Mg/l	BDL	
22	Sulphates	Mg/l	0.2	200
23	Sulphides	Mg/l	BDL	
24	Lead	Mg/l	BDL	0.1
25	Chromium	Mg/l	BDL	
26	Zinc	Mg/l	0.03	5.0
27	Copper	Mg/l	BDL	
28	COD	Mg/l	15.6	
29	BOD	Mg/l	1.0	
30	Feacal Coliforms	MPN/100ml	2	
31	Total Coliforms	MPN/100ml	12	Less Than 10

Table –4.14 SURFACE WATER QUALITY (10.12.2008) IN WINTER (Down stream)				
Sl. No	**Parameter**	**Units**	**Sample 4**	**Drinking water standard**
1	Temperature	^0C	15.0	20
2	pH	-	7.6	6.50-8.50
3	Electrical Conductivity	Micro mhos/cm	30.0	-
4	Dissolved Solids	mg/l	15	500
5	Total Solids	mg/l	23	500
6	Total suspended Solids	mg/l	8	500
7	Turbidity	NTU	0.3	05
8	Dissolved oxygen(DO)	Mg/l	6.8	
9	Alkalinity	mg/l	18.0	200
10	Total Hardness as C_aCO_3	Mgl	12.0	300
11	Calcium as Ca	mg/l	2.0	75
12	Magnesium as Mg	mg/l	1.7	30
13	Chlorides as Cl	mg/l	7.0	250
14	Sulphates as SO_4	mg/l	0.4	200
15	Nitrate -Nitrogen	mg/l	2.8	45
16	Nitrite Nitrogen	mg/l	Nil	45
17	Ammonia Nitrogen	mg/l	Nil	45
18	Organic Nitrogen	mg/l	Nil	45
19	Fluorides as F	Mg/l	0.03	1.00-1.50
20	Iron as Fe	mg/l	0.09	0.3
21	Phosphates	Mg/l	BDL	
22	Sulphates	mg/l	0.2	200
23	Sulphides	mg/l	BDL	
24	Lead	mg/l	BDL	0.1
25	Chromium	mg/l	BDL	
26	Zinc	mg/l	0.03	5.0
27	Copper	Mg/l	BDL	
28	COD	mg/l	15.6	
29	BOD	mg/l	1.0	
30	Feacal Coliforms	MPN/100ml	2	
31	Total Coliforms	MPN/100ml	12	< than 10

Downstream Water Use and Its Impact

4.19 Water on the down stream side of the proposed dam site on Umngot River is not under use for irrigation purposes. Present scheme is contemplated for hydro power generation duly diverting water from the storage to power house situated about 20 km downstream of the river through tunnel. The water after generating the required power will be let into the river through Tail Race Tunnel. Thus there will be no impact on the downstream water utilization except impacts on reverie ecology in the stretch between the dam and the confluence point with tail race tunnel. There will be reduction in water flow in the above stretch. Significant reduction in flow is likely to have a minor impact on the aquatic environment. Minimum releases of water below the dam are to be ensured for the sustenance of the aquatic fauna.

Impact on water quality

4.20 The Umngot HEP is located in an area where the population density is very low with no major sources of pollution. The habitations are much away from the river. The area under assured irrigation is only 2% and is negligible. The usage of agro-chemicals and manures is also meager. No industries are in the closer vicinity of the river. As such the pollution loading from different sources such as domestic sewage, industrial effluents and agro-chemical residues of agricultural lands in the project area is virtually negligible. Since the proposed project contemplates no irrigation, no impact on the surface or ground water is anticipated.

4.21 No disposals of sewage waste systems into Umngot River on the downstream side were existed. Labour colonies are proposed on the upstream of the river and project colony is proposed in Siangkhanai village near dam site and near power house on downstream side. Impacts due to these colonies are discussed below.

Sewage from project colonies, labour colonies – impact

4.22 The project construction is likely to last for a period of 6 years in addition to preliminary works which may take another two years prior to the actual construction work. About 1500 workers and 500 technical staff are likely to work during the construction phase. The construction phase also leads to mushrooming of various allied activities to meet the demands of the immigrant labour population in the area. Normally during the construction phase a large portion of the labour population migrate in the area with their families as well. Thus in the proposed Umngot HEP, the total labour population may be of the order of about 5000. The domestic water requirements have been estimated as 110 lpd. Thus, total water requirement works out to 0.55 mld. It is assumed that about 80% of the water supplied will be generated as sewage. The total quantum of waste water generated is expected to be of the order of 0.44 mld. The BOD load contributed by domestic sources will be about 270 kg/day.

4.23 In the case of Umngot HEP, labour colonies are proposed at 6 locations on the left flank, right flank and upstream of the proposed dam location and at other head works. Considering the worst case scenario for the purpose of assessment of impacts on water quality, it is assumed that all the waste water generated from various labour colonies would fall into the river at a common point. It is also assumed that the sewage is let out without any treatment. For these conditions the minimum flow required for dilution of sewage is about 1.00 cumec with a dilution ratio of 1:200. However as precaution areas measure, adequate sewage treatment facilities shall be made as suggested under part II EMP. The lowest existing flows recorded were from April to May. These flows are between 1.35 and 0.90 cumec. Thus minimum releases of 1.0 cumec shall be ensured below the dam during operation period to neutralize the sewage loads as well as for the sustenance of aquatic fauna between the dam and the confluence point of Tail Race Channel.

Impact on Drainage system and existing water bodies

4.24 Umngot River is originating in East Khasi hills district near NH44 road crossing with a village road to Namkreng village. The only tributary joining the river upstream of the proposed Umngot HEP is Umiam River, besides other small streams are confluencing with the river. Generally due to the water spread area of the reservoir, the lengths of the tributaries joining the main river will get shortened and there is likelihood of the mouth being widened near the periphery, causing siltation at the mouth. The topography of the proposed area is undulating and with steep slopes and gorges. Most of the submergence area is in gorge portion and the streams and tributaries joining the main river are also with rapid falls. In view of the slopes and velocities, siltation at the mouths near the confluence points does not arise. Hence the impact of the proposed reservoir on the existing water bodies will be negligible.

Impact due to change in Hydraulic regime

4.25 The design peak flood is 8969.0 cumec. Even though no moderation of flood is proposed, the storage and diversion will provide some kind of relief to the lower reaches of the river in the flood probabilities, before it confluences with Surma river in Bangladesh. Also, due to the storage in the reservoir there will be development of greenery, rise in water table in the area which will tend to increase the runoff characteristics. Thus no major change in the hydraulic regime of Umngot River due to the dam is anticipated.

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - I

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Chapter - V

BIOLOGICAL ENVIRONMENT

INDIA
MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS
UMNGOT HYDRO-ELECTRIC PROJECT
(3 X 80 MW)

PART - I
ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

V

BIOLOGICAL ENVIRONMENT

General Introduction to the Vegetation of Meghalaya

5.01 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.

5.02 The State is basically an agricultural State. It has a total geographical area of 22,429 km^2. The total estimated forest area of the State is 8,514 km^2 of which only 722.36 km^2 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 km^2 being protected by the tribals as 'Sacred Groves'. Essentially they are located in strategic watersheds and still play an important role.

5.03 The State, however, contain areas of very beautiful scenery with evergreen forests and waterfalls as well as areas of unique floral and faunal varieties. The reserve forests are managed under prescriptions of the working plan prepared for such forests by the Working Plan Unit of the Department. The protected forests are managed for preservation of the catchment areas of water sources. The forests, which are not reserved forests, are managed by the respective Councils. Under them, they have three kinds of forests, the old un-classed state forests which are directly under their control; the forests owned by the clans or communities and the private forests. For the second and third (private forests) categories, the District Councils have very little control except for collection of royalty when they export the timber outside their own area for trade.

Characterization of forest types in the study area:

5.04 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. The general vegetation pattern of the catchment and reservoir area are indicated in Annexures **V.1 to V.10.** There are no Sanctuaries or National parks or Biosphere reserves in the catchment area which includes the reservoir.

Tropical forests:

5.05 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*:*

5.06 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 in to the river in the form of narrow strips.

Tropical semi-evergreen forests*:*

5.07 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*:*

5.08 This type of forest occurs where annual rainfall is below 150 Cm and at comparatively low elevations. Typical natural deciduous forests do not occur anywhere in Meghalaya but are only sub-climax or man-made forests. These forests are characterized by seasonal leaf shedding and profuse flowering of the trees. Recurrence of forest fires are a common phenomenon here.

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* both as natural and as plantations. Deciduous trees of *Schima wallichii, Artocarpus gameziana, Tetrameles nudiflora, Lannea coromandelica, Salmalia malabarica Erythrina stricta, Premna milliflora, Vitex peduncularis, Albizia lebbeck, Terminalia bellirica* etc, are always lofty with straight bole and spreading crown.

Grass and Savannas:

5.09 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.

5.11 In Meghalaya, all the above classes of plant life are found to occur naturally, constituting its rich and varied natural vegetation. Meghalaya's endemic Pitcher Plant or *Nepenthes khasiana* remains till now an inexplicable phenomenon to the botanists. It occurs in the Jarain area of the Jaintia Hills and the Baghmara area of the Garo Hills. The people in the Khasi Hills where the plant grows call it Tiew-Rakot, which means demon-flower or devouring-plant. The Jaintias call it Kset Phare, Kset means net with a lid and Phare means fly. The Garos call the plant Memang-Koksi, which literally means the basket of the devil. The pitcher is designed to catch insects

5.12 Meghalaya is a storehouse of richly varied and colorful orchids with as many as 325 species, which grow all over the Khasi, Jaintia and Garo Hills in the meadows, hill-slopes and swamps, even on the wayside. Orchids are found in Meghalaya growing at different heights, mostly on trees, on mossy rocks and also on the ground. Meghalaya is rightly called a Land of Orchids.

General vegetation pattern and floral diversity viz., trees, shrubs, grasses, herbs, significant micro flora:

5.13 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 when the dam is built. 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. The catchment area towards the Jaintia Hills was represented mainly by private or community croplands. Potato, Cabbage, Cauliflower, Carrot, Radish, Tomato, Chillies, 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, Chillies, Paddy, Millets, Pulses, Jute, Mesta and Ginger. Black Pepper, Areca nuts and Pineapple are grown in a few localities. Large areas are also under the cultivation of broom grass *(Thysanolaena maxima) on the plateau regions.*

5.14 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. There are no sacred grooves within a distance of 5 Km from the full reservoir level.

5.15 The land use and land cover details of the catchment and submergence (reservoir) are given in Table 5.1. Out of the total forest area, only 4% is a reserve forest and the rest are treated as unclassified community forests.

Table 5.1. Land use and land cover of the catchment and reservoir areas of the Umngot H.E. Project

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**

5.16 A list of trees including the lianas, Bamboos, shrubs, non-woody plants, grasses, orchids, Pteridophytes, Bryophytes and other macrophytes are given in Annexures V.I (Trees including the climbers), V.2 (Bamboos), V.3 (Shrubs), V.4 (Herbs), V.5 (Grasses), V.6 (Non woody plants), V.7 (Orchids), V.8 (Gymnosperms) and V.9 (Bryophytes and Pteridophytes). Plant species which were spotted in the study area during the survey are also included in the list even if they were not found in the quadrats.

5.17 There are a couple of small sacred groves in the catchment area. One is near Mosakhia in Jaintia Hills and the other at Nonghulew near Siangkhanai in East Khasi Hills. The floral diversity of trees including tree top lianas is represented in Annexure V.1. A specific feature of the perennial vegetation of the area is the abundance of members of Moraceae and Lauraceae among dicots. A list of Bamboos occurring in the study area is given in Annexure V.2. Though as many as 38 species of bamboos were found to occur in the catchment area, clump forming species of *Dendrocalamus strictus, Dendrocalamus hamiltonii, Bambusa arundinacea*, *Bambusa pallida, Bambusa tulda* and non-clump forming *Melocanna bambusoides* were more common, abundant and economically important while the rest were rare or uncommon.

Methods of Study, Sampling Procedures and Calculation of Frequency, Density, Abundance, IVI and Shannon-Weaver Index of Biodiversity

5.18: Standard ecological sampling procedures were adopted for the study. Except where it was not possible to undertake any survey (inaccessible areas), random sampling techniques were used. Further details are given hereunder:

Consultants and experts

5.19 The study was carried out under the guidance and supervision of Prof.K.B.Reddy, Retired Professor of Botany and Head of the Department of Environmental Sciences and a senior scientific advisor on flora, fauna and ecology for major irrigation and hydro-electric projects and his team of field biologists, Botanists and Zoologists. Prof.K.B.Reddy has successfully guided several research Scholars for M.Phil and Ph.D degrees in Community and Production Ecology. He has also modified the line intercept method for estimation of plant cover in 1986. Other members of the team include Dr.J.Asha Kumari (Plant Ecologist), Dr.C.S.Chandra Sekhar (Fisheries), I. Siva Rama Krishna (Environmental Biologist) and Ms. Malakhi Deuri (Environmental Scientist) from Guwahati along with local field assistants including botanical guides.

5.20 An extensive survey of flora and fauna of the catchment area including the area of submergence and its environments extending up to a radius of 10 Km from dam site and 1 Km from the full reservoir level was carried out between April 2008 and February 2009 covering the summer and monsoon and winter seasons. Lists of all plant and animal species collected or spotted by the survey teams were identified either by comparing with the type specimens or drawings or the pictures in web resources including ‘virtual herbarium’. Further, for identification of plant species, the library resources of the B.S.I and Z.S.I., Shillong were used for verification. The list of vertebrate animal species is based both on primary and authentic secondary data. Reports and working plants of the different divisions of the Forest Department, Meghalaya State Fauna Series of ZSI, research publications as well as the information provided by the locals have been considered for the survey of fauna of the area. Fauna of Meghalaya (Part I &II) published by the ZSI, Meghalaya Flora & Fauna Published by the Directorate of Information and Public Relations, Government of Meghalaya have also been procured for cross checking.

Methodology

5.21 A comprehensive list of the plant species of the study area was made based on the plant species collected during different seasons by the survey teams. The species were further separated in to trees and shrubs (perennials), herbaceous species, medicinal plants and aquatic plants. For the purpose of calculation of Importance value indices (IVI), quadrat and line intercept methods were used for estimation of frequency, density, cover. For the determination of frequency and density of the herbaceous species, a nested quadrat of 1 m x 1 m subdivided in to 10x10 Cm was used. A total of 20 quadrats from each sampling site were taken at random. However, for the determination of the frequency and density of different shrubs 10 quadrats of 2m x 5 m were used. For the determination of the frequency and density of different trees 10 quadrats of 5m x 20m were taken. Thus the area of each quadrat for herbs, shrubs and trees was 1, 10 and 100 m^2 respectively. In other words, one tree is considered equivalent to 10 shrubs or 100 herbs and one shrub as equivalent to 10 herbs for the purposes of calculation of Importance value indices, indices of diversity, dominance and evenness. Such kind of equivalencies is useful for calculation of indices of natural communities composed of herbs, shrubs and trees. But the cover in case of both the herbaceous species as well as the trees including shrubs was estimated by a modified line intercept method as the percent cover. The distance intercepted, overlaid or laid under by each species along a line transect of 100 m in case of herbaceous species and 250 m in case of shrubs and trees were measured and calculated as the % cover based on the distance intercepted. Density was calculated as the number per m^2 in case of herbaceous plants and as number per hectare in case of trees and tree like plants. The IVI values were calculated as the sum of relative frequency, relative density and relative dominance (dominance was based on cover). Frequency, density, abundance, IVI values and the indices of diversity of the plant species in the catchment area of the Umngot River including the area of submergence were determined basing on standard ecological methods widely used in phytosociology as outlined hereunder:

5.22 Based on the IVI values, Shannon –Wiener Indices of Diversity, Simpson Index of dominance and Jaccard index of Evenness were calculated by using a computer progamme called "PAST".

Indices of similarity were called by using the following formula:
Indices of similarity = 2C/A+B

Where, C represents the number of species common to both the communities A & B; A and B represent the number of species present in communities A and B including the common species.

The frequency, density, dominance, IVI values and the Shannnon –Wiener Indices of diversity of plant communities of the catchment area including the reservoir were estimated by quadrat method.

Frequency was calculated by using the following formula:

$$\frac{\text{Number of quadrats of occurrence of a species}}{\text{Total number of quadrats examined}} \times 100$$

Based on the number of plants present in quadrats, average density per hectare was calculated by using the following formula:

$$\frac{\text{Total number of trees present in all the 10 quadrats of 5 x 20 m}}{\text{Total area of all the 10 quadrats in square meters}} \times 100$$

Dominance was calculated as the percent cover of each species along a line transect by using the following equation:

$$\frac{\text{Distance intercepted or overlaid or under- laid along a line transect in meters}}{\text{Length of line transect in meters}} \times 100$$

Relative frequency, Relative density and Relative dominance were calculated from frequency, density and dominance by using the following equations:

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

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

Relative Dominance = Percent cover of a species

Importance Value Indices (IVI) was calculated by summing the Relative frequency, Relative Density and Relative Dominance.

Shannon - Wiener indices of diversity, indices of dominance and evenness were calculated by taking the IVI values in to consideration. Frequency, density, dominance and IVI values of the structural species based on the phytosociological study are given in Annexure V.9 and V.10.

Sampling sites:

5.23 Names, location and the vegetation type of the sampling locations of the catchment and reservoir areas are given in Tables 5.2 and 5.3 respectively.

Table 5.2 Sampling locations of vegetation and flora in the catchment area. E.K. Hills means East Khasi Hills and J.Hills means Jaintia Hills.

S.No.	Vegetation Type	Name of Location	Latitude	Longitude	District
1	Tree Clad	Umsawwar	92 05 36	25 22 41	E.K.Hills
2	Open Forest	Umsawwar	92 06 05	25 22 44	E.K.Hills
3	Shifting Cultivation	Umsawwar	92 04 35	25 22 41	E.K.Hills
4	Dense Forest	Umsawwar	92 06 22	25 22 50	E.K.Hills
5	Dense Forest	Jatah	92 04 01	25 24 33	E.K.Hills
6	Scrub Land	Siangkhanai	92 05 44	25 25 15	E.K.Hills
7	Open Forest	Mynsong	92 05 11	25 26 45	E.K.Hills
8	Scrub land	Mynriang	92 04 18	25 26 22	E.K.Hills
9	Dense Forest	Syngiasya	92 0330	25 27 55	E.K.Hills
10	Open Forest	Syngiasya	92 04 37	25 27 59	E.K.Hills
11	Dense Forest	Nongjrong	92 05 36	25 29 08	E.K.Hills
12	Scrub Land	Tanglei	92 02 29	25 28 13	E.K.Hills
13	Tree clad	Pingwait	92 01 34	24 27 50	E.K.Hills
14	Open Forest	Kharang	92 00 42	25 28 03	E.K.Hills
15	Shifting Cultivation	Jongksha	91 59 16	25 26 07	E.K.Hills
16	Open forest	Jongksha	91 58 49	25 28 11	E.K.Hills
17	Scrub land	Rapleng	91 56 20	25 28 32	E.K.Hills
18	Fallow Land	Mawlynrei	91 58 00	25 29 56	E.K.Hills
19	Open Forest	Thadan	91 58 00	25 30 39	E.K.Hills
20	Shifting Cultivation	Umphyrnai	91 55 21	25 31 63	E.K.Hills
21	Open Forest	Jatah	91 56 03	25 30 49	E.K.Hills
22	Scrub Land	Sohryngkhamneng	91 57 08	25 32 03	E.K.Hills
23	Open Forest	Sohryngkhamneng	91 57 20	25 32 32	E.K.Hills
24	Open Forest	Pommura	92 00 46	25 32 32	E.K.Hills
25	Open Forest	Mawpyrshong	92 02 58	25 31 31	E.K.Hills
26	Scrub Land	Puriang	92 06 07	25 32 34	E.K.Hills
30	Dense Forest	Nongjrong	92 06 10	25 28 30	E.K.Hills
27	Open Forest	Mawdymai	92 07 55	25 31 33	J. Hills
28	Scrub Land	Madur	92 08 01	25 29 52	J.Hills
29	Open Forest	Niriang	92 07 08	25 30 07	J.Hills
31	Open Forest	Madur	92 07 06	25 28 11	J. Hills
32	Scrub Land	Sohmynting	92 08 20	25 26 52	J. Hills
33	Open Forest	Sohmynting	92 07 46	25 25 55	J.Hills
34	Scrub Land	Sohmanong	92 07 19	25 23 53	J.Hills

Table 5.2 Sampling locations of vegetation and flora in the catchment area. E.K. Hills means East Khasi Hills and J.Hills means Jaintia Hills.					
S.No.	**Vegetation Type**	**Name of Location**	**Latitude**	**Longitude**	**District**
35	Fallow Land	Mawber	91 59 47	25 30 53	E.K.Hills &J. Hills
36	Open Forest	Sohmynting	92 06 31	25 27 27	J.Hills
37	Scrub Land	Dam Site	92 06 49	25 21 38	J.Hills

Table 5.3 Sampling locations of vegetation and flora in the area of submergence (Reservoir).				
S.No.	**Vegetation Type**	**Latitude**	**Longitude**	**District**
1	Dense Forest	92 06 39	25 21 41	East Khasi Hills
2	Open Forest	92 06 41	25 22 19	East Khasi Hills
3	Open Forest	92 06 48	25 22 28	East Khasi Hills
4	Dense Forest	92 06 41	25 33 00	East Khasi Hills
5	Scrub Land	92 06 15	25 23 14	East Khasi Hills
6	Scrub Land	92 05 30	25 24 11	East Khasi Hills
7	Scrub Land	92 06 11	25 24 00	East Khasi Hills
8	Open Forest	92 06 06	25 23 53	East Khasi Hills
9	Dense Forest	92 05 48	25 24 09	East Khasi Hills
10	Dense Forest	92 06 43	25 24 18	East Khasi Hills
11	Shifting Cultivation	92 06 22	25 25 45	East Khasi Hills
12	Open Forest	92 06 12	25 25 40	East Khasi Hills
13	Scrub Land	92 06 45	25 24 54	East Khasi Hills
14	Open Forest	92 06 17	25 26 03	East Khasi Hills
15	Open Forest	92 06 28	25 25 52	Jaintia Hills
16	Open Forest	92 06 54	25 25 52	Jaintia Hills
17	Open Forest	92 06 48	25 25 45	Jaintia Hills
18	Scrub Land	92 06 52	25 25 03	Jaintia Hills
19	Scrub Land	92 07 17	25 24 30	Jaintia Hills
20	Dense Forest	92 06 57	25 24 22	Jaintia Hills
21	Open Forest	92 06 36	25 24 03	Jaintia Hills
22	Dense Forest	92 06 47	25 23 17	Jaintia Hills
23	Dense Forest	92 07 14	25 22 49	Jaintia Hills
24	Scrub Land	92 06 58	25 22 24	Jaintia Hills
25	Shifting Cultivation	92 06 55	25 21 59	Jaintia Hills
26	Scrub Land	92 07 07	25 21 47	Jaintia Hills
27	Scrub Land	92 06 50	25 21 37	Jaintia Hills

5.24 Frequency, density, dominance (as percent cover) and IVI values of the structural species encountered in the sampling locations in the catchment area and reservoir area are presented in Annexure V.10 and V.11 respectively. Based on the data (Annexures V.10 & V.11), it may be concluded that the Shannon – Weaver Indices of diversity was over 4 and the evenness was higher than 0.95 but dominance was lower. Maps showing the sample location are given in Fig.V.I & V.II

Economically Important Species Viz. Medicinal, Timber, Fuel Wood Etc
Sacred groves:

5.25 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.

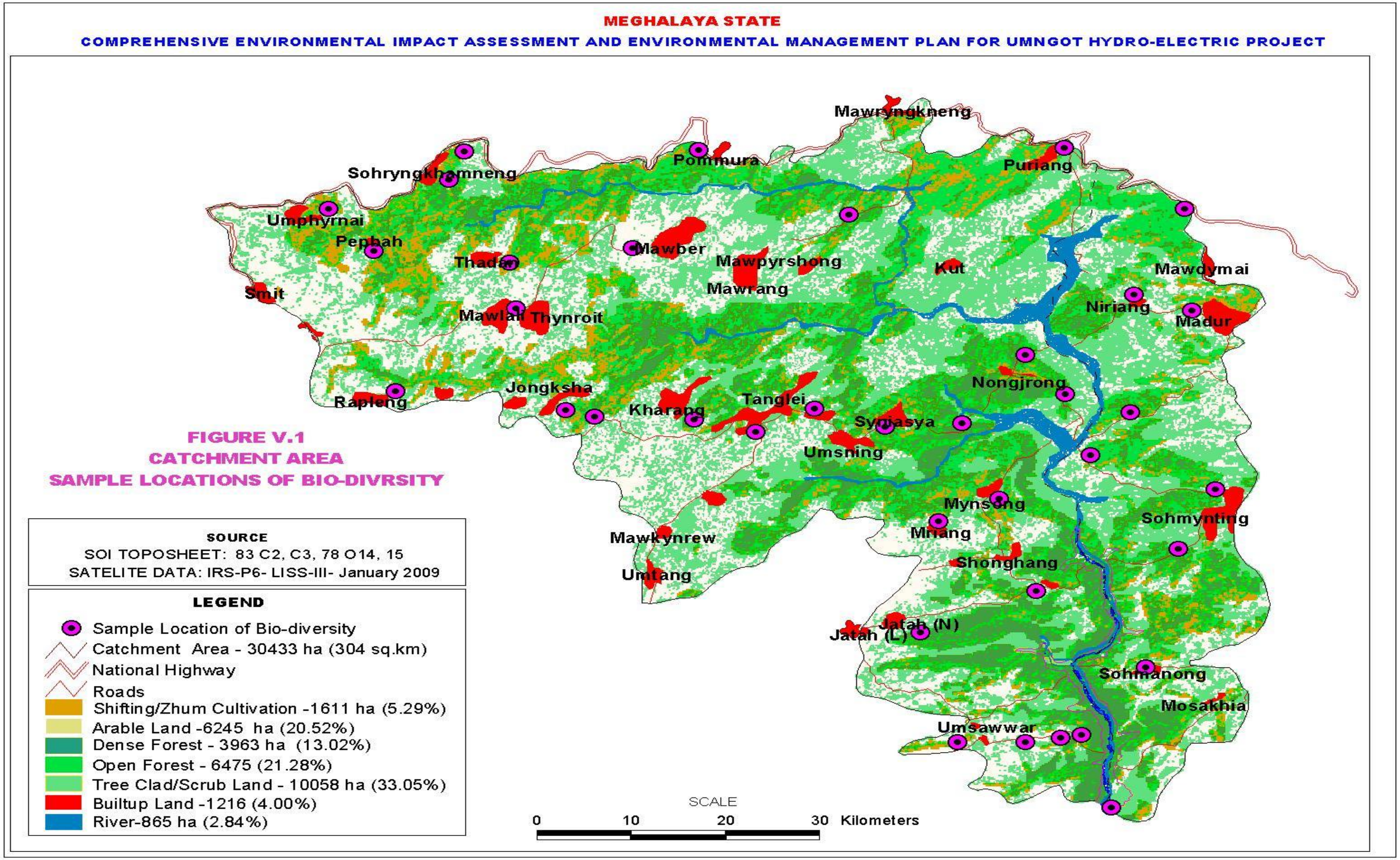
Decor Plants or Ornamental Plants:

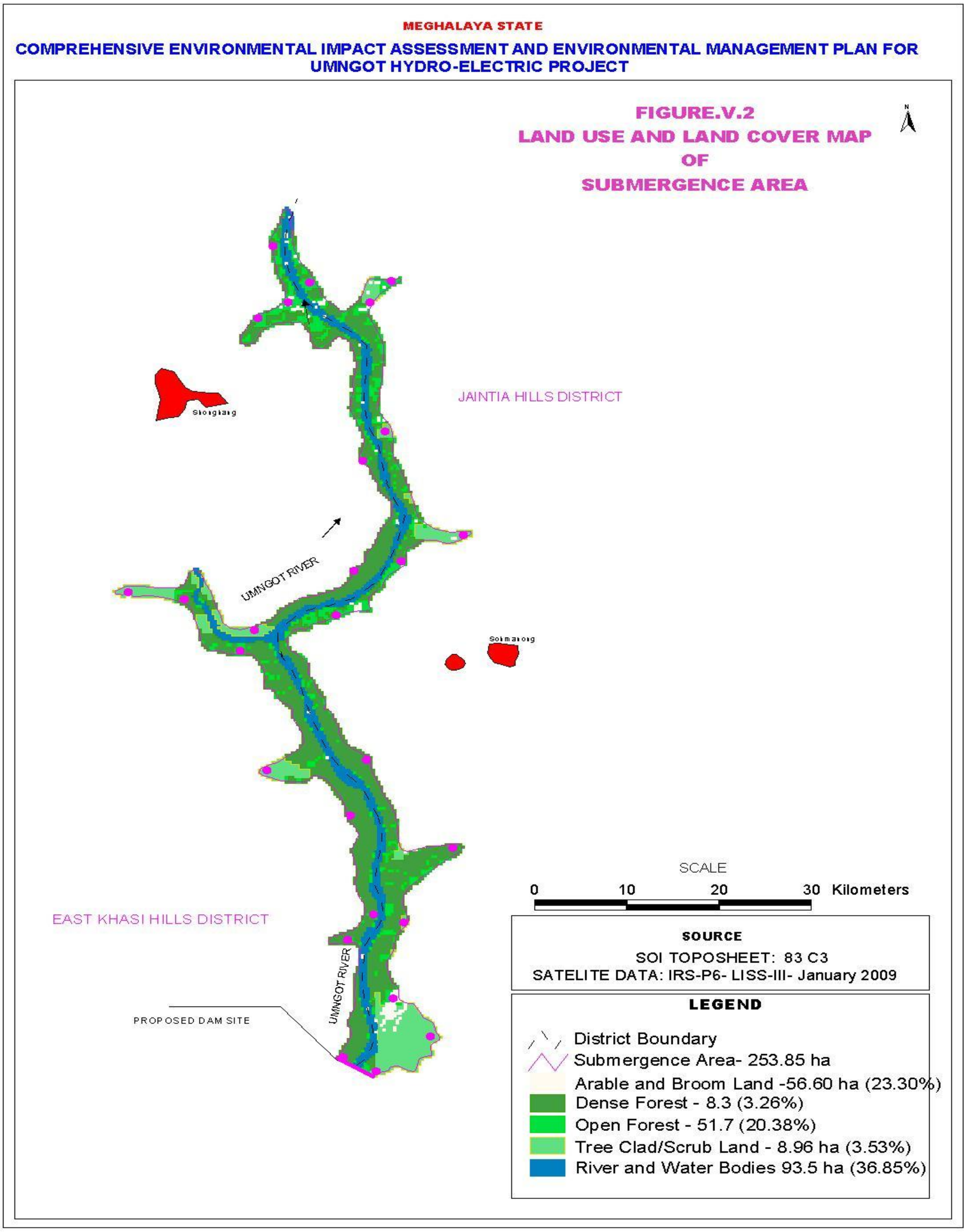
5.26 The forests of Meghalaya are treasure house of valuable products such a timber, fuel wood, fodder, resin, tannin, gums, shellac, fiber, latex, essential oils, fats, edible fruits, honey and a large number of medicinal plants. Meghalaya is well known for bay leaves and cinnamon. *Morus alba, Quercus 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.

5.27 Meghalayans in general are fond of decorating their courtyards with seasonal flowers and one comes across *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.

Economically Important Plants:

5.28 The forests of Meghalaya are a rich source of timber. The State as such is surplus in timber production and the bulk of timber for trade originates from private forests. Timber trade forms an integral and vital element in the economy of Meghalaya. 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 Meghalaya. Meghalayan forests offer tremendous scope for sericulture or silk worm rearing industry. Meghalaya is famous for its honey, derived mostly from forests in beehives. The major crop plants of Meghalaya are Paddy, Maize, Millets, Pulses, Potato, Jute and Mesta, Ginger, Turmeric, Black Pepper, Sugar Cane, Oil Seeds. Both Areca nut and Betel


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
FIGURE V.1
CATCHMENT AREA
SAMPLE LOCATIONS OF BIO-DIVRSITY
SOURCE
SOI TOPOSHEET: 83 C2, C3, 78 O14, 15
SATELITE DATA: IRS-P6- LISS-III- January 2009
LEGEND
Sample Location of Bio-diversity
Catchment Area - 30433 ha (304 sq.km)
National Highway
Roads
Shifting/Zhum Cultivation -1611 ha (5.29%)
Arable Land -6245 ha (20.52%)
Dense Forest - 3963 ha (13.02%)
Open Forest - 6475 (21.28%)
Tree Clad/Scrub Land - 10058 ha (33.05%)
Builtup Land -1216 (4.00%)
River-865 ha (2.84%)
SCALE
0
10
20
30
Kilometers
Mawryngkneng
Pommura
Puriang
Sohryngkhamneng
Umphyrnai
Pephah
Thadan
Mawber
Mawpyrshong
Mawrang
Kut
Mawdymai
Niriang
Madur
Smit
Mawlai
Thynroit
Nongjrong
Jongksha
Rapleng
Kharang
Tanglei
Symasya
Umsning
Mynsong
Mriang
Sohmynting
Mawkynrew
Umtang
Shonghang
Jatah (N)
Jatah (L)
Sohmanong
Mosakhia
Umsawwar


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
FIGURE.V.2
LAND USE AND LAND COVER MAP
OF
SUBMERGENCE AREA
JAINTIA HILLS DISTRICT
UMNGOT RIVER
EAST KHASI HILLS DISTRICT
UMNGOT RIVER
PROPOSED DAM SITE
SCALE
0 10 20 30 Kilometers
SOURCE
SOI TOPOSHEET: 83 C3
SATELITE DATA: IRS-P6- LISS-III- January 2009
LEGEND
District Boundary
Submergence Area- 253.85 ha
Arable and Broom Land -56.60 ha (23.30%)
Dense Forest - 8.3 (3.26%)
Open Forest - 51.7 (20.38%)
Tree Clad/Scrub Land - 8.96 ha (3.53%)
River and Water Bodies 93.5 ha (36.85%)

vine are important cash crops of the State. Khasis are used to chew betel nuts with betel leaves since time immemorial. The State is basically a home of many horticultural plants such as fruit bearing trees, cultivated fruit bearing plants, citrus varieties of fruits. Vegetables are grown extensively in the central plateau of the Khasi Hills with loamy soil and also in the plains of the Garo Hills. Recently Tea and Coffee are being grown in lands abandoned after jhuming.

Plants that Cure and Heal (Medicinal plants):

5.29 Different parts of many plants growing in Meghalaya have been put to medicinal use. Among the important and recognized medicinal plants found and cultivated in Meghalaya 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.*

Timber yielding plants:

5.30 A list of timber yielding plants of the catchment and reservoir areas of the project is given in Annexure V.12. Timber is extensively used locally in construction work. Local timbers are not very valuable in terms of quality and marketability compared to Teak and Red Sanders.

Fuel wood resources.

5.31 Any locally available woody plant material with good burning quality is suitable for fuel wood. Where coal is locally available people use coal and hence they don't depend on firewood. Rat hole mining for coal is extensive in parts of the catchment area where coal is available. But coal is not available in most areas of the catchment and the river and hence wood is the primary source of cooking fuel. During the process of clearing the wooded areas for shifting cultivation, trees are felled and the wood which is not suitable for timber is used as firewood. Felling of trees for timber and firewood in the catchment and reservoir areas is still extensive.

Rare or Endangered or Endemic or Threatened (REET) Species:

5.32 Based on the data furnished by the BSI in the web site www.*envfor.nic.in/bsi/research.html* the Red data Book of IUCN 2007, Red Data Book Plants of India (Nayar & Sastry 1987-88), and Threatened Plants of Meghalaya from www.wii.gov.in/nwdc/ threatened_plants_meghalaya.pdf a list of rare / endangered / endemic / threatened (REET) species of plants reported from Khasi and or Jaintia Hills is prepared and presented as Annexure V.11. *Nepenthes khasiana,* a rare and endemic insectivorous plant is not found to occur either in the catchment or reservoir area of the River.

5.33 Herbaceous species including grasses and sedges recorded during different seasons of the study period are given in Annexure V.6. The note worthy feature of the grassland and savanna type of vegetation of the Umngot River catchment area was the abundance of *Drosera rotundifolia,* and *Drosera indica*., both insectivorous plants of Sundew family., *Lycopodium cernum,* which grows more like a runner and *Lycopodium centrochinense.* The grasslands are derived from abandoned jhum cultivation and hence they are secondary in origin. Perennial grasses were more abundant and dominant than the annual grasses. Over a period of time, these grasslands are invaded and dominated by bamboos leading to the development of Bamboo forests. A list of REET species based on IUCN red data / BSI is given in Annexure V.13. *Ceropegia angustifolia* (Medicinal plant), *Fimbristylis stolonifera* (Fodder), *Elaeocarpus prunifolius* (Fuel wood), *Paphiopedilum venustum* (Orchid), *Vanda coerulea* (Orchid), *Ophiorrhiza tingens* (Medicinal plant), *Cleyera japonica* (Medicinal plant) and *Coryphopteris didymochlaenoides* (A rare fern of medicinal properties) were spotted very rarely in the catchment area of the Umngot River but none was found in the area of submergence.

Cropping and Horticulture Pattern and Practices in the Study Area

5.34 The catchment area towards the Jaintia Hills was represented mainly by private or community croplands. Potato, Cabbage, Cauliflower, Carrot, Radish, Tomato, Chillies, 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, Chillies, 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.

Terrestrial Fauna

5.35 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, Meghalya 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.

5.36 A list of local, resident, migrant and vagrant birds of the catchment area of the Umngot River is given in Annexure V.14. The list shows the occurrence of a few vulnerable species such as the Indian Pea fowl, and three species of Hornbills belonging to the Schedule I category of the WPA. But the endangered great Indian Hornbill has not been spotted or reported from the area. A list of mammals reported from the catchment area is given in Annexure V.15. The list is mainly based on secondary sources as the species under consideration were rare and highly elusive. But the local residents are apprehensive about their occurrence. They say have never seen them. Some of the mammals shown in the list come under the REET category but none belongs to the endangered category of the IUCN. The reptilian fauna of the Umngot Hydro electric project is given in Annexure V.16. None of the species that come under the REET category were spotted during the surveys. They may either be very rare or elusive or absent in the area under study. But they have been reported from the study area earlier. Family wise list of Butterflies and Moths collected or reported from the study area is given in Annexure V.17.

REET Fauna

5.37 All the rare, endangered, endemic and threatened species of the birds (Annexure V.14), mammals (Annexure V.15) and reptiles (Annexure V.16) of the reported from the catchment area are indicated based on the ZSI / IUCN and the WPA 1972. Hunting has been a customary cultural practice in the area and the practice is still continued. There are no large game animals like deer and hence there are no chances of occurrence of any hunting animals.

Existence of Barriers and Corridors for Wild Animals and Habitat Fragmentation and Destruction of Wild Animal due to Project

5.38 The tall hills and deep valleys may have been acting as barriers for migration. As evidenced by the differences in the fauna of Garo Hills, Khasi hills and Jaintia hills, the occurrence of barriers for migration can not be totally ruled out. Except during floods for a few days in rainy season, the River may not be a barrier for local migrations between Khasi Hills and Jaintia hills. There are no known corridors for migration of fauna between Khasi Hills and Jaintia hills between which the River Umngot runs.

5.39 The land use and land cover data (Table 5.1) reveals that about 253.85 ha is going to be submerged by the reservoir including the river portion of 93.55 ha (36.85%). Another 34.74 Ha (13.68%) is a barren rocky area. Thus about 50% of total area of submergence is represented by the river and the barren rocks. A mere 8.28 ha or 3.26% of the area of submergence is a thick riverine forest along the course of the River. Nearly 94 ha of River is going to be permanently flooded due to submergence. As such, it is expected to create a barrier by fragmentation. Further, the area mentioned above refers to the full reservoir level. Since, it is a hydroelectric project; the reservoir is not expected to be full except during the rainy season. On the other hand, the reservoir may provide water for wild animals through out the year. It may also reduce poaching. As there are no sanctuaries or wildlife parks or biosphere reserves or other protected areas within the impact zone of the project, it may not have any significant impacts on the wild life except at dam site and the power house.

Effect on fish migration and habitat degradation due to project:

5.40 Unlike the mainland, the administrative set up of the North East India is different. Except those under the direct control of the government, the rest of the areas are managed by the respective District Councils of Khasi Hills and Jaintia Hills as per provisions of the Sixth Schedule to the Constitution of India. The fisheries department of Meghalaya does not have any data regarding the catch composition, fish density, fish standing crop, and fish population dynamics in and around project area.

5.41 It is mainly due to the following:

a). Fishing and fisheries in not a major economic activity. It is not an organized activity. Along the stretch of the river, the locals are allowed to catch fish from the river. There is no organized marketing activity also.

b). Neither the State government nor the Fisheries department is empowered to regulate any fishing activity.

5.42 Further, Umngot is a small river which flows towards South into Bangladesh and it is not a tributary of Brahmaputra. A list of fish either caught by the fisherman engaged during the survey or reported by the ZSI is given in Annexure V.19. None of the species was endemic to the River. Since it is not a tributary of River Brahmaputra, its fish fauna is slightly different. Although many of the species were scarce, they do not come under the REET category.

5.43 The project may alter the physico-chemical parameters of the River water during construction which in turn can influence the food chain. As such the project has the potential to influence the fish species composition of the River. The impacts may last for a year or two. Subsequently, availability of water in the reservoir may stimulate fish production. Seasonal variations in composition of aquatic insects, Phytoplankton and Zooplankton of the River and other water bodies within the study area are indicated in Annexures V.21, V.22 and V.23 respectively.

Existence of National Parks, Sanctuaries, Biosphere Reserves, Forests etc in the study area

5.44 As stated earlier, there are no National Parks or Sanctuaries or Biosphere Reserves or other protected areas within the study area. But there are two small sacred groves, one on either side beyond the FRL. The 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. As indicated in Table 5.1, there are unclassified dense (private forests) and open forests in the catchment and reservoir areas.

Predicted impacts of the H.E project:

5.45 A logical and systematic approach has been adopted for impact identification based on the guidelines evolved by the International Association for Impact Assessment (IAIA). The aim is to take in to account all the important environmental impacts and interactions, with a view to making sure that indirect and cumulative effect, which may be potentially significant, is not inadvertently omitted. The likely impacts are analysed in greater detail in accordance with terms of reference specifically established for this purpose.

5.46 Over time, a number of EIA methodologies and tools have been developed for use in impact identification. In practice, relatively simple methodologies and tools are applied to impact identification. Vast experience of the experts in the field indicates these simple methods are of proven value for undertaking a systematic approach to impact identification. Checklists, matrices, networks, overlays and geographic information systems (GIS), expert systems, and professional judgment are the most common formal methods used for impact identification

5.47 The impacts of Umngot H.E Project may be divided in to two categories based on the time / stage of occurrence of impacts. They are as follows:

- Impacts during construction or establishment and
- Impacts after establishment i.e., operational phase.

5.48 The impacts may further be divided in to reversible or irreversible; direct or indirect; severe, moderate or light depending on magnitude; short term or long term depending on duration of impacts. Prediction of impacts is based both on the direct and indirect; short-term as well as long-term; irreversible and irreversible impacts that are most likely to occur owing to the proposed HE project during establishment and operation. The ecological factors that are considered most significant as far as the impact on flora and fauna concerned are:

- Whether there shall be any reduction in species diversity?
- Whether there shall be any habitat loss or fragmentation?
- Whether there shall be any additional risk or threat to the rare or endangered or endemic or threatened (REET) species?
- Whether there shall be any impairment of ecological functions such as (i) disruption of food chains, (ii) decline in species population and or (iii) alterations in predator-prey relationships?
- Whether it is possible to attain the global objectives of '*no net loss*' of biodiversity?

- Whether it is possible to improve the biological diversity through the proposed activity?

5.49 The direct impacts of the proposed Hydel Power plant shall be limited to an area of about 260 ha only (254 Ha for reservoir and 6 ha for power plant). Most of the REET species of mammals have not been spotted either in the reservoir or catchment area. All the trees and the terrestrial plant species present in the area of submergence of 253.85 ha are going to be lost permanently. But there are no REET species and hence there shall be no loss of any REET biological species. Similarly, the flora and fauna of the power plant site of 6 ha and the quarry area are going to be severely effected. As there are no manufacturing or processing facilities, the project will not contribute to any atmospheric pollution except during construction phase. Further, as there are no rare or endangered or endemic or threatened (REET) species within the core area (Reservoir and power plant), the project does not pose any direct threat to the survival of any rare species. Hence, the proposed project activity is unlikely to pose any additional threat to REET species in the core area. Further, construction of the H.E Power plant and a reservoir is bound to provide water for wild animals during the dry summer season also. As the reservoir is very small and as the loss of terrestrial vegetation shall be limited less than 130 ha or 50 % area of submergence (other 50% is river and barren rocky area), loss of carbon sequestration capacity and production shall be negligible. On the other hand, the renewable hydel power, a clean and green source of energy is going to more than compensate for loss of carbon sequestration capacity. Further the reservoir is going to promote growth of hydrophytes and fish production. Hence, the anticipated environmental impacts on the flora and fauna of the study area are manageable and easily reversible. It is not going to pose any kind of additional environmental stress to the loss of trees in the reservoir since the same can be easily compensated by compensatory afforestation. As there are no ecologically sensitive areas in the impact zone, the project is not going to pose any threat to sensitive ecosystems.

Conservation of flora, fauna and biodiversity

5.50 The main aim of Conservation of Biodiversity is to ensure “No Net Loss”. The biodiversity-related Conventions are based on the premise that further loss of biodiversity is unacceptable. Biodiversity must be conserved to ensure it survives, continuing to provide services, values and benefits for current and future generations. The following approach has been chosen by the International Association for Impact Assessment (IAIA) to help achieve ‘*no net loss’* of biodiversity:

- Avoidance of irreversible loss of biodiversity.
- Seeking alternative solutions to minimize biodiversity losses.
- Use of mitigation to restore biodiversity resources.
- Compensation for unavoidable loss by providing substitutes of at least similar biodiversity value.
- Looking for opportunities for enhancement.

The Umngot H.E Power Plant undertakes to enforce and strictly adhere to the provisions of the following acts and legislations for conservation of biodiversity:

i). The Environment (Protection) Act of 1986: The objective is to provide for the protection and improvement of the environment. It empowers the Central Government to establish authorities charged with the mandate of preventing environmental pollution in all its forms and to tackle specific environmental problems that are peculiar to different parts of the country.

ii). The Biological Diversity Act 2002: It was born out of India's attempt to realize the objectives enshrined in the United Nations Convention on Biological Diversity (CBD) 1992 which recognizes the sovereign rights of states to use their own Biological Resources. The Act aims at the conservation of biological resources and associated knowledge as well as facilitating access to them in a sustainable manner and through a just process. .

iii) Wild Life (Protection) Act 1972: The Government of India enacted the Act with the objective of effectively protecting the wildlife of this country and to control poaching, smuggling and illegal trade in wildlife and its derivatives. The Act was amended in January 2003 and punishment and penalty for offences under the Act have been made more stringent. The Ministry has proposed further amendments in the law by introducing more rigid measures to strengthen the Act. The objective is to provide protection to the listed endangered flora and fauna and ecologically important protected areas.

iv). Forest Conservation Act 1980: It was enacted to help conserve the country's forests. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of Central Government. To this end the Act lays down the pre-requisites for the diversion of forest land for non-forest purposes.

v). The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006: It recognizes the rights of forest-dwelling Scheduled Tribes and other traditional forest dwellers over the forest areas inhabited by them and provides a framework for according the same.

The mechanisms and modes of conservation

5.51 Efforts for ex-situ conservation of any rare or threatened or endangered species of wild plant or animal which enjoy total protection under the Wildlife Protection Act can not be made without the consent of the National Wildlife Board or any other competent authority such as the Principal Chief Conservator (Wildlife). Hence, the role of a project owner or operator shall be limited under such circumstances. Hence, the wildlife conservation and management plans outside the project boundaries are beyond the scope of the project proponent.

5.52 In the Protected Areas (PA) such as National Parks, Biosphere Reserves, sanctuaries emphasis is laid on the habitat improvement for in-situ conservation. In such areas, no conservation can be undertaken by an outsider or outside agency without the consent of the competent authority. Hence any proposal or plan submitted by a project developer for conservation of wildlife or biodiversity within the protected areas has no practical use. But this can not be done effectively by the wildlife authorities in the absence of co-operation from the local people residing in and around the Sanctuaries and National Parks. In order to reduce the destructive dependency of the villagers or forest dependent communities on the protected areas, it is essential to provide them with alternative resources and employment to sustain them. Further, depending on the magnitude and duration of adverse impacts, the project proponent may be asked to support the scientific conservation and management plans undertaken by the authorities concerned.

5.53 Eco-development is a multi-pronged strategy that addresses these issues effectively. It aims at ecologically sustainable economic revival of the rural ecosystem. Akin to the Vana Samrakshana Samathi (VSS) formation in non-PA forest areas, village level committees called Eco Development Committees may be constituted in the protected areas. With the objective of bio-diversity conservation, measures have been initiated to improve demarcation and strengthening of boundaries of the protected areas, habitat improvement, water resource development and soil and moisture conservation. Since human and livestock pressures are a major problem for protected areas management, attempt should be made to link eco-development activities with protected areas management through the coordinated efforts of local communities, forest department and non government organizations. The project proponent or developer or operator may be encouraged to fund eco-development and conservation activities. The project authorities propose to undertake to plant and grow locally adapted plant species for rim treatment, afforestation of degraded areas, avenue plantations, fuel wood, timber and fodder plantations depending on the local needs in association with the locals and local authorities. A suggested list of plants is given in Annexure V.24.

Annexure V.I: Trees and tree top lianas of the catchment area of Umngot River. Climbers, creepers, stragglers are indicated by *	
Name of species	Family
Acer laevigatum	Aceraceae
Acer oblongum	Aceraceae
Rhododendron arboreum	Ericaceae
Drymicarpus racemosus	Anacardiaceae
Rhus acuminata	Anacardiaceae
Spondias axillaris	Anacardiaceae
Desmos longiflorus	Annonaceae
*Fissistigma verrucosum**	Annonaceae
*Melodinus monogynous**	Apocynaceae
Ilex embeloides	Aqualifoliaceae
Macropanax dispermus	Araliaceae
Pseudobrassiopsis hispida	Araliaceae
Schefflera elata	Araliaceae
Schefflera hypoleuca	Araliaceae
Schima venulosa	Araliaceae
Schima wallichiana	Araliaceae
Tupidanthus calyptratus	Araliaceae
Caryota urens	Arecaceae
Betula alnoides	Betulaceae
Sarcococca pruniformis	Buxaceae
Capparis acutifolia	Capparaceae
Viburnum foetidum	Caprifoliaceae
Microtropis discolor	Celastraceae
Calophyllum polyanthium	Clusiaceae
Garcinia morella	Clusiaceae
Garcinia tinctoria	Clusiaceae
*Rourea minor**	Connanaceae
Alangium chinensis	Cornaceae
Dillenia pentagyna	Dilleniaceae
Diospyros kaki	Ebenaceae
Elaeocarpus lancifolius	Elaeocarpaceae
Elaeocarpus sikkimensis	Elaeocarpaceae
Rhododendron arboreaum	Ericaceae
Erythroxylon kunthianum	Erythroxylaceae
Antidesma bunius	Euphorbiaceae
Antidesma diandrum	Euphorbiaceae
Antidesma khasiana	Euphorbiaceae
Croton oblongus	Euphorbiaceae
Macaranga denticulata	Euphorbiaceae
Erythrina arborescens	Fabaceae
Castanopsis indica	Fagaceae
Castanopsis purpurella	Fagaceae

Annexure V.I: Trees and tree top lianas of the catchment area of Umngot River. Climbers, creepers, stragglers are indicated by *	
Castanopsis tribuloides	Fagaceae
Lithocarpus fenestrata	Fagaceae
Lithocarpus elagans	Fagaceae
Quercus griffithii	Fagaceae
Quercus serrata	Fagaceae
Itea chinensis	Iteaceae
Itea macrophylla	Iteaceae
Engelhardtia spicata	Juglandaceae
Actinodaphne obovata	Lauraceae
Atcinodaphne petiolaris	Lauraceae
Beilschmiedia roxburghiana	Lauraceae
Beilschmiedia assamica	Lauraceae
Cinnamomum bejolghota	Lauraceae
Cinnamomum glanduliferum	Lauraceae
Cinnamomum glaucescens	Lauraceae
Cinnamomum tamala	Lauraceae
Cryptocarya floribunda	Lauraceae
Lindera latifolia	Lauraceae
Lindera nagusa	Lauraceae
Lindera reticulata	Lauraceae
Lindera salicifolia	Lauraceae
Litsea semicarpifolia	Lauraceae
Neolitsea cassia	Lauraceae
Persea bombocyania	Lauraceae
Persea duthiei	Lauraceae
Persea gamblei	Lauraceae
Persea odoratissima	Lauraceae
Persea parviflora	Lauraceae
Phoebe lanceolata	Lauraceae
Manglietia insignis	Magnoliaceae
Michelia doltsopa	Magnoliaceae
Polyalthia cerasoides	Magnoliaceae
Dysoxylon gobara	Meliaceae
Melia azedarach	Meliaceae
Pithecellobium monadelphum	Mimosaceae
Ficus altissima	Moraceae
Ficus concinna	Moraceae
Ficus elmerii	Moraceae
Ficus hirta var. roxburghii	Moraceae
Ficus rhododendrifolia	Moraceae
Ficus nerifolia	Moraceae
Ficus virens	Moraceae
Pseudostreblus indica	Moraceae
Myrica esculanta	Myricaceae
Knema angustifolia	Myristicaceae
*Embelia subcoriaceous**	Myrsinaceae

Annexure V.I: Trees and tree top lianas of the catchment area of Umngot River. Climbers, creepers, stragglers are indicated by *	
Maesa indica	Myrsinaceae
Myrsine semiserrata	Myrsinaceae
Syzygium tetragonum	Myrtaceae
Syzygium grande	Myrtaceae
Pinus kesiya	Pinaceae (Gymnosperm)
Pittosporum podocarpum	Pittosporaceae
Podocarpus neriifolia	Podocarpaceae (Gymnosperm)
Helecia nilagirica	Proteaceae
Prunus acuminata	Rosaceae
Prunus jenkinsii	Rosaceae
Coffea khasiana	Rubiaceae
Ixora subsessilis	Rubiaceae
Mynea spinosa	Rubiaceae
Randia griffithii	Rubiaceae
Wendlandia wallichii	Rubiaceae
Citrus latipes	Rutaceae
Paramignya micrantha	Rutaceae
*Todallia asiatica**	Rutaceae
Pyrularia edulis	Santalaceae
Sapindus rarak	Sapindaceae
Sarcosperma griffithii	Sapotaceae
Picresema sp	Simaroubaceae
Stercularia hamiltonii	Sterculiaceae
Styrax hookerii	Styracaceae
Styrax serrulatum	Styracaceae
Symplocos spicata	Symplocaceae
Symplocos pyrifolia	Symplocaceae
Camellia caudata	Theaceae
Eurya acuminata	Theaceae
Eurya cerasifolia	Theaceae
Eurya japonica	Theaceae
Schima wallichii	Theaceae
Pouzolzia frondosa	Urticaceae
Vaccinium sprengelii	Vacciniaceae
Clerodendron bracteatum	Verbenaceae
*Tetrastigma leucostaphylum**	Vitaceae
*Tetrastigma serullatum**	Vitaceae

Annexure V.2: Bamboo species of the Umngot River catchment area. Most common and widely cultivated species are indicated by *		
S. No.	Species	Remarks
1	*Arundinaria hirsuta*	The important clump forming species include *Dendrocalamus strictus, Dendrocalamus hamiltonii, Bambusa arundinacea*, *Bambusa pallida, Bambusa tulda,* whereas *Melocanna bambusoides* is the important non-clump forming species. Rest of the other species was locally rare and uncommon.
2	*Arundinaria mannii*	
3	*Arundinaria microphylla*	
4	*Arundinaria suberecta*	
5	*Bambusa arundinacea* *	
6	*Bambusa balcooa*	
7	*Bambusa glauscescens = Bambusa nana*	
8	*Bambusa khasiana*	
9	*Bambusa longispiculata*	
10	*Bambusa nutans*	
11	*Bambusa pallida**	
12	*Bambusa tulda* *	
13	*Bambusa vulgaris*	
14	*Cephalostachyum capitatum*	
15	*Cephalostachyum fuchsianum*	
16	*Cephalostachyum pallidum*	
17	*Cephalostachyum griffithiana = Arundinaria griffithiana*	
18	*Cephalostachyum hookeriana = Arundinaria polystachys*	
19	*Cephalostachyum khasiana = Arundinaria khasiana*	
20	*Cephalostachyum polystachya = Arundinaria polystachya*	
21	*Dendrocalamus calostachys*	
22	*Dendrocalamus hamiltonii* *	
23	*Dendrocalamus hookeri*	
24	*Dendrocalamus sikkimensis*	
25	*Dendrocalamus strictus* *	
26	*Dinochloa compactiflora = Melocalamus compacitiflorus*	
27	*Gigantochloa macrostachya*	
28	*Gigantochloa takeserah*	
29	*Melocanna baccifera = Melocanna bambusoides* *	
30	*Neohouzeoua dullooa*	
31	*Neohouzeoua helferi*	
32	*Oxytenanthera albociliata*	
33	*Oxytenanthera nigrociliata*	
34	*Phyllostachys mannii*	
35	*Pseudostachyum polymorphum*	
36	*Teinostachyum griffithii*	
37	*Thamnocalamus prainii = Arundinaria prainii*	

Annexure V.3. List of shrubs found in the catchment area of the Umngot HEP. * Common in grasslands

Botanical name	Family
Pavetta indica	Acanthaceae
Pavetta subcapitata	Acanthaceae
Phlogacanthus curriflorus	Acanthaceae
Phlogacanthus thyrsiflorus	Acanthaceae
Phlogacanthus pauciflorus	Acanthaceae
Phlogacanthus tubiflorus	Acanthaceae
Strobilanthes cusia	Acanthaceae
Artabotrys hexapetalus	Annonaceae
Desmos dumosa	Annonaceae
Goniothalamus sesquipedalis	Annonaceae
Holarrhena antidysenterica	Apocyanaceae
Wallichia densiflora	Arecaceae
Eupatorium barmanicum	Asteraceae
Tithonia diversifolia	Asteraceae
Urena lobeta	Asteraceae
Gynocardia odorata	Bixaceae
Cassia didymobotrys	Caesalpineae
Crateva magna	Capparidaceae
Lonicera micrantha	Caprifoliaceae
Ludwigia actovalvis	Caprifoliaceae
Elaeocarpus chinensis	Elaeocarpaceae
Rhododendron formosum *	Ericaceae
Erythroxylon kunthiana	Erythroxylaceae
Aporusa roxburghii	Euphorbiaceae
Breynia rhamnoides	Euphorbiaceae
Bridelia stipularis	Euphorbiaceae
Croton caudatus	Euphorbiaceae
Kirganelia reticulata	Euphorbiaceae
Trewia nudiflora	Euphorbiaceae
Derris ferrugifolia	Fabaceae
Desmodium gangeticum	Fabaceae
Derris elliptica	Fabaceae
Desmodium laxiflorum	Fabaceae
Flemingia congesta	Fabaceae
Moghania semialata	Fabaceae
Pueraraia thumbergiana	Fabaceae
Sesbania grandiflora	Fabaceae
Quercus roxburghiana	Fagaceae
Casearia vareca	Flacourtiaceae
Machilus duthii	Lauraceae
Manglieta insignis	Magnoliaceae
Hiptage benghalensis	Malpighiaceae
Melastoma malabaricum	Melastomataceae
Ficus drupacea	Moraceae

Annexure V.3. List of shrubs found in the catchment area of the Umngot HEP. * Common in grasslands	
Ficus fistulosa	Moraceae
Ficus pyriformis	Moraceae
Ficus tinctoria	Moraceae
Morus laevigata	Moraceae
Maesa monbang	Myrsinaceae
Maesa ramentacea	Myrsinaceae
Ligustrum indicum	Oleaceae
Duchesnea indica	Rosaceae
Rubus ellipticus	Rosaceae
Rubus niveus	Rosaceae
Canthirum gracillepes	Rubiaceae
Gardenia jasminioides	Rubiaceae
Ixora acuminata	Rubiaceae
Lasianthus hookeri	Rubiaceae
Mussaenda roxburghii	Rubiaceae
Mussaenda macrophylla	Rubiaceae
Psychotria curviflora	Rubiaceae
Meyna laxiflora	Rubiceae
Glycomis mauritiana	Rutaceae
Allophyllus cobbe	Sapindaceae
Itea macrophylla	Saxifragaceae
*Brugmansia suaveolens**	Solanaceae
Solamum crienthum	Solanaceae
Solanum ferox	Solanaceae
Abroma angusta	Sterculiaceae
Symplocos chinensis	Symplocaceae
Eurya sanguinea	Theaceae
Daphne cannabina *	Thymelaeaceae
Clerodendron bracteatum	Verbenaceae
Clerodendron nutans	Verbenaceae
Clerodendron viscosum	Verbenaceae
Clerodendron serratum	Verbenaceae
Congea tomentosa	Verbenaceae
Duranta plumerii	Verbenaceae
Duranta repens	Verbenaceae
Holmskioldia sanguinea	Verbenaceae
Leea edgeworthii	Vitaceae
Leea indica	Vitaceae

Annexure V.4
List of herbaceous species recorded during the rainy season of 2008 from the study area. (Graminoid species (Grasses + sedges) are given separately in Annexure V).

Latin name	Family
Adhatoda vasica	Acanthaceae
Andrographis paniculata	Acanthaceae
Andrographis wrightiana	Acanthaceae
Eranthemum scabrum	Acanthaceae
Justicia simplex	Acanthaceae
Phlogocanthus pauciflorus	Acanthaceae
Rungia racemosa	Acanthaceae
Achyranthes aspera	Amaranthaceae
Alternanthera sessilis	Amaranthaceae
Amaranthus tricolor	Amaranthaceae
Amaranthus compestris	Amaranthceae
Amaranthus spinosus	Amaranthceae
Centella asiatica	Apiaceae
Foeniculum vulgare	Apiaceae
Hydrocotyl javanica	Apiaceae
Hydrocotyl sibthorpioides	Apiaceae
Melodinus khasianus	Apocynaceae
Melodinus monogynus	Apocynaceae
Thevetia peruviana	Apocynaceae
Acorus calamus	Araceae
Alocasia acuminate	Araceae
Alocasia farnicata	Araceae
Alocasia macrorrhiza	Araceae
Arisema tortuosum	Araceae
Aegyratum conyzoides	Asteraceae
Artemesia parviflora	Asteraceae
Artemisia vulgaris	Asteraceae
Blumea heiracifolia	Asteraceae
Blumeopsis falcata	Asteraceae
Carthamus tinctorius	Asteraceae
Conyza japonica	Asteraceae
Conyza bifoliata	Asteraceae
Crasscephalum crepidioides	Asteraceae
Crepis japonica	Asteraceae
Daedalcanthus nervosus	Asteraceae
Dicliptera roxburghiana	Asteraceae
Dicrocephaola latifolia	Asteraceae
Eclipta prostrata	Asteraceae
Enhydra fluctuans	Asteraceae
Eupatorium odoratum	Asteraceae
Gynura cusimba	Asteraceae
Mikania scandens	Asteraceae
Seigesbeckia orientalis	Asteraceae
Sonchus aspera	Asteraceae

Annexure V.4 List of herbaceous species recorded during the rainy season of 2008 from the study area. (Graminoid species (Grasses + sedges) are given separately in Annexure V).	
Vernonia cineria	Asteraceae
Xantihum strumarium	Asteraceae
Impatiens chinensis	Balsaminaceae
Impatiens trilobata	Balsaminaceae
Mahonia manipurensis	Berberidaceae
Brassica napusglauca	Brassicaceae
Paraya macrocarpa	Brassicaceae
Raphamus saivus	Brassicaceae
Ananas comosus	Bromeliaceae
Cucurbita pepo	Cacurbitaceae
Cassia tora	Caesalpinaceae
Cannabis sativa	Cannabinaceae
Drymarta cordata	Caryophyllaceae
Stellaria media	Caryophyllaceae
Stellaria vagans	Caryophyllaceae
Chenopodium album	Chenopodiaceae
Spinacea oleacea	Chenopodiaceae
Momordica dioica	Circurbitaceae
Commelina paludosa	Commelinaceae
Commelina salicifolia	Commelinaceae
Cyanotis barbata	Commelinaceae
Mucuna pruriens	Commelinaceae
Iodes ovalis	Convolvulaceae
Ipomoea carnea	Convolvulaceae
Ipomoea linifolia	Convolvulaceae
Ipomoea aquatica	Convolvulacene
Ipomoea batatas	Convolvulacene
Kalanchoe rosea	Crassulaceae
Citrillus vulgaris	Cucubitaceae
Cucumis melo	Cucubitaceae
Cucurbita maxima	Cucubitaceae
Thladiantha calcarata	Cucurbitacea
Momordica charantia	Cucurbitaceae
Drosera indica	Droseraceae
Drosera rotundifolia	Droseraceae
Euphorbia hirta	Euphorbiacea
Manihot esculenta	Euphorbiaceae
Phyllanhus fraternus	Euphorbiaceae
Croton bonplandianum	Euphorbiaeae
Crtoton caudatus	Euphorbiaeae
Calamus cajam	Fabaceae
Desmodium concenum	Fabaceae
Desmodium pseudotriquetrum	Fabaceae
Flemingia involucrata	Fabaceae
Flemingia strobilifera	Fabaceae

Annexure V.4 List of herbaceous species recorded during the rainy season of 2008 from the study area. (Graminoid species (Grasses + sedges) are given separately in Annexure V).	
Gliycine max	Fabaceae
Smithia sensitive	Fabaceae
Biophytum sensitivum	Geraniaceae
Murdania simplex	Haemodaraceae
Inula cappa	Icacinaceae
Anisomeles indica	Lamiaceae
Hyptis suaveolens	Lamiaceae
Leucas aspera	Lamiaceae
Linum usitatissimum	Lamiaceae
Meriandra bengalensis	Lamiaceae
Ocimum americanum	Lamiaceae
Ocimum sanctum	Lamiaceae
Poganatherum purpurescens	Lamiaceae
Scutellaria assamica	Lamiaceae
Scutellaria bicolor	Lamiaceae
Pogostemon benghalensis	Lamiaceae
Orthosiphon spiralis	Laminaceae
Asparagus filicinus	Liliaceae
Asparagus racemosus	Liliaceae
Ocimum baslicum	Lmiaceae
Pratia mummularia	Lobeliaceae
Rotala rotundifolia	Lythraceae
Abutilon indicum	Malvaceae
Hibiscus cannabinus	Malvaceae
Mimosa dulcis	Mimosaceae
Mimosa pudica	Mimosaceae
Neptunia triquetra	Mimosaceae
Musa bulbisiana	Musaceae
Mirabilis jalapa	Nyctaginaceae
Jasminum angustifolium	Oleaceae
Oxalis corniculata	Oxalidaceae
Crotalaria incana	Papilonaceae
Crotalaria striata	Papilonaceae
Crotalaria trifoliastrum	Papilonaceae
Phytoloca acinosa	Phytolacaceae
Phytoloca gracilis	Phytolacaceae
Plantago crosa	Plantaginaceae
Plumbago ariculata	Plumbaginaceae
Plumbago indica	Plumbaginaceae
Plumbago zeylanica	Plumbaginaceae
Polygala chinensis	Polygalaceae
Polygala leptolia	Polygalaceae
Polygomum chinense	Polygonaceae
Polygonum barbatum	Polygonaceae
Polygonum hydropiper	Polygonaceae

Annexure V.4 List of herbaceous species recorded during the rainy season of 2008 from the study area. (Graminoid species (Grasses + sedges) are given separately in Annexure V).	
Polygonum lapathinfolium	Polygonaceae
Rumex maritimus	Polygonaceae
Oleandra wallichii	Polypodiaceae
Portulaca oleracea	Portulaceae
Ranunculus sclerosis	Ranunculaceae
Anotis foetida	Rubiaceae
Borreria articularis	Rubiaceae
Borreria hispida	Rubiaceae
Hedyotis auriculata	Rubiaceae
Hedyotis diffusa	Rubiaceae
Ixora acuminata	Rubiaceae
Ixora roxburghii	Rubiaceae
Ixora undulata	Rubiaceae
Knoxia lanciolata	Rubiaceae
Houttunia cordata	Saururaceae
Scoparia dulcis	Scrophulariaceae
Capsicum minuta	Solanaceae
Nicotiana tabacum	Solanaceae
Solamum verbacifolium	Solanaceae
Corchorus hydropiper	Tiliaceae
Gerardiana heterophylla	Urticaceae
Clerodendron nutans	Verbenaceae
Phyla nodiflora	Verbenaceae
Viola patrinii	Violaceae
Globba orixensis	Zingeberaceae
Alphinia galanga	Zingiberaceae
Alpinia nigra	Zingiberaceae
Costus speciosus	Zingiberaceae
Curcuma augustifolia	Zingiberaceae
Curcuma domestica	Zingiberaceae
Hedychium marginatum	Zingiberaceae
Hedychium spicatum	Zingiberaceae
Hydychium coronarium	Zingiberaceae
Kaempferia rotunda	Zingiberaceae
Zingiber cassumnar	Zingiberaceae
Zingiber officinale	Zingiberaceae
Zingiber zerumbet	Zingiberaceae

Annexure V.5: List of graminoids (grasses and sedges) belonging to Poaceae, Cyperaceae and Eriocaulaceae recorded from the study area during the rainy season of 2008.	
Latin name	Family
Bulbostylis barbata	Cyperaceae
Carex spoinosa	Cyperaceae
Cyperus arenarius	Cyperaceae
Cyperus castaneus	Cyperaceae
Cyperus compressus	Cyperaceae
Cyperus cypernicles	Cyperaceae
Cyperus diffusus	Cyperaceae
Cyperus distans	Cyperaceae
Cyperus iria	Cyperaceae
Cyperus kyllingia	Cyperaceae
Cyperus rotundus	Cyperaceae
Fimbristylis cymosa	Cyperaceae
Fimbristylis dichotoma	Cyperaceae
Fimbristylis ferruginea	Cyperaceae
Fimbristylis miliacea	Cyperaceae
Kyllinga brevifolia	Cyperaceae
Kyllinga bulbosa	Cyperaceae
Schoenoplectus articularis	Cyperaceae
Eriocaulon cinereum	Eriocaulaceae
Eriocaulon truncatum	Eriocaulaceae
Eriocaulon minutum	Eriocaulaceae
Eriocaulon quinquangulare	Eriocaulaceae
Cymbopogon nardus	Poaceae
Cynodon barberi	Poaceae
Cynodon dactylon	Poaceae
Dactyloctenium aegyptium	Poaceae
Dichanthium annulatum	Poaceae
Dichanthium persutum	Poaceae
Dichanthium pseudoischaemum	Poaceae
Digitaria longiflora	Poaceae
Digitaria tomentosa	Poaceae
Dimeria lehmanii	Poaceae
Dinebra retroflexa	Poaceae
Echinochloa colona	Poaceae
Echinochloa crus-galli	Poaceae
Echinochloa frumentacea	Poaceae
Eleusine indica	Poaceae
Eragrostiella brachyphylla	Poaceae
Eragrostis atrovirens	Poaceae
Eragrostis gangetica	Poaceae
Eragrostis nigra	Poaceae
Eragrostis nutans	Poaceae
Eragrostis riparia	Poaceae
Eragrostis viscosa	Poaceae
Eremopogon foveolatus	Poaceae

Eriochloa procera	Poaceae
Eulalia phaeothrix	Poaceae
Garnotia elata	Poaceae
Heteropogon contortus	Poaceae
Hymenachae amplexicaulis	Poaceae
Imperata cylindrica	Poaceae
Ischaemum indicum	Poaceae
Ischaemum rugosum	Poaceae
Iseilema laxum	Poaceae
Leptochloa chinensis	Poaceae
Lophopogon tridentatus	Poaceae
Manisuris myuros	Poaceae
Melanocenchris monoica	Poaceae
Oplismenus compositus	Poaceae
Oryza meyeriana	Poaceae
Oryza rufipogon	Poaceae
Panicum brevifolium	Poaceae
Panicum notatum	Poaceae
Panicum paludosa	Poaceae
Panicum repens	Poaceae
Panicum sumatrense	Poaceae
Paspalidium flavidum	Poaceae
Pennisetum hohenackeri	Poaceae
Pennisetum purpureum	Poaceae
Phragmites karka	Poaceae
Pogonatherum citrinum	Poaceae
Saccharum officinarum	Poaceae
Saccharum spontaneum	Poaceae
Schima nervosum	Poaceae
Setaria palmifolia	Poaceae
Sporobolus indicus	Poaceae
Sporobolus wallichii	Poaceae
Themeda triandra	Poaceae
Thysanolaena maxima	Poaceae
Tragus roxburghii	Poaceae
Tripogon jacquemontii	Poaceae
Tripogon wrightii	Poaceae
Urochloa panicoides	Poaceae
Vetiveria zizanoides	Poaceae

Annexure V.6
List of non woody plant species found in the catchment area of the Umngot River during different seasons of 2008. A= Absent and P= Present.

Botanical Name	Family	Seasons		
		Winter	Summer	Rainy
Adhatoda vasica	Acanthaceae	P	P	P
Andrographis paniculata	Acanthaceae	A	P	P
Andrographis wrightiana	Acanthaceae	A	P	P
Eranthemum scabrum	Acanthaceae	P	P	P
Justicia simplex	Acanthaceae	A	P	P
Phlogocanthus pauciflorus	Acanthaceae	P	P	P
Rungia racemosa	Acanthaceae	A	P	P
Achyranthes aspera	Amaranthaceae	A	P	P
Alternanthera sessilis	Amaranthaceae	A	A	P
Amaranthus tricolor	Amaranthaceae	A	P	P
Amaranthus compestris	Amaranthceae	A	A	P
Amaranthus spinosus	Amaranthceae	A	A	P
Centella asiatica	Apiaceae	A	P	P
Foeniculum vulgare	Apiaceae	A	A	P
Hydrocotyl javanica	Apiaceae	A	A	P
Hydrocotyl sibthorpioides	Apiaceae	A	P	P
Melodinus khasianus	Apocynaceae	P	P	P
Melodinus monogynus	Apocynaceae	P	P	P
Thevetia peruviana	Apocynaceae	P	P	P
Acorus calamus	Araceae	P	P	P
Alocasia acuminate	Araceae	P	P	P
Alocasia farnicata	Araceae	P	P	P
Alocasia macrorrhiza	Araceae	P	P	P
Arisema tortuosum	Araceae	P	P	P
Aegyratum conyzoides	Asteraceae	A	P	P
Artemesia parviflora	Asteraceae	A	P	P
Artemisia vulgaris	Asteraceae	A	P	P
Blumea heiracifolia	Asteraceae	A	P	P
Blumeopsis falcata	Asteraceae	A	P	P
Carthamus tinctorius	Asteraceae	P	P	P
Conyza japonica	Asteraceae	P	P	P
Conyza bifoliata	Asteraceae	A	P	P
Crasscephalum crepidioides	Asteraceae	P	P	P
Crepis japonica	Asteraceae	A	P	P
Daedalcanthus nervosus	Asteraceae	A	P	P
Dicliptera roxburghiana	Asteraceae	A	A	P
Dicrocephaola latifolia	Asteraceae	A	P	P
Eclipta prostrata	Asteraceae	A	A	P
Enhydra fluctuans	Asteraceae	P	P	P
Eupatorium odoratum	Asteraceae	A	P	P
Gynura cusimba	Asteraceae	P	P	P
Mikania scandens	Asteraceae	A	P	P

Annexure V.6
List of non woody plant species found in the catchment area of the Umngot River during different seasons of 2008. A= Absent and P= Present.

Botanical Name	Family	Seasons		
		Winter	Summer	Rainy
Seigesbeckia orientalis	Asteraceae	A	P	P
Sonchus aspera	Asteraceae	P	P	A
Vernonia cineria	Asteraceae	A	P	P
Xantihum strumarium	Asteraceae	A	P	P
Impatiens chinensis	Balsaminaceae	A	P	P
Impatiens trilobata	Balsaminaceae	A	P	P
Mahonia manipurensis	Berberidaceae	A	P	P
Brassica napusglauca	Brassicaceae	A	A	P
Paraya macrocarpa	Brassicaceae	A	P	P
Raphamus saivus	Brassicaceae	A	P	P
Ananas comosus	Bromeliaceae	P	P	P
Cucurbita pepo	Cacurbitaceae	A	P	P
Cassia tora	Caesalpinaceae	A	P	P
Cannabis sativa	Cannabinaceae	A	P	P
Drymarta cordata	Caryophyllaceae	A	A	P
Stellaria media	Caryophyllaceae	A	A	P
Stellaria vagans	Caryophyllaceae	A	P	P
Chenopodium album	Chenopodiaceae	A	A	P
Spinacea oleacea	Chenopodiaceae	A	P	P
Momordica dioica	Circurbitaceae	A	A	P
Commelina paludosa	Commelinaceae	P	P	P
Commelina salicifolia	Commelinaceae	P	P	P
Cyanotis barbata	Commelinaceae	A	P	P
Mucuna pruriens	Commelinaceae	P	A	P
Iodes ovalis	Convolvulaceae	A	P	P
Ipomoea carnea	Convolvulaceae	P	P	P
Ipomoea linifolia	Convolvulaceae	P	P	P
Ipomoea aquatica	Convolvulacene	P	P	P
Ipomoea batatas	Convolvulacene	P	P	A
Kalanchoe rosea	Crassulaceae	P	P	P
Citrillus vulgaris	Cucubitaceae	A	A	P
Cucumis melo	Cucubitaceae	A	A	P
Cucurbita maxima	Cucubitaceae	A	A	P
Thladiantha calcarata	Cucurbitacea	A	P	P
Momordica charantia	Cucurbitaceae	A	P	P
Bulbostylis barbata	Cyperaceae	A	A	P
Carex spoinosa	Cyperaceae	A	P	P
Cyperus arenarius	Cyperaceae	A	A	P
Cyperus castaneus	Cyperaceae	A	P	P
Cyperus compressus	Cyperaceae	A	P	P
Cyperus cypernicles	Cyperaceae	A	P	P
Cyperus diffusus	Cyperaceae	A	P	P

Annexure V.6
List of non woody plant species found in the catchment area of the Umngot River during different seasons of 2008. A= Absent and P= Present.

Botanical Name	Family	Seasons		
		Winter	Summer	Rainy
Cyperus distans	Cyperaceae	A	P	P
Cyperus iria	Cyperaceae	A	P	P
Cyperus kyllingia	Cyperaceae	A	P	P
Cyperus rotundus	Cyperaceae	P	P	P
Fimbristylis cymosa	Cyperaceae	A	P	P
Fimbristylis dichotoma	Cyperaceae	A	P	P
Fimbristylis ferruginea	Cyperaceae	A	P	P
Fimbristylis miliacea	Cyperaceae	A	A	P
Kyllinga brevifolia	Cyperaceae	A	A	P
Kyllinga bulbosa	Cyperaceae	A	A	P
Schoenoplectus articularis	Cyperaceae	A	A	P
Drosera indica	Dorseraceae	A	A	P
Drosera rotundifolia	Dorseraceae	A	A	P
Eriocaulon cinereum	Eriocaulaceae	A	A	P
Eriocaulon truncatum	Eriocaulaceae	A	A	P
Eriocaulon minutum	Eriocaulaceae	A	A	P
Eriocaulon quinquangulare	Eriocaulaceae	A	A	P
Euphorbia hirta	Euphorbiacea	A	P	P
Manihot esculenta	Euphorbiaceae	P	P	P
Phyllanhus fraternus	Euphorbiaceae	A	A	P
Croton bonplandianum	Euphorbiaeae	A	P	P
Crtoton caudatus	Euphorbiaeae	A	P	P
Calamus cajam	Fabaceae	P	P	P
Desmodium concenum	Fabaceae	A	P	P
Desmodium pseudotriquetrum	Fabaceae	A	P	P
Flemingia involucrata	Fabaceae	A	A	P
Flemingia strobilifera	Fabaceae	A	P	P
Gliycine max	Fabaceae	A	P	P
Smithia sensitive	Fabaceae	P	P	P
Biophytum sensitivum	Geraniaceae	A	P	P
Murdania simplex	Haemodaraceae	A	P	P
Inula cappa	Icacinaceae	A	A	P
Anisomeles indica	Lamiaceae	P	P	P
Hyptis suaveolens	Lamiaceae	P	P	P
Leucas aspera	Lamiaceae	P	P	P
Linum usitatissimum	Lamiaceae	P	P	P
Meriandra bengalensis	Lamiaceae	P	P	A
Ocimum americanum	Lamiaceae	P	P	P
Ocimum sanctum	Lamiaceae	A	A	P
Pagostemon sp.	Lamiaceae	A	A	P
Poganatherum purpurescens	Lamiaceae	A	A	P
Scutellaria assamica	Lamiaceae	A	P	P

Annexure V.6
List of non woody plant species found in the catchment area of the Umngot River during different seasons of 2008. A= Absent and P= Present.

Botanical Name	Family	Seasons		
		Winter	Summer	Rainy
Scutellaria bicolor	Lamiaceae	A	P	P
Pogostemon benghalensis	Lamiaceae	A	P	P
Orthosiphon spiralis	Laminaceae	P	P	P
Asparagus filicinus	Liliaceae	P	P	P
Asparagus racemosus	Liliaceae	A	P	P
Ocimum baslicum	Lmiaceae	P	P	P
Pratia mummularia	Lobeliaceae	A	P	P
Rotala rotundifolia	Lythraceae	A	P	P
Abutilon indicum	Malvaceae	P	P	P
Hibiscus cannabinus	Malvaceae	P	P	P
Mimosa dulcis	Mimosaceae	P	P	P
Mimosa pudica	Mimosaceae	A	P	P
Neptunia triquetra	Mimosaceae	A	P	P
Musa bulbisiana	Musaceae	P	P	P
Mirabilis jalapa	Nyctaginaceae	A	P	P
Jasminum angustifolium	Oleaceae	P	P	P
Oxalis corniculata	Oxalidaceae	A	P	P
Crotalaria incana	Papilonaceae	A	P	P
Crotalaria striata	Papilonaceae	A	P	P
Crotalaria trifoliastrum	Papilonaceae	A	P	P
Phytoloca acinosa	Phytolacaceae	A	P	P
Phytoloca gracilis	Phytolacaceae	A	P	P
Plantago crosa	Plantaginaceae	P	P	P
Plumbago ariculata	Plumbaginaceae	P	P	P
Plumbago indica	Plumbaginaceae	P	P	P
Plumbago zeylanica	Plumbaginaceae	P	P	P
Aleuropus lagopoides	Poaceae	P	P	P
Apluda mutica	Poaceae	P	P	P
Bothriochloa pertusa	Poaceae	P	P	P
Brachiaria ramosa	Poaceae	A	A	P
Brachiaria reptans	Poaceae	A	A	P
Brachypodium wattii	Poaceae	A	P	P
Cenchrus cilliaris	Poaceae	P	P	P
Centotheca lappacea	Poaceae	P	P	P
Chloris barbata	Poaceae	A	A	P
Chloris dolichostachya	Poaceae	P	P	P
Chloris roxburghiana	Poaceae	P	P	P
Chrysopogon articularus	Poaceae	P	P	P
Chrysopogon asper	Poaceae	P	P	P
Chrysopogon fulvus	Poaceae	P	P	P
Coix lacryma-jobi	Poaceae	A	P	P
Cryptococcum oxyphyllum	Poaceae	P	P	P

Annexure V.6
List of non woody plant species found in the catchment area of the Umngot River during different seasons of 2008. A= Absent and P= Present.

Botanical Name	Family	Seasons		
		Winter	Summer	Rainy
Cymbopogon gidarba	Poaceae	P	A	P
Cymbopogon nardus	Poaceae	P	A	P
Cynodon barberi	Poaceae	P	P	P
Cynodon dactylon	Poaceae	P	P	P
Dactyloctenium aegyptium	Poaceae	A	A	P
Dichanthium annulatum	Poaceae	P	A	P
Dichanthium persutum	Poaceae	P	P	P
Dichanthium pseudoischaemum	Poaceae	P	A	P
Digitaria longiflora	Poaceae	P	A	P
Digitaria tomentosa	Poaceae	P	A	P
Dimeria lehmanii	Poaceae	P	A	P
Dinebra retroflexa	Poaceae	A	A	P
Echinochloa colona	Poaceae	A	A	P
Echinochloa crus-galli	Poaceae	A	A	P
Echinochloa frumentacea	Poaceae	P	A	P
Eleusine indica	Poaceae	A	A	P
Eragrostiella brachyphylla	Poaceae	P	A	P
Eragrostis atrovirens	Poaceae	P	P	P
Eragrostis gangetica	Poaceae	P	A	P
Eragrostis nigra	Poaceae	P	A	P
Eragrostis nutans	Poaceae	P	A	P
Eragrostis riparia	Poaceae	P	P	P
Eragrostis viscosa	Poaceae	P	A	P
Eremopogon foveolatus	Poaceae	P	A	P
Eriochloa procera	Poaceae	P	A	P
Eulalia phaeothrix	Poaceae	P	P	P
Garnotia elata	Poaceae	P	P	P
Heteropogon contortus	Poaceae	P	A	P
Hymenachae amplexicaulis	Poaceae	A	P	P
Imperata cylindrica	Poaceae	P	P	P
Ischaemum indicum	Poaceae	P	P	P
Ischaemum rugosum	Poaceae	P	P	P
Iseilema laxum	Poaceae	A	A	P
Leptochloa chinensis	Poaceae	A	A	P
Lophopogon tridentatus	Poaceae	P	P	P
Manisuris myuros	Poaceae	P	A	P
Melanocenchris monoica	Poaceae	P	A	P
Oplismenus compositus	Poaceae	P	A	P
Oryza meyeriana	Poaceae	P	A	P
Oryza rufipogon	Poaceae	P	A	P
Panicum brevifolium	Poaceae	P	A	P
Panicum notatum	Poaceae	P	A	P

Annexure V.6 List of non woody plant species found in the catchment area of the Umngot River during different seasons of 2008. A= Absent and P= Present.				
Botanical Name	**Family**	**Seasons**		
		Winter	**Summer**	**Rainy**
Panicum paludosa	Poaceae	A	P	P
Panicum repens	Poaceae	P	A	P
Panicum sumatrense	Poaceae	P	A	P
Paspalidium flavidum	Poaceae	A	A	P
Pennisetum hohenackeri	Poaceae	P	A	P
Pennisetum purpureum	Poaceae	A	A	P
Phragmites karka	Poaceae	P	P	P
Pogonatherum citrinum	Poaceae	P	A	P
Saccharum officinarum	Poaceae	P	P	P
Saccharum spontaneum	Poaceae	P	P	P
Schima nervosum	Poaceae	P	A	P
Setaria palmifolia	Poaceae	P	A	P
Sporobolus indicus	Poaceae	P	A	P
Sporobolus wallichii	Poaceae	P	A	P
Themeda triandra	Poaceae	P	A	P
Thysanolaena maxima	Poaceae	P	P	P
Tragus roxburghii	Poaceae	P	A	P
Tripogon jacquemontii	Poaceae	P	A	P
Tripogon wrightii	Poaceae	P	A	P
Urochloa panicoides	Poaceae	P	A	P
Vetiveria zizanoides	Poaceae	P	A	P
Polygala chinensis	Polygalaceae	A	A	P
Polygala leptolia	Polygalaceae	A	A	P
Polygomum chinense	Polygonaceae	A	A	P
Polygonum barbatum	Polygonaceae	A	A	P
Polygonum hydropiper	Polygonaceae	A	A	P
Polygonum lapathinfolium	Polygonaceae	A	P	P
Rumex maritimus	Polygonaceae	A	P	P
Oleandra wallichii	Polypodiaceae	P	P	P
Portulaca oleracea	Portulaceae	A	A	P
Ranunculus sclerosis	Ranunculaceae	P	P	P
Anotis foetida	Rubiaceae	P	P	P
Borreria articularis	Rubiaceae	A	A	P
Borreria hispida	Rubiaceae	A	A	P
Hedyotis auriculata	Rubiaceae	A	A	P
Hedyotis diffusa	Rubiaceae	A	A	P
Ixora acuminata	Rubiaceae	A	A	P
Ixora roxburghii	Rubiaceae	A	A	P
Ixora undulata	Rubiaceae	A	A	P
Knoxia lanciolata	Rubiaceae	A	A	P
Houttunia cordata	Saururaceae	A	A	P
Scoparia dulcis	Scrophulariaceae	A	A	P

Annexure V.6
List of non woody plant species found in the catchment area of the Umngot River during different seasons of 2008. A= Absent and P= Present.

Botanical Name	Family	Seasons		
		Winter	Summer	Rainy
Capsicum minuta	Solanaceae	A	P	P
Nicotiana tabacum	Solanaceae	A	P	P
Solamum verbacifolium	Solanaceae	P	P	P
Corchorus hydropiper	Tiliaceae	A	A	P
Gerardiana heterophylla	Urticaceae	P	P	P
Clerodendron nutans	Verbenaceae	P	P	P
Phyla nodiflora	Verbenaceae	A	A	P
Viola patrinii	Violaceae	P	P	P
Globba orixensis	Zingeberaceae	A	A	P
Alphinia galanga	Zingiberaceae	P	P	P
Alpinia nigra	Zingiberaceae	P	P	P
Costus speciosus	Zingiberaceae	A	P	P
Curcuma augustifolia	Zingiberaceae	A	P	P
Curcuma domestica	Zingiberaceae	A	P	P
Hedychium marginatum	Zingiberaceae	A	P	P
Hedychium spicatum	Zingiberaceae	A	P	P
Hydychium coronarium	Zingiberaceae	A	A	P
Kaempferia rotunda	Zingiberaceae	A	A	P
Zingiber cassumnar	Zingiberaceae	A	P	P
Zingiber officinale	Zingiberaceae	P	P	P
Zingiber zerumbet	Zingiberaceae	A	P	P

Annexure V.7. Orchid species recorded from the study area.	
Latin name	**Habitat**
Acampe rigida	Epiphytic
Aerides multiflora	Epiphytic
Aerides odorata	Epiphytic
Arundina chinensis	Terrestrial
Arundina graminifolia	Bamboo Orchid – terrestrial
Ascocentrum ampullaceum	Terrestrial
Bulbophyllum crassipes	Epiphytic
Cymbidium aloifolium	Epiphytic
Cymbidium devonianum	Epiphytic
Cymbidium elegans	Epiphytic
Cymbidium macrorhizon	Terrestrial
Dendrobium aphyllum	Epiphytic
Dendrobium chrysanthum	Epiphytic
Dendrobium crepidatum	Epiphytic
Dendrobium fimbriatum	Epiphytic
Dendrobium fimbriatum	Epiphytic
Dendrobium herbaceum	Epiphytic
Dendrobium moschatum	Lithophytic
Dendrobium nobile	Epiphytic
Dendrobium regium	Epiphytic
Eulophia graminea	Terrestrial
Eulophia spectabilis	Terrestrial
Geodorum densiflorum	Terrestrial
Geodorum laxiflorum	Terrestrial
Geodorum recurvum	Terrestrial
Habenaria commelinifolia	Terrestrial
Habenaria digitata	Terrestrial
Habenaria diphylla	Terrestrial
Habenaria marginata	Terrestrial
Liparis paradoxa	Terrestrial

Annexure V.7. Orchid species recorded from the study area.	
Luisia zeylanica	Epiphytic
Malaxis purpurea	Terrestrial
Nervilia biflora	Terrestrial
Nervilia 109ndus109e	Terrestrial
Nervilia infundibulifolia	Terrestrial
Nervilia prainiana	Terrestrial
Oberonia falconeri	Epiphytic
Papilionanthe vandarum	Epiphytic
Paphiopedilum insigne	Terrestrial (Lady's slipper)
Peristylus affinis	Terrestrial
Peristylus constrictus	Terrestrial
Pholidota articulata	Lithophytic
Plantaginorchis plantaginea	Lithophytic
Rhynchostylis retusa	Epiphytic
Vanda tessellata	Epiphytic
Vanda testacea	Epiphytic

Annexure V.8

Gymnosperms found in the catchment area of Umngot River.

Latin name	**Division**	**Importance**
Cycas circinalis	Cycadopsida	Grown as an ornamental
Cycas revoluta	Cycadopsida	Grown as an ornamental
Cryptomeria japonica	Coniferopsida	Avenue and ornamental
Podocarpus neriifolia	Coniferopsida	Avenue and ornamental
Thuja compacta	Coniferopsida	Avenue and ornamental
Thuja orientalis	Coniferopsida	Avenue and ornamental
Araucaria arucana	Coniferopsida	Avenue and ornamental
Araucaria excelsa	Coniferopsida	Avenue and ornamental
Araucaria angustifolia	Coniferopsida	Avenue and ornamental
Pinus kesiya	Coniferopsida	Commonly known as Khasi Pine is widely grown for timber.
Salix alba	Coniferopsida	Weeping willow

Annexure V.9: Bryophytes and Pteridophytes found in the catchment area of the Umngot River during the rainy season of 2008.	
Bryophytes	
Latin name	Main taxonomic category / habitat
Anthoceros fusiformis	Anthocerotopsida
Anthoceros crispulus	Anthocerotopsida
Anthoceros erectus	Anthocerotopsida
Anthoceros laevis	Anthocerotopsida
Notothylus indica	Anthocerotopsida
Notothylus javanicus	Anthocerotopsida
Sphaerothecium reconditum	Bryopsida (Moss)
Andraea densifolia	Bryopsida (Moss)
Andraea indica	Bryopsida (Moss)
Andraea pterophyla	Bryopsida (Moss)
Andraea rigida	Bryopsida (Moss)
Bryum apiculatum	Bryopsida (Moss)
Bryum argentium	Bryopsida (Moss)
Bryum wrightii	Bryopsida (Moss)
Ceratodon purpureus	Bryopsida (Moss)
Fabronia pusilla	Bryopsida (Moss)
Hyophila cosmosa	Bryopsida (Moss)
Papillaria crocea	Bryopsida (Moss)
Pogonatum patulum	Bryopsida (Moss)
Polytrichum densifolium	Bryopsida (Moss)
Polytrichum juniperum	Bryopsida (Moss)
Polytrichum xanthopilum	Bryopsida (Moss)
Pterobryopsis acuminata	Bryopsida (Moss)
Trachyphyllum inflexum	Bryopsida (Moss)
Zygodon humilis	Bryopsida (Moss)
Aitchisoniella himalayensis	Hepaticopsida
Conocephalum conicum	Hepaticopsida
Cyathodium tuberosum	Hepaticopsida
Dumoriera hirsuta	Hepaticopsida
Exoemotheca tubifera	Hepaticopsida
Pellia calycina	Hepaticopsida
Pellia epiphylla	Hepaticopsida
Plagiochasma intermedium	Hepaticopsida
Plagiochasma articulatum	Hepaticopsida
Plagiochasma appendiculatum	Hepaticopsida
Reboulia hemisperica	Hepaticopsida
Riccia melanospora	Hepaticopsida
Riccia discolor	Hepaticopsida (Liver wort)
Riccia frostii	Hepaticopsida (Liver wort)
Targionia hypophylla	Hepaticopsida (Targionia)
Targionia indica	Hepaticopsida (Targionia)
Marchantia 111ndus111e	Marchantia (Liver wort)
Marchantia polymorpha	Marchantia (Liver wort)
Pteridophytes	

Annexure V.9: Bryophytes and Pteridophytes found in the catchment area of the Umngot River during the rainy season of 2008.	
Actinopteris radiata	A fern with important medicinal properties
Adiantum pectinatum	Maiden Hair Fern
Adiantum peruvianum	Maiden Hair Fern
Adiantum caudatum	Maiden Hair Fern
Adiantum edgeworthii	Maiden Hair Fern
Adiantum pedatum	Maiden Hair Fern
Adiantum philippense	Maiden Hair Fern
Asplenium trichomanes	
Asplenium nidus	Fern
Asplenium scolopendrium	
Azolla pinnata	Aquatic fern
Blechnum orientale	
Botrychium virginianaum	Moonwort fern
Dicramopteris linaris	
Drymoglossum pilosIloides	
Drynaria mollis	Polypodiaceae fern
Drynaria quencifolia	Fern
Dryopteris cochleata	
Dryopteris eburescens	
Dryopteris fibrillosa	
Dryopteris marginata	Fern
Dryopteris ramosa	
Dryopterisrigida	
Equisetum debile	Horse tails
Equisetum arvense	Horse tails
Equisetum diffusum	Horse tails
Equisetum laevigatum	Horse tails
Equisetum sylvaticum	Horse tails
Glechenia linearis	Fern
Gleichenia linearis	Wild fern
Isoites indica	Isoites
Isoites hysrix	
Isoites japonica	
Kaulinis pteropus	
Lepisorus clathratus	Polypodiaceae fern
Lepisorus excavatus	Polypodiaceae fern
Lepisorus nudus	Polypodiaceae fern
Lycopodium cernum	Lycopodium
Lycopodium centrochinense.	Lycopodium
Lycopodium clavatum	Epiphytic
Lycopodium dichotomum	Lycopodiaceae
Lycopodium phlegmarium	Lycopodium
Lycopodium squarrosum	Lycopodium
Lygodium flexuosum	
Marsilea diffusa	Aquatic
Marsilea hirsuta	Aquatic

Annexure V.9: Bryophytes and Pteridophytes found in the catchment area of the Umngot River during the rainy season of 2008.	
Marsilea minuta	Aquatic
Marsilea quadrifida	Aquatic
Microsorium punctatum	Fern
Microsporium membranaceum	Polypodiaceae fern
Ophioglossum nudicaule	
Ophioglossum pendulum	
Ophioglossum simplex	
Osmunda japonica	
Osmunda regalis	Fern
Phymatodes malcadron	Polypodiaceae fern
Phymatodes oxyloba	Polypodiaceae fern
Phymatodes stracheyi	Polypodiaceae fern
Pieris eniformis	Lei changkhrang
Plegmariurus plegmaria	Fern
Polypodium lachnopus	
Polypodium microrhizoma	
Polypodium quercifolium	Fern
Polypodium stewartii	
Polypodium vulgare	
Pteris palmata	Fern
Pteris stenophylla	
Pteris cretica	
Pteris excelsa	Fern
Pteris quadriaurita	
Pteris vittata	
Pteris wallichiana	
Ptieris eniformis	Fern
Salvinia auriculata	Aquatic fern
Salvinia natans	Aquatic fern
Selaginella apoda	
Selaginella barbicans	
Selaginella cilliaris	
Selaginella densa	
Selaginella gracilis	
Selaginella kraussiana	
Selaginella lepidophylla	
Selaginella nepalensis	
Selaginella picta	

Annexure V.10. Frequency, density, dominance, Imporatance value indices (IVI), indices of diversity, dominance and evenenss of trees and tree top lianas of the catchment area.

Name of species	Family	Freque ncy	Den-sity	Domi-nance	IVI
Acer laevigatum	Aceraceae	22	1.2	1.1	3.4
Acer oblongum	Aceraceae	32	1.5	1.8	4.6
Rhus acuminata	Anacardiaceae	35	2.1	1.9	4.7
Spondias axillaris	Anacardiaceae	12	0.8	0.7	2.2
Desmos longiflorus	Annonaceae	8.5	0.5	0.7	1.6
*Fissistigma verrucosum**	Annonaceae	12	0.4	0.3	1.1
*Melodinus monogynous**	Apocynaceae	5.0	0.5	0.5	1.5
*Schima venulosa**	Araliaceae	5.0	0.4	0.6	1.4
*Schima wallichiana**	Araliaceae	45	0.8	0.7	2.2
*Tupidanthus calyptratus**	Araliaceae	5.0	0.4	0.5	1.1
Caryota urens	Arecaceae	24	1.1	0.9	2.6
Betula alnoides	Betulaceae	56	2.0	1.6	4.4
Capparis acutifolia	Capparaceae	30	1.1	1.2	3.2
Viburnum foetidum	Caprifoliaceae	10	1.1	0.7	2.4
Microtropis discolor	Celastraceae	8.0	0.4	0.4	1.1
Calophyllum polyanthium	Clusiaceae	27	1.0	1.2	3.2
Garcinia morella	Clusiaceae	65	1.7	1.5	5.3
Garcinia tinctoria	Clusiaceae	43	1.1	1.2	3.8
*Rourea minor**	Connanaceae	65	1.6	1.8	5.2
Alangium chinensis	Cornaceae	53	1.0	1.5	4.7
Diospyros kaki	Ebenaceae	62	1.6	1.1	5.4
Elaeocarpus lancifolius	Elaeocarpaceae	58	1.3	1.5	4.6
Elaeocarpus sikkimensis	Elaeocarpaceae	15	0.6	0.8	2.7
Rhododendron arboreaum	Ericaceae	72	1.4	1.5	4.5
Erythroxylon kunthianum	Erythroxylaceae	16	1.0	0.8	3.3
Antidesma bunius	Euphorbiaceae	6.5	0.9	1.2	2.4
Antidesma diandrum	Euphorbiaceae	9.5	1.0	1.1	3.1
Antidesma khasiana	Euphorbiaceae	34	0.8	0.7	2.6
Croton oblongus	Euphorbiaceae	9.0	0.6	0.8	2.2
Macaranga denticulata	Euphorbiaceae	7.5	0.5	0.7	2.0
Erythrina arborescens	Fabaceae	10	0.5	0.8	2.5
Castanopsis indica	Fagaceae	74	2.1	1.8	6.6
Castanopsis purpurella	Fagaceae	76	2.4	2.5	7.9
Castanopsis tribuloides	Fagaceae	82	2.5	2.8	8.4
Lithocarpus fenestrata	Fagaceae	36	0.9	1.0	3.3
Lithocarpus elagans	Fagaceae	39	1.1	0.9	3.6
Quercus griffithii	Fagaceae	16	0.8	0.7	2.4
Quercus serrata	Fagaceae	21	1.1	0.9	3.2
Itea chinensis	Iteaceae	11	0.8	0.7	2.3
Itea macrophylla	Iteaceae	6.5	0.6	0.8	2.2
Engelhardita spicata	Juglandaceae	16	1.1	1.2	4.6
Actinodaphne obovata	Lauraceae	63	2.1	2.4	6.7
Alseodaphne petiolaris	Lauraceae	11	0.7	0.6	2.6

Annexure V.10. Frequency, density, dominance, Imporatance value indices (IVI), indices of diversity, dominance and evenenss of trees and tree top lianas of the catchment area.					
Name of species	**Family**	**Freque ncy**	**Den- sity**	**Domi- nance**	**IVI**
Cinnamomum bejolghota	Lauraceae	10	0.6	0.6	2.1
Cinnamomum glanduliferum	Lauraceae	55	1.8	2.1	6.4
Cinnamomum glaucescens	Lauraceae	24	0.8	0.9	3.4
Cinnamomum tamala	Lauraceae	7.0	0.4	0.6	2.0
Cryptocarya floribunda	Lauraceae	8.5	0.5	0.6	2.2
Lindera latifolia	Lauraceae	11	0.7	0.9	3.2
Lindera nagusa	Lauraceae	10	0.6	0.8	3.1
Lindera reticulata	Lauraceae	4.5	0.2	0.3	1.6
Lindera salicifolia	Lauraceae	5.5	0.3	0.2	1.6
Litsea semicarpifolia	Lauraceae	16	0.6	0.7	3.3
Persea odoratissima	Lauraceae	38	1.0	1.4	5.3
Persea parviflora	Lauraceae	42	1.1	0.8	4.2
Phoebe lanceolata	Lauraceae	48	1.4	1.2	5.5
Manglietia insignis	Magnoliaceae	12	0.5	0.6	2.3
Michelia doltsopa	Magnoliaceae	8.0	0.5	0.5	2.0
Dysoxylon gobara	Meliaceae	24	1.0	0.7	4.4
Melia azedarach	Meliaceae	27	0.4	0.3	1.6
Pithecellobium monadelphum	Mimosaceae	28	0.7	0.9	3.5
Ficus altissima	Moraceae	14	0.6	0.5	3.1
Ficus concinna	Moraceae	30	0.7	0.8	3.6
Ficus elmerii	Moraceae	11	0.4	0.5	2.4
Ficus hirta var. roxburghii	Moraceae	18	0.6	0.8	3.2
Ficus rhododendrifolia	Moraceae	9.0	0.3	0.4	1.2
Ficus nerifolia	Moraceae	16	0.5	0.6	2.2
Ficus virens	Moraceae	21	1.1	0.9	3.4
Pseudostreblus indica	Moraceae	25	1.2	0.8	3.6
Myrica esculanta	Myricaceae	9.5	0.6	0.5	2.5
Knema angustifolia	Myristicaceae	45	1.4	1.1	5.7
*Embelia subcoriaceous**	Myrsinaceae	8.0	0.2	0.3	1.3
Maesa indica	Myrsinaceae	10	0.3	0.4	1.8
Myrsine semiserrata	Myrsinaceae	16	1.5	1.0	5.4
Syzygium tetragonum	Myrtaceae	61	1.7	1.4	7.5
Pittosporum podocarpum	Pittosporaceae	19	0.7	0.8	3.3
Helecia nilagirica	Proteaceae	17	0.8	0.7	3.2
Prunus acuminata	Rosaceae	15	0.2	0.2	1.3
Prunus jenkinsii	Rosaceae	36	1.3	1.2	4.5
Coffea khasiana	Rubiaceae	16	0.8	0.9	2.8
Ixora subsessilis	Rubiaceae	8.5	0.5	0.5	1.6
Randia griffithii	Rubiaceae	11	0.8	0.9	2.1
Wendlandia wallichii	Rubiaceae	21	1.2	1.3	3.4
Citrus latipes	Rutaceae	10	0.7	0.9	2.2
Paramignya micrantha	Rutaceae	6.5	0.4	0.6	1.5
*Todallia asiatica**	Rutaceae	7.5	0.8	0.7	2.1

Annexure V.10. Frequency, density, dominance, Imporatance value indices (IVI), indices of diversity, dominance and evenenss of trees and tree top lianas of the catchment area.

Name of species	Family	Freque ncy	Den-sity	Domi-nance	IVI
Pyrularia edulis	Santalaceae	18	0.9	0.8	3.2
Sapindus rarak	Sapindaceae	5.0	0.3	0.4	1.4
Sarcosperma griffithii	Sapotaceae	22	1.1	1.3	3.6
Stercularia hamiltonii	Sterculiaceae	6.0	0.4	0.7	2.0
Styrax serrulatum	Styracaceae	5.5	0.6	0.8	2.3
Symplocos spicata	Symplocaceae	23	1.0	1.3	3.6
Symplocos pyrifolia	Symplocaceae	6.5	0.5	0.4	1.4
Camellia caudata	Theaceae	32	0.9	1.0	3.8
Eurya acuminata	Theaceae	6.0	0.4	0.5	1.3
Eurya cerasifolia	Theaceae	9.0	0.8	0.7	2.6
Eurya japonica	Theaceae	21	1.4	1.5	4.4
Schima wallichii	Theaceae	38	0.9	1.1	3.6
Pouzolzia frondosa	Urticaceae	4.5	0.4	0.6	1.3
Vaccinium sprengelii	Vacciniaceae	5.0	0.3	0.6	1.2
Clerodendron bracteatum	Verbenaceae	8.0	0.5	0.4	1.2
*Tetrastigma leucostaphylum**	Vitaceae	5.0	0.4	0.4	1.2
*Tetrastigma serullatum**	Vitaceae	22	0.8	0.9	2.4
* = Lianas	Shannon – Weaver Index of Diversity =				4.52
Dominance =	0.14	Equitability =			0.96

Annexure – V.11.Frequency, density, dominance and IVI values of structural species of the reservoir area.

Name of the species	Frequency (Quadrat of 5x20 m)	Density (No/Ha)	Domin-ance (% cover)	IVI
Actinodaphne obovata	25	4.5	1.5	3.9
Alangium chinensis	15	3.2	0.8	2.3
Anthocephalus cadamba	30	5.1	1.3	3.1
Antidesma diandrum	10	1.6	0.7	1.8
Antidesma khasiana	35	3.7	1.4	3.3
Bambusa arundinacea	60	6.8	3.1	7.4
Bambusa pallida	65	7.2	2.4	6.3
Bambusa tulda	55	8.6	2.7	5.6
Calophyllum polyanthium	45	3.4	1.2	3.4
Camellia caudata	10	1.2	0.6	1.0
Capparis acutifolia	25	2.6	0.7	1.9
Caryota urens	30	3.2	1.5	3.9
Cinnamomum tamala	5	1.4	0.9	1.4
Citrus latipes	40	4.4	1.6	4.2
Clerodendron bracteatum	70	7.9	1.5	4.1
Croton oblongus	65	6.5	1.2	3.6

Annexure – V.11.Frequency, density, dominance and IVI values of structural species of the reservoir area.

Name of the species	Frequency (Quadrat of 5x20 m)	Density (No/Ha)	Domin-ance (% cover)	IVI
Dendrocalamus hamiltonii	80	9.5	1.7	5.5
Dendrocalamus strictus	90	12.2	2.2	8.4
Desmos longiflorus	10	1.2	0.5	1.0
Diospyros kaki	60	6.5	1.7	5.4
Dysoxylon gobara	55	7.2	1.4	4.2
*Embelia subcoriaceous**	20	2.5	0.4	1.3
Erythrina arborescens	30	3.4	1.0	2.8
Erythroxylon kunthianum	45	5.1	1.3	3.5
Eurya acuminata	15	2.1	1.2	2.1
Eurya japonica	20	1.5	0.8	1.8
Ficus rhododendrifolia	45	5.4	1.1	3.0
Ficus altissima	30	3.8	1.4	3.6
Ficus concinna	40	4.6	1.3	3.7
Ficus elmerii	45	3.9	2.4	7.8
Ficus hirta var. roxburghii	60	7.3	2.1	8.4
Ficus nerifolia	65	7.7	2.7	8.5
Ficus virens	70	8.2	3.2	10.2
*Fissistigma verrucosum**	45	3.8	1.4	3.2
Garcinia morella	30	3.3	1.0	2.7
Garcinia tinctoria	20	2.5	1.1	2.6
Ixora subsessilis	35	3.5	1.0	2.6
Litsea semicarpifolia	20	2.1	0.8	1.9
Macaranga denticulata	40	4.2	1.5	4.2
Macropanax dispermus	10	1.2	1.1	1.7
Maesa indica	10	1.0	0.5	1.6
Manglietia insignis	20	1.7	0.8	2.3
Melia azedarach	35	2.6	1.4	3.9
Melocanna bambusoides	80	9.6	2.4	8.2
*Melodinus monogynous**	55	4.7	1.5	4.5
Michelia doltsopa	65	6.9	1.4	5.5
Mynea spinosa	20	1.5	0.6	1.3
Myrica esculanta	15	1.2	0.4	1.0
Myrsine semiserrata	25	2.1	0.4	1.5
Paramignya micrantha	10	1.1	0.3	1.0
Persea odoratissima	5	1.0	0.4	1.0
Persea parviflora	5	1.3	0.3	1.0
Pinus kesiya	65	6.8	2.3	6.6
Pithecellobium monadelphum	45	4.3	1.2	3.4
Pittosporum podocarpum	70	7.8	2.1	6.9
Pouzolzia frondosa	60	6.9	1.5	4.7
Pseudobrassiopsis hispida	50	5.5	1.7	4.2
Pseudostrebulus indica	65	8.6	1.6	4.6

Annexure – V.11.Frequency, density, dominance and IVI values of structural species of the reservoir area.

Name of the species	Frequency (Quadrat of 5x20 m)	Density (No/Ha)	Domin-ance (% cover)	IVI
Pyrularia edulis	15	1.3	0.6	1.7
Randia griffithii	30	2.6	0.5	1.8
Rhus acuminata	65	7.7	1.3	3.3
Sapindus rarak	45	5.4	1.1	3.0
Sarcosperma griffithii	20	2.7	0.8	2.1
Schefflera elata	75	7.1	2.2	6.4
Schefflera hypoleuca	50	3.4	0.7	2.5
Schima wallichiana	90	8.8	3.3	10.6
Schima wallichii	75	6.6	1.6	5.6
Spondias axillaris	80	9.1	2.8	8.5
Stercularia hamiltonii	65	5.7	1.3	3.7
Styrax serrulatum	40	3.7	1.1	3.0
Symplocos spicata	25	2.3	1.0	2.6
Symplocos pyrifolia	10	1.4	0.4	1.3
Syzygium tetragonum	45	3.6	1.4	3.1
*Tetrastigma leucostaphylum**	35	2.8	1.2	2.7
*Tetrastigma serullatum**	25	1.4	0.5	1.1
*Todallia asiatica**	45	4.2	1.3	2.6
Vaccinium sprengelii	20	1.7	0.6	1.8
Wendlandia wallichii	35	3.2	0.7	2.1
* = Lianas	Shannon – Weaver Index of Diversity =			4.12
Dominance =	0.17	Equitability =		0.97

Annexure V.12: Important Timber yielding plants of the catchment area of Umngot River		
Local / common name	Latin name	Family
Borpat	*Ailanthus grandis*	Simaroubaceae
Safed Siris	*Albizia procera*	Mimosaceae
Amari	*Amoora wallichii*	Meliaceae
Kadam	*Anthocephalus cadamba*	Rubiaceae
Chaplash	*Artocarpus chaplasha*	Moraceae
Mundani	*Artocarpus fraxinifolius*	Moraceae
Birch	*Betula alnoides*	Betulaceae
Semul	*Bombax ceiba*	Bombacaceae
Kurta	*Calophyllum polyanthum*	Clusiaceae
Dhoop	*Canarium resiniferum*	Burseraceae
Indian Horn Beam	*Carpinus viminea*	Betulaceae
Indian Chestnut	*Castanopsis speciosa*	Fagaceae
Gonsorai	*Cinnamomum cecicodaphne*	Lauraceae
Khokan	*Duabanga sonneratioides*	Lythraceae
Gamari	*Gmelina arborea*	Verbenaceae
Badam	*Mansonia dipikai*	Sterculeaceae
Champ	*Michelia champaca*	Magnoliaceae
Bola	*Morus laevigata*	Moraceae
Khasi pine	*Pinus kesiya*	Pinaceae (Conifer)
Podocarpus	*Podocarpus neriifolia*	Podocarpaceae (Conifer)
Chilauni	*Schima wallichii*	Theaceae
Sal	*Shorea robusta*	Dipterocarpaceae
Talauma	*Talauma phellocarpa*	Magnoliaceae
Teak	*Tectona grandis*	Verbenaceae
Bhelu	*Tetrameles nudiflora*	Tetramelaceae
Toon	*Toona ciliata*	Meliaceae
Ahoi	*Vitex peduncularis*	Verbenaceae

Annexure V.13: Rare / endangered / endemic / threatened (REET) species of plants reported from Khasi and or Jaintia Hills. Among them, only the species marked by * were found in the catchment area of Umngot River.

Family	Name of plant species	Status as per IUCN / BSI
Annonaceae	*Trivalvaria kanjilali*	Endangered & Endemic
Arecaceae	*Phoenix rupicola*	Rare. Khasi and Jaintia hills
Arecaceae	*Livistona jenkinsiana*	Endangered. Khasi and Jaintia hills
Asclepiadaceae	*Ceropegia arnottiana*	Endangered. Khasi hills
Asclepiadaceae	*Ceropegia lucida*	Endangered/ Possibly Extinct. Khasi hills
Asclepiadaceae	*Ceropegia angustifolia**	Vulnerable North-Eastern Hilly region, Khasi
Asteraceae	*Senecio mishmi*	Vulnerable
Asteraceae	*Inula kalapani*	Rare / Endemic to Khasi hills
Balanophoraceae	*Rhopalocnemis phalloides*	Rare.Khasi hills.
Begoniaceae	*Begonia rubrovenia*	Rare. Khasi hills. Endemic
Begoniaceae	*Begonia brevicaulis*	Endangered Khasia
Caryophyllaceae	*Silene khasiana*	Indeterminate .Khasi hills. 1500-1800 m.
Cyperaceae	*Fimbristylis stolonifera**	Rare in abandoned jhum of Khasi hills
Cyperaceae	*Scleria alta*	Indeterminate
Cyperaceae	*Carex repanda*	Presumed Extinct. Cherrapunji
Elaeagnaceae	*Elaeagnus conferta*	Endangered & Endemic. Khasi hills
Elaeocarpaceae	*Elaeocarpus prunifolius**	Rare.
Elaeocarpaceae	*Elaeocarpus acuminate*	Rare. Limited to sacred forest groves
Fabaceae	*Gleditsia assamica*	Indeterminate & Endemic to hills
Fabaceae	*Crotalaria noveoides*	Indeterminate or Endemic to Khasi hills.
Ixonanthaceae	*Ixonanthes khasiana*	Vulnerable & Endemic
Magnoliaceae	*Michelia punduana*	Rare
Malpighiaceae	*Aspidopterys oxyphylla*	Indeterminate
Menispermaceae	*Cyclea debiliflora*	Indeterminate/ Endemic. Possibly Extinct
Menispermaceae	*Albertisia mecistophylla*	Indeterminate –Possibly Extinct
Mitrastemonaceae	*Mitrastemon yamamotoi*	Endangered. Limited to sacred forest groves
Nepenthaceae	*Nepenthes khasiana*	Endemic and endangered
Orchidaceae	*Calanthe mannii*	Rare in Khasi Hills.
Orchidaceae	*Corybas purpureus*	Rare in Khasi Hills.
Orchidaceae	*Cymbidium eburneum*	Vulnerable / Endemic

Annexure V.13: Rare / endangered / endemic / threatened (REET) species of plants reported from Khasi and or Jaintia Hills. Among them, only the species marked by * were found in the catchment area of Umngot River.		
Orchidaceae	*Diplomeris pulchella*	Vulnerable. Cherranpunjee in Khasi hills
Orchidaceae	*Paphiopedilum insigne*	Vulnerable .Khasi hills.
Orchidaceae	*Paphiopedilum venustum**	Vulnerable
Orchidaceae	*Pleione lagenaria*	Presumed Extinct
Orchidaceae	*Vanda coerulea**	Rare
Orchidaceae	*Zeuxine pulchra*	Endangered / Possibly Extinct
Orchidaceae	*Calanthe anthropophora*	Endangered
Polypodiaceae	*Dendroglossa minutula*	Endangered / Endemic to Khasia hills
Rafflesiaceae	*Sapria himalayana*	Rare
Ranunculaceae	*Clematis apiculata*	Endangered / Endemic to Khasi hills
Rubiaceae	*Argostemma khasianum*	Indeterminate
Rubiaceae	*Indopolysolenia wallichii*	Rare & Endemic
Rubiaceae	*Neanotis oxyphylla*	Rare / Endemic
Rubiaceae	*Ophiorrhiza hispida*	Endangered
Rubiaceae	*Ophiorrhiza subcapitata*	Endangered
Rubiaceae	*Ophiorrhiza tingens*	Vulnerable
Rubiaceae	*Ophiorrhiza wattii*	Endangered
Sterculaceae	*Acranthera tomentosa*	Vulnerable / Endemic
Sterculaceae	*Sterculia khasiana*	Possibly Extinct .Endemic to the Khasi hills
Ternstroemiaceae	*Adinandra griffithii*	Endangered & Endemic to Khasi hills
Theaceae	*Pyrenaria khasiana*	Indeterminate / Endemic
Theaceae	*Cleyera japonica**	Rare
Thelypteridaceae	*Metathelypteris decipiens**	Rare / Endemic
Thelypteridaceae	*Coryphopteris didymochlaenoides**	Rare / Endemic Fern

Annexure V.14: Avian fauna of the project area				
Common name	**Latin name**	**Order**	**Residential status**	**WPA Schedu-le**
Little grebe	*Podiceps rufficollis*	Podicipediformis	Migratory	IV
Large cormorant	*Phalacrocorax carbo sinensis*	Felicaniformis	Local migrant	IV
Little cormorant	*Phalacrocorax niger*	Felicaniformis	Local migrant	IV
Eastern Grey Heron	*Ardea cinerea*	Ciconiformes	Local migrant	IV
Eastern Purple Heron	*Ardea purpurea*	Ciconiformes	Local migrant	IV
Little egret	*Ardea alba*	Ciconiformes	Local migrant	IV
Little green Heron	*Ardea striatus*	Ciconiformes	Local migrant	IV
Cattle Egret	*Bubulcus ibis*	Ciconiformes	Local migrant	IV
Smaller / median Egret	*Egretta intermedia*	Ciconiformes	Local migrant	IV
Night Heron	*Nycticorax nycticorax*	Ciconiformes	Local migrant	IV
Eastern Grey Goose	*Anser anser*	Ciconiformes	Migratory	IV
Lesser whistling Teal	*Anas javanica*	Ciconiformes	Local migrant	IV
Paintail	*Anas acuta*	Ciconiformes	Local migrant	IV
Common Teal	*Anas crecca*	Ciconiformes	Local migrant	IV
Common Pochard	*Aythya ferina*	Ciconiformes	Local migrant	IV
Black winged kite	*Elanus caeruleus*	Falconiformes	Local migrant	IV
Large Indian Kite	*Milvus migrans*	Falconiformes	Local migrant	IV
Brahmy Kite	*Heliaster 122ndus*	Falconiformes	Local migrant	IV
Pariah kite	*Milvus migrans*	Falconiformes	Vagrant	IV
Goshawk	*Accipiter gentiles*	Falconiformes	Local migrant	IV
Indian Shikra	*Accipiter badius*	Falconiformes	Local migrant	IV
Eeastern Steppe Eagle	*Aquila rapax*	Falconiformes	Local migrant	IV
Indian Black Vulture	*Sarcogyps calvus*	Falconiformes	Local migrant	IV
Assam Black Partridge	*Francolinus francolinus*	Galiformes	Local migrant	IV
Assam Bamboo Partridge	*Bambusicola fytchii*	Galiformes	Local migrant	IV
Indian Red jungle Fowl	*Gallua gallus murghi*	Galiformes	Resident	IV
Peacock Pheasant	*Polyplectron bicalcaratum*	Galiformes	Vulnerable	IV
Khalij Pheasant	*Polyplectron biclcaratum*	Galiformes	Local migrant	IV
Indian Pea Fowl	*Pavo cristatus*	Galiformes	Vulnerable	I (iii)
Little Bustard Quail	*Turnix sylvatica*	Gruciformes	Local migrant	IV
Indian Moorhen	*Gallinula chloropus*	Gruciformes	Local migrant	IV
Coot	*Fulica atra atra*	Gruciformes	Resident	IV

Annexure V.14: Avian fauna of the project area

Common name	Latin name	Order	Residential status	WPA Schedu-le
Pheasant tailed Jacana	*Hydrophasianus chirurgus*	Gruciformes	Resident	IV
Red Wattled Lapwing	*Vanellus indicus*	Gruciformes	Resident	IV
Eastern golden Plover	*Pluvialis dominica*	Gruciformes	Resident	IV
Eastern Little Ringed Plover	*Charadrius dubius curonicus*	Gruciformes	Resident	IV
Spotted Sandpiper	*Tringa glareola*	Gruciformes	Resident	IV
Common sandpiper	*Tringa hypoleucos*	Gruciformes	Resident	IV
Fantail Snipe	*Gallinago gallinago*	Gruciformes	Local migrant	IV
Woodcock	*Scolopax rusticola*	Gruciformes	Resident	IV
Painted snipe	*Rostratula benghalensis*	Gruciformes	Local migrant	IV
Indian River Tern	*Sterna aurantia*	Gruciformes	Local migrant	IV
Wedge tailed Pigeon	*Treron spenura*	Columbiformes	Resident	IV
Bengal green Pigeon	*Treron phoenocoptera*	Columbiformes	Resident	IV
Indian Blue rock Pigeon	*Columba livia*	Columbiformes	Resident	IV
Indian Ring Dove	*Streptopelia decaocto*	Columbiformes	Resident	IV
Indian spotted dove	*Streptopelia chinensis*	Columbiformes	Resident	IV
Northern Ring nosed Parakeet	*Psittacula krameri*	Psittaciformes	Resident	IV
Northern blossom headed Parakeet	*Psittacula cyanocephala*	Psittaciformes	Resident	IV
Indian Lorikeet	*Loriculus vernalis*	Psittaciformes	Resident	IV
Red winged crested Cuckoo	*Clamator coromandus*	Cuculiformes	Local migrant	IV
Common Hawk Cuckoo	*Cuculus varius*	Cuculiformes	Local migrant	IV
Indian Cuckoo	*Cuculus micropterus*	Cuculiformes	Local migrant	IV
Khasi Hills Cuckoo	*Cuculus canorus*	Cuculiformes	Resident	IV
Indian Koel	*Eudynamis scolopacea*	Cuculiformes	Local migrant	IV
Grass Owl	*Tyto capensis*	Strigiformes	Local migrant	IV
Indian great horned Owl	*Bubo bubo bengalensis*	Strigiformes	Local migrant	IV
Northern Spotted Owl	*Athene brama indica*	Strigiformes	Local migrant	IV
Eastern Palm Swift	*Cypsiurus parvus*	Apordiformes	Local migrant	IV
Crested tree Swift	*Hemiprocne*	Apordiformes	Local migrant	IV

Annexure V.14: Avian fauna of the project area				
Common name	**Latin name**	**Order**	**Residential status**	**WPA Schedu-le**
	longipennis			
Indian Pied Kingfisher	*Ceryle rudis*	Coraciformes	Local migrant	IV
Great Blue Kingfisher	*Alcedo hercules*	Coraciformes	Local migrant	IV
Assam Blue – eared Kingfisher	*Alcedo meninting*	Coraciformes	Local migrant	IV
Eastern White breasted Kingfisher	*Halcyon smyrnensis*	Coraciformes	Local migrant	IV
Burmese Roller	*Coracias bengalensis*	Coraciformes	Local migrant	IV
White throated brown Hornbill	*Ptilolaemus tickelli*	Coraciformes	Vulnerable	I(Part III)
Assam Wreathed Hornbill	*Rhyticeros undulates*	Coraciformes	Vulnerable	I(Part III)
Indian Pied Hornbill	*Anthracoceros malabaricus*	Coraciformes	Vulnerable	I(Part III)
Assam Great Barbet	*Megalaima virens*	Piciformes	Local migrant	IV
Blue throated Barbet	*Megalaima asiatica*	Piciformes	Local migrant	IV
Eastern Rufus Woodpecker	*Micropternus brachyurus*	Piciformes	Local migrant	IV
Black necked green Woodpecker	*Picus canus*	Piciformes	Local migrant	IV
Pole headed Woodpecker	*Gecinulus grantia*	Piciformes	Local migrant	IV
Assam Great Slaty Woodpecker	*Mulleripicus pulverulentus*	Piciformes	Resident	IV
Green breasted Pitta	*Pitta sordida*	Piciformes	Resident	IV
Black necked Oriole	*Oriolus xanthornus*	Piciformes	Resident	IV
North Indian Black Drongo	*Dicrurus adsimillis*	Piciformes	Local migrant	IV
Assam Grey Drongo	*Dicrus leucophaeus*	Piciformes	Resident	IV
Grey headed Myna	*Sturnus malabaricus*	Piciformes	Resident	IV
Indian Pied Myna	*Sturnus contra*	Piciformes	Resident	IV
Hill Myna	*Gracula religiosa*	Piciformes	Resident	IV
Indian House Crow	*Corvus splendens*	Piciformes	Resident	V
Eastern Jungle Crow	*Corvus macrorhynchos*	Piciformes	Resident	IV
Indian wood Shrike	*Tephrodornis pondicerianus*	Piciformes	Local migrant	IV
Small Grey	*Coracina*	Piciformes	Local migrant	IV

Annexure V.14: Avian fauna of the project area				
Common name	**Latin name**	**Order**	**Residential status**	**WPA Schedu-le**
Cuckoo Shrike	*melaschistos*			
Finch billed Bulbul	*Spizixos canifrons*	Piciformes	Resident	IV
Black headed Bulbul	*Pycnonotus atriceps*	Piciformes	Resident	IV
Striated green Bulbul	*Pycnonotus striatus*	Piciformes	Resident	IV
White throated Bulbul	*Criniger flaveolus*	Piciformes	Resident	IV
Assam brown Babbler	*Pellorneum albiventre*	Piciformes	Resident	IV
Long tailed Wren Babbler	*Spelaeornis longicaudatus*	Piciformes	Local migrant	IV
Red headed Babbler	*Stachrys chrysaea*	Piciformes	Local migrant	IV
Yellow breasted Babbler	*Macronous gularis*	Piciformes	Local migrant	IV
Red capped Babbler	*Tamalia pileata*	Piciformes	Local migrant	IV
Assam orange Parrot bill	*Paradoxornis nipalensis*	Piciformes	Local migrant	IV
Assam red headed Parrot bill	*Paradoxornis ruficeps*	Piciformes	Local migrant	IV

Annexure V.15

Mammalian fauna of the Umngot hydroelectric project. (IK means Insuffiently Known)

Common name	Latin name	Distribution w.r.t Meghalaya	IUCN status	WPA Schedule
Capped monkey	*Prestybis pileatus*	Widespread	Vulnerable	I (Part I)
Indian Pangolin	*Manis pentadactyla aurita*	Scattered	IK	I (Part I)
Asiatic Jackal	*Canis aureus*	Scattered	Rare	I (Part I)
Bengal Fox	*Vulpes bengalensis*	Scarce and scattered	Vulnerable	I (Part I)
Sloth Bear	*Melursus ursinus*	Scarce and scattered	Vulnerable	I (Part I)
Large Indian Civet	*Viverra zibetha zibetha*	Widespread	Vulnerable	I (Part I)
Small Indian Civet	*Viverricula indica*	Widespread	Vulnerable	I (Part I)
Masked Palm Civet	*Paguma larvata neglecta*	Widespread	Vulnerable	I (Part I)
Crab eating Mongoose	*Herpestes urva*	Scarce and scattered	Rare	I (Part I)
Indian Grey Mongoose	*Herpestes edwardsii*	Scarce and scattered	Rare	I (Part I)
Jungle Cat	*Felis chaus*	Widespread	Vulnerable	I (Part I)
Leopard Cat	*Felis bengalensis*	Scarce and scattered	Vulnerable	I (Part I)
Barking Deer	*Muntiacus muntijak*	Rare and scattered	Vulnerable	I (Part I)
Hog Deer	*Axis porcinus*	Rare and scattered	Vulnerable	I (Part I)
Sambar	*Cervus unicolor equinus*	Rare and scattered	Vulnerable	I (Part I)
Four horned Antelope	*Tetraceros quadricornis*	Rare and scattered	Vulnerable	I (Part I)
Goral	*Nemorhaedus goral*	Rare and scattered	Vulnerable	I (Part I)
Rhesus monkey	*Macaca mulatto mulatto*	Common and widespread	Common	II (Part I)
Assamese macaque	*Macaca assamensis assamensis*	Scattered	Rare	II (Part I)
Hairy footed flying Squirrel	*Belomys pearsoni*	Scarce and scattered	Rare	I (Part I)
Common giant flying Squirrel	*Petaurista petaurista*	Common and widespread	Vulnerable	I (Part I)
Hodgson's flying Squirrel	*Petaurista magnificus*	Common and widespread	Vulnerable	II (Part I)
Phayre's flying Squirrel	*Holopetes alboniger*	Common and widespread	Vulnerable	II (Part I)
House shrew	*Suncus murinus*	Common and widespread	IK	II (Part I)
Indian fulvus fruit bat	*Rousettus leschenaultia*	Common and widespread	IK	II(Part I)
Indian flying fox	*Pteropus giganteus*	Common and	IK	II (Part I)

Annexure V.15 Mammalian fauna of the Umngot hydroelectric project. (IK means Insuffiently Known)				
Common name	**Latin name**	**Distribution w.r.t Meghalaya**	**IUCN status**	**WPA Schedule**
		widespread		
Khasi leaf nosed bat	*Hipposideros larvatus*	Endemic	Rare	II (Part I)
Indian pygmy bat	*Pipistrellus minus*	Common and widespread	IK	II (Part I)
Long eared bat	*Plecotus auritus*	Common and widespread	IK	II (Part I)

Annexure V.16 :Reptilian fauna of the Umngot project area				
Common name	**Latin name**	**Distribution w.r.t Meghalaya**	**Status**	
			ZSI /IUCN	**WPA Schedule**
Lizard	*Cyrtodactylus khasiensis*	Widespread	Common	II(Part II)
Lizards	*Cosymbotus platyurus*		Common	II(Part II)
Lizards	*Calotes emma*	Widespread	Common	II(Part II)
Lizards	*Calotes jerdoni*	Widespread	Common	II(Part II)
Lizards	*Calotes versicolor*	Widespread	Common	II(Part II)
Lizards	*Gecko gecko*	Widespread	Common	II(Part II)
House Gecko	*Hemidactylus brooki*	Widespread	Common	II(Part II)
Monitor lizard	*Varanus bengalensis*	Common	Vulnerable	I(Part II)
Yellow Monitor	*Varanus flavescens*	Common	Endangered	I(Part II)
Water Monitor	*Varanus salvator*	Common	Endangered	I(Part II)
Rock Python	*Python molorus*	Scarce	Endangered	I(Part II)
Rat snake	*Ptyas korros*	Very common	Common	II(Part I)
Black Krait	*Bungarus niger*	Common	Scarce	I(Part II)
Banded Krait	*Bungarus fasciatus*	Common	Scarce	II(Part II)
Indian Cobra	*Naja naja*	Scarce	Threatened	I(Part II)
Pit Viper	*Trimeresurus albolabris*	Common	common	I(Part II)
Assam Fresh water Tortoise	*Cyclemys mouhoti*	Common	Scarce	I(Part II)
Black-spotted pond Turtle	*Geoclemys hamiltoni*	Common	Scarce	I(Part II)
Brahminy River Turtle	*Hardella thurgi*	Common	Scarce	I(Part II)
North Indian Roofed Turtle	*Kachuga tacta*	Scarce.	Scarce	I(Part II)

Annexure V.17 Family wise list of Butterflies and Moths recorded from the Umngot river and its catchment area

Family : Danaidae
Parantica aglea (Stoll)
Danaus (Anosia) chrysippus (Linnaeus)
D. (Salatura) genutia (Cramer)
D. melaneus (Cramer)
D. sita (Kollar)
Euploea core (Cramer)
E. mulciber (Cramer)
Family : Satyridae
Lethe confusa Aurivillius
L. verma (Kollar)
L. yama (Moore)
L. Vindhya (C-Fedler)
Melanitis leda ismene (Cramer)
M. phedima (Stoll)
M. zitenius (Herbst)
Ypthima nareda (Kollar)
Y. sakra Moore
Elymnias hypermnestra Linnaeus
E. malelas (Hewitson)
Ethope himachala (Moore)
Family : Amathusiidae
Thaumantis diores Doubleday
Family : Nymphalidae
Argynnis childreni Gray
A. hyperbius (Johanssen)
A. laodice (Pallas)
Cethosia biblis (Drury)
C. cyane (Drury)
Cirrochroa aoris Doubleday
Family : Acraeidae
Acraea issoria (Hubner)
Family : Erycinidae
Abisara chela (de-Niceville)
Zemeros flegyas (Cramer)
Family : Lycaenidae
Heliophorus androcles (Hewitson)
H. brahma (Moore)
Jamides alecto (Felder)
Zizeeria maha (Kollar)
Family : Papilionidae
Graphium sarpedon (Linnaeus)
G. antiphates (Cramer)
Papilo clytia Linnaeus
P. demoleus (Linnaeus
P. helenus (Linnaeus)
P. polyctor (Boisduval)
P. polytes romulus Cramer
P. protenor (Cramer)
P. chaon Westwood
Troides helena (Linnaeus)
Atrophaneura aidoneus (Doubleday)
A. aristoochiae (Fabricius)
A dasarada (Moore)
A. philoxenus (Gray)
Family : Pieridae
Aporia agathon (Gray)
Appias lyncida (Cramer)
A. pandione (Geyer)
Catopsilia crocale (Cramer)

Cyrestis thyodamas (Boisduval)
Ergolis merione (Cramer)
Eriboea dolon (Westwood)
E. arja (Felder)
Neptis hordonia Stoll
N. hylas Moore
N.nandina Moore
N. yeburyi Butler
Pantoporia perius (Linnaeus)
P. selanophora (Kollar)
Phalanta phalantha (Drury)
Precis almana (Linnaeus)
P. atlities (Johanssen)
P. hierta (Fabricius)
P. iphita (Cramer)
P. lemonias (Linnaeus)
P. orithyia (Linnaeus)
Vanessa canace (Johanssen)
V. cardui (Linnaeus)
V. indica (Herbst)
Kallima inachus (Boisduval)
Cynthia erota (Fabricius)
Chersonesia risa (Doubleday)
Symbrenthia hypselis (Godart)
Hestina nama (Doubleday)
Apatura ambica (Kollar)
Stibochiona nicea (Gray)
Charaxes polyxena (Cramer)
Issoria sinha (Kollar)
Euthalia phemius (Doubleday)
E. lepidea (Butler)
Doleschallia bisaltide (Cramer)
C. pyranthe (Linnaeus)
Colias electo fieldi Menetries
Delias acalis (Godart)
D. pasithoe (Linnaeus)
D. belladonna (Fabricius)
D. descombesi (Boisduval)
D. hyparete (Linnaeus)
Eurema blanda silhetana (Wallace)
E. brigitta rubella (Wallace)
E. hecabe (Linnaeus)
E. leata (Boisduval)
Ixias pyrene (Linnaeus)
Pieis brassicae nepalensis (Doubleday)
P. canidia (Sparrman)
P. napi (Linnaeus)
Prioneris thestylis (Doubleday)

Family : Hesperiidae

Badamia exclamationis (Fabricius)
Celaenorrhinus leucocera (Kollar)
Notocrypta curvifacia (Felder)
Pelopidas mathias (Fabricius)
Udaspes folus (Cramer)

AQUATIC FLORA and FAUNA

Annexure V.18

List of aquatic and semi aquatic macrophytes found in the catchment areas of the project.

Latin name	Family
Acanthus ilicifolius	Acanthaceae
Hygrophila auriculata	Acanthaceae
Alternanthera philoxeroides	Amaranthaceae
Centella asiatica	Apiaceae
Aponogeton echinatus	Aponogetonaceae
Aponogeton natans	Aponogetonaceae
Alocasia indica	Araceae
Colocassia esculenta	Araceae
Pistis stratioides	Araceae
Ageratum conizoides	Asteraceae
Eclipta prostrata	Asteraeae
Azolla pinnata	Azollaceae
Canna indica	Cannaceae
Ceratophyllum demersum	Ceratophyllaceae
Commelina bengahlensis	Commelinaceae
Ipomoea cairica	Convolvulaceae
Ipomoea aquatica	Convolvulaceae
Ipomoea aquatica	Convolvulaceae
Rotula aquatica	Cordiaceae
Carex cruciata	Cyperaceae
Cyperus diffuses	Cyperaceae
Cyperus difformis	Cyperaceae
Cyperus exaltatus	Cyperaceae
Cyperus iria	Cyperaceae
Eleocharis atropurpurea	Cyperaceae
Frimbristylis scaberrima	Cyperaceae
Kyllinga triceps	Cyperaceae
Phragmites karka	Cyperaceae
Scirpus supinus	Cyperaceae
Bergia ammannioides	Elantinaceae
Eriocaulon truncatum	Eriocaulaceae
Cajanus ascarabaeoides	Fabaceae
Ottelia alismoides	Hydrocharitaceace
Hydrilla verticillata	Hydrocharitaceae
Vallisneria spiralis	Hydrocharitaceae
Spirodea polyrhiza	Lemnaceae
Marsilia quadrifida	Marsiliaceae
Najas grminea	Najadaceae
Nelumbo nucifera	Nelumbiaceae
Nymphaea nauchali	Nympheaceae

Annexure V.18 List of aquatic and semi aquatic macrophytes found in the catchment areas of the project.	
Latin name	**Family**
Nymphaea stellata	Nympheaceae
Nymphoides hydrophylla	Nympheaceae
Nymphoides indica	Nympheaceae
Ludwigia perennis	Onagraceae
Oxalis corniculata	Oxalidaceae
Ceratopteris thalictroides	Parkeriaceae
Brachiaria mutica	Poaceae
Chrysopogon aciculatus	Poaceae
Echinochloa crusgalli	Poaceae
Echinochloa colona	Poaceae
Panicum sanguinale	Poaceae
Paspalidium geminatum	Poaceae
Saccharum arundinaceum	Poaceae
Zizania latifolia	Poaceae
Polygonum glabrum	Polygonaceae
Polygonum hydropiper	Polygonaceae
Polygonum pulchrum	Polygonaceae
Eichhornia crassipes	Pontederiaceae
Dentella repens (=Oldenlandia repens)	Rubiaceae
Hedyotis crataegonus	Rubiaceae
Salvinia auriculata	Salviniaceae
Salvinia cucullata	Salviniaceae
Limnophila chinensis	Scrophulariaceae
Limnophila indica	Scrophulariaceae
Lindernia antipoda	Scrophulariaceae
Lindernia ciliata	Scrophulariaceae
Lindernia parviflora	Scrophulariaceae
Stemodia viscosa	Scrophulariaceae
Sutera dissecta	Scrophulariaceae
Verbascum chinense	Scrophulariaceae
Typha angustata	Typhaceae
Alpinia calcarata	Zinziberaceae

Annexure V.19

Fishes (Pisces) of the reservoir and catchment area.

Latin name	Common name	Local name (Khasi)	Status
Catla catla	Catla		Very common
Cirrhinus mrigala	Mrigala	Kha mirka	Very common
Cirrhinus reba	Mrigala	Kha mirka	Common
Cyprinus carpio	Carp	Kha dkhar	Very common
Labeo bata	Major Carp	Kha bah	Common
Labeo boga	Major Carp	Kha bah	Common
Labio rohita	Rohu		Very common
Labeo calbasu	Calbas	Kha Jong	Very common
Labeo dero	Major Carp	Kha bah	Common
Labeo gonius	Major Carp	Kha ski	Common
Neolissochilus hexagonolepis	Major Carp	Kha dkhar	Common
Puntius chola	Major Carp	Shalynni	Common
Puntius clavatus	Major Carp		Common
Puntius sarana	Sarana		Common
Barilius barila		Kha Ilong	Common
Barilius barna		Kha Ilong	Common
Danio devario		Shalynni	Scarce
Garra annandalei		Doh Jei	Scarce
Garra lamta		Doh Jei	Scarce
Garra rupecula		Kha kulai	Scarce
Nemacheilus botia		Doh Sher	Common
Nemacheilus elongatus		Doh Sher	Common
Botia dario		Kha syiem	Common
Mystus bleekeri		Kha tynkra	Common
Mystus vittatus		Kha tynkriong	Very Common
Ompok bimaculatus		Kha Babia	Common
Ompok pabda		Kha Babia	Common
Wallago attu	Cat fish	Kha Buwa	Very Common
Ailia coila		Kha tungkra	Common
Bangarius bangarius		Kha khla	Scarce
Glyptothorax striatus		Doh Than	Scarce
Clarias batrachus		Kha Magur	Scarce
Heteropneustes fossilis		Kha singhi	Common
Chanda nama		Kha Snad	Common
Pseudambassis baculis		Kha Snad	Scarce
Pseudambassis ranga		Kha Snad	Scarce
Nandus nandus		Kha Sniang	Scarce
Badis badis		Kha Snoing	Scarce
Glossogobius giuris		Kha thli	Scarce
Anabas testudineus	Climbing Perch	Kha Koi	Scarce
Colisa fasciatus		Kha snoing	Scarce
Channa orientalis	Murrels	Dohthli	Common

Annexure V.19 Fishes (Pisces) of the reservoir and catchment area.			
Latin name	**Common name**	**Local name (Khasi)**	**Status**
Channa punctatus	Murrels	Dohthli	Common
Channa stewartii	Murrels	Dohthli	Common
Channa striatus	Murrels	Dohthli	Common
Macrognatha aral		Kha bain	Scarce
Macrognatha panacalus		Kha tynriew	Scarce
Mastacembelus armatus		Kha banein	Scarce
Chanduria indica		Kha bsein	Scarce

Annexure V.20

List of Annelids and Mollusca encountered during the survey in the sudy area..

Name of the species	***Habitat***
Phylum : **ANNELIDA**	
Megascolex mauritii	In damp loose soils with rich organic matter
Drawida willsi	Mostly in Paddy fields
Drawida limella	Mostly in Paddy fields
Drawidascandens	Mostly in Paddy fields
Branchiodrilus semperi	Aquatic benthic form
Myzostoma sp.	Damp soils
Stelechopus sp	Damp soils
Hirudinaria granulose	Aquatic, cattle leech
Myxobdella sp.	Hill streams, popular leach
Dinobdella sp.	Parasitic in wild animals and domestic animals, aquatic
Haemadipsa sp.	Land leech found in forest areas
Phylum : MOLLUSCA	
Pila globosa	Aquatic bodies
Rupertomenia borealis	Damp edges of stagnant waters
Wirenia argentea	Damp edges of stagnant waters
Simrothiella margaritacea	Stagnant water bodies
Kruppomenia borealis	Freshwater streams
Pachymenia abyssorum	Aquatic
Neomenia carinata	Damp areas
Nematomenia banyulensis	Damp soils near freshwater bodies
Cyclomenia sp.	Damp soils near freshwater bodies
Acanthochitona fascicularis	Damp soils near freshwater bodies
Cryptoconchus porosus	Water bodies
Notochiton mirandus	Water bodies
Haliotis cracherodi	Water bodies
Littorina tentaculata	Freshwater bodies
Pomatias sp.	Freshwater bodies
Adeorbis vitrinella	Freshwater bodies
Nassarius mutabilis	Freshwater bodies
Pterobranchia	Freshwater bodies
Cerethidia valvata	Freshwater bodies
Cellana sp.	Freshwater bodies
Neritina	Freshwater bodies
Turritella	Freshwater bodies
Goniobasis	Freshwater bodies
Theodoxus fluviatilis	Freshwater bodies
Crucibulum spinosum	Freshwater bodies
Hipponix antiquates	Freshwater bodies
Melanoides sp.	Freshwater bodies
Siliquaria	Freshwater bodies
Thais patula	Freshwater bodies
Patella vulgata	Freshwater bodies
Littorina littorea	Freshwater bodies

Annexure V.21 Aquatic insects collected from the reservoir and catchment areas		
ORDER	**FAMILY**	**LATIN NAME**
Coleoptera	Dytiscidae	*Cybister confusus*
Coleoptera	Dytiscidae	*Cybister tripunctatus*
Coleoptera	Dytiscidae	*Eretes strictus*
Coleoptera	Dytiscidae	*Hydaticus vittatus*
Coleoptera	Dytiscidae	*Santrascottus dejeani*
Coleoptera	Dytiscidae	*Canhydrus laetabilis*
Coleoptera	Dytiscidae	*Laccophilus pravulus*
Coleoptera	Dytiscidae	*Agathus sp.*
Coleoptera	Dytiscidae	*Neopasternus sp.*
Coleoptera	G yrinidae	*Dineulus indicus*
Coleoptera	G yrinidae	*Gyrinus sp.*
Coleoptera	Hydroplidae	*Hydrous indicus*
Coleoptera	Hydroplidae	*Hydrous sp.*
Coleoptera	Hydroplidae	*Sternolophus rufipes*
Coleoptera	Hydroplidae	*Berosus sp.*
Coleoptera	Hydroplidae	*Enochorus sp.*
Coleoptera	Hydroplidae	*Laccobius sp.*
Hemiptera	Notonectidae	*Anisops bouvieri*
Hemiptera	Notonectidae	*Anisops breddini*
Hemiptera	Notonectidae	*Anisops walterensis*
Hemiptera	Notonectidae	*Anisops barbata*
Hemiptera	Notonectidae	*Anisops sardea*
Hemiptera	Notonectidae	*Nychia marshalli*
Hemiptera	Pleidae	*Plea frontalis*
Hemiptera	Nepidae	*Ranatra filiformis*
Hemiptera	Nepidae	*Ranatra elongata*
Hemiptera	Nepidae	*Ranatra digitata*
Hemiptera	Nepidae	*Ranatra varipes*
Hemiptera	Nepidae	*Laccotrephes griseus*
Hemiptera	Belostomitidae	*Diplonychus rusticum*
Hemiptera	Belostomitidae	*Spaerodema annulatum*
Hemiptera	Belostomitidae	*Belostoma indicum*
Hemiptera	Corixidae	*Micronecta scutellaris*
Hemiptera	Corixidae	*Micronecta quadristrigata*
Hemiptera	Corixidae	*Micronecta thyesta*
Hemiptera	Corixidae	*Micronecta albifoons*
Hemiptera	Corixidae	*Micronecta heliplpides*
Hemiptera	Corixidae	*Corixa distorta*
Hemiptera	Corixidae	*Agraptocorixa sp.*
Odonata	Gomphidae	*Anax sp.*
Odonata	Libelluidae	*Macromia sp.*

Annexure V.22

Phytoplankton collected from the reservoir and catchment areas of the Umngot River during different seasons.

RAINY SEASON	WINTER	SUMMER
Chlorophyceace	Chlorophyceace	Chlorophyceace
Ankistrodesmus	*Ankistrodesmus*	*Ankistrodesmus*
Botryococcus	*Botrydium*	*Bahdomonas*
Chara	*Botryococcus*	*Bitricia*
Coelestrum	*Characium*	*Botrydium*
Dictyospergum	*Chlamydomonas*	*Botryococcus*
Euglena	*Chlorella*	*Chara*
Geminella	*Chlorella*	*Chlamydomonas*
Hormidium	*Coeleastrum*	*Cladophora*
Microspora	*Dinobryon*	*Coelestrum*
Nougeotia	*Distysphaerium*	*Dermatophyton*
Pediastrum	*Euglena*	*Euglena*
Protococcus	*Eutreptia*	*Hydrodictyon*
Sorastrum	*Hydrodictyon*	*Microspora*
Spirogyra	*Kirchneritla*	*Nougeotia*
Tetraspora	*Microspora*	*Oedogonium*
Tribonema	*Monalanthus*	*Richterella*
Ulothrix	*Nougeotia*	*Sacrastrum*
Volvox	*Ophiocythium*	*Spirogyra*
Zygnema	*Pediastrum*	*Tetraspora*
Bacillariophyceae	*Richterella*	*Tribonema*
Asterionella	*Schizogonium*	*Ulothrix*
Cyclotella	*Selenestrum*	*Zygnema*
Cymbella	*Sorastrum*	Bacillariophyceae
Diatoma	*Spirogyra*	*Amphora*
Frastulia	*Synura*	*Asterionella*
Gomaphonema	*Tetraspora*	*Campylodiscus*
Gysosioma	*Tribonema*	*Cyclotella*
Melosira	*Ulothrix*	*Cymbella*
Navicula	*Uronema*	*Diatoma*
Nitzchia	*Vaucheria*	*Fragilaria*
Pinnularia	*Volvox*	*Frastulia*
Stauroneis	*Xanthidium*	*Gomaphonema*
Surirella	*Zygnema*	*Gysosioma*
Synedra	Bacillariophyceae	*Melosira*
Tabellaria	*Asterionella*	*Navicula*
Cyanophyceae	*Cyclotella*	*Nitzchia*
Anabaena	*Campylodiscus*	*Pinnularia*
Coelosphaerium	*Cymbella*	*Stauroneis*
Merismopedia	*Diatoma*	*Surirella*
Microcystis	*Epithamia*	*Synedra*
Nostoc	*Frastulia*	*Tabellaria*

Oscillatoria	*Fraquillaria*	Cyanophyceae
Phormidium	*Frustulia*	*Coelosphaerium*
Polycystis	*Gomaphonema*	*Merismopedia*
Spirulina	*Gysosioma*	*Microcystis*
Desmids	*Hantzchia*	*Nostoc*
Closterium	*Melosira*	*Oscillatoria*
Desmodium	*Navicula*	*Phormidium*
Docicium	*Nitzchia*	*Spirulina*
Euastrum	*Pinnularia*	*DESMIDS*
Genucularia	*Stauroneis*	*Closterium*
Gonatozygon	*Surirella*	*Decidium*
Microasterias	*Synedra*	*Desmodium*
Microsterias	*Tabellaria*	*Genucularia*
Nestonemium	Cyanophyceae	*Microsterias*
Nestrium	*Anabaena*	*Nestaenium*
Pleurotaenium	*Coelosphaerium*	*Netrium*
	Merismopedia	*Plerotaenium*
	Microcystis	*Stauroastrum*
	Nostoc	
	Oscillatoria	
	Phormidium	
	Polycystis	
	Rivularia	
	Spirulina	
	DESMIDS	
	Closterium	
	Cosmarium	
	Desmodium	
	Docicium	
	Euastrum	
	Genucularia	
	Gonatozygon	
	Microsterias	
	Netrium	
	Spirotaenia	

Annexure V.23

Zooplankton collected from the reservoir and catchment areas of the Umngot River during different seasons

RAINY SEASON	WINTER	SUMMER
Rotifers	Rotifers	Rotifers
Ascomorpha	*Ascomorpha*	*Ascomorphella*
Asplanchna	*Asplanchna*	*Asplanchna*
Brachionus	*Brachionus*	*Brachionus*
Chromogaster	*Brachionus*	*Chromogaster*
Collotheca	*Castropus*	*Collotheca*
Conochilus	*Cephalodela*	*Conochilus*
Epighanes	*Chromogaster*	*Epighanes*
Pilinia	*Collotheca*	*Pilinia*
Gastropus	*Conochilus*	*Gastropus*
Kellicottia	*Epighanes*	*Kellicottia*
Keratella	*Euchlanis*	*Keratella*
Monostyla	*Gastropus*	*Mystilina*
Noteus	*Kellicottia*	*Noteus*
Nothocla	*Keratella*	*Nothocla*
Poleosoma	*Lacane*	*Poleosoma*
Polyarthra	*Monostyla*	*Polyarthra*
Rattalus	*Noteus*	*Rotaria*
Rotaria	*Nothocla*	*Salpina*
Salpina	*Pilinia*	*Synchaeta*
Synchaeta	*Pleosoma*	*Trichocera*
Trichocera	*Poleosoma*	COPEPODS
COPEPODS	*Polyarthra*	*Cyclops*
Cyclops	*Rattalus*	*Diaptomus*
Diaptomus	*Rotaria*	*Nauplius*
Nauplius	*Salpina*	CLADOCERANS
CLADOCERANS	*Synchaeta*	*Alonella*
Alonella	*Testudinella*	*Bosmina*
Bosmina	*Trichocera*	*Ceriodaphnia*
Chydorus	*Trichocerca*	*Chydorus*
Moina	*Wigrella*	*Sida*
Simocephalus Simocephalus	COPEPODS	*Simocephalus*
	Brycocamoyus	
	Cyclops	
	Diaptomus	
	Nauplius	
	CLADOCERANS	
	Alonella	
	Bosmina	
	Camptocercus	
	Canthocamotus	
	Ceriodaphnia	

Annexure V.23

Zooplankton collected from the reservoir and catchment areas of the Umngot River during different seasons

RAINY SEASON	WINTER	SUMMER
	Chydorus	
	Daphnia	
	Diaphanosoma	
	Leotodora alona	
	Moina	

Annexure V.24. List of trees identified for avenue and homestead plantations.		
Local / common name	Latin name	Family
Austalian wattle	*Acacia auriculiformis*	Mimosaceae
Borpat	*Ailanthus grandis*	Simaroubaceae
Safed Siris	*Albizia procera*	Mimosaceae
Amari	*Amoora wallichii*	Meliaceae
Kadam	*Anthocephalus cadamba*	Rubiaceae
Chaplash	*Artocarpus chaplasha*	Moraceae
Mundani	*Artocarpus fraxinifolius*	Moraceae
Birch	*Betula alnoides*	Betulaceae
Semul	*Bombax ceiba*	Bombacaceae
Kurta	*Calophyllum polyanthum*	Clusiaceae
Dhoop	*Canarium resiniferum*	Burseraceae
Indian Horn Beam	*Carpinus viminea*	Betulaceae
Indian Chestnut	*Castanopsis speciosa*	Fagaceae
Gonsorai	*Cinnamomum cecicodaphne*	Lauraceae
Khokan	*Duabanga sonneratioides*	Lythraceae
Gamari	*Gmelina arborea*	Verbenaceae
Jacaranda	*Jacaranda acutifolia*	Bignoniaceae
Lagerstoemia	*Lagerstoemia parviflora*	Lythraceae
Badam	*Mansonia dipikai*	Sterculeaceae
Champ	*Michelia champaca*	Magnoliaceae
Bola	*Morus laevigata*	Moraceae
Khasi pine	*Pinus kesiya*	Pinaceae (Conifer)
Podocarpus	*Podocarpus neriifolia*	Podocarpaceae (Conifer)
Rhododendron	*Rhododendron arboreum*	Ericaceae
Chilauni	*Schima wallichii*	Theaceae
Sal	*Shorea robusta*	Dipterocarpaceae
Spathodia	*Spathodia companulata*	Bignoniaceae
Talauma	*Talauma phellocarpa*	Magnoliaceae
Teak	*Tectona grandis*	Verbenaceae
Bhelu	*Tetrameles nudiflora*	Tetramelaceae
Toon	*Toona ciliata*	Meliaceae
Ahoi	*Vitex peduncularis*	Verbenaceae

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - I

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Chapter - VI

CLIMATE AND METEOROLOGY

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

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VI

CLIMATE AND METEOROLOGY

Introduction

6.01 Before start of any Environmental Impact Assessment study, it is essential to identify the baseline status of relevant environmental parameters which are likely to be affected as a result of the construction and operation of the proposed project. A similar approach has been adopted for conducting the Environmental Impact Assessment study for the proposed Umngot Hydro Electric Project. Planning of the baseline survey commenced with the short listing of impacts and identification of parameters for which necessary data is collected.

6.02 The Umngot HE project is proposed for diversion of storage water for generating power. The site was selected considering minimum submergence, better storage capacity, socio economic interests and aspects.

6.03 The whole of Meghalaya is a plateau interspersed with high hills and deep valleys across the state .The southern face of the state, where the Umngot HEP is located, is marked by deep gorges, spurs and abrupt slopes. Through deep cut valleys and escapes rush down swift flowing rivers, like the Umngot, towards the southern plains leaving in their way numerous cataracts which are very amenable for development of hydroelectric power. The catchment is situated in the mid-central upland, specially called the Shillong Plateau. The plateau extends east-west with altitudes ranging from 150m to 1965 m above MSL. The entire plateau is mountainous but the eastern and western extensions are relatively lower. Shillong peak is the highest point on the plateau from where the origin of the river Umngot is very near.

Climate

6.04 The climate in the catchments, as in the whole of Meghalaya, is determined by the altitude of the land surface and 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 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.

6.05 The four distinct seasons are as below:

*	Spring	:	March to April (Pre-monsoon)
*	Monsoon	:	May to September
*	Autumn	:	October to November (Post monsoon)
*	Winter	:	December to February (Post monsoon)

Climatic Factors

6.06 The four major factors that determine the climate of a project area are (a) rainfall; (b) temperature; (c) Relative humidity and (d) wind velocity. Required data relating to the above factors has been collected from the Indian Meteorological Department GOI to the extent of availability. The above four climatic factors are discussed below

Temperature

6.07 The mean Maximum and Minimum temperatures observed in 1999-2000 years are 25.1^{0}C and 6.1 ^{0}C. The variations of temperatures are marginal. The four seasons start with spring during March/April during which the atmosphere gradually warms up and the temperature hots up by May. The summer season starts as soon as the South-West monsoon winds begin to blow in the last part of May and lasts till the end of September or early October. Autumn follows and cool temperature prevails upto the end of November. Winter lasts till the end of February.

Rainfall

6.08 The directly draining catchment at Umngot HE project dam site is 304 sq.km. The catchment is in East Khasi hills district and Jaintia hills district in two blocks each. Data was utilized for DPR preparation from 8 numbers of raingauge stations in the catchment area which are (i) Umphyrnai; (2) Kharang ; (3) Umngot ; (4) Jatah ; (5) Sohmynting ; (6) Nongjrong; (7) Puriang ; (8) Pommura. The rain gauge stations are located inside the catchment area.

6.09 The site of Umngot H.E Project is located at an altitude of about 940 m above mean sea level, across the Umngot River near village Siangkhanai in the East Khasi Hills District in Meghalaya. The climate of the sub basin is characterized by torrential rains caused by South West monsoon from mid May to October and 60% to 70% rainfall occurs between June and September. The normal mean annual rainfall of the project area is 3530.626 mm.

6.10 The mean monthly rainfall data of the Umngot catchment area for the years from 1991-1992 are furnished in Tables 6.1, where as the month wise rainfall data for all the rain guage station are being collected.

Relative Humidity

6.11 The Umngot Hydro-Electric Project is situated in the humid region where the relative humidity is high. The monthly relative humidity is observed at the observatory station located by MeECL. The relative humidity values are in the range of 35% to 82% in the post monsoon season, 65% to 85% during hot weather season and 76% to 82% in the monsoon season. The season-wise relative humidity relating to the years of observation for the project area as a whole are being collected. .

Wind Speed and wind Direction

6.12 The wind speed is observed to be moderate in the project area. As per the observation, the wind speed during post monsoon season varied between 1.0 to 9.0 kmph, in hot weather period varied between 1.0 and 3.0 kmph and in monsoon season it varied between 1 to 2 kmph. Warm moist winds blow in Southwest direction during summer and cold winds from the north-west during winter. The wind speeds and direction at dam site of Umngot as a whole for year (December) is given in Table 6.2. The wind rose diagram of Shillong IMD station which is 70 km away from project site have been procured from IMD for the years for 1996-2001 and are appended as Appendix– 3.

Noise and Air Pollution Sources

6.13 The main cause of air and noise pollution is due to the construction activity and the socio-economic development. Due to this eventually there will be short-term impact on the surroundings. The activities that will increase the air pollution are the vehicular movement, excavation and other related construction activities. The air pollution is generated due the activities of the temporary human settlements also. The same activities will have impact on the noise environment also. For the study required data was collected from the project area and it is overviewed in an angle to estimate how the area will be polluted with the activity.

Table - 6.1 : UMNGOT HE PROJECT
TOTAL MEAN MONTHLY RAINFALL IN MM
CATCHMENT AREA (304 SQ.KM.)

Month / Year	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
JUN		790.82	1302.53	1021.40	1513.09	943.08	1003.36	928.93	768.63	1379.85	728.68	1465.61	1252.80	584.94	544.56
JUL		879.14	870.01	360.77	1118.95	1155.76	998.45	998.45	1161.22	459.36	966.68	1085.22	958.92	1990.33	581.59
AUG		364.48	735.58	488.39	847.64	424.95	481.59	454.45	553.63	766.41	450.34	481.89	305.76	378.17	804.84
SEP	966.38	378.19	380.72	200.63	528.79	284.85	371.33	388.45	168.43	376.24	535.40	405.44	194.83	416.49	154.02
OCT	542.93	195.92	246.21	276.86	102.82	755.47	63.89	50.60	431.57	298.41	313.15	48.32	400.95	737.90	308.84
NOV	0.33	14.09	20.24	29.31	228.93	0.00	12.05	8.79	25.98	0.00	21.73	230.00	18.13	1.05	8.57
DEC	49.23	12.81	2.91	3.21	4.34	0.00	21.61	14.70	2.15	0.00	0.00	0.00	11.59	3.30	0.07
JAN	3.47	71.22	16.85	11.99	7.72	6.47	8.45	8.45	10.09	1.50	38.31	3.80	1.36	5.09	0.00
FEB	25.32	16.39	49.60	36.37	36.15	27.34	5.82	5.82	8.65	34.34	6.90	9.56	5.84	7.89	4.03
MAR	28.16	198.02	143.33	9.42	56.63	63.33	157.58	135.56	78.60	31.80	56.95	119.00	58.67	194.20	23.51
APR	165.35	196.29	99.09	62.62	127.39	207.47	180.36	182.85	203.08	162.64	342.79	125.67	271.68	188.95	190.85
MAY	254.75	351.94	570.46	389.20	332.07	273.04	388.48	353.58	695.98	237.81	333.09	145.85	295.64	298.37	615.85
ANNUAL TOTAL	**2035.92**	**3469.30**	**4437.53**	**2890.16**	**4904.52**	**4141.75**	**3692.96**	**3530.63**	**4108.02**	**3748.36**	**3794.01**	**4120.36**	**3776.15**		**3236.73**

Table – 6.2 Ambient Noise Levels in the Project Area : Residential Category (dB(A) Leq)					
Sl. No.	Date of Observation	Noise levels st Siangkhrai (dam site)		Noise Levels at Synting (Power house site)	
		Day time	Night time	Day time	Night time
1	Monsoon season				
	28.06.2008	48.7	42.7	47.1	40.2
	23.07.2008	47.1	40.2	48.7	42.7
	Average	47.9	41.5	47.9	41.5
2	Post-monsoon season				
	04.11.2008 / 06.11.2008	49.3	41.1	49.0	40.0
3	Pre-monsoon season				
	28.03.2009	50.6	41.2	50.2	42.6
	Standards	**55.0**	**45.0**	**55.0**	**45.0**

Noise environment

6.14 The noise environment is one of the prime concerns in any project as it may cause problems in the project area. Exposure to excessive noise may lead to the following:

- Prevention of sleep, insomnia and fatigue ;
- Decrease in speech reception, communication, distraction and diminished concentration which adversely affect the job performance or efficiency of the worker attached to the works where there is high noise;
- Chronic psychological disturbance including impaired hearing; and
- In certain extreme cases, there are irreparable cardiovascular damages.

6.15 The noise levels in the sampling stations were recorded on hourly basis using sound level meters. The average sound level in each sampling station for day time (7.00 am to 6.00 pm) and night time (7.00 pm to 6.00 am) are computed. Study conducted to know the existing noise levels in the region indicate that the noise levels are in normal range. The existing noise levels at Syntung and Siangkhanai of Umngot H.E project area have been observed during monsoon season post-monsoon season of 2008 and pre-monsoon season of 2009. The levels found to range between 40.2 and 48.7 dB (A). The results are shown in Table: 6.2

6.16 Ambient Noise Levels observed during day and night times were found to be within standard limits for Residential area as prescribed vide EPA Notification. The noise level recorded is mainly attributed to climate conditions, i.e due to intense rainfall and strong winds.

Impacts on Noise levels

6.17 Broadly, the possible impacts due to the project proposal on noise environment are little. The main impacts occur during the construction activity period. Excavators are used for removing the topsoil and drilling and blasting is done to clear the rocky area, then the following equipments will generate the corresponding noise levels vide Table 6.3. Increased noise levels are anticipated only during construction phase due to operation of various equipments, increased vehicular traffic and blasting tunnel ting etc. Increased noise level especially blasting could scare away wildlife from the area. Since no major wildlife is reported in the area, significant impacts are not anticipated on this account. Free noise alternation distance, noise levels generated at different times and maximum permissible and poser to sound intensities are shown in tables 6.4, 6.5 and 6.6 respectively.

Table – 6.3
Noise Levels generated by Various Equipments

S. No	Equipment or machinery	Noise levels generated in db (A)
1.	Excavator	70-90
2.	Tippers	70-85
3.	Drill	85-95
4.	Compressor	75-90
5.	Turbine	80-90
6.	Motor scraper	85-92
7.	D.G. set	80-90
8.	Vibrator	70-80
9.	Compactor	81-85

Table – 6.4
Free Noise Attenuation with Distance

Noise level at Source db (A)	Distance in m	Noise level at receptor db (A)
90	100	42
90	200	36
90	300	33
90	400	30
90	500	28

Table 6.5 Noise levels that are generated by various equipments at different times		
Machines	**Conditions**	**Noise Levels db (A)**
Tippers	While being loaded	78-85
	Traveling with load	76-83
	Traveling without load	75-80
Drill Machine	Close to the Machine with Compressor	88-95
	50 mts away from the Machine	75-85
	100 mts away from the Machine	60-65

Table – 6.6 Maximum permissible exposure to sound intensities	
Sound level dB(A)	Maximum exposure hours
90	8.000
93	4.000
96	2.000
99	1.000
102	0.500
105	0.250
108	0.125

6.18 It is inferred from the above table that maximum exposure levels is 8 hrs for noise level of 90 db (A) and 0.125 hrs for noise level of 108 db(A) Leq.

Ground Vibrations Due to Blasting:

6.19 At project site there is a requirement for tunnels and canal construction and clearance of rocky surface, where blasting or tunnel boring machines are required. When an explosive charge is fired in a hole, stress waves propagate radically in all directions and cause the rock particles to oscillate. This oscillation is felt as ground vibration. The vibration intensity, experienced by structures, can be characterized by three parameters viz. Amplitude, frequency and particle velocity. Out of these, the Peak Particle Velocity (PPV) has been considered as the best damage criterion.

Conclusions and recommendations are as follows:

1. The air over pressure (Sound level) due to blasting should be well within limits.
2. The vibrations due to blasting can be further minimized by adopting the following measures.
   - Ensure systematic burden and spacing
   - Ensure designed depth and inclination of blast holes, keeping the sub-grade drilling to optimum
   - Ensure proper free face for first row of holes

6.20 The recommendations of regulatory authority should be strictly followed. As the blasting pattern shall be minimal, there is no danger to any structures from ground vibrations due to blasting in future.

Air Environment

6.21 Assessment of impacts on air environment and feedback for environmental management Program (EMP) requires information of ambient air quality status. The data has been collected, analyzed and evaluated through a well-designed air quality surveillance program. The basic considerations for designing such a program include information on micro-meteorological conditions, quantity, quality, location, time availability, and resources, monitoring technology and operation criteria. All these aspects were considered for devising operational scheme for air quality monitoring along the proposed activity.

Ambient Air Quality in the Project Area

6.22 The ambient air quality measurements are monitored in the project area. The prime objective of the Ambient Air Quality Monitoring (AAQM) is to assess the existing levels of air pollution as well as the regional background of air basin surrounding the site. Two ambient air quality-monitoring stations were selected and monitoring was carried out depending upon the importance of the site / location and prevailing meteorological situation. The ambient air quality results obtained from Meghalaya State Pollution Control Board, Shillong during the study period presented in this report are considered as the baseline status of the air quality in the project area. The results are presented subsequently in this chapter.

Sampling Methodology

6.23 The sampling duration was fixed at 24 hours for all the parameters based on the guidelines of Ministry of Environment and Forests (MOEF). Sampling was done at two locations (Dam site and Powerhouse site), during monsoon season July, 2008 and Autumn season November 2008 and during Winter in January 2009. The analysis for SPM, RPM, SO_2 and NOx parameters were carried out by Meghalaya State Pollution Board. The parameters analyzed were found to be within the permissible limits of Ambient Air Quality Standard (National) for Residential, Rural areas as per EPA Notification GSR176 (E), April 02, 1996.

The status of Ambient Air quality has been observed at the following locations:

i) Siangkhanai Village,(MeECL-1Guest House), East Khasi Hills 2 kms from Barrack to Damsite
ii) Syntung Village, East Khasi Hills 4 kms from Syntung Village to power house

The results of the Ambient quality levels in the existing status are tabulated below in Table – 6.7

Environmental Impact Evaluation:

Impact evaluation

6.24 In this report attempt has been made to evaluate the impact on the environmental terms. The environmental parameters considered are those that have some impact due to the proposed activity. The environmental impact evaluation of possible effects as a result of proposed activity and various environmental parameters is primarily based on careful study of plans, geological field survey, its operation, surrounding environment, etc. The aspects, such as air components of environment have been assessed on the basis of experience for similar activities. The environmental impacts identify the possible relationship of proposed activity with respect to environmental parameters. These relationships can be beneficial or adverse and can be classified as short term or long term, reversible or irreversible, local or regional.

Impacts on AIR

6.25 The impact on air environment on the surroundings is mainly during construction phase. Most of the operations are mechanized and are operated on Diesel. This activity contributes to increase in suspended particulate matter (SPM), SO_2 and NO_x. Indirect air pollution may be there due to co and HC. The attached activity like the temporary human settlements near the project will also have impact but it is insignificant when compared to the other sources of air pollution. The listing of major pollutants, their sources and effects of the same are presented in Annexure VI.1

6.26 The list of Potential pollution generating equipments and the level of pollution generated by them is quantified in the following paragraphs.

Table – 6.7
AMBIENT AIR QUALITY STATUS

Sl. No	Season Pollutants	Permissible limits for residential rural and other areas	Locations							
			Sianghkhanai (dam site)				Syntung (power house site)			
			6.00pm - 10.00 am	2.00 am - 10.00 am	10.00 am – 6.00 pm	Average 24 hrs	6.00pm - 10.00 am	2.00 am - 10.00 am	10.00 am – 6.00 pm	Average 24 hrs
I	Monsoon (7/2008)									
	SPM		22.1	20.0	18.0	20.0	21.1	18.6	23.0	20.7
	RPM		20.7	19.0	17.0	18.9	20.1	17.0	21.5	19.5
	SO_2		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	NOx		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
II	Winter (11/2008)	Period of observation	4.00 pm – 12.00 am	12.00 am – 8.00 am	8.00 am – 4.00 pm	Average	6.00 pm – 2.00 am	2.00 am – 10.00 am	10.00 am – 6.00 pm	Average
	SPM	200.00	30.3	24.0	37.5	30.6	38.0	27.2	50.3	38.5
	RPM	100.00	14.3	3.7	18.4	12.1	18.0	19.4	2.8	13.4
	SO_2	80.00	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	NOx	80.00	4.5	4.5	4.5	4.5	0.57	6.88	0.65	2.7
III	Autumn (1/2009)		2.00 pm – 10.00 pm	10.00 pm – 6.00 am	6.00 am – 2.00 pm	Average	5.00 pm – 1.00 am	1.00 am – 9.00 9m	9.00 am – 5.00 pm	Average
	SPM	200	42.2	36.5	40.5	39.7	52.1	42.5	60.0	51.5
	RPM	100	36.2	28.4	33.3	32.6	45.1	36.0	51.0	44.0
	SO_2	80	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	NOx	80	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5

Table 6.8 Major pollutants and sources				
S. No	**Equipment**	**Activity**	**Mode of operation**	**Emissions of pollutants**
1	Shovel	Excavation	Diesel	SPM, SO_2 & NO_x
2	Tippers / Trucks	Transportation	Diesel	SPM, SO_2 & NO_x
3	Compressors	Drilling	Diesel	SPM, SO_2 & NO_x
4	D.G. Set	Power supply	Diesel	SPM, SO_2 & NO_x

Table – 6.9 Fuel consumption details of certain equipment			
S. No	**Type of Equipment**	**Average Fuel Consumption (lts/hr)**	**Approximate No. of vehicles or equipment to be used in a Day**
1	Shovel	49	20
2	Tippers	10	50
3	Compressor	26	10
4	D.G. Set	55	5
5	Tanned boring machine	100	2

Sources and release of pollutants from road transportation are given below :

S. No	Description	Emission in gm/m^2			
		Dust	NOx	SO_2	CO
1	Transport Empty	0.000011	0.0001	0.000011	0.000078
2	Transport loaded	0.000031	0.00015	0.000017	0.000117

Calculation of Emission factor for SO_2

Sulphur dioxide emission factor = 138 lb X (% of Sulphur)/ 1000 gallons of Diesel

= 138 lb X (0.25)/1000 gallons

= 34.5 lb/ 1000 gallons = 3.44 gms/ ltr of Diesel

6.27 Based on No. of vehicles or Equipment, quantity of Fuel used, SO_2 emissions can be calculated as follows:

No. of vehicles or equipment used = 87

Total diesel consumed by them in litres per hour: 980 + 500 + 260 + 275 + 200 = 2217

Total SO_2 emitted by the equipments and vehicles is 2.12 gms/ sec

Calculation of Emission factor for NO_x

NOx emission factor = 68 lb/1000 gallons of Diesel = 6.79 gms/ ltr of Diesel

Based on No. of vehicles or Equipment used, quantity of Fuel used NO_x emissions can be calculated as follows:

No. of vehicles or equipments used = 87

Total diesel consumed by them in litres: 2217

Total NO_x emitted by the vehicles and equipment is **4.18-gms/ sec**

6.28 The emissions of the vehicles and equipments are moderate in quantity and the pollution due to the activity is short term as the vehicles and equipment are operated for few hours only in the region and not concentrated at one place. The nearest habitation Siangkhanai about 2 kms from the proposed Umngot dam site and Syntung is about 2.5 km from the proposed power house. Hence the effect of the emissions on the habitations is minimal. The generated air pollution due to the activity will be dispersed easily since the region has an average wind speed around 3-kmph and above and the dispersion of the air emissions is easier. The wind direction is south west direction towards North west during winter. The nearest habitations Siangkhanai is towards west of the proposed dam and syntung is towards North West of the proposed power house. However the Air pollution will be minimal.

6.29 The different parameters of ambient air quality are with permissible limits as per the baseline data. The proposed activity has little or marginal adverse effect on various environmental parameters related to air quality, and noise levels while they have positive impact on socio-economic status of community. The proposed activity creating air pollution such as fugitive emissions from drilling, excavation, construction material handling, etc have marginal adverse effects with respect to air quality and aesthetics during construction phase. Utmost care has to be taken because even in the case of minor lapses, appreciable adverse effects may be possible.

Environmental Benefits and Estimation of CDM revenues

Clean Development Mechanism (CDM)

6.30 Emission of Green House Gases (GHG) like Carbon Dioxide (CO_2), Methane (CH_2), Nitrous Oxide (N_2O), Hydro Flouro Carbons (HFCs), Perflouro Carbons (PFCs) and Sulphus Hexaflouride (SFs), etc, into the atmosphere results in Global Warming. In order to control and regulate emission of these gases, United Nations Framework Convention on Climate Change (UNFCCC) adopted land mark 'Kyoto Protocol' on December 11, 1997 at Kyoto, Japan. In the Kyoto Protocol, developed countries were made mandatory to reduce Green house Gas emissions to an extent of 5.2% below to 1990 level during first commitment period 2008-2012. India signed the Protocol on August 26, 2002. The Kyoto Protocol came into force on February 15, 2005. The Kyoto Protocol divided the countries into 41 industrialised developed countries whose per capita emissions are high and 145 other developing countries. Targets for reducing emissions for fixed to developed countries and no targets were fixed for developing countries for the first commitment period. For the purpose of meeting targets three flexible mechanisms were identified. They are 1) Joint Implementation; 2) Clean Development Mechanism; and 3) Emissions Trading.

6.31 Out of the above three mechanisms, Clean Development Mechanism (CDM) is applicable to developing countries implementing projects that reduce emission of green house gases. The Clean Development Mechanism (CDM) allows developed countries to fund projects in developing countries that reduce GHGs. In return the developed countries receive Certified Emission Reduction Units (CERs) also called carbon credits from UNFEEE, which can be used to meet their targets. 1 CER stands for one tone of carbon dioxide reduction. Government or Private organisations in developing countries may implement the projects that can reduce CO2 emissions and obtain CERs from UNFCCC. These CERs can be sold to any parties in developed countries at mutually agreed rates. Thus, potential role of carbon finance and the Clean Development Mechanism has attained global importance. The Government of India has set up National CDM Authority under Ministry of Environment & Forests on April 16, 2004 to approve the projects coming under CDM. This authority clears the CDM projects submitted to it after thorough scrutiny of meeting the eligibility criteria.

MeSEB Initiative and Selection of Project

6.32 MeECL is responsible for generation of Power, including operations and maintenance, renovation & modernization etc. They are also in the process of setting up new hydro capacities in the state of Meghalaya. The MeECL is responsible for the coordinated development as it is a major beneficiary of the south west monsoon. The government has been taking several initiatives such as generation capacity addition, strengthening of T&D network, participation of private sector etc, in order to improve the overall situation of power sector in the state. The share of power sector outlay in Meghalaya has been increased to 26.5% of the total outlay in the 9th plan towards meeting power sector requirement. The per capita energy consumption in the state in just 337.58 units as computed national average of about 450 units. Further, of the total 5337 inhibited villages, 3428 villages have been electrified as on 2006. The percentage of house holds having electricity is only 64.2%.

Project Activity

6.33 The main purpose of the project activity is to generate electrical energy through sustainable means without causing any negative impact on the environment and to contribute to climate change mitigation efforts.

6.34 Apart from the generation of electrical power, the project also contributes to the following:

a) Sustainable development, through utilization of renewable hydro resources available in the project region.

b) Avoid emission of 261 tons of particulate matter, 3265 tons of sulphurdioxide, 933 tons of nitrogen oxide and 0.38 million tons of carbon dioxide.

c) Avoid discharge of 1.44 million tons of liquid effluent.

d) Avoid 0.13 million tons of ash accumulation in the ash ponds.

e) Apart from the above, fugitive emissions, requirement of fuel oil can be avoided. Rural area development due to the location of the project being proposed in rural area.

f) Capacity addition to the present installed capacity and increase in the energy availability.

g) Generation of additional employment.

CDM Revenues for the Project

6.35 The project is likely to avoid emission of substantial CO_2. The project will become eligible for Clean Development Mechanism (CDM) benefits and revenue is likely to be accrued from sale of CERs (Certified Emission Reduction Units) which is a carbon credit from a CDM project, expressed in tonnes of carbon dioxide equivalent (CO_2 e) after registering the project at UNFCCC under CDM. One CER represents one tonne of CO_2 equivalent which may be sold on the international emissions market. This will reduce the unit cost to Rs 0.41 per unit of energy and the details of the same are furnished in Table 6.10 below.

Table 6.10

Estimated CDM Revenues for the Project

1	Design Energy per annum	838.73	MU
2	Auxiliary Power Consumption	8.39	MU
3	Ex-bus energy, (1-2)	830.34	MU
4	Baseline Emission factor for NE Grid for FY 2005-06 [#]	420	t/MU
	or	0.42	t/mWH
5	Expected CERs per annum, (3 x 4)	348743.93	t CO_2e
	or	348744	Units
6	1 Certified Emission Reduction Unit (CER) =	20	US$
	or	980	Rs
7	Expected Revenue Generation (4 x 6)	3,417.69	Rs lakhs
8	Reduction of cost of Unit generation, (7/3)	0.41	Rs/Unit
		41.16	Paise/Unit

 # Source : http://www.cea.nic.in/planning/c%20and%20e/ user_guide_ver2.pdf: Weighted average emission factor, simple operating margin (OM), build margin (BM) and combined margin (CM) of all Indian regional grids for FY 2005-06 (adjusted for inter-regional and cross-border electricity transfers included), in tCO2/MWh)

Conclusions

6.36 With the above mentioned aspects and results it is clear that the activity will have minor and short term effect on Air & Noise environment during development phase and will have a lot of beneficial impacts during operation. In the operational phase of the project there will be good improvement in aesthetics, greenbelt, air quality, water levels, etc. The establishment of the project has no detrimental effect on the surroundings but will in fact benefit them as it will develop the aesthetic value and increase the green belt area.

Annexure –VI.1

MAJOR POLLUTANTS, THEIR SOURCES AND EFFECTS ON HUMAN HEALTH, VEGETATION, MODULES AND AESTHETICS

Pollutants	Major sources	Human Health	Vegetation	Materials	Aesthetics/Nuisances	Comments
CO_2	Transportation, Industrial processes	Reacts with hemoglobin, reducing mental attentiveness, physical exertion and exacerbating cardio vascular disease symptoms	None	None	None	Past knowledge was based on study of high exposure for short periods with healthy, young individuals. New data show possible health effects for susceptible persons at CO levels in the blood found in urban populations
NOx	Transportation space heating/cooling, power generation	Interfere with respiratory function producing long term (chronic) disease symptoms	Reduction of growth of broad leaves plants (tomatoes, beans)	Accelerated deterioration of dyes and paints	Creation of a brownish color in urban air	Conclusion are based on limited exposure of healthy adults to low doses, extensive animal studies, and only limited data

Pollutants	Major sources	Human Health	Vegetation	Materials	Aesthetics/Nuisances	Comments
						relevant to ambient condition
HC	Transportation, Industrial processes	Interfere with respiratory functions and cause eye irritation	None	None	None	Indirectly polluting through the production of photochemical oxidants upon reaction with NO &NO_2 in the presence of sunlight
Photo Oxidants	Transportation space heating/cooling, power generation	Same as HC	Severe reduction in death and eventual death of leafy vegetables, field and forage crops, shrubs, fruit and forest trees caused by Ozone and PAN	Ozone causes the cracking of rubber and the accelerated deterioration of nylon, rayon, dyes and paints.	Ozone has a distinct although not terribly offensive odour.	O_3 is the most common type and the key indicator for Photo Oxidants. Health effects are based on limited and inadequate data. Ozone, PAN are formed by atmospheric reactions

Pollutants	Major sources	Human Health	Vegetation	Materials	Aesthetics/Nuisances	Comments
SOx	Space heating/cooling, power generation, Industrial processes	Little effect on pure gas form; similar effects as particulates when combined with them	Reduction of growth of broad leaves plants	Corrosion of iron, metal, accelerated deterioration of building stone, cotton, paper, leather, paints etc.	Scattering of sunlight to produce haze production of unpleasant odours	SO_2 is readily converted to SO_3 and then to H_2SO_4
Particulates	Space heating/cooling, power generation, Industrial processes, oil erosion	Interfere with respiratory function, possible contribution of lung cancer	Reduction of plant growth by physical blockage of light on the leaf surface	Soiling of fabrics and building and corrosion of metals when combined with SO_2	Creation of smog plumes, scattering of sunlight to produce colorful sunsets & helps formation of fog	The effects of particulates are difficult to separate from those of SO_2

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - I

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Chapter - VII

PUBLIC HEALTH

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART – 1

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

VII

PUBLIC HEALTH

Introduction

7.01 Public Health constitutes one of the most important aspects of Environmental Impact Assessment in construction of a reservoir or a dam. The health and hygiene of the population residing in the Project area is of great importance in Environment Impact Assessment (EIA) and needs special attention. The habitations near the project area have been studied in detail from the point of view of impact of the proposed project on health and hygiene of the people. Present level of the incidence of water borne diseases, their control and present delivery system and its adequacy are also analyzed in this chapter. Even though the storage capacity of reservoir is small, it is likely to affect the status of occurrence of water borne diseases to some extent. This impact is attributed to likely change in the pattern of prevailing diseases due to disturbance in the existing environmental status in the form creation of two reservoirs, which may act as the breeding grounds for mosquitoes. The influx of new diseases into the area will be due to the migration of labour to the project area during the construction phase. Hence, an attempt has been made in this chapter to study the prevailing water borne diseases and the impact of project on water borne and other diseases in the area.

Prevailing Water Borne Diseases

7.02 Environmental hazards on human health can be divided into two broad categories, namely:

a) Lack of access to essential environment resources, chief among them are clean water, air, food, shelter and fuel: and
b) Exposure to hazards in the environment which include agents like micro-organics, insects etc. like bacteria, Parasites and virus, which contribute to the burden of infectious diseases.

7.03 It is second health hazard that is very important from the human health point of view. The role of these biological agents become more pronounced and significant in hydro project area as water related power projects vis-à-vis diseases, there are two groups of water related diseases, viz., water bass and the water related vector borne diseases which are the most prevalent and important in the project area. Biological agents are implicated in most of the gastro-enteritis diseases, respiratory diseases and more importantly Malaria, Filaria, Japanese Encephalitis and Schistosomiasis, etc. It could thus be seen that of all the environmental hazards human encounters, the formidable foes remain the micro-organisms and the insects' vectors. The present status of the diseases, control and the health delivery systems operating in the project area are highlighted below:

Malaria

7.04 Malaria is the most deadly of the insect borne diseases. It is very debilitating in nature, therefore it is also called the 'laziness' disease. It is the most prevalent disease in poor rural regions. It produces frequent infections with attacks of fever in warm and rainy season just when the services of the rural population are required for sowing, intercultural operations upto harvesting of crops.

7.05 Malaria is caused by four different species of protozal parasites belonging to the Plasmodium species, important among those being the two species Plasmodium vivax and Plasmodium falciperum. Malaria is transmitted through the bite of "Anopheles" mosquito. The severity and complications of Malaria vary from mild to serve depending upon the species of the plasmodium which has caused the infection immunity status of the patient, the intensity of the infection and also the presence of concomitant conditions such as malnutrition or other diseases.

7.06 The proposed Umngot HEP area spreads over Mawkynrew and Mawryngkneng blocks of East Khasi Hills district on the right flank of the river, Amlarem and Thadlaskein blocks of Jaintia Hills districts on the left flank. No cases of Malaria were reported in the blocks in East Khasi Hills district during the last 5 years, while Stray cases were reported in the villages under Jaintia Hills district. The number of Malaria cases reported in Jaintia Hills district is shown in Table 7.1

Table 7.1- Incidence of Malaria – Jantia Hills district during 2004-2005 to 2008-2009				
Sl. No	Year	Incidence of Malaria cases in blocks		
		Amlarem	Thadlaskein	Total
1	2004-2005	-	7	7
2	2005-2006	-	4	4
3	2006-2007	-	6	6
4	2007-2008	-	9	9
5	208-2009	-	21	21

Gastroenteritis and Other Intestinal infectious diseases

7.07 Several cases of Gastroenteritis and other infectious diseases were reported in the connected blocks of East Khasi Hills district and Jaintia Hills districts. The details of the incidence of the GE and other infectious diseases area furnished in Table 7.2 for the last five years i.e., from 2004 - 2005 to 2008 – 2009.

Table 7.2 : Incidence of Gastroenteritis and other infectious diseases								
Sl. No	Year	Incidence from 2004 to 2009 in districts						Grand Total
		East Khasi Hills (Blocks)			Jaintia Hills (Blocks)			
		Mawkynrew	Mawryngkneng	Total	Amlarem	Thadlaskein	Total	(Nos)
I. GASTROENTERITIS								
1	2004-05	1005	-	1005	-	85	85	1090
2	2005-06	963	-	963	-	88	88	1051
3	2006-07	842	-	842	-	100	100	942
4	2007-08	333	162	495	-	80	80	575
5	2008-09	237	513	750	-	82	82	832
II. Other Infectious Diseases								
1	2004-05	1447	12	1459	-	118	118	1577
2	2005-06	816	41	857	-	108	108	965
3	2006-07	599	24	623	-	54	54	677
4	2007-08	186	100	286	-	64	64	350
5	2008-09	830	36	866	-	42	42	908

7.08 In spite of non availability of data in respect of Amlarem block of Jaintia Hills district, it can be opined that the present status of gastroenteritis and other infectious diseases in the project area is on higher side on the right flank and on lower side on the left flank of Umngot river. Tropical aggregation of labour and the insanitary and unhygienic conditions already prevailing in the area may perhaps lead to the incidence of such diseases.

7.09 Other diseases such as Amoebiasis, Diarrohoea, Helminthiasis, Shigellesis, Viral-Hepatitis-A and Filariasis are also prevailing in the project area, though in a small scale. The number of cases reported is tabulated as in Table 7.3

Table 7.3 : Number of Cases Reported of Diseases Such as Amoebiasis, Diarrheoa etc.,

Sl. no	Diseases	District	Years					
			2004-05	2005-06	2006-07	2007-08	2008-09	Average
1	Amoebiasis	EKHD	505	330	51	224	169	256
		JHD	234	272	206	137	150	200
2	Diarrhoea	EKHD	5117	4612	3646	3218	3566	4032
		JHD	359	395	518	668	710	530
3	Helminthiasis	EKHD	-	-	-	-	-	-
		JHD	218	239	222	204	253	227
4	Shingellesis	EKHD	-	-	-	-	-	-
		JHD	125	163	131	121	88	126
5	Hepatitis A	EKHD	-	-	-	-	-	-
		JHD	2	-	-	-	-	0.4
6	Filaria	EKHD	-	-	-	-	-	-
		JHD	-	-	-	-	-	-

7.10 The above table infers that average annual number of 256 cases and 200 in East Khasi Hills district and Jaintia Hills district which can be taken as moderate large number of Diarrhoea cases are being reported annually (4032) in respect of East Khasi Hills district where as they are less in the case of Jaintia Hills district. Other diseases in Jaintia Hills district are moderate. The diseases are likely to increase during construction and operation phases of the HEP. Higher number of waterborne diseases suggests improvement of sanitary conditions to check the spread of water borne diseases.

7.11 Open drainage system is prevalent in all the areas. In most of the villages open defecation is observed. Adequate sanitation facilities are also not available in the areas. Drainage system is also lacking in the areas; so much so open defecation is very common. It is a known fact that fecal matter is a store house of infection. Flies and other insects get attracted to the fecal matter and carry germs causing Gastroenteritis and other such related diseases. These become all the more virulent during the rainy season when water gets accumulated.

7.12 Tropical aggregation of labour during project construction will further aggravate the situation, as they would also be resorting to open defection unless the contractors take proper steps in constructing good toilet facilities. The creation reservoir under the project will change the micro-climate in the area. Due to evaporation of water round the year from the reservoir will create moist conditions in the area near to the reservoir. Such moist conditions along with impounded water in the reservoir will provide ideal conditions for growth of insects like mosquitoes. This in turn will lead for increase insects born diseases like malaria, filarial, JE, etc.,.

Sexually Transmitted Diseases (HIV / STD)

7.13 In recent years, sexually transmitted diseases like HIV in general are gaining ground. The intermingling of labour both within the project area and those coming for employment from out side will increase the scope of STD and HIV diseases. Thus adverse impact on health is anticipated due to the project even though they are not prevalent at present. Looking to the favorable conditions for the spread of some of the diseases like Malaria, respiratory diseases like Asthma, STD and HIV, necessary steps should be taken to ensure adequate and prompt health delivery system under the Environment Management Plan.

Health Care and Health Delivery System

7.14 As per the information furnished by the DHMO's of East Kahsi Hills and Jaintia Hills districts there are Primary Health Centers and CHC sub-centres around the project area. These are tabulated as in Table 7.4.

Table 7.4: PUBLIC HEALTH CENTERS

Sl. No	Name of block	Medical Centers			
		PHCS	CHCS (Subcentres)	Others	Total
	EAST KHASI HILLS DISTRICT				
1	Mawkynrew	1	-	-	1
2	Mawryngkneng	-	-	--	-
3	Urban Area SHILLONG	-	-	Civil hospital	1
	JAINTIA HILLS DISTRICT				
1	Amlarem	7	2	-	9
2	Thadlaskein	14	6	-	20
3	Urban Area JOWAI	-	-	Civil Hospital	1

7.15 As is evident from the above table, PHCs and other medical centres are meager in the connected blocks of East Khasi Hills district which may be the reason for the large number of GE, other infectious diseases, Amoebiasis and Diarrhea in the area. On the contrary the medical centers in the Jaintia Hills district are more. Thus there is urgent need to improve the health care facilities in the project area in order to curb the pace of the diseases in view of the constructions of Umngot HEP which will increase the labour activities in the area.

Environment Impact Assessment

7.16 The study revealed that lack of health, hygiene and sanitation in the project area would cause the following impacts.

- During the construction phase large number of labour force will be employed. The labours are generally housed in temporary colonies with sheds which may be far from satisfactory from the point of view of sanitation. The seasonal congregation of labour at the project site can create new health problems. The project workers may come from non-malarial zone of vice-versa thereby increasing the incidence of Malaria. Similarly, due to intermingling of local population and the migrated labour, chances of increase in HIV can be suspected.

- If proper toilet facilities are not provided, the construction labours resort to open defecation. The feacal matter is the biggest source of infection of diseases like Ameobiasis, worms, etc. Similarly, during the rainy season, the poor sanitary system contributes towards increases in Gastro Enteritis, Diarrhea, etc.

- Pollution due to dust and debris during the construction phase at the project site would lead to lung and respiratory diseases.

- Poor quality of drinking water may also lead to water borne diseases.

Summing up

7.17 It could thus be summed up that the construction of the project can cause the following environmental impacts on Public health.

- Increase in the spread of water borne diseases like Malaria, G.E; and other infectious diseases, Amoebiasis, Diarrhea, etc.,

- Incidence of AIDS and Sexually Transmitted diseases.

- Debris, dust and cement would increase the respiratory and lung diseases like asthma, bronchitis and other such diseases.

7.18 It is, therefore, necessary to plan mitigative measures to keep the impacts at the minimum both during construction and in post – construction phases.

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Chapter - VIII

CATCHMENT AREA TREATMENT

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVORINMENT MANAGEMENT PLAN (EMP)

VIII

CATCHMENT AREA TREATMENT

Introduction

8.01 Umngot River is one of the major Southerly flowing river in Meghalaya state with origination at the junction of Nongkrem road and NH-44 at an altitude of 1840 m. The river is flowing along the border of East Khasi Hills and Jaintia Hills districts. Umngot Hydro Electric Project is proposed on the river after it traverses for a length of about 51 Km from its origin. The drainage is of trellis pattern.

8.02 A dam is proposed on the Umngot River near Siangkhanai village in East Khasi Hills district. The proposed reservoir envisages generation of (3x80 MW) 240 MW of Hydro power. In order to prevent degradation of soils and promote terrestrial ecology so as to reduce sedimentation into the reservoir, the treatable area in the catchment is to be identified and proper mitigative measures, such as biological and engineering measures are to be proposed. The ensuing paragraphs provide details.

8.03 **River Basin**: The Umngot river sub basin forms part of Surma river main basin in Bangladesh. The river flows towards East for a distance of about 22 Km through dense shrubs and jungle with gentle gradient. From there the river takes a short turn towards South along the border of East Khasi Hills and Jaintia Hills districts and flows a further distance of 5 Km thorough rapids where it is joined by a major tributary. It then takes a mild turn towards East for about 4 Km, to join another tributary Umtang nalla from the West. . From this point the river flows in a zig-zag fashion towards south for a distance of 20 km before reaching village Jarain and then it takes a short turn towards East with rapids and falls. 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 proposed dam site intercepts catchment area of 304 sq.km.

8.04 The catchment area is spread over East Khasi Hills and Jaintia Hills districts and in the following blocks

1. East Khasi Hills
    a) Mawkynrew
    b) Mawryngkneng

2. Jaintia Hills
    a) Amlarem
    b) Thadlas Kein

No projects exist on Umngot River on upstream of the proposed dam location or on the downstream upto the confluences of tailrace.

Need for Catchment Area Treatment

8.05 It is a well-established fact that reservoirs formed by dams on rivers are subjected to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entrainment, transportation, deposition and compaction of sediment. The steady erosion and sediment accumulator in reservoir reduces its capacity, and thus affecting the water availability for the designated use. The eroded sediment from catchment when deposited on streambeds and banks cause braiding of river reach. Thus, a well designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above mentioned adverse impacts of soil erosion.

8.06 Soil erosion may be defined as the detachment and transportation of soil. Water is the major agent responsible for this erosion. In many locations, winds, glaciers, etc., also cause soil erosion. In a hilly catchment area, erosion due to water is a common phenomenon and the same has been studied as a part of the Catchment Area Treatment (CAT) Plan. The total annual rainfall in the Umngot HEP catchment area varied between 2890 to 4904 mm during the years 1991-92 to 2005-2006. Hence soil erosion in this area will be very high.

8.07 The catchment Area Treatment (CAT) Plan highlights the management techniques to control erosion in the catchment area of HE project. The life span of a reservoir is greatly reduced due to erosion in the catchment area. Adequate preventive measures are thus needed for the treatment of catchment for its stabilization against future erosion. The total catchment area is directly draining catchment area and considered for treatment under the present project. The catchment area treatment involves

- Understanding of the erosion characteristics of the terrain; and
- Suggesting remedial measures to reduce the erosion rate.

8.08 In the present study 'Silt Yield Index' (SYI) method has been used. In this method, the terrain is sub-dived into various small sub-watersheds and the erodibility is determined on relative basis. SYI's provide comparative erodibility criteria of catchment (low, moderate, high, etc.) and do not provide the absolute silt yield. SYI method developed by All India Soil and Land Use Surveys (AISLUS), is widely used and can be applied to areas like sub-watersheds of Umngot HEP.

Approach and Methodology of the Study

8.09 A detailed database on natural resources, terrain conditions, soil type of the catchment area, socio-economic status, etc. is a pre-requisite to prepare treatment plan keeping in view the concept of sustainable development. Various thematic maps have been used in preparation of the CAT Plan. Due to the spatial variability of the site parameters such as soils, topography, land use and rainfall, all areas do not contribute for erosion equally. Several techniques like manual overlay of spatially index-mapped data have been used to estimate soil erosion in complex landscapes. In order to ensure that latest and accurate data is used for the analysis, satellite data has been used for deriving land use data and ground truth studies too have been conducted. The various steps covered in the study are data acquisition, data preparation and output presentation. The steps are briefly described in the following paragraphs.

Data Acquisition

8.10 The requirement of the study was first defined and the outputs expected were listed. The various data layers of the catchment area used for the study are as follows:

- Land use Classification map
- Slope map
- Soil map
- Surface drainage map

8.11 Digitalized contours from toposheets were used for preparation of Digital Elevation Model (DEM) of the catchment areas and to prepare a slope map. The fist step in generation of slope map is to create surface using the elevation values stores in the form of contours or points. The output of the digitization procedure was the contours as well as points on contours in form of x,y & z points (x,y location and their elevation). All this information was in real world coordinates (latitude, longitude and height in meters above sea level). A Digital Terrain Model (DTM) of the area was then prepared, which was used to derive a slope map. The slope was divided into classes of slope percentages.

Estimation of soil loss using silt Yield Index (SYI) Method

8.12 The Silt Yield Index (SYI) considering sedimentation as product of erositvity, erodibility and aerial extent was conceptualized in the All India Soil and Land Use survey (AISLUS) in 1972. The methodology has been progressively refined overtime and tested for validity. The sediment detachment process predominates in the upland phase where as sediment transport and deposition are the main processes in low land phase. The most basic sediment yield model that could be conceived should involve precipitation, runoff, infiltration, soil characteristics and transport component. The erosivity determinants are the climatic factors and soil and land attributes that have direct or reciprocal bearing on the unit 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)

8.13 Sediment delivery from a hydrologic unit to a reservoir is a multiplicative function of the potential soil detachment representing the erosivity factor, transportability of the detached material (delivery ratio) and area of hydrologic entity. This can be expressed as

Sediment Yield = f x delivery ratio x area

So, the erosivity is simulated whereas the delivery ratio is adjusted with the sediment yield weightage value, by the likely delivery of the eroded material

8.14 The Silt Yield Index (SYI) is defined as the yield per unit area and SYI value for hydrologic unit is obtained by taking the weighted arithmetic mean over the entire area of the hydrologic unit by using suitable empirical equation.

Prioritization of Watersheds / Sub-watersheds

8.15 The prioritization of smaller hydrologic units within the vast catchments is based on the Silt Yield Indices (SYI) of the smaller units. The boundary values or range of SYI values for different priority categories are arrived at by studying the frequency distribution of SYI Values and locating the suitable breaking points. The watersheds / Sub watershed are subsequently rated into various categories corresponding to their respective SYI values. The application of SYI model for prioritization of sub-watershed in the catchment area involved the evaluation of:

a) Climatic factors comprising total precipitation, its frequency and intensity,

b) Geomorphic factors comprising land forms, physiography, slope and drainage characteristics;

c) Surface cover factors governing the flow hydraulics and

d) Management factors.

8.16 The data on climatic factors can be obtained for different locations in the catchment area from the meteorological stations whereas the field investigators are required for estimating the other attributes. The various steps involved in the application of model are:

⇒ Preparation of a framework of sub-watersheds through systematic delineation

⇒ Generation of map indicating erosion- intensity mapping units.

⇒ Assignment of weightage values to various mapping units based on relative silt-yield potentional;

⇒ Computing silt Yield Index for individual watershed / sub-watersheds

⇒ Grading of watersheds / sub-watershed into very high, high, medium, low and very low priority categories.

8.17 The area of each of the mapping unit is computed and silt yield indices of individual sub-watersheds are calculated using the following equation:

Silt Yield Index

$$SYI = \frac{\sum (Ai \times Wi \times Di) \times 100}{Aw} : \qquad \text{where } i = 1 \text{ to } n$$

Where
Ai = Area of i^{th} unit (EIMU)
Wi= weightage value of i^{th} mapping unit
N = No. of mapping units
Aw= Total area of sub-watershed
Di = Adjusted delivery ratio assigned to the mapping unit.

8.18 In general no adjustment is initially carried out for sub-watershed located within the periphery of 40 km from the reservoir site. The SYI values obtained thus are further adjusted by multiplication with a suitable factor to account for the deposition of the material enroute the reservoir site.

8.19 The gradation and assignment of priority ratings to the sub-watershed are based on the descending values of sediment yield index / runoff the potentional index values. An abrupt change in the number of sub watershed is indicative of the breaking points and is deciding factor for fixing upper and lower limits of different priority categories. The boundaries for the various categories are shown in Table 8.1

Table 8.1
Boundaries for the Various Categories for Prioritization of Sub-watersheds

S.No.	Priority categories	SYI Values
1	Very High	> 1300
2	High	1200 – 1299
3	Medium	1100 – 1199
4	Low	1000-1099
5	Very Low	< 1000

Characteristics of Catchment Areas

8.20 Characteristics of catchment areas such as land use/ land cover, slope and soils have been generate through RS imageries and GIS for Umngot river upto dam site. The details are discussed in the following paragraphs.

A) Land Use and Land Cover.

8.21 Land use and land cover mapping was carried out by standard methods of analysis of remotely sensed data followed by ground truth collection and visual interpretation of satellite data. For this purpose digital data on CDROMs was procured from National Remote Sensing Agency (NRSA), Hyderabad. Digital image processing of the satellite data and the analysis of interpreted maps were carried out using ERDAS imagine 8 .6 and arc GIS for GIS analysis.

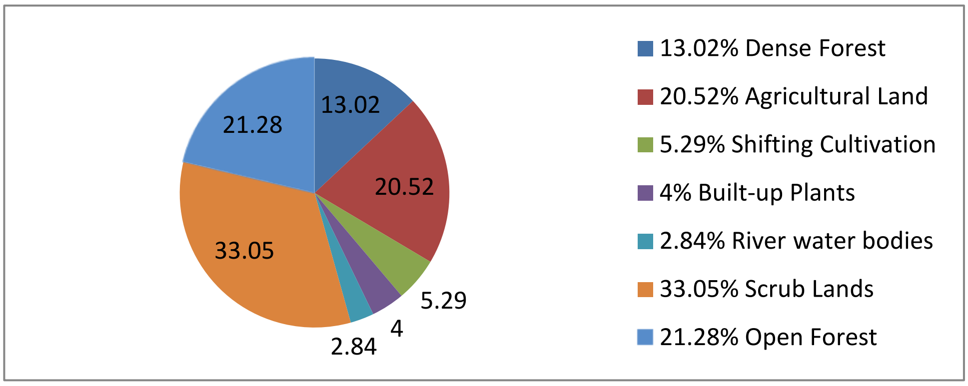
8.22 The IRS P6 Liss-III full sense for the year January 2009 was procured from NRSA for image processing and thematic map preparation. Before processing of image for image enhancement, transformation or classification, pre-processing was done for band separation. Geo-referencing of the composite image was done using digital vector layer of drainage, road network, water bodies and other permanent grant features extracted from SOI toposheet. Distinguishable ground control points (GCPs) both on image and vector data base were identified and using these GCPs the image was resampled and geo-coded. The digital vector layer for the entire catchment area was used as a mask to extract the required area from the image for further processing.

8.23 The spatial distribution of land use and land cover analysis for the catchment area of Umngot River upto the proposed dam location is furnished in Table 8.2

Table 8.2.
Umngot river – Catchment area – Land use / Land cover

S.No.	Classification	Area in ha	%
1.	Shifting cultivation	1611	5.29
2.	Agricultural Land (current fallows)	6245	20.52
3.	Dense forest	3963	13.02
4.	Open forest	6475	21.28
5.	Scrub lands / Tree clods	10058	33.05
6.	Built-up lands (Settlements)	1216	4.00
7.	River / Water bodies	865	2.84
Total		30433	100.00

8.24 The table indicates forest lands in the catchment area occupy 34.30 percent where as scrublands account for 33.05 percent of the total catchment area. Arable lands including shifting cultivation area accounted for 25.81 percent. Map indicating the land use / land cover of the catchment area is appended as Fig VIII.I



Slope Classification:

8.25 The total catchment area upto the dam location is assessed to be 30433 ha. Five groups of slope categories i.e. 0-5 percent, 5-10 percent, 10-15 percent, 15-35 percent and above 35 percent are considered for slope analysis. The area under different slope categories as worked out through remote sensing technique is presented in table 8.3.

Table 8.3 :
Slope Classification of Umngot Catchment area

S.No.	Classification	Percentage	Area in ha.	Percentage to total Area
1.	Gentle to moderate	0-5	2238	7.36
2.	Gentle steep	5-10	2503	8.22
3.	Moderate steep	10-15	2509	8.24
4.	Steep	15-35	9328	30.65
5.	Very step	>35	13855	45.52
Total			**30433**	**100.00**

8.26 The table indicates that strong slopes of above 35 percent are to an extent of 45.52 percent in view of the topography of the catchment area, followed by slopes of 15-35 percent accounting 30.65 percent of the total area. Areas with normal slopes of 0 to 15 percent are only about 23.82 percent of total catchment area. Map showing the different slope classifications is appended as Fig. VIII.2

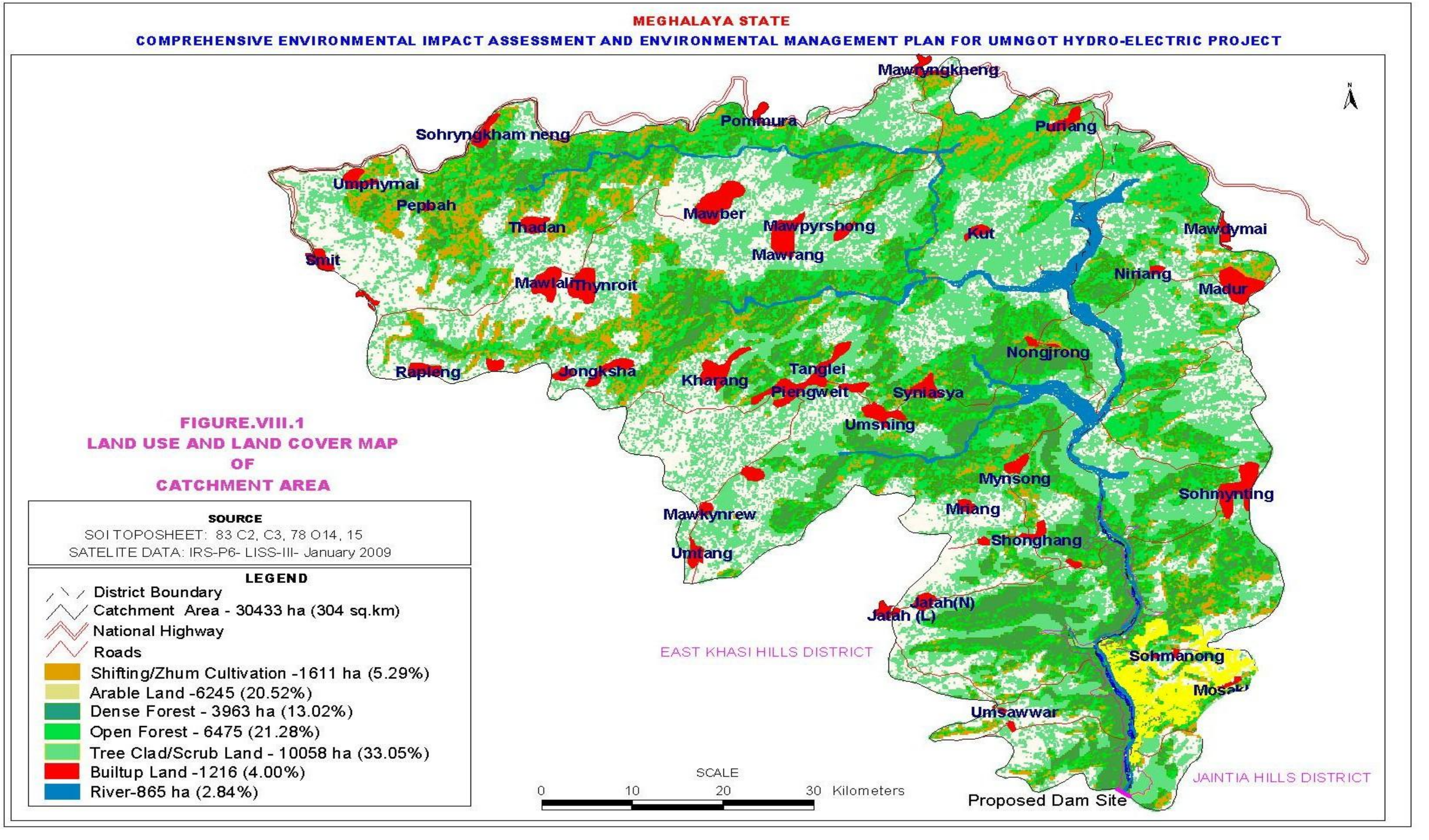
Soil Characteristics

8.27 Umngot basin is geologically formed mainly by the Jaintia group of rocks; oralying over the Archean Gneissic rocks which formed a substantial part of Granite, Quartzite Schists, Sills and dykes. The soil thickness is very thin in most of the catchment area. The highlands are divided into hills foot slopes pediments plains, valleys and flood plains.

8.28 Red loamy soil occupies the northern portion whereas the southern part comprises of mainly red, yellow soil. Stony waste land and grass lands occupy most of the drainage basin. The soils in the undulating plains, plains and valleys are excessively drained deep to moderately deep. Shallow, excessively drained loamy stealetal soils on moderatively steep side hill slopes prevail to a minor extent. Coarse loamy soils prevail on gently sloping hill tops. Fine loamy soils; also exist in gently sloping hip tops. The soils in the entire catchment exhibit severe to very severe erosion hazard. The areas under different classification of soils are given in Table.8.4

Table 8.4 Catchment area – Soil classification

S.No.	Mapping Unit No.	Classification	Area (ha)	Percentage
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**


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
FIGURE.VIII.1
LAND USE AND LAND COVER MAP
OF
CATCHMENT AREA
SOURCE
SOI TOPOSHEET: 83 C2, C3, 78 O14, 15
SATELITE DATA: IRS-P6- LISS-III- January 2009
LEGEND
District Boundary
Catchment Area - 30433 ha (304 sq.km)
National Highway
Roads
Shifting/Zhum Cultivation -1611 ha (5.29%)
Arable Land -6245 (20.52%)
Dense Forest - 3963 ha (13.02%)
Open Forest - 6475 (21.28%)
Tree Clad/Scrub Land - 10058 ha (33.05%)
Builtup Land -1216 (4.00%)
River-865 ha (2.84%)
SCALE
0 10 20 30 Kilometers
Mawryngkneng
Pommura
Puriang
Sohryngkham neng
Umphymai
Pepbah
Thadan
Mawber
Mawpyrshong
Mawrang
Kut
Mawdymai
Smit
Mawlai
Thynroit
Niriang
Madur
Nongjrong
Rapleng
Jongksha
Kharang
Tanglei
Piengwelt
Syniasya
Umsning
Mynsong
Sohmynting
Mawkynrew
Mriang
Shonghang
Umtang
Jatah(N)
Jatah (L)
EAST KHASI HILLS DISTRICT
Sohmanong
Mosaki
Umsawwar
JAINTIA HILLS DISTRICT
Proposed Dam Site

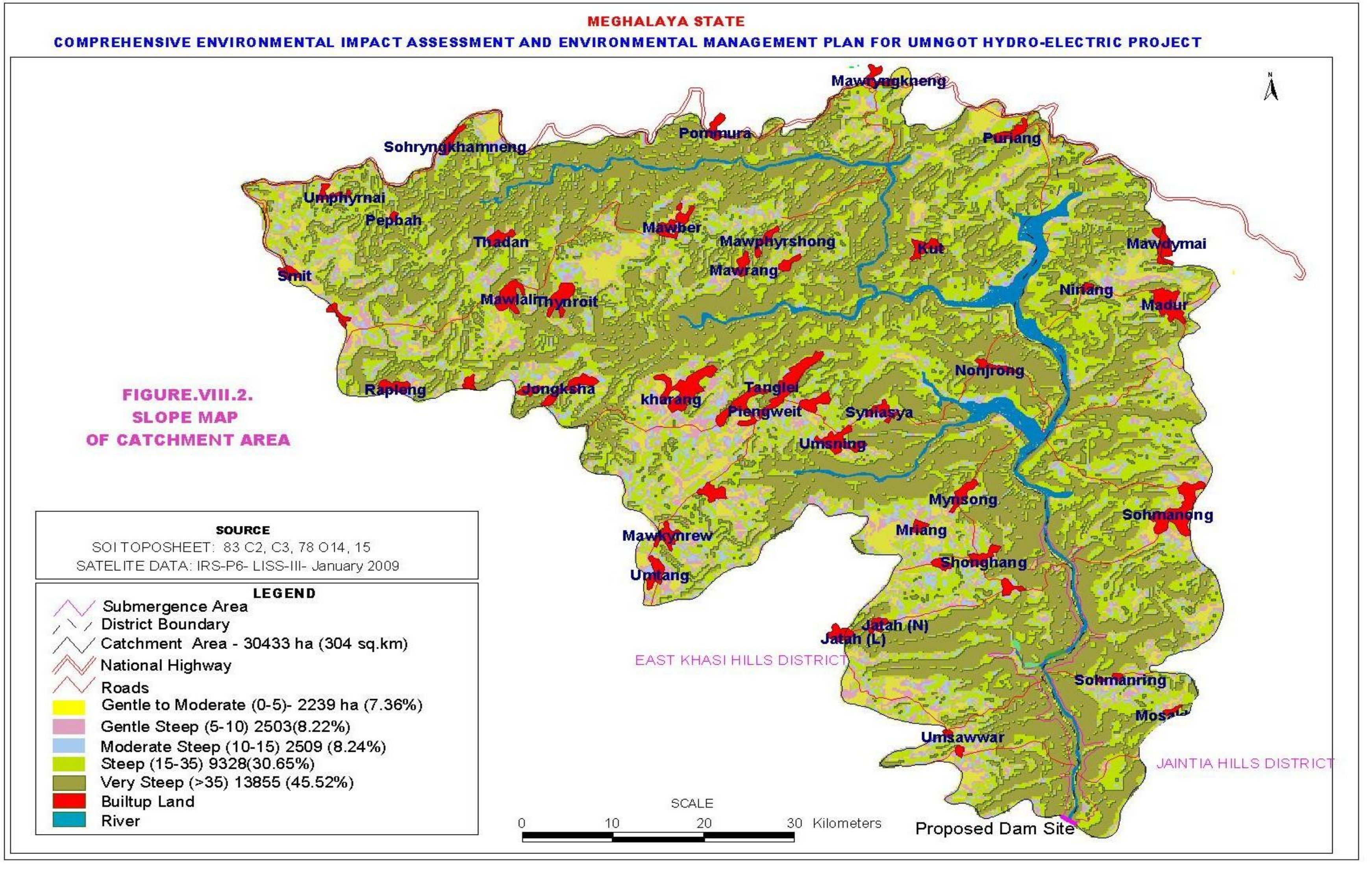


FIGURE.VIII.2.
SLOPE MAP
OF CATCHMENT AREA

Vegetation

8.29 The catchment area for planned reservoir consists of a few patches of dense forests (Serbs and mixed forest). The topography of the area is generally hill and undulating and is conducive for soil erosion which is manifested in the form of sheet, rill and gully erosion. About 5.29 percent of the area is under shifting cultivation. Irrigation is usually not practicable and almost absent. The natural vegetation ranges from coniferous trees in the upper region to temperate forests in the middle and stony waste lands and grass lands in the lower hills. No wild life or bird sanctuaries located near or inside the catchment area. The general flora species available in the project area are as follows;

- Pine
- Cry ptomeria tropical pine
- Ex-buclandia
- Alder
- Tita Chap
- Pama
- Myrica spp

8.30 The details of the vegetation were already discussed under chapter V (Part-I) Biological environment. The density of forests in the area close to the settlements is degraded as a result of human interferences. Large parts of the study area are barren land without any tree cover. The soil map showing the erosion status in the different sub water sheds in appended as Fig.VIII.3

Prioritization of Sub Watersheds – Ratings

Land Use / Land cover

8.31 The total catchment area of Umngot river upto the dam for HEP is 304 sq.km. For the preparation of watershed management plans in the catchment area, the later is divided into small hydrological units. In total the area is divided into 19 micro-watersheds with areas ranging from 754 ha to as high as 2736 ha. The land use / land cover of the micro watersheds using R.S. techniques is shown in Table 8.5. The land use land cover is one of the determinant factors as for arriving at the SYI and thereby prioritization. Map showing the land use / land cover with delineation Micro watersheds is shown in Fig. VIII.4

Table-8.5

UMNGOT HE PROJECT – WATERSHED-WISE AREA UNDER LAND SE AND LAND COVER

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

Table-8.5 UMNGOT HE PROJECT – WATERSHED-WISE AREA UNDER LAND SE AND LAND COVER									
S.No	**Micro WSNO**	**Shifting Cultivation**	**Arable Land**	**Dense Forest**	**Open Forest**	**Tree Clad/Scrub Land**	**Built-up**	**River**	**Total**
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**
Source: Computed by AFCL									

Slope

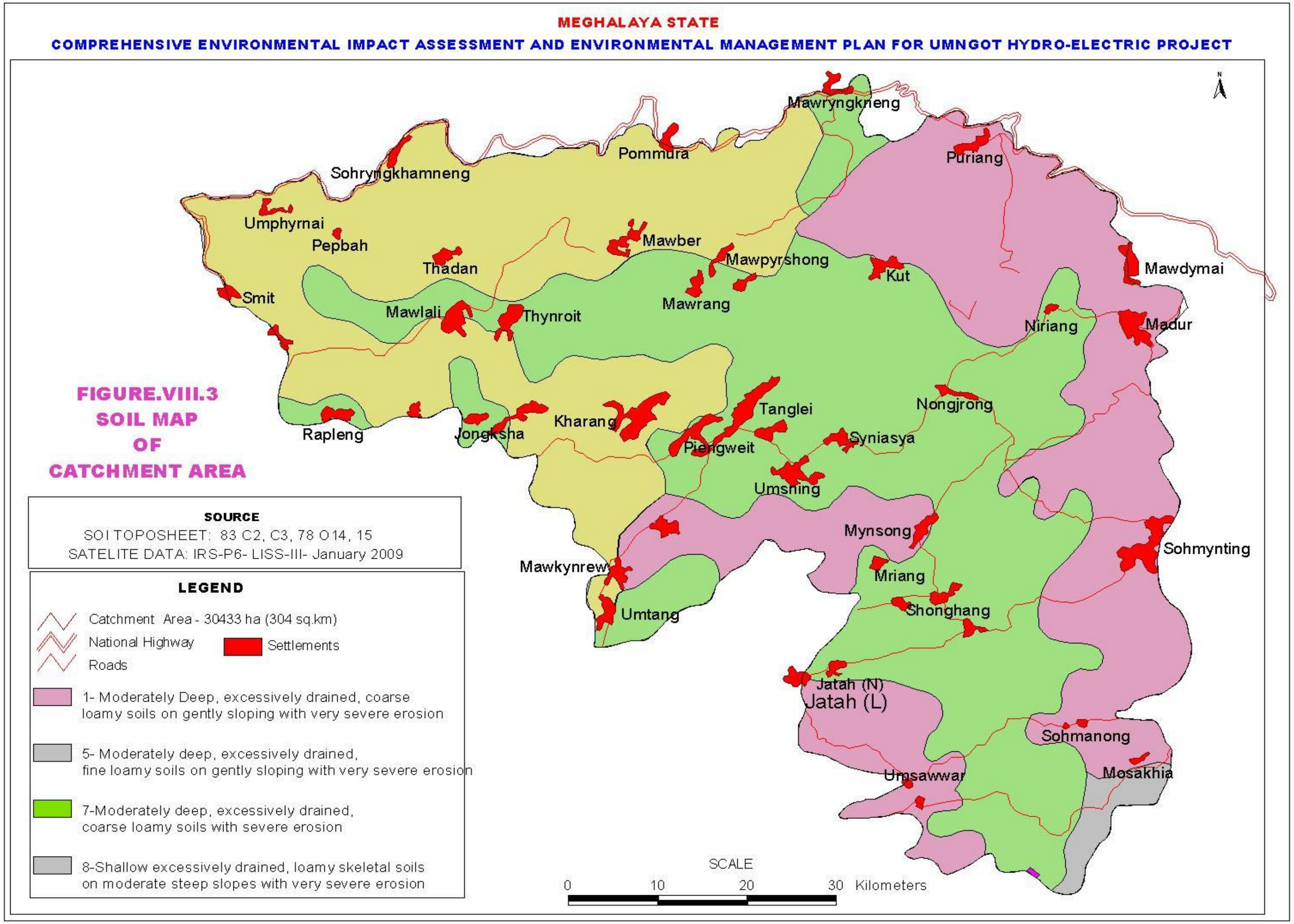
8.32 The slope of the terrain in the catchment area is also one of the determinant facts as for arriving at the SYI and thereby prioritization. Slope analysis for the different sub watersheds has been done and given in the table 8.6. Map showing the slope with delineation of sub watershed is appended in Fig. VIII.5

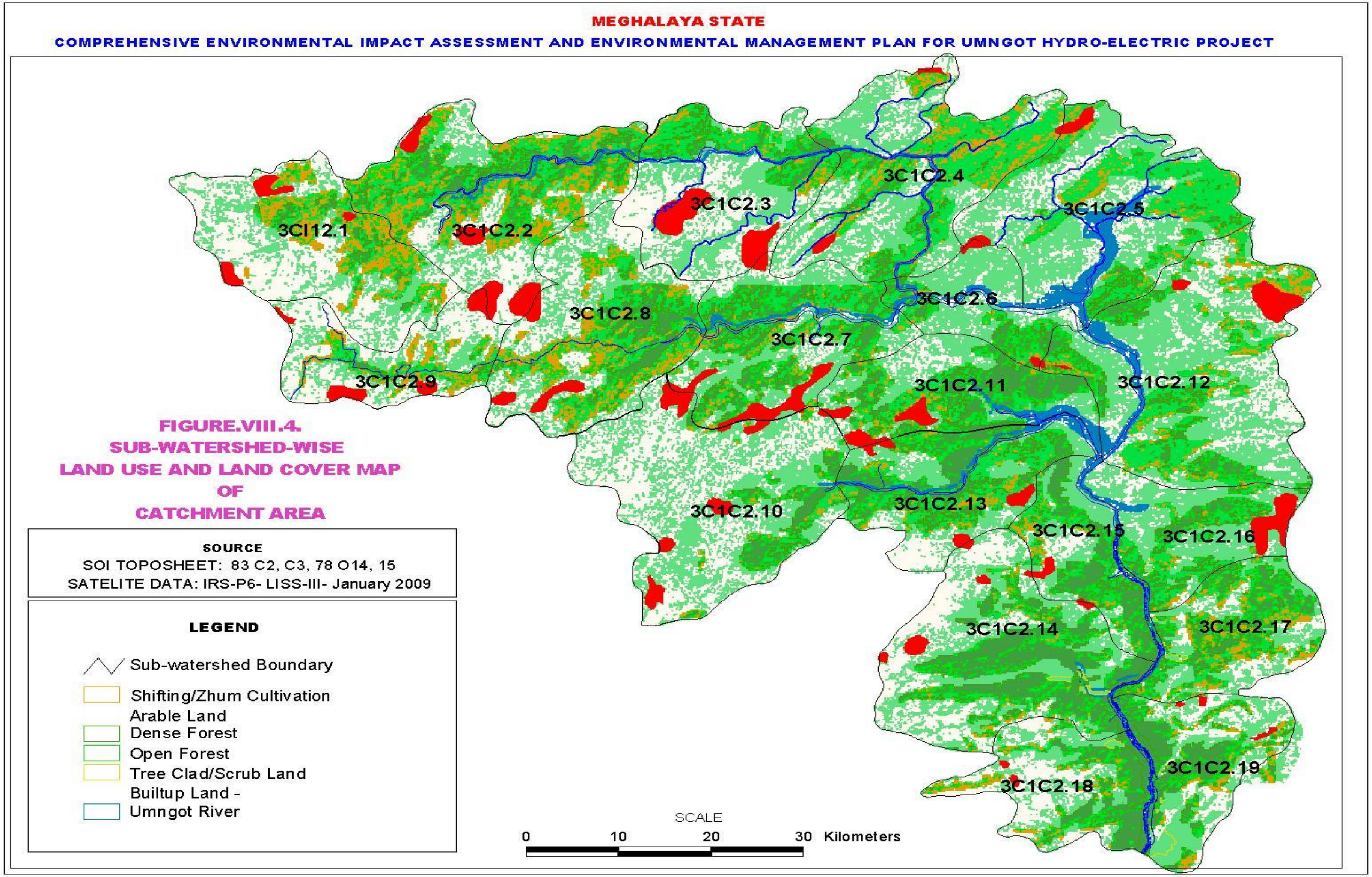
Table 8.6 UMNGOT HE PROJECT – WATERSHED-WISE AREA UNDER SLOPE CATEGORIES (Area in ha)							
S.No	**WSNO**	**Gentle to Moderate (0-5)**	**Gentle Steep (5-10)**	**Moderate steep (10-15)**	**Steep (15-35)**	**Very Steep (>35)**	**Total**
1	3C1C2.1	171	195	197	647	578	1788
2	3C1C2.2	81	99	126	467	1320	2093
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

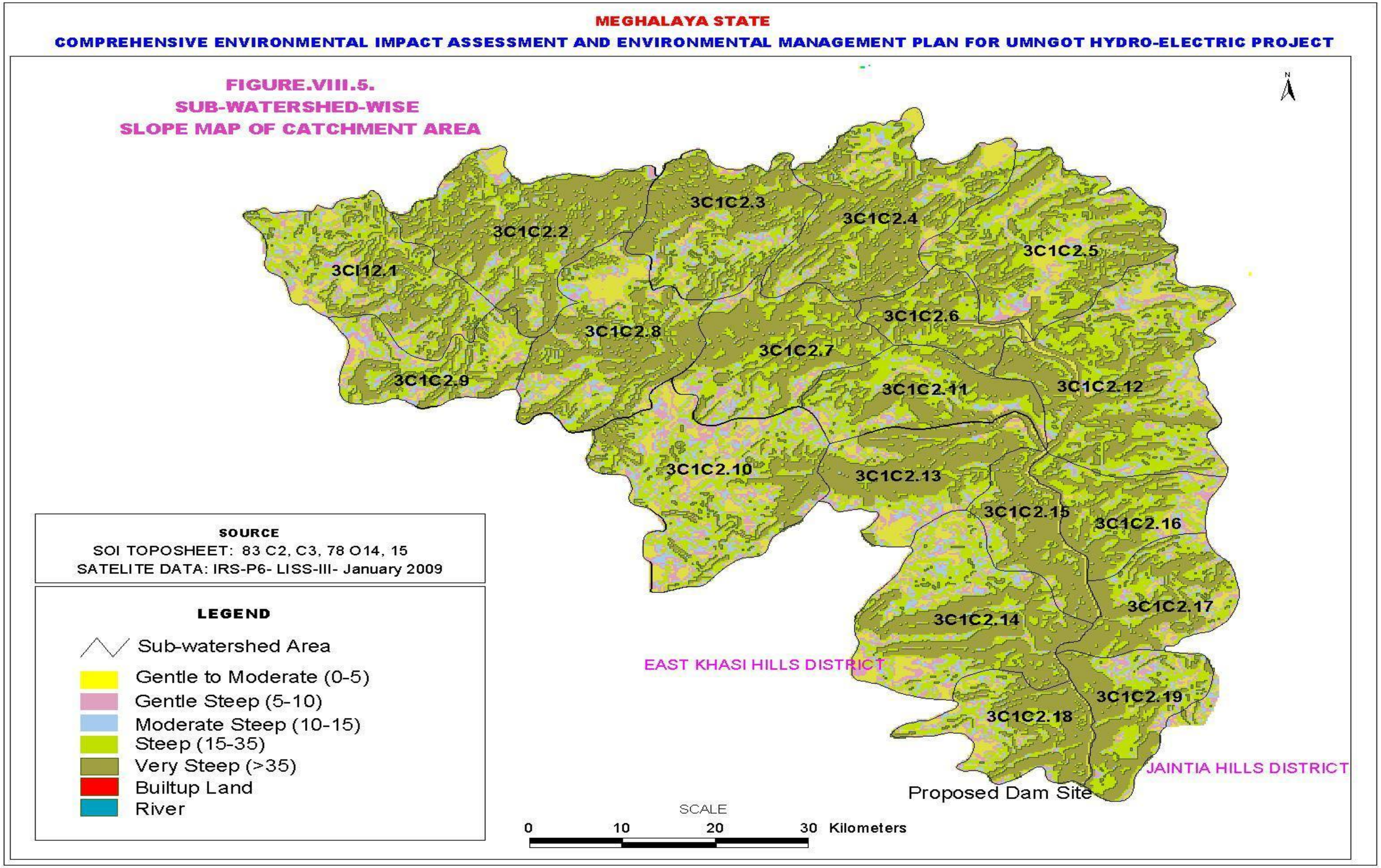
Table 8.6
UMNGOT HE PROJECT – WATERSHED-WISE AREA UNDER SLOPE CATEGORIES
(Area in ha)

S.No	WSNO	Gentle to Moderate (0-5)	Gentle Steep (5-10)	Moderate steep (10-15)	Steep (15-35)	Very Steep (>35)	Total
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**

Source: Computed by AFCL


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
FIGURE.VIII.3
SOIL MAP
OF
CATCHMENT AREA
SOURCE
SOI TOPOSHEET: 83 C2, C3, 78 O14, 15
SATELITE DATA: IRS-P6- LISS-III- January 2009
LEGEND
Catchment Area - 30433 ha (304 sq.km)
National Highway
Roads
Settlements
1- Moderately Deep, excessively drained, coarse loamy soils on gently sloping with very severe erosion
5- Moderately deep, excessively drained, fine loamy soils on gently sloping with very severe erosion
7-Moderately deep, excessively drained, coarse loamy soils with severe erosion
8-Shallow excessively drained, loamy skeletal soils on moderate steep slopes with very severe erosion
SCALE
0 10 20 30 Kilometers
Mawryngkneng
Pommura
Puriang
Sohryngkhamneng
Umphyrnai
Pepbah
Thadan
Mawber
Mawpyrshong
Kut
Mawdymai
Smit
Mawlali
Thynroit
Mawrang
Niriang
Madur
Nongjrong
Tanglei
Kharang
Rapleng
Jongksha
Syniasya
Piengweit
Umsning
Mynsong
Sohmynting
Mawkynrew
Mriang
Umtang
Shonghang
Jatah (N)
Jatah (L)
Sohmanong
Umsawwar
Mosakhia


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
3CI12.1
3C1C2.2
3C1C2.3
3C1C2.4
3C1C2.5
3C1C2.6
3C1C2.7
3C1C2.8
3C1C2.9
3C1C2.10
3C1C2.11
3C1C2.12
3C1C2.13
3C1C2.14
3C1C2.15
3C1C2.16
3C1C2.17
3C1C2.18
3C1C2.19
FIGURE.VIII.4.
SUB-WATERSHED-WISE
LAND USE AND LAND COVER MAP
OF
CATCHMENT AREA
SOURCE
SOI TOPOSHEET: 83 C2, C3, 78 O14, 15
SATELITE DATA: IRS-P6- LISS-III- January 2009
LEGEND
Sub-watershed Boundary
Shifting/Zhum Cultivation
Arable Land
Dense Forest
Open Forest
Tree Clad/Scrub Land
Builtup Land -
Umngot River
SCALE
0
10
20
30 Kilometers


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
FIGURE.VIII.5.
SUB-WATERSHED-WISE
SLOPE MAP OF CATCHMENT AREA
3CI12.1
3C1C2.2
3C1C2.3
3C1C2.4
3C1C2.5
3C1C2.6
3C1C2.7
3C1C2.8
3C1C2.9
3C1C2.10
3C1C2.11
3C1C2.12
3C1C2.13
3C1C2.14
3C1C2.15
3C1C2.16
3C1C2.17
3C1C2.18
3C1C2.19
EAST KHASI HILLS DISTRICT
JAINTIA HILLS DISTRICT
Proposed Dam Site
SOURCE
SOI TOPOSHEET: 83 C2, C3, 78 O14, 15
SATELITE DATA: IRS-P6- LISS-III- January 2009
LEGEND
Sub-watershed Area
Gentle to Moderate (0-5)
Gentle Steep (5-10)
Moderate Steep (10-15)
Steep (15-35)
Very Steep (>35)
Builtup Land
River
SCALE
0
10
20
30
Kilometers
N

SOIL EROSION STATUS

8.33 The soil inventory of the catchment area indicates severe to very severe erosion hazard. The hills foot slopes and pediments are covered with partially degraded forests and scrub lands exposing the top soils to vagaries of erosion by surface runoff carrying sediment and depositing elsewhere in the lower slopes. The undulating uplands and plains are also subjected to erosion due to inadequate protection which may be due to private community forests. The priority ratings of the micro-watershed based on the descending values of SYI are furnished in Table 8.7 Soil map showing the delineation of micro-watersheds is appended in Fig VIII.6.

Table: 8.7 Umngot HEP
Priority rating of sub water sheds

S.No.	Sub-water sheds No.	Area (Ha)	Sediment Yield Index	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

Source: Computed by AFCL

Catchment Area Treatment

8.34 Areas prioritized in the catchment area of Umngot HEP are given in **Table 8.8**

Table 8.8 Prioritized micro-watersheds

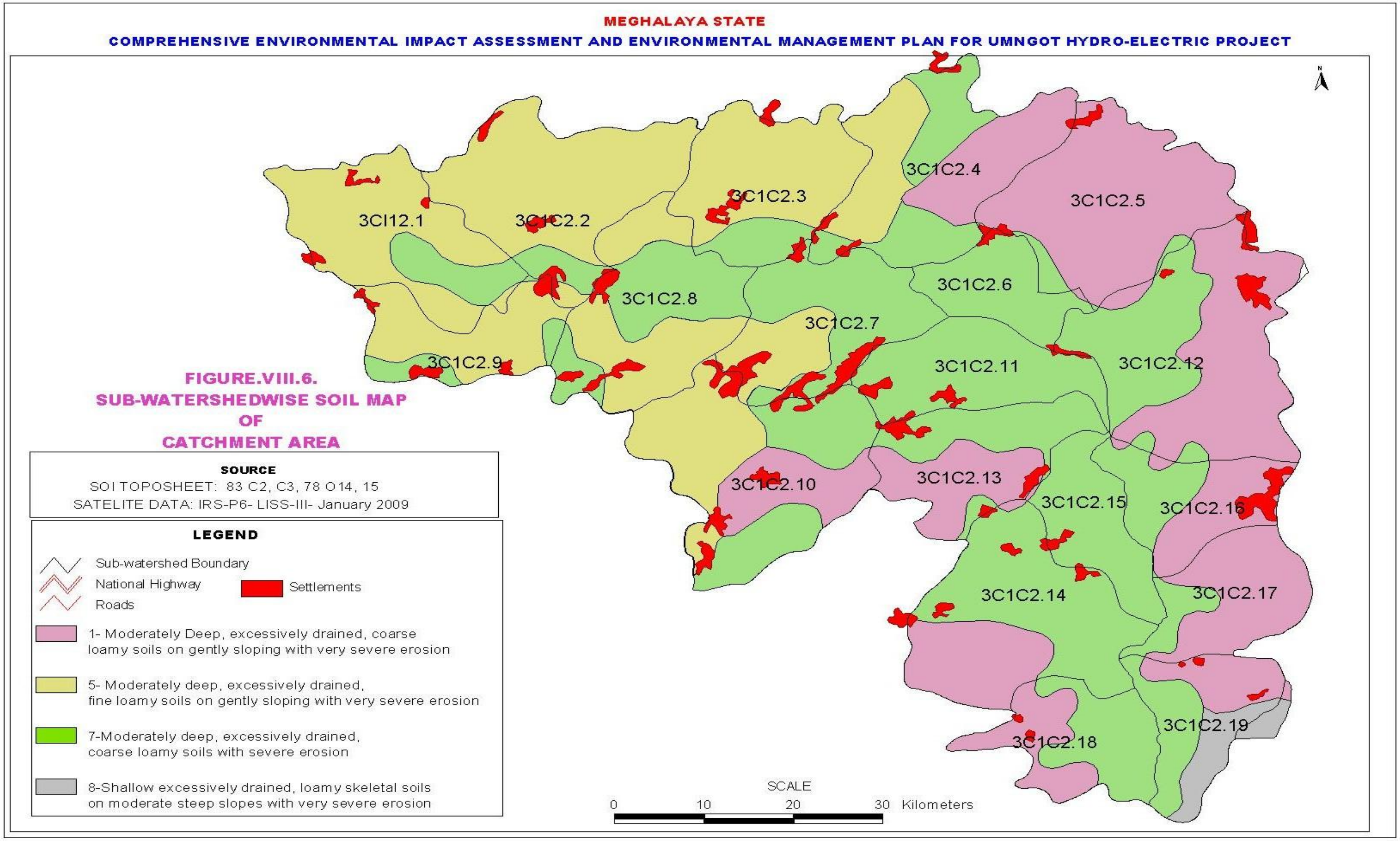
S.No	Total No. of micro-watersheds	Total area (ha)	No of micro-watershed prioritized as V.High	Area prioritized as V.High (ha)	Percentage to total area
1	19	30433	5	8819	28.98

8.35 Suitable treatment measures are proposed for five micro-watersheds, which are under very high category covering an area of 8819 ha. This accounted for 28.98 percent of total catchment area. The other category micro-water sheds have not been recommended for any treatment. The treatable areas identified in the priority micro-water sheds are tabulated in Table 8.9.

Table 8.9 Prioritized Sub water sheds and treatable areas in (ha) Land used / Land cover

S.No.	Sub water sheds No.	Total area of sub water sheds	Land use and area proposed for treatment , ha									
			Shifting cultivation		Arable land Other		Dense forest		Open forest		Scrub lands (tree clads)	
			Total	Proposed	Total	Pro	Total	Pro	Total	Pr	Total	Pro
1	3C1C2.2	2093	279	279	422	200	248	-	709	142	266	80
2	3C1C2.3	1597	37	37	410	200	104	-	277	58	576	173
3	3C1C2.4	2166	141	141	314	160	102	-	716	145	811	243
4	3C1C2.8	1915	228	228	421	210	20	-	503	100	584	174
5	3C1C2.9	1048	103	103	517	260	27	-	129	25	198	60
TOTAL		**8819**	**788**	**788**	**2084**	**1030**	**501**	**-**	**2334**	**470**	**2435**	**730**

Source: Computed by AFCL


MEGHALAYA STATE
COMPREHENSIVE ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN FOR UMNGOT HYDRO-ELECTRIC PROJECT
3CI12.1
3C1C2.2
3C1C2.3
3C1C2.4
3C1C2.5
3C1C2.6
3C1C2.7
3C1C2.8
3C1C2.9
3C1C2.10
3C1C2.11
3C1C2.12
3C1C2.13
3C1C2.14
3C1C2.15
3C1C2.16
3C1C2.17
3C1C2.18
3C1C2.19
FIGURE.VIII.6.
SUB-WATERSHEDWISE SOIL MAP
OF
CATCHMENT AREA
SOURCE
SOI TOPOSHEET: 83 C2, C3, 78 O14, 15
SATELITE DATA: IRS-P6- LISS-III- January 2009
LEGEND
Sub-watershed Boundary
National Highway
Roads
Settlements
1- Moderately Deep, excessively drained, coarse loamy soils on gently sloping with very severe erosion
5- Moderately deep, excessively drained, fine loamy soils on gently sloping with very severe erosion
7-Moderately deep, excessively drained, coarse loamy soils with severe erosion
8-Shallow excessively drained, loamy skeletal soils on moderate steep slopes with very severe erosion
SCALE
0
10
20
30
Kilometers

8.36 The very high priority areas of sub water sheds i.e. 8819 ha are considered for suitable treatment measures. However the following classes of land cover have been excluded as they are not disturbed.

- Settlements or built-up areas.
- Existing water bodies / river / streams
- Dense forest having more than 40 percent canopy cover.

8.37 Major portion of the forest area is open forest having canopy cover between 20 and 40 percent. Hence treatment measures are proposed to restore the canopy cover by 20 percent area. Scrub lands / trees clads occupy 27.6 percent of the prioritized area. The canopy is about 10 percent and much degradation in view of the undulated topography and heavy rainfalls is observed. Hence it is proposed to restore the canopy for about 30 percent.

8.38 Shifting cultivation occupied about 8.94 percent only (788 ha) of the total prioritized areas. The entire areas need mitigative measures to arrest soil erosion in view of the lack of vegetation cover or proper bunds. The arable area which is not cultivated at present occupies about 23.6 percent of the total area prioritized. About 49 percent of this areas i.e., 1030 ha is proposed for treatment measure, as this area is without vegetation.

8.39 Thus the areas proposed for treatment measures are as below.

1.	Open forest	-	-	470 ha
2.	Scrub lands	-	-	730 ha
3.	Shifting cultivation	-	-	788 ha
4.	Arable area	-	-	<u>1030 ha</u>
	Total area	-	-	<u>3018 ha</u>

Conservation and Management Measures

8.40 In general although environmental problem is the creation of science and technology, it can also be controlled by science and technology only. For a sustainable action plan, the watershed development concept has been applied. The approach is holistic, multi disciplinary and practicable approximation of systems planning. Keeping this in view, different types of measures have been drawn out on the basis of topography, relief and degree of degradation, classes of land cover etc.,

Forestry and Silivpatroal Management

8.41 It is an established fact that forests and vegetation play the most crucial role in the protection of the river catchments in hilly regions. The gap between demand and supply of fuel and fodder has been the most important reason for the degradation of the Leo system in many hilly regions. In the state of Meghalaya about 94.1 percent of the rural households are utilizing fire wood as fuel. This indicates the major source of degradation.

8.42 The area under the dense forest in the catchment is only 13.02 percent (above 40% canopy cover) whereas the area under open forest category is 21.28 percent (between 20 and 40 percent canopy cover) and scrublands / tree clads occupies major share of 33.05 percent (having canopy cover below 20 percent). The loss of more forest area due to the Umngot HEP has to be considered in all seriousness.

Target of Afforestation and Reforestation Programme

8.43 An area of 1200 ha in the micro-watersheds of very high priority category is proposed for forestry and Silvi-pastoral measures in the open forest and scrub lands. The forest areas are entirely community forests and the scrublands may be Government owned or private lands. No reserve forest areas exist within the catchment area. The target for the above measures is proposed to be achieved in five years. No additional staff is envisaged of this project and the existing staff of forest department will be adequate.

Cost of afforestation / Reforestation.

8.44 The forest department of East Khasi hills district was consulted regarding plantation costs, species for plantation adopted by them for similar works. Plantation costs are fixed on the basis of wage rates of labour at Rs.70/- per day as suggested, and considering the gap areas in the existing open forests and scrubs to improve the canopy cover. Considering the data furnished by the forest department and accepting the information regarding possible increase in wage rates in near future and to bring uniformity in the rates for the purpose of compilation of the report, the cost per ha is fixed at Rs.32,100 per ha.

8.45 No provision for barbed wire fencing is adopted, since this has been found unnecessary and unproductive particularly in hill plantations. On the other hand provision has been made for engaging watchers (local persons) for cattle watching during the formative stages of the plantation. The detailed breakup of item wise cost for creation and maintenance for a period of 5 years is furnished in Table 8.9.

Table – 8.10 Break-up of Cost of Plantations per Hectare (500 Plants) for Afforestation

Item of work		Cost / ha	
Preliminary works / Advance works			
1.	Nursery costs (including seed collection and)	Rs	5000
2.	Survey and demarcation	Rs	2000
3.	Jungle clearance and burning (15 Man days x Rs 100/day)	Rs	1500
4.	Contour trenching	Rs	3000
5.	Digging planting pits at 30 x 30 x 30 cm (1Man day can dig about 1 cum of Soil/Murrum in day therefore for 500 plants 13.5 m^3 require about 14 Man days)	Rs	1400
6.	Filling of Pits (3 Man days)	Rs	300
		Rs	**13200**
Creation of Plantation (1st year)			
1.	Nursery costs (watering etc)	Rs	1500
2.	Sowing and planting	Rs	1500
3.	Weeding – 3 times @ Rs 1000/- ha	Rs	3000
4.	Fire protection & watching (one watcher for 2 ha)	Rs	1500
5.	In filling vacancies	Rs	500
6.	Inspection paths, camp sheds etc	Rs	500
		Rs	**8500**
Maintenance of Plantation (2nd year)			
1.	Weeding – 2 times @ Rs 1000/- ha	Rs	2000
2.	In filling vacancies	Rs	500
3.	Fire protection & watching	Rs	1500
		Rs	**4000**
Maintenance of Plantation (3rd year)			
1.	Weeding – 2 times @ Rs 1000/- ha	Rs	2000
2.	Fire protection & watching (1 for 4 hectares)	Rs	1200
		Rs	**3200**
Maintenance of Plantation (4th year)			
1.	Weeding – 2 times @ Rs 1000/- ha	Rs	2000
2.	Fire protection & watching	Rs	1200
		Rs	**3200**
	Total Plantation Cost per hectare	**Rs**	**32100**
Labour wage is considered at the rate of Rs 100 per day			
Source : AFCL			

Afforestation Technique and Choice of Species:

8.46 Sowing and planting will be done at a spacing of 4.5 m x 4.5 m in planting pits of size 30 cm x 30 cm x 30 cm dug on rough contour terraces, about 45 cm wide. Contour trenching may be necessary in exceptional cases where soil is refractory and moisture conservation is a must for success of plantation. Application of fertilizers should not be necessary in all cases. Where planting of nursery grown seedlings in silviculture recommended, nursery work may be done in advance, particularly for species like Teak, Champ, Diptercarps, and Eucalyptus etc. Barbed wire fencing should not be necessary and engagement of watchers for fire protection and cattle watching should be insisted upon. 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 for the first tow years and jungle clearing thereafter for 2 years are provided for.

8.47 The choice of species to be sown or planted will depend on the altitude of the site and environmental need and the local experience and success which will always be an important factor. By and large, the following guidelines are recommended. The following afforestation species are recommended by the forest department in the catchment area.

i) Pine

ii) Cryptomeria

iii) Tropical Pine

iv) Ex-buclandia

v) Alder

vi) Tita Chap

vii) Poma

viii) Myrica SPP

8.48 In many cases, open scrub areas may be partially stocked with natural growth of colonizing tree species as well as bamboo and enrichment planting at spacing of 5 m x 5 m or 3.5 m x 3.5 m may give the desired results. The costs on such cases will be proportionately less and a comparatively bigger area may be treated. The species recommended in such cases are Alnus nepalensis, Betula spp, Grivellia robusta, Macarange sp., Cupressus cashmeriana, Pinus kesiya an Acacia auriculiformia. Planting of only nursery grown tall seedlings are recommended in such cases.

8.49 Since the forest areas are predominantly of open forest and scrub categories, intensive afforestation reforestation and enrichment of planting are suggested for these gap areas along with reservoir rim treatment by creation of a Green Belt along the periphery of the reservoir which will be dealt with separately in the forth coming paragraphs. The breakups of the areas are as given in Table 8.9

Table 8.9
Treatable area under Forestry and Silvi-Pastoral Measures –Umngot HEP

S.No.	Land Cover	Treatable area (ha)
1.	Open Forest	470
2.	Open Scrub	730
	Total	**1200**

Phasing of Planting Target and Expenditure

8.50 Six year programme of afforestation / reforestation is proposed, the first year being earmarked for advance work only. The phasing of planting target is proposed as in Table 8.10.

Physical phasing of planting target for afforestation programmes (ha)	
1st year	200
2nd year	250
3rd year	250
4th year	250
5th year	250
Total	**1200**

Cost:

8.51 Cost of afforestation by Silvi- pastural measures in the priority zone works out to **Rs. 385.20 lakhs** phased for 5 years. It is suggested that the entire amount of expenditure on this account will be borne by the Project authority to compensate for the loss of forest area in the catchment as per environmental guidelines issued by the Government of India and the funds will be released annually in advance to the concerned forest Department, depending on the progress of expenditure in the previous year. The forest Department should be the sole authority in charge of implementation of the programme subject to overall supervision and monitoring by a High Level Co-ordination Committee to be set up by the state Government.

SILVI PASTURE DEVELOPMENT

8.52 Since catchment area has about 34.30 percent area under forests covers including Dense and open forest and 35.05 percent Scrub land. Grazing in Un-classed State Forests is not prohibited. Therefore there should not be any scarcity of cattle fodder. Under the present circumstances, large scale development of pasture land in this catchment does not appear to be necessary. However, from the point of view of environmental conservation and catchment protection, unregulated forest grazing is not to be encouraged. The cross breed cattle also need good pasture land for higher milk production. It should form an essential part of any integrated watershed development programme to be undertaken in the catchment in future. Obviously, the State Animal Husbandry Department should be involved in such programme.

8.53 Properly managed pastures may be the best use of land that cannot support cropping and combination of widely spaced trees, preferably leguminous raised in combination with developed grassland, may considerably enhance productivity. Belts of trees in between pastures can provide shade, food for livestock and small timber and fire-wood, at the same time shielding the animals from hot sun, cold wind and water stress. This variant of agrisilviculture with a strong pastoral bias is commonly known as Silvi-Pastoral System.

8.54 The World Bank recommended an average density of 200 trees per ha to ensure optimal grass yield, but agreed that depending on local conditions the number could be increased. Since fodder trees will be lopped fairly heavily, a spacing of 4.25 m x 4.25 m or 500 trees per ha may be recommended for planting. The MOEF is also recommending 500 plants per ha for afforestation. The tree species recommended for planting are Melia azarderach, Leucaena leucocephal, Morus alba, Morus laevigata, Bahinia purpurea, Albizzia lebbeck, Artocarpus sp. Ficus hispida and Alnus nepalensis, Bucklandia populnea, Quercus sp, Ficus nemoralis, Sauraunia nepalensis and Brassiopsis sp at slightly higher altitudes. Trees may be lopped for fodder from the third year onwards and only 50% lopping is recommended.

8.55 Accessible areas of banks or denuded open scrub with a ground slope not exceeding 35% in land capability classes IV and V may be selected for the purpose of raising silvi-pasture. Resedding of selected land with grasses like Apluda aristata, Aurundinella napalensis, Bromus inermes, chrysopogon aciculatus, Eragrostis curvula, Panicum antidotale, Panucum maximum, Penisetum polystachyon, and legumes like stylosanthes, Macroptilum purpureum, Centrosoma pubescens etc are generally recommended. Final selection may, however, be done in consultation with the Indian Grassland and Fodder Research Institute, Jhansi.

Indicative Forestry Management Plan of Future.

8.56 Land use maps reveal that about 34.30 percent of the catchment area is covered by forest (dense and open) besides 33.05 percent open scrubs, which by standard norms is in unsatisfactory position.

8.57 It is perhaps not too late to think about ways and means to protect the remaining good forests and rehabilitate the open forests as far as possible. It is for the State Government to consider the best and the most effective manner to control future management of the forests in greater public interest. The forests in this catchment have assumed much greater importance due to the proposed huge project involving invests of thousand plus crores of public money.

8.58 It is suggested that in this case, the State Government concerned my consider the possibilities of taking the following steps:

- To accept in principle that the Government control on the future management of the unclassed forests in the catchment should be increased and degraded forests should be rehabilitated as far as possible.
- To control and prohibit unregulated felling of trees for the purpose of domestic use and sale in the unclassed forests under provision of Transit Rules and recent orders of the Hon’ble Supreme Court prohibiting felling of standing green trees. Forest fire and grazing should be controlled.

- For the remaining unclassed forests, including degraded areas, community projects where rights of the local people to enjoy forest produce is recognized, a Joint Forest Management Plan, with people's participation, may be worked out on the condition of Government arranging to supply to the villagers their domestic demands of forest produce and sharing net profits of commercial sales with the Village Councils on 50:50 basis.

- Creation of village level Forest Protection Committees for protection of community forests with people's participation on income sharing basis will be quite effective. Some modified form of this scheme of participatory management may be conveniently tried for better protection of catchment forests,

- Future forest management should as far as possible be done in a planned manner under proper working Plans or working Schemes

- Social forestry including agro-forestry should be given due importance in land management in areas under dry cultivation so as to have a balanced land use.

Afforestation, Reforestation and Soil Conservation

8.59 As an integral part of future Forestry Management Plan, a fairly big six year plan of afforestation / reforestation of 1200 ha have been proposed for the catchment. The entire programme which is proposed to be financed out of the funds under Catchment Area Treatment Plan for afforestation, to be provided by the project as its statutory obligation, is considered to be achievable for implementation by the Forest Department under existing infrastructure. This should fully take care of the watershed needs of the proposed reservoir and its neighboring catchment. However, so far as the afforestation / reforestation of balance area open scrub in the basin is concerned, it is suggested that the work should be progressively undertaken by the State Forest Department under the normal afforestation and soil conservation programmes like Operation Soil Watch, Afforestation and Eco-Development programmes (IAEP), Wasteland Development, Rural Fuel wood Plantation Social Forestry Programmes etc., These plantations should preferably be planned on watershed basis.

Staggered Trenches

8.60 Staggered trenches will be constructed for silvi-horticultural plantation as well as for treatment of open scrub / degraded areas for detention and conservation of rain water and eroded soil. Run-off water from mixed crop strips will flow through staggered trenches in silvi-horticulture strip, resulting in setting of sediments and arrest of run-off water to recharge soil profile and ground water. Staggered contour trenches will be constructed in rows spaced at 5 m, with a spacing of 3.30m within the rows. In the alternate row, the trenches will be located directly below one another. The trenches in successive rows will be staggered, with the trenches in the upper row and inter-space in the lower row being directly below each other. After every 5 rows of staggered trenches on contours, one continuous trench will be laid out to arrest escaped run-off water. The trenches may be trapezoidal in section with side slope of 1:1 for stability purposes. Each trench will be followed by a bund on the down stream side, with 1.00 m top width, 0.85 m height and 1:1 side slopes. These bunds will be constructed by the excavated materials from the trenches. As per design, there will be 180 trenches of 5.00 m (length) x 0.50 m (depth) x 0.45 m (width) per hectare and their capacity to conserve run-off volume will be 202.5 cum.

8.61 As this storage will be available reportedly during monsoon period, their total storage capacity will be about 5 times of above volume. Details of design and cost estimate have been provided in Annexure-VIII.1.Cost per hectare works out to Rs.11701/-. Area proposed for formation of staggered trenches in respect of Umngot worked out to be 2230 of Scrub and Arable lands. Total cost is worked out as **Rs 260.93 lakhs.**

Staggered contour Trenches and Development of Pasture & Fodder Grasses (subsidy)

8.62 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. In accordance to rate analysis, cost for constructing staggered trenches works out to Rs 11701/- per hectare. For raising 'fuel-wood and fodder' plantations a subsidy of Rs.2,500/- per ha to be provided in the estimate. The subsidy cost worked out to Rs.55.75 lakhs. Total cost including subsidy works out to **Rs. 316.68 lakhs.**

Bench Terracing

8.63 Bench terracing is proposed for an area where slope is in the range of 10 to 35%, so as to modify the degree of slope by cutting and filling. 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. A typical design and cost estimate (for an average dimension) are provided in Annexure.VIII.2. The cost per ha worked out to Rs.47245. Total area proposed is 3011 ha for Umngot HEP in prioritized sub-watersheds and in the slope range. Total cost works out to be **Rs 1422.55 lakhs**.

SOIL AND WATER CONSERVATION – ENGINEERING / MECHANICAL MEASURES

Objectives and Strategies

8.64 Engineering / Mechanical measures are suggested for treatment of excessively erosive and vulnerable areas which have lost considerable soil and vegetative cover. About 7.36 percent of the catchment area only is having nearly gentle slops (0-5 percent). Gentle steep to moderate steep slopes comprise of about 16-46 percent. Maximum of the land slopes are in the range from 15 to 35 and above for about 76.17 percent. Due to the topography with severe undulations, heavy rainfall, several gully and rill erosionsl are noticed.

8.65 Considering the resource potential, socio-economic needs of the area, besides the present position of the catchment, i.e. land use / land cover, soil erosion status, basin's relief etc, the soil and water conservation measures/programme have been drawn up and designed to suit the specific requirements of such areas as well as to create a long term interest in land and water resources management by the people.

Pre – Requisites for Soil and Water Conservation Measures

8.66 The pre – requisites for soil and water conservation measures are physiography, soil properties, vegetative cover and land use practices and resin fall and runoff. These factors have been described in detail in the previous chapters/paragraphs.

Suggested Erosion Control Measures and Design

8.67 Engineering measures for such purposes is aimed at constructing barriers across the direction of flow of run-off water to retard or retain the run-off and thereby to reduce the siltation into reservoir. The important principle for conservation treatment is to create favorable conditions by:

i)	Increasing the time of concentration and thereby allowing more run-off water to be absorbed and held in the soil profile
ii)	Intercepting a long slope into several short ones, so as to maintain less than critical velocity for the run-off water, and
iii)	Protection against damage owing to excessive run-off.

8.68 To achieve this, following engineering measures are suggested:

- Gully Control Structures for arresting gully erosion
- Contour and Staggered Trenches along with development of pasture and fodder grasses for an area of 2230 ha as already discussed before;
- These measures will however be in addition to other measures, like afforestaion / reforestation etc, suggested separately.

Gully Control Structures or Gully Plugging

Gully Development and Checking the Growth of Gullies

8.69 Gully erosion is an advanced stage of rill erosion, while the later is an advanced stage of sheet erosion. It is seen during the filed survey that at some places in the catchment area, especially in high and very high priority areas, sheet erosion is in process, which if not checked immediately, may take shape of rill erosion and thereafter to gully erosion.

8.70 Stabilization of gullies through vegetative or biotic measures is a difficult task as they are mostly used for conveying or temporarily evacuating the run-off during the time when plantations for afforestation, reforestation etc are started. In such cases engineering measures are to be adopted to prevent washing away of the plantations by large volume of run-off, as once the vegetation is established, it will take care of gullies.

Principles

8.71 In control of gullies, the erosive velocities are reduced by flattening out the steep gradient of the gullies, by constructing a series of checks or rock fill dams which transform the longitudinal gradient into a series of steps with low risers and long flat treads. Temporary structures are selected for small and medium gullies to function as a provider or necessary protection, till vegetation is established on their beds. Similarly, semi-permanent or permanent gully control structures are necessary for conservation of water, in addition to stabilization of bed. These are erected across steep gullies traversing hilly or mountainous region and at locations where high degree of safety is needed during disposing time of the peak run-off. Further, the semi-permanent and permanent structures are needs to be supported by temporary structures for conveying runoff over critical portion of gully. They have longer life and do not require any maintenance. All the three types of gully control structures are generally constructed with local material available and thus become cheaper.

8.72 Two main purposes being served by the gully control structures are

- to collect sufficient soil and water to enable the proper growth of vegetative cover and
- to check erosion until adequate stabilizing vegetation can be established at critical points.

8.73 Based on the field surveys and other maps generated from satellite imageries (drainage system and pattern, lineament maps, soil erosion status maps, and slope maps) practically all the gullies have originated from hill slopes and got aggravated at gentle slope of foot hill areas. After taking care of all such facts the following gully control measured proposed (Table 8.11)

8.74 In the planning, only twp types of gully control structures have been proposed for construction on the basis of present status of gullies. For land slope upto 10 percent, these can be spread at 0.90m to 1.20m vertical interval, whereas for slope above 10 percent, the vertical interval may be kept at 1.80 m to 3.60 m. Further the number, area etc shown Table 8.11 are approximate and may vary during the construction period.

Table 8.11
Suggested type and number of gully control works and other structures in the prioritized sub-watersheds

Sl. No.	Prioritized sub watershed	Type and No. of gully control structures			Mini percolation tanks No.	Area proposed to be protected (ha)	Areas to be protected by other measures (ha)	
		Double row post brush dam No.	Loose boulder check dam No.	Total Nos.			Staggered terracing	Bench terracing
1	3C1C2.2	40	78	118	1	1924	422	593
2	3C1C2.3	26	54	80	2	1404	431	524
3	3C1C2.4	28	72	100	1	2084	548	743
4	3C1C2.8	22	72	94	1	1756	484	686
5	3C1C2.9	24	34	48	1	974	345	465
	Total	**140**	**310**	**440**	**6**	**8142**	**2230**	**3011**

Design

Double Row Post Brush Dam

8.75 This type of check dam is generally used to control medium and deep gullies (about 2 m to 2.50 m deep and upto 6 m wide) which have contributory watershed of about 19 ha. This can be repaired immediately as all the construction materials for the purpose are locally available, besides being inexpensive.

8.76 Before commencing the construction of the check dam, the sides of the gully at the selected sites are sloped to 1:1 and the gully bottom, for the whole length of the dam, is lowered by about 15 cm. Also, 15 cm excavation is carried up into the bank as high as required, to give the necessary notch capacity for discharging the run-off. The country wood stakes, about 10 cm to 13 cm in diameter, are driven 0.90 m apart, in two rows, to go at least 0.90 m to 1.20 m into the hard bed of gully. The distance between the rows will be around 0.90 m. The tops of the stakes are kept at such heights as to form a distinct depression in the middle to form a notch of the required waterway to enable the maximum run-off to discharge. The first layer of straw and brushwood is laid across the gully between two rows of wood stakes. Over it, long branches of specially selected species are laid lengthwise of the gully and well pressed. The process is repeated till the required height is obtained. The brush is anchored onto the stakes by means of galvanized iron wire. Intermediate stakes of shorter lengths are driven and the brush is anchored onto them to prevent lifting from bed by water. Estimated cost for each Double Row Post Brush Dam is given in Annexure.VIII.3. Cost per each structure of average dimension works out to be Rs1783/- and the total cost for constructing 140 Double Row Post Brush Dam works out to **Rs 2.50 lakhs.**

Loose Boulder Check Dam

8.77 This is used for forming check dams when loose boulders of fairly good size are available in large quantities. The site where the dam is to be erected is cleared and the sides are sloped to 1.5:1. The bed of the gully is excavated to a uniform depth of about 0.30 m and dry boulders are packed, over pressed straw, from that level. In the center of the dam portion sufficient waterway is allowed to discharge the maximum run-off from the catchment. The boulder filling should go upto 0.30 m to 0.60 m into the stable portion of the gully side to prevent end cutting. In the rear, sufficient length (0.90 m) and width of apron has to be provided to prevent scour. The thickness of apron packing should not be less than 0.45 m and gully sides above the apron have to be protected with stone pitching to a height of at least 0.30 m above the anticipated maximum water level to prevent side scouring. Cost per each of such check dam of average dimension is shown in Annexure.VIII.4 which works about to be Rs12966/- and the total cost for constructing 310 Loose boulder check Dam works out to **Rs 40.19 lakhs.**

Water Conservation Structures

Percolation Tanks (PTs)

8.78 At places where there is sudden depression and hump on either side or in wide and deep gullies at the location of entering gentle slope areas where maximum water can be stored an earthen bund with stone revetment on the upstream side and a surplus weir on one side are to be constructed. About 15.60 percent of the catchment constitutes area is having slopes upto 5 percent which enables limited plans for construction of mini percolation tanks in the areas prioritized and this helps good water conservation, drinking water facilities to nearby settlements besides serving as silt traps. The technical details are provided in Annexure-VIII 5. In total 6 numbers of such tanks are proposed at a lump sum cost of Rs.1.00 lakh each. The total cost works out to Rs 6.00 lakh. Map showing the approximate locations of various gully control structures proposed is appended as Fig.VIII.7

Financial Involvement

8.79 The total work earmarked under engineering / mechanical measures is proposed to be carried out in five years period. The cost involved is shown in Table 8.12 and year wise phasing is provided in Table8.13

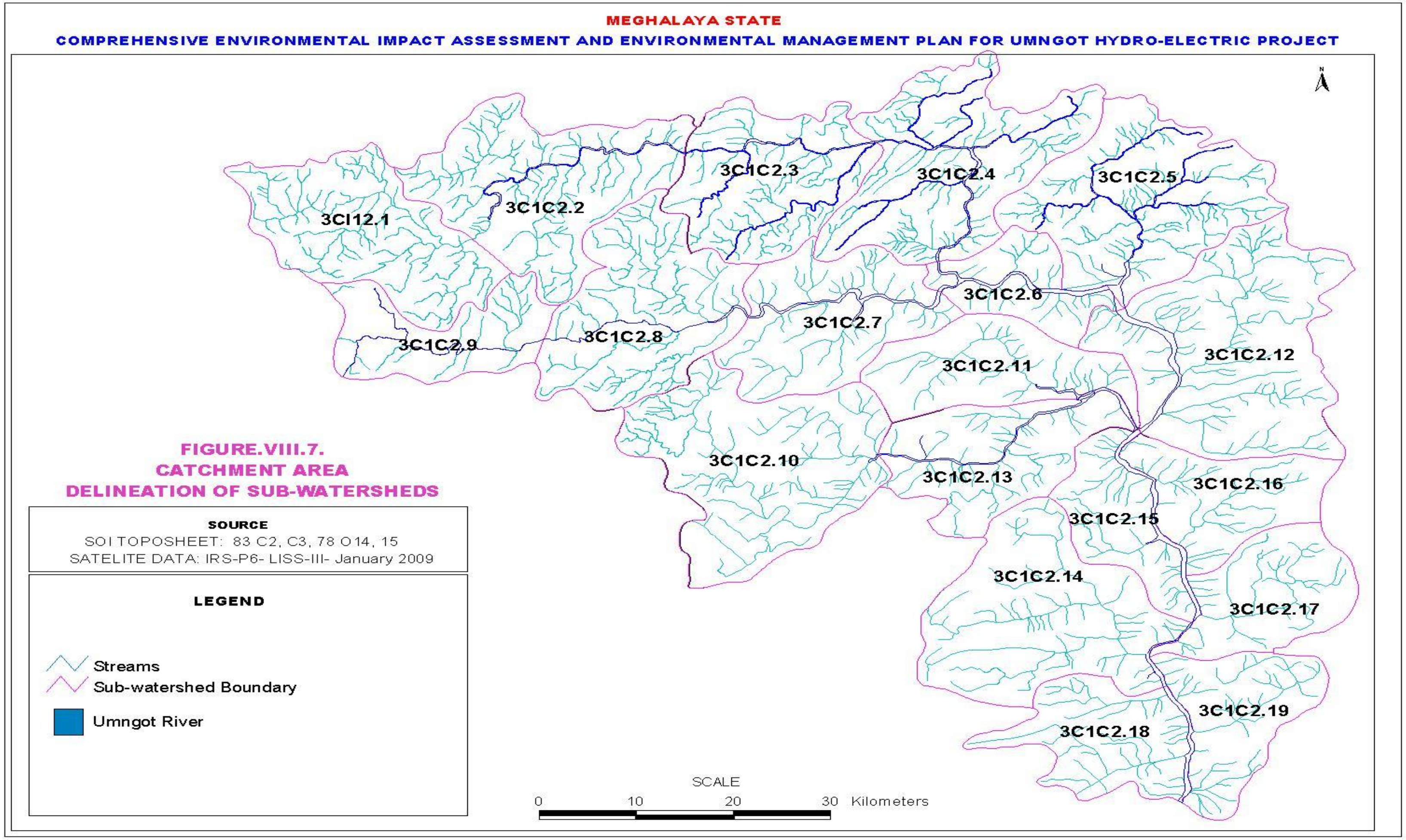


FIGURE.VIII.7.
CATCHMENT AREA
DELINEATION OF SUB-WATERSHEDS

Table 8.12 Breakup of expenditure for erosion control by Engineering / Mechanical means					
S.No.	*Description*	*Unit*	*Unit Rate, Rs.*	*No*	*Cost, Rs Lakhs*
I	Gully control Structures				
a)	Double Row Post Brush Dam	Each	1783	140	2.496
b)	Loose boulder check Dam	Each	12966	310	40.195
II	Water Conservation measures				
	Mini Percolation tanks	Each	1,00,000	6	6.000
III	Staggered trenches	ha	11701	2230	260.930
	Planting and development of pasture and fodder grasses (by subsidy)	ha	2500	2230	55.750
IV	Bench terracing	ha	47245	3011	1422.547
	Total				**1,787.920**

Table- 8.13 Year-wise phasing

S.No.	Year	DRPB (No)	LBCD (No)	MPT (No)	ST (Ha)	BT (Ha)
1	1st year	20	60	1	230	600
2	2nd year	30	60	1	500	600
3	3rd year	30	60	1	500	600
4	4th year	30	60	1	500	600
5	5th year	30	70	2	500	611
	Total	**140**	**310**	**6**	**2230**	**3011**

Control of Shifting Cultivation in the Catchment

8.80 Shifting cultivation or jhumming, an age-old traditional practice is at the crux of the land use problem in the catchment. Fortunately, the statement Government is fully aware of the situation and its harmful effects on the forests in the hilly catchment. There are no two opinions on the fact that the stoppage of shifting cultivation alone will bring marked ecological and hydrological changes in the catchment. Rehabilitation of jhumias in settled life and settled agriculture is likely to be welcomed by the villagers as a break from the hard and back-breaking practice of shifting cultivation. The following action plan, among others, may be effective,:

a) In re-settlement of jhumlias, the highest priority may be given to shifting of jhumias from identified “ Critical Areas”

b) No new settlement should be located in Critical and Vulnerable areas or in close proximity of storage reservoir.

c) The re-settlement plan should preferably be on watershed basis, but should be family oriented and for the village as a whole.

d) Cultivable areas may be converted into bench terraces at the lower slopes with irrigation facilities from neighboring rivers, wherever possible,

e) Scientific method of dry farming and soil conservation techniques should be adopted in other cultivated areas,

f) Moderately sloping lands should be earmarked for horticulture and hill tops and sloping land above 35% slope may be put under forest cover,

g) Provision may be made for subsidiary occupation in animal husbandry, fisheries, piggery, poultry, tassar cultivation and cottage industries.

h) Attention should be given to development of infrastructure like roads, markets and dwelling houses,

i) Adequate publicity and public relations will be necessary to convince the local villagers to new mode of living.

8.81 A high power implementation committee with representatives of the departments of Forests, Agriculture, Water resources, Animal husbandry, Horticulture, Soil Conversation and Cottage Industries etc., may be set up for the propose of implementation the project. The overall responsibility of preparation of watershed plans will rest within this Committee, with or without the assistance of outside consultants and experts. The appointment of a Project Co-coordinator for this purpose may also be considered.

Induction of Permanent Farming System to Replace Shifting Cultivation.

Land Based Conservation-cum-Production schemes

8.82 The Government of India has accorded the highest priority to the holistic and sustainable development of rain fed areas through integrated watershed management system. The current strategy is based on the concept of conservation of rain water for integrated development of watersheds, promotion of diversified and integrated farming systems approach, management of common property resources, and augmenting family income and nutritional levels of participating watershed communities through alternate household production system.

8.83 Resorting to the watershed approach is the core to the development of rain fed areas, including various special problem areas, such as hill areas, ravines, waterlogged lands etc. Some of the broad based development objectives under these projects are:

- Attainment of targeted level of food grain production in a given time frame, in a sustainable manner,
- Restoring ecological balance in the degraded and fragile rain fed eco-systems, by greening these areas through appropriate mix of trees, shrubs and grasses,
- Reduction of disparity between irrigated and vast rain fed area, and
- Creation of sustained employment opportunities for the rural poor.

8.84 Various land based – conservation-cum-production schemes are being implemented under Central and State Sector Programmes. These include (1) Watershed Development Project in Shifting Cultivation Areas (WDPSCA); (2) Soil Conservation in the catchment of River Valley Projects (RV), (3) National watershed development Project in Rain fed Areas (NWDPRA) etc. The main components of watershed management are:

1. Soil-water Conservation
2. Water Harvesting
3. Crop Management
4. Alternate Land use System
5. Integrated Farming System

Alternate Landuse system

8.85 In the Jhum lands, due to successive cultivation without adequate care for soil conservation, the lands are degraded and become low productive. Due to population pressure, more and more marginal land s are brought under cultivation. Apart from their being un-economical in the long run, cultivation of such lands can lead to serious imbalances into the eco-systems. For such lands, some alternate efficient land use system, other than arable cropping, is desirable. In alternate Land use System, by encouraging tree and grass components, the demand for food and fodder is also solved to a large extent.

Strip- Cropping (Contour Stripping) and Modified Strip Cropping (Field Stripping)

8.86 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.

8.87 In choosing any system of strip-cropping, the following guide principles should be kept in mind:

1. Strip-cropping should be made to fit into the farm management,
2. Strip should be laid out as nearly on the contour as possible, and
3. Consideration should be given to the degree of erosion, the percentage of slope, the length of the rotation and the ratio of erosion resisting and erosion permitting crops.

8.88 Field stripping is a modified form of contour strip cropping under which strips are laid parallels and across the general slope but not exactly on the contour. This system is best suited to land of uniform slopes and to gentle slopes with minor surface irregularities that make accurate strip cropping impracticable. Filed stripping is very beneficial for checking water erosion. If strips deviate from the contour for only short distance, more that 30 m, little damage may result, especially on soil of high erodibility as in the present case. However, if the deviation should be more than 3 percent, and the distance of such deviation greater than 30 m, filed stripping should give way to contour stripping.

Integrated Strip Farming System Module:

8.89 The model has been developed by deriving guidelines from Soil Survey Manual of All India Soil and Land Use Survey Organization, IARI, aiming at to protect land from degradation and to grow erosion-resisting crops in paired alleys of 10 m width, across the slope in a selected topo sequences. Each strip will have an average length of 100 m.

8.90 A total area of 788 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 under different land use in the unit would be as follows:

Silvi-horticulture crop	-	0.60 ha (3 strips of 20 m x 100 m)
Cover Crop	-	0.60 ha (3 strips of 20 m x 100 m)
Silvi-pasture crop	-	0.60 ha (3 strips of 20 m x 100 m)

Mixed crop	-	0.40 ha (2 strips of 20 m x 100 m)
Total	-	2.20 ha (1 unit of 11 strips)

8.91 The distribution of area of 788 ha (358 units of 2.2.0 ha each) under strip farming is showing in Table: 8.14

Table – 8.14 Strip Farming			
S.No.	Type of Crop Strip	Area (Ha)	No. of strips
1	Cover Crop (with Vegetative hedge)	215	98
2	Mixed Crop (with vegetative hedge)	143	64
	Total Agricultural Crop Area	***358***	***162***
3	Silvi-horticultural Crop (with staggered trenches)	215	98
4.	Silvi-pasture Crop	215	98
	Total Silvi-horticultural Crop Area	430	196
	Total Crop Area	***788***	-
	No. of Units of 2.20 ha	**358**	**358**

The details of Integrated Strip Farming Programme and crops to be grown in different strips / alleys etc are provided subsequently.

Crop Management

Agricultural and Horticultural Development

8.92 The catchment area of Umngot Hydro Electric Project consists predominantly of hilly terrain where it is difficult to take up normal agricultural practices as adopted in the plain areas. However, agriculture continues to be prime necessity, although the cultivation practices followed are mostly traditional and unscientific, yielding very little return to the farmers as compared to their efforts.

Objectives and strategies

8.93 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.

8.94 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 upto 35% slope is found to be profitable with adequate returns.

i. The low yielding local crop traditionally grown by the farmers must be replaced by HYVs suitable under respective agro-climatic conditions whereby crop productivity can be increased upto 50%. For this purpose, a time bound programme for supply of the appropriate variety and quantity of the seeds of the different crops has to be drawn up well in advance and implemented.

ii. Price plays a vital role in introducing new seed varieties to replace the indigenous local ones. Provision of adequate subsidy may be necessary at the beginning to attract the farmers for accepting newly introduced high yielding seeds.

iii. 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.

iv. On the fields, simple Contour Bunding at one meter vertical intervals is laid out to effect conservation of soils. Atop the contour bunds Pineapple and fodder grasses like Thin Napier, Setoria etc can be planted. In due course, say in 4 to 8 years, the beds, i.e. plots between 2 contour bunds take the shape of 'bench terraces' ad ensures better crop and higher yield. The purpose of such bunds is to divert excess run-off down to the grassed waterways and retain eroded soils with the bund. On gentle slopes, vegetative barriers also serve the same purpose. The vertical interval may vary from 0.5 m to 5 meter depending on the land use and soil depth.

v. Higher return can be achieved by resorting to crop rotations with selected crops, such as:

a) Rice – Maize, or

b) Maize-Groundnut/Soyabean

a) Narrow valleys, which are also termed as 'Wet Terraces", remain almost over saturated with water, and often cause serious drainage problem. By providing drainage at intervals of 2 meter, the water table can be brought down for growing potato.

b) Similarly, by providing suitable drainage a good crop of rice can be raised.

c) In valleys, by making raised beds for maintaining moisture in the root zone, vegetable crops like Tomato, French Bean, chilies' can be successfully grown before rice as the main crop.

Horticultural Crop Strips

8.95 For horticultural plantation in the strips, half-moon trenches (staggered or continuous) are to be laid out according to their suitability, before the rain starts. In the inter-spaces, planting of pineapples is considered to be best in the sub-tropical fruit orchards. Also fruit crops like Orange, Guava, Banana, Pomegranate, Papaya, Litchi, Coconut, Apricot etc., may be grown.

8.96 The generally grown horticultural crops in the foothills and hillsides are:

1. On foothill Areas

1. Orange	6. Coconut
2. Litchi	7. Guava
3. Pineapple	8. Ginger
4. Papaya	9. Turmeric
5. Banana	10.Blackpepper

11. Large Cardamom

2. On Hillside Areas

1. Orange	5. Peach
2. Guava	6. Appricot.
3. Pear	7. Walnut
4. Plum	8. Pomegranate

8.97 The programme for Integrated Strip Farming is drawn for 5 years. Estimated Input Costs of Horticultural Crops is given in Annexure.VIII.6 while year wise Physical and Financial Target is shown in Annexure.VIII.7

Cover Crop and Mixed Crop Strips

8.98 The crops will be grown in the paired alley having 10 m width across the slope by providing vegetative hedge to be created with vetiver grass in the middle of 20 m strip of Cover Crop as well as of Mixed Crop Strips. To improve the soil conditions, growing of green manuring crops, like Dhaincha, is beneficial for Cover Crop Strips. Also, cultivation of pulse crops, like Cowpea, Black gram, Moong, Soybean and such other crops, which provide better cover and check soil erosion, are suggested.

8.99 For mixed cropping, it is not only necessary to have the erosion control properties by the crops to be grown into the mix, but agronomic measures to reduce run-off and effect higher water retention by soil, should also be applied. Following combinations for mix cropping in the strips are suggested:

Maize / Milled / Buck wheat

+

Mung / Cowpea / Urnd

+

Groundnut / Soybean /Urd mung

8.100 The Estimated Input Costs of Crops and Mixed Crops are provided in Annexure.VIII.8 and VIII.9 respectively. Corresponding year wise Physical and Financial Target is shown in Annexure VIII.10 & VIII.11

Silvi-Pasture Crop Strips

8.101 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 down stream, to work as buffer. This will filter the sediment from the run-off water and reduce the velocity, thus minimizing the erosion power of excess run-off, allowing maximum time for infiltration.

8.102 The common local pasture grasses are:

i) Calopogonium mucunoides

ii) Cenchrus eiliaris

iii) Cynondon dactylon

iv) Dichathium annulatum

v) Pueraria thundergiana

8.103 During the growing season of fodder trees, they should be lopped twice for stall feeding of livestock. Since, density of fodder trees is 200 per ha, chances of shading effect will be minimum. Year wise Physical and Financial Target is provided in Annexure.VIII.12

Vegetative barriers

<u>Suggested techniques</u>

8.104 As per central soil and water conservation research and training institute, Dehradun, the Meghalaya Region fall under Eastern Himalayan sub-region of Hill region. Mostly alluvial, laterite and submantanered and yellow soils are found in the region. As the earmarked catchment area of 30433 ha is in isolated patches as well as prone to heavy soil erosion, the technique of creating vegetative barriers for forming terraces in the shifting cultivated area of 788 ha in the priority watersheds is suggested. The vegetative barriers / hedges will be created by growing vetiver grasses in rows along the contour at a horizontal interval of 45 m to 60 m that will enable to form terraces to reduce the velocity of run-off water down the slopes. They also will serve as filter for the sediments to be carried by the runoff water and thereby reduce the erosion power of the runoff from the second year itself. The technique of planting and maintenance has been described in Annexure VIII.13

Financial Involvement

8.105 Cost of planting of 500 m total length in the middle of 20 m width strips of mixed and cover crops worked out to Rs.1550/- (2.20 ha). The total financial involvement towards this item covering total areas of 358 ha or 162 units will be in the order of **Rs.2.51 lakhs.**

Total financial outlay for measures to control shifting cultivation

8.106 The total financial outlay for implementing measures to control shifting cultivation is given in Table 8.15 and the year-wise plasting of the same is presented in Table 8.16.

Table: 8.15 Control measures for shifting cultivation

S.No.	Name of treatment	Area (Ha)	Cost Rs. Lakhs
1	Horticultural plantation under integrated strip farming programme	215	37.30
2	Planting cover crops	215	2.42
3	Planting mixed crops	143	2.38
4	Planting Silvi-pastural Crops	215	2.05
5	Vegetative barriers with vetiver grass hedges	358	2.51
Total			**46.66**

Table 8.16 Year-wise phasing of control measures for shifting cultivation

S.No.	Description	Cost in Rs. Lakhs					
		1st year	2nd year	3rd year	4th year	5th year	Total
1	Horticulture crop plantation	3.31	5.52	7.70	9.47	11.30	37.30
2	Cover crops plantation	0.48	0.48	0.48	0.49	0.49	2.42

3	Mixed crop plantation	0.47	0.47	0.48	0.48	0.48	2.38
4	Silvi Pastures	0.41	0.41	0.41	0.41	0.41	2.05
5.	Vetiver grass hedges	0.50	0.50	0.50	0.50	0.51	2.51
	Total	**5.17**	**7.38**	**9.57**	**11.35**	**13.19**	**46.66**

Reservoir Rim Treatment / Green Belt Development

8.107 Umngot HE Project primarily envisages construction of dam across Umngot River near Siangkhanai duly impounding 38.59 MCM of water at FRL +1040 m. The impounded water is proposed to meet the power generation requirements to a tune of 240 MW 3 x 80 MW.

8.108 Under the reservoir the total identified sub-mergeable area of 253.85 ha upto FRL contour will be impounded with water during monsoon period. Flash floods occur only for a few weeks and the reservoir level attains MWL and flood waters will be let into the river below through spill way. Thus the area between FRL and Maximum Flood level / MWL will be under submergence for a few weeks only. After recession of rains the water level recedes upto and below FRL due to outflows for power generation leaving some foreshore area cleared with water. This area can be better utilized for plantation and made productive with some suitable tree spices which can withstand flood waters for certain period. The foreshore is better suited for foreshore plantations / reservoir rim plantation with the available moisture and sediment deposits.

Advantages of Foreshore Plantation / Green Belt Development

1. The trees planted on foreshore prevent soil erosion and movement of silt towards reservoir from the upper reaches to some extent.
2. It prevents illegal encroachments and cultivation in the reservoir bed lands. Otherwise due to the encroachers these lands and soil gets eroded easily being loose causing siltation in the reservoir.
3. These trees will be useful as perches to the water birds for laying their eggs and help in their breeding
4. These trees when grown up, provide fuel, fodder, timber and others for the benefit of society and income to the Government; and
5. Foreshore plantation will help to maintain ecological balance in nature.

Spacing and number of trees to be planted: A spacing of 3 to 4 m is proposed depending on the availability of land. The plantation is proposed above FRL contour level to form as a reservoir rim.

List of species, suitable for green belt plantation are furnished elsewhere in Biological Management chapter.

Plantation method: Bagged plants preferred over direct sowing of the seed. But unlike other seedling, special care should be taken as it develops long tap root, and seeding should be planted out at young age of about 4 months old.

Pitting and Planting Pits: Pits of 0.3 x 0.3 m are dug and bagged seedlings raised in polypots are planted in the pits and the pits are filled up. In case it is not raining, small quantity of water is put for settlement of soil. Planting is done in the months from June to August.

After Planting Care: For the initial 2 years weeding and soil consolidation around the plants is recommended. Gap filling can be taken up in the third year in case of any causality. Watch and ward for two years is to be ensured. After 5 years the surviving trees would be large enough to withstand grazing.

Area for Reservoir Rim Treatment

8.109 The reservoir peripheries are having gentle to steep slopes in view of the topography. The proposed width for the reservoir rim treatment with plantation differs according to the slope. Plantations along the periphery in the areas having slopes above 35 percent are not proposed in view of small widths available between FRL and MWL for plantations.

Submergence area

8.110 Umngot river sub basin forms part of Surma river basin in Bangladesh. The river flows in its later part through rapids, falls and deep gorges in a zigzag way. The location of the Umngot HEP is also proposed in a deep gorge. The submergence area at FRL 1040 m is broadly confined within the left and right flanks with small portions of village lands here and there. The gross area of submergence as arrived from GIS application is worked out as 160.3 ha and excluding water bodies, it is 93.55 ha. The classification of the land use of the area is shown in Table 8.17. Map showing the land use in the submergence area is appended in fig 8.6

Table 8.17
Classification of land use in the submergence area.

S.No.	Classification	Area ha	Percentage
1	Arable Land	8.85	3.49
2	Broom Land	47.75	18.81
3	Dense Forest	8.28	3.26
4	Open Forest	51.72	20.38

Table 8.17 Classification of land use in the submergence area.			
5	Scrub Land/ Tree Clad	8.96	3.53
6	Barren Land	34.74	13.68
7	River Water Bodies.	93.55	36.85
	Total	253.85	100.00

8.111 The table indicates that the submergence in arable area is only 3.49 percent. Hence the submergence of land on left and right flanks comprises mainly gentle to moderate steep slope. Since FRL and MWL (RL 1040 m) are same, no area is available between FRL and MWL. Hence it is proposed to provide reservoir rim treatment on left and right flanks uniformly for a width of 10 m with three rows of plantations at 5 m intervals within MWL. The total length of reservoir rim is as follows

- On left flank - 32,000 m
- On right flank - 28,000 m

8.112 Total length of the proposed reservoir rim treatment is 60000 m or 60 km and the area of greenbelt works out to 60 ha. Hence it is proposed to provide afforestation in an extent of 60 ha for green belt development along reservoir rim.

Cost

8.113 Cost of reservoir rim treatment for 60 ha will be **Rs.19.26 lakh** at the rate (Rs 32100 per ha) already adopted under catchment treatment for afforestation. It is proposed to execute over a period of 5 years at the rate of 12 ha per year.

Catchment Area Treatment Cost:

8.114 The cost of catchment area treatment comprises components such as biotic treatment with soil and water conservation measures, engineering and gully control works, measures to control shifting cultivation besides Reservoir Rim treatment. The treatment measures are proposed mostly in Government lands. The catchment area treatment shall be taken up by forest department in association with Agricultural department and district counsels with the funds provided by the project proponents. The total cost estimated is only approximate and may vary depending upon the field surveys and designs made by the line departments, and escalation in prices. The estimated cost for the recommended treatment measures is **Rs. 2,239.04 lakhs** excluding compensatory afforestation in lieu of submergence of forest lands. The details of financial outlay for different treatment measures including year wise phasing for 5 years is shown in Table 8.18.

Table: 8.18 catchment area treatment cost and year wise phasing							
S.No	**Treatment measures**	**Years – Cost in Rs. Lakhs**					**Total Cost Rs Lakhs**
		1	**2**	**3**	**4**	**5**	
I.	Forest and Silvi-pastural management						
1	Afforestation / reforestation	64.20	80.25	80.25	80.25	80.25	**385.20**
II	Soil and water conservation measures						
1	Engineering and mechanical measures						
	a) Double Row Brush Wood Dams	0.36	0.53	0.53	0.53	0.53	**2.50**
	b) Loose Boulder Check Dam	7.78	7.78	7.78	7.78	9.08	**40.19**
	c) Mini Percolations Tanks	1.00	1.00	1.00	1.00	2.00	**6.00**
2	Staggered trenches including planting and development of fodder grasses	32.66	71.01	71.01	71.01	71.01	**316.68**
3	Bench terracing	283.47	283.47	283.47	283.47	288.67	**1,422.55**
III	Control of shifting cultivation	5.17	7.38	9.57	11.35	13.19	**46.66**
IV	Reservoir Rim Treatment	3.85	3.85	3.85	3.85	3.85	19.26
	Total catchment area treatment cost	**398.49**	**455.27**	**457.46**	**459.24**	**468.58**	**2,239.04**

Compensatory Afforestation

<u>Stipulation under forest conservation Act 1980</u>

8.115 Following norms have been laid down for compensatory afforestation.

i. Where non forest lands are available compensatory afforestation is raised over equivalent area of non forest land.

ii. Where non forest lands are not available, compensatory afforestation is raised over degraded forest twice in extent to the area to be diverted.

8.116 But as per the provision of the sixth schedule to the constitution of India, 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. The forest are likely to be submerged is under community forest maintained by the district and village councils. Hence the forest conservation act may not be applicable to the forest area under the project catchment 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 submergence area contains the following clarification of land as per GIS applications made by AFC excluding water bodies' occupied by Umngot river and other tributaries.

- Dense forest -- 12.91 ha
- Open forest -- 80.62 ha

Total 93.53 ha

It is proposed to raise compensatory afforestation in an area of 93.53 ha in liew of submergence dense and open forest.

8.117 The area has to be transferred to the control of the project proponents after necessary land acquisition as applicable ample degraded area is available in the catchment area adjoining the submergence portion under the nomenclature of open forest/scrubs. Thus compensatory afforestation is proposed in this area which is yet to be identified.

Cost of Afforestation

8.118 The cost of afforestation would be born by the project proponents at the rate of Rs 32,100/- per ha as already furnished in this chapter VIII. The cost of plantation would be born by the Umngot HEP proponents. The unit area working cost in un-irrigated plantation activity is collected from forest department authorities. Since the area has to be planted in later years, the cost escalation consideration is kept in mind and a modest rate of Rs 32,100/- per ha reckoned for working out the cost of compensatory afforestation. The total amount for the activity in an area of 93.53 ha is estimated to be at Rs 30.02 lakhs. Compensatory afforestation will be under taken in degraded open forest lands.

8.119 As per the instruction of the center in view of apex court's directives, the insistence is on a successful plantation, where compensatory afforestation scheme is taken up. In practice wove wore fencing/chain fencing mechanism has to be adopted for raised compensatory afforestation for security full protection not only from cattle and human entry but also from wild life. However, the cost estimates working sheets. (Annexure VIII.14) does not provide for the above and since not included in the cost.

8.120 Twin objective of this proposal of compensatory afforestation would fulfill largely the goal of compensating the loss of forest area going under submergence. Besides, these plantation sites would also fulfill the need based causes of treating the catchment area of the reservoir in preventing silting of the reservoir and soil runoff as the plantation sites are proposed in the catchment Zone.

Cost Estimation

8.121 The cost estimation for compensatory afforestation will have three main components as follows:

- Cost of afforestation
- Cost of deforestation and
- Cost of land acquisition and NPV cost.

8.122 The cost norms followed for the above all as bellow:

- The cost of afforestation is at the rate of Rs 32,100/- per ha for an area of 93.53 ha.
- The cost of deforestation for an area of 93.53 ha at a rate of Rs 26250/- per ha as per the Forest Department.
- NPV cost is assessed at the rate of Rs 8.03 and 6.26 lakhs per ha respectively for Dense (12.91 ha) and Open Forests (80.62 ha).

Note : On the basis of the orders of Hon. Supreme Court dated 28.4.2008 and 9.5.2008 and economic value of forests after the changes in the forest land. In the states of Madhya Pradesh and Chhattisgarh, the NPV is being recovered at the rate of Rs.5.80 lakh Rs.9.20 per hectare of the forest land depending upon the quality and density of the forest land diverted for non-forestry use. (Source : http://nitya34.blogspot.com/2009/12/npv-supreme-court-moef-and-projects.html, MP Forest Department Manual and http://iegindia.org/npvreport.pdf)

8.123 The total cost required for compensatory afforestation of forest land and other items given in Table 8.19

Table 8.19 cost of Compensatory afforestation

Sl.No	Description	Area (ha)	Rate per ha.	Cost in Rs lakhs
1	Cost of afforestation	93.53	32,100	30.02
2	Cost of deforestation	93.53	26,250	24.55
3	NPV cost.			
	Dense Forest	12.91	803,000	103.67
	Open Forest	80.62	626,000	504.68

			Total	**662.92**

8.124 Total cost of catchment area treatment inclusive of compensatory afforestation is as below (Table 8.20) which worked out to be **Rs 2961.76 lakhs.**

Table 8.20 Total cost of Catchment Area Treatment		
Sl.No	*Description*	*Cost in Rs lakhs*
1	Catchment area treatment in priority zones	2,239.04
2	Compensatory afforestation	662.92
	Total	**2,901.96**

ANNEXURE – VIII.I

DESIGN AND ESTIMATED COST OF STAGGERED CONTOUR TRENCHES
(For Horticultural Plantations)

Slope of land	-	10% to 35%
Average depth of soil	-	0.90 m
Length of contour trench	-	5.00 m
Width of trench	-	45 cm
Depth of trench	-	50 cm
CS of trench	-	2.25 sq m
Spacing between the trenches in same row	-	3.30 m
Horizontal spacing	-	5.00 m

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.

Total No. of trenches per ha	-	180 nos.
Total length of trenches per ha including 3 nos. Continuous trenches.	-	1,200 m
Earth work involved	-	270.0 cum
Jungle area to be cleared @ 1 sq m throughout the length	-	1,200 sq m
Cost of Jungle clearing etc @ Rs.0.5113 per sq m	-	Rs. 613.56
Cost of excavation of trenches: 270.0 cum x Rs.39.00	-	Rs.10530.00
Total cost	-	Rs. 11143.56
5% contingency	-	Rs. 557.18
Grand Total	-	Rs.11701 per ha

ANNEXURE – VIII.2

TYPICAL DESIGN OF BENCH TERRACE
(One Hectare)

Terrace

Average slope of land(s)	-	10%
Riser Slope	-	1: 1
Average Depth of slope	-	0.60 m
Average depth of cut (d)	-	0.30 m
Width of trench (W)= $\left(\frac{200xd}{S}\right)$ m = $\left(\frac{200 \times 0.30}{10}\right)$m	-	6.0 m
Vertical Interval (VI)= $\left(\frac{W \times S}{100-S}\right)$, m = $\left(\frac{6 \times 10}{100-10}\right)$m = 0.67 m	-	0.70 m (Say)
Horizontal interval (HI) = (W + VI) m = (6.00+0.70)m	-	6.70 m
Length of terrace per ha (L)= $\left(\frac{10000}{HI}\right)$ m = $\left(\frac{10000}{6.70}\right)$m	-	1492.50 m (Say) 1492
Earth work involved per ha (EW) = $\left(\frac{L \times VI \times HI}{8}\right)$ cum	-	875.00 sum
Cost of earth work @ Rs. 39.00 per cum (ordinary soil)	-	34125/-

Shoulder Bund

Top width	-	0.30 m
Bottom width	-	0.90 m
Height	-	0.30 m
Cross sectional area = $\left(\frac{0.30 + 0.90}{2} \times 30\right)$ sq m	-	0.18 sq m
The earth work in shoulder bund = 0.18 sq m x 1492 m	-	269.00 cum
Cost of earth work @ Rs.39.00 per cum (ordinary soil)	-	Rs.10491/-

ANNEXURE – VIII.2 Contd….

TYPICAL DESIGN OF BENCH TERRACE
(One Hectare)

Drain

Critical length of terrace (K)	-	100 m
No. of outlets per ha (N) = $\left(\frac{L}{2K}\right) = \left(\frac{1492}{2 \times 100}\right)$ = 7.46 Nos	-	8 Nos. (Say)
Approximate length of vertical drain per ha = (1 x N x H)m	-	54.00 m (Say)
Cross section of the disposal drain		
Bottom width	-	0.30 m
Top width	-	0.90 m
Height	-	0.30 m
Cross-sectional area	-	0.18 sq m
Total earth work in vertical drain =(0.18 sq m x 54 m)	-	9.72 cum
Cost of earth work @ Rs.39.00 per cum (ordinary soil)	-	Rs.379.08
Say	-	Rs.379
Total Cost per terracing per ha		
Terrace (Earth work)	-	Rs .34125.00
Shoulder bund	-	Rs. 10491.00
Drain	-	Rs. 379.00
Total	**-**	**Rs. 44995.00**
Add contingency @ 5%	-	Rs. 2250.00
Grand Total	**-**	**Rs. 47245.00**

ANNEXURE – VIII.3

ESTIMATED COST FOR EACH DOUBLE ROW POST BRUSH DAM

Average depth of gully	-	2.25 m
Average width of gully	-	6.00 m
Earth work for excavation of bed and abutments (sides) upto 15 cm depth for a width of 1.00 m = (12.36 m x 0.15 m x 1.00 m)	-	1.85 cum
No. of 12 cm diameter, 5.00 m long stakes	-	28 Nos.
Cost of earth work excavation @ Rs.39.00 per cum	-	Rs. 72.15
Cost of 28 Nos. stakes @ Rs.42.00 each	-	Rs. 1176.00
Cost of miscellaneous articles like galvanized wire, Repe etc. on lump sum basis	-	Rs. 250.00
Labour charges for 1 day = (2 nos. @ 100.00 per day)	-	Rs. 200.00
Total	**-**	**Rs.1698.15**
Contingency @ 5%	-	Rs. 84.90
Grand Total	-	**Rs.1783.05**
Say	-	Rs.1783.00

ANNEXURE – VIII.4

ESTIMATE OF LOOSE BOULDER CHECK DAM
(Considering 10.00 m width and overall Length of 12.40 m)

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1. Boulder Sausage

   a) Earth work in excavation including removing the spoils as directed upto a distance of 100 m including dressing, cambering, grading the surface etc complete as directed.

   b) Loose bolder above one man size or soil mixed with boulders above one man size or soft shale not requiring blasting.

Body wall side	$2 \times \frac{(0.30\ m + 1.20\ m)}{2} \times 1.20\ m$	-	1.80 cum	
Body wall foundation	10.00 m x 1.00 m x 0.30 m	-	3.00 cum	
Down stream side apron	10.00 m x 0.90 m x 0.15 m	-	1.35 cum	
Sub-Total :	@ 42.00 per cum	-	6.15 cum	Rs.258.30

2. Collection of hard river boulder at quarry size 23 cm to 30 cm (man size) of weighing not less than 40 kg free from dirt and dust and other foreign impurities.

Body wall bottom	10.00 m x 1.00 m x 0.30 m	-	3.00 cum	
Body wall	$12.4\ m \times \frac{(1.0\ m + 0.3\ m)}{2} \times 0.3\ m$	-	2.42 cum	
Stepped wall	2 x 0.60 m x 0.30 m x0.30 m	-	0.11 cum	
	2 x 0.60 m x 0.60 m x0.30 m	-	0.22 cum	
	2 x 1.20 m x 0.90 m x0.30 m	-	0.65 cum	
Upstream apron	2 x 0.60 m x 0.30 m x0.30 m	-	1.35 cum	
Sub-Total :	@ 88.00 per cum	-	7.75 cum	Rs.682.00

(forest royalty rate)

ANNEXURE – VIII.4

ESTIMATE OF LOOSE BOULDER CHECK DAM
(Considering 10.00 m width and overall Length of 12.40 m)

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3. Cost of dumping of boulders and making 8.6 wire sausage wire cages including fixing and fitting and placing in position are :

Size of one cage 1.51 m x 1.51 m x 0.45 m - 1.03 m3

No. of cages Required = Total quantity of boulders / Size of cage

Total Quantify As per item No.2 = 7.75 cum / (1.51 m x 1.51 m x 0.45 m) Say 8 Nos

Cost per one cage comes to Rs.1260/- - Rs.11408.00
(As per SSR per CUM Rs 184 (7.75 x 184 =Rs 1426.00)
Total : - Rs.12348.30

4. Add 5% contingency - Rs.617.41

Grand Total : - Rs.12965.72

Say - Rs.12966/-

Average cost per running Meter length = Rs.12966.00 / 12.40 m - Rs.1045.62
Say - Rs.1046/- per meter

ANNEXURE. VIII.5

TECHNICAL DETAILS OF MINI-PERCOLATION TANKS		
Sl.No	**Description of Parameter**	**Dimension adopted**
	Works involved	Earthwork excavation and formation of bank
1	Average length of mini-percolation tank	120 m
2	Top width of bank	2.0 m
3	Width at bottom	9.0 m
4.	Front side slopes	1 ½ : 1
5	Rear side slopes	2 : 1

ANNEXURE – VIII.6

ESTIMATED INPUT COSTS OF HORTICULTURAL CROPS

S.No.	Fruit Crop	Year	Planting material		Fertilizer				Plant Protection Chemical Cost / Ha (Rs.)	Total Cost / Ha (Rs.)
					Qty / Plant (Gm)			Cost / Ha (Rs.)		
			Qty (Nos)	Cost (Rs.)	Urea	SSP	MoP			
1.	Pineapple	1st	30,000	10,851.00	8	8	8	4,550.00	390.00	15,791.00
		2nd	-	-	8	8	8	4,550.00	390.00	4,940.00
	Total		**30,000**	**10851.00**	**16**	**16**	**16**	**9,100.00**	**780.00**	**20,731.00**
2.	Orange	1st	278	2,250.00	55	125	40	260.00	170.00	2,680.00
		2nd	40	335.00	110	250	85	540.00	180.00	1,055.00
		3rd	-	-	225	500	200	1,095.00	195.00	1,290.00
		4th	-	-	350	800	300	1,645.00	225.00	1,870.00
		5th	-	-	500	1200	400	2,345.00	257.00	2,602.00
	Total		**318**	**2,585.00**	**1240**	**2875**	**1,025**	**5,885.00**	**1,027.00**	**9,497.00**
3.	Lemon	1st	800	5,615.00	325	525	240	3,020.00	645.00	9,280.00
		2nd	80	570.00	650	1,250	480	6,565.00	710.00	7,845.00
		3rd	-	-	975	1,875	720	11,675.00	710.00	12,385.00
		4th	-	-	1,300	2500	960	15,580.00	725.00	16,305.00
		5th	-	-	1,300	2500	960	15,580.00	725.00	16,305.00
	Total		**880**	**6,185.00**	**4,550**	**8,750**	**3,360**	**52,420.00**	**3,515.00**	**62,120.00**
4.	Guava	1st	278	1,075.00	50	75	25	175.00	260.00	1,510.00
		2nd	30	130.00	100	150	50	350.00	285.00	765.00
		3rd	-	-	100	150	50	350.00	285.00	635.00
		4th	-	-	100	150	50	350.00	285.00	635.00
		5th	-	-	100	150	50	350.00	285.00	635.00
	Total		**308**	**1,205.00**	**450**	**675**	**225**	**1,575.00**	**1,400.00**	**4,180.00**
5.	Papaya	1st	2,600	1,675.00	163	156	83	4,315.00	180.00	6,170.00
		2nd	-	-	325	312	167	8,625.00	300.00	8,925.00
		3rd	-	-	325	312	167	8,625.00	300.00	8,925.00
	Total		**2,600**	**1,675.00**	**813**	**780**	**417**	**21,565.00**	**780.00**	**24,020.00**
	Grand Total (for 5 ha)	**-**	**-**	**22,501.00**	**-**	**-**	**-**	**90,545.00**	**7,502.00**	**1,20,548.00**

Annexure VIII.7

Year-wise Physical and Financial Targets for Horticultural Crops under Integrated strip Farming Programme

Sl No	Horticultural Crops	Year-1		Year-2		Year-3		Year-4		Year-5		Total	
		Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs
1	Pine Apple	10	1.58	10	0.49							10	2.07
				10	1.58	10	0.49					10	2.07
						10	1.58	10	0.49			10	2.07
								10	1.58	10	0.49	10	2.07
										10	1.58	10	1.58
	Total	**10**	**1.58**	**10**	**2.07**	**10**	**2.07**	**10**	**2.07**	**10**	**2.07**	**50**	**9.86**
2	Orange	10	0.27	10	0.11	10	0.13	10	0.19	10	0.26	10	0.96
				10	0.27	10	0.11	10	0.13	10	0.19	10	0.70
						10	0.27	10	0.11	10	0.13	10	0.51
								10	0.27	10	0.11	10	0.38
										10	0.27	10	0.27
	Total	**10**	**0.27**	**10**	**0.38**	**10**	**0.51**	**10**	**0.70**	**10**	**0.96**	**50**	**2.82**
3	Lemon	10	0.93	10	0.78	10	1.24	10	1.63	10	1.63	10	6.21
				10	0.93	10	0.78	10	1.24	10	1.63	10	4.58
						10	0.93	10	0.78	10	1.24	10	2.95
								10	0.93	10	0.78	10	1.71
										10	0.93	10	0.93
	Total	**10**	**0.93**	**10**	**1.71**	**10**	**2.95**	**10**	**4.58**	**10**	**6.21**	**50**	**16.38**
4	Guava	3	0.05	3	0.03	3	0.02	3	0.02	3	0.02	3	0.14
				3	0.05	3	0.02	3	0.02	3	0.02	3	0.11
						3	0.05	3	0.03	3	0.03	3	0.11
								3	0.05	3	0.03	3	0.08
										3	0.05	3	0.05
	Total	**3**	**0.05**	**3**	**0.08**	**3**	**0.09**	**3**	**0.12**	**3**	**0.15**	**15**	**0.49**

Annexure VIII.7

Year-wise Physical and Financial Targets for Horticultural Crops under Integrated strip Farming Programme

Sl No	Horticultural Crops	Year-1		Year-2		Year-3		Year-4		Year-5		Total	
		Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs
5	Papaya	10	0.62	10	0.89	10	0.89					10	2.40
				10	0.62	10	0.89	10	0.89			10	2.40
						10	0.62	10	0.89	10	0.89	10	2.40
								10	0.62	10	0.89	10	1.51
										10	0.62	10	0.62
	Total	**10**	**0.62**	**10**	**1.51**	**10**	**2.40**	**10**	**2.40**	**10**	**2.40**	**50**	**9.33**
	Grand Total	**43**	**3.45**	**43**	**5.75**	**43**	**8.02**	**43**	**9.87**	**43**	**11.79**	**215**	**38.88**

1	Total area of Horticultural Crop Strips	215.00	ha
2	Deduct area of vegetative hedge @ 0.0405 ha/ha (180 Nos x 5 m length x 0.45 m width) / 10000	-8.71	ha
3	Net area of Horticultural Crop Strips to be covered by crops	206.29	ha
4	Proportionate cost for planting Horticultural Crop in net area (Rs. 38.88 lakh x 206.29 ha) / 215 ha	37.30	Rs Lakhs

ANNEXURE VIII.8

ESTIMATED INPUT COSTS OF COVER CROPS

S.No.	Crop	Area (ha)	Seed			Fertilizer			Plant protection Chemical Cost/ Ha Rs.	Total cost / Ha (Rs.)
			Name	Qty (Kg)	Cost (Rs.)	Name	Qty (Kg)	Cost (Rs.)		
1.	Cowpea	1	Local	25	330.00	N	20	920.00	100.00	1,350.00
						P	30			
						K	10			
2.	Black gram (Urad)	1	Pant, T-2,T-9, U-19	20	525.00	N	15	765.00	150.00	1,440.00
						P	30			
						K	0			
3.	Soyabeen	1	JS-2, Moti	40	590.00	N	15	985.00	130.00	1,705.00
						P	30			
						K	20			
4.	Green Manure	1	-	60	395.00	N	-	-	-	395.00
						P	-			
						K	-			
	Total	**4**	**-**	**145**	**1,840.00**	**-**	**-**	**2,670.00**	**380.00**	**4,890.00**

ANNEXURE VIII.9

ESTIMATED INPUT COSTS OF MIXED CROPS

S.No.	Crop	Area (ha)	Seed			Fertilizer			Plant protection Chemical Cost/ Ha Rs.	Total cost / Ha (Rs.)
			Name	Qty (Kg)	Cost (Rs.)	Name	Qty (Kg)	Cost (Rs.)		
1.	Maize + Cowpea	1	Maize	12	290	N	20	1125.00	245.00	1660.00
			Cowpea	10	-	P	40			
						K	10			
2.	Maize + Black gram (Urad)	1	Millet	12	525.00	N	20	1025.00	170.00	1720.00
			Blackgram	15		P	35			
						K	10			
3.	Maize + Soyabeen	1	Maize	12	525.00	N	20	1025.00	160.00	1,710.00
			Soyabeen	15	-	P	35			
						K	10			
4.	Millet + Mung	1	Millet	8	495.00	N	20	815.00	230.00	1540.00
			Mung	15		P	25			
						K	10			
5.	Millet Blackgram (Urad)	1	Millet	8	470.00	N	20	815.00	200.00	1485.00
			Blackgram	15		P	25			
						K	10			
	Total	**5**	**-**	**-**	**2305.00**	**-**	**-**	**4805.00**	**1005.00**	**8115.00**

Annexure VIII.10

Yearwise Physical and Financial Targets for Planting Cover Crops under Integrated strip Farming Programme

Sl No	Cover Crops	Year-1		Year-2		Year-3		Year-4		Year-5		Total	
		Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs
1	Cowpea	10	0.13	10	0.13	10	0.13	10	0.13	10	0.13	50	0.65
2	Blackgram	10	0.14	10	0.14	10	0.14	10	0.14	10	0.14	50	0.70
3	Soyabean	10	0.17	10	0.17	10	0.17	10	0.17	10	0.17	50	0.85
4	Green Manure	13	0.05	13	0.05	13	0.05	13	0.05	13	0.05	65	0.25
	Total	**43**	**0.49**	**43**	**0.49**	**43**	**0.49**	**43**	**0.49**	**43**	**0.49**	**215**	**2.45**

1	Total area of Cover crop Strips	215.00	ha
2	Deduct area of vegetative hedge @ 0.0136 ha/ha $\frac{\text{3 strips x 100 m length x1 m width}}{\text{10000 x 2.20 ha Unit}}$	-2.92	ha
3	Net area of cover crop strips to be covered by crops	212.08	ha
4	Proportionate cost for planting cover crops in net area $\frac{\text{Rs. 2.45 lakh x 212.08 ha}}{\text{215 ha}}$	2.42	Rs Lakhs

Annexure VIII.11

Yearwise Physical and Financial Targets for Planting Mixed Crops under Integrated strip Farming Programme

Sl No	Mixed Crops	Year-1		Year-2		Year-3		Year-4		Year-5		Total	
		Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs
1	Maize + Cowpea	6	0.10	6	0.10	6	0.10	6	0.10	5	0.10	29	0.50
2	Maize + Black Gram	6	0.10	6	0.10	6	0.10	6	0.10	5	0.10	29	0.50
3	Maize + Soyabean	6	0.10	6	0.10	6	0.10	6	0.10	5	0.10	29	0.50
4	Millet + Mung	6	0.09	6	0.09	6	0.09	6	0.09	5	0.09	29	0.45
5	Millet + Black Gram	6	0.09	6	0.09	6	0.09	6	0.09	3	0.09	27	0.45
	Total	**30**	**0.48**	**30**	**0.48**	**30**	**0.48**	**30**	**0.48**	**23**	**0.48**	**143**	**2.40**

1	Total area of Mixed Crop strips	143.00	ha
2	Deduct area of vegetative hedge @ 0.0091 ha/ha (2 strips x 100 m length x1 m width) / 10000 x 2.20 ha Unit	-1.30	ha
3	Net area of Mixed crop strips to be covered by crops	141.70	ha
4	Proportionate cost for planting cover crops in net area (Rs. 2.40 lakh x 141.70 ha) / 143 ha	2.38	Rs Lakhs

Annexure VIII.12

Yearwise Physical and Financial Targets for Planting Silvi-Pastural Crops under Integrated strip Farming Programme

Sl No	Silvi Pastural Crops	Year-1		Year-2		Year-3		Year-4		Year-5		Total	
		Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs	Area, ha	Rs Lakhs
1	Fodder Trees + Pasture Grasses	43	0.41	43	0.41	43	0.41	43	0.41	43	0.41	215	2.05
	Total	**43**	**0.41**	**43**	**0.41**	**43**	**0.41**	**43**	**0.41**	**43**	**0.41**	**215**	**2.05**

ANNEXURE – VIII.13

VEGETATIVE HEDGES – VETIVER GRASS PLANTING TECHNIQUE

1. Planting Materials

Veltiver grass is propagated by transplanting of slips. ' Clumps' of vetiver grass would be best removes with a pick-axe, form or spade from the nursery. Root system being massive and very strong, it cannot be pulled out with hand. From the clump, slips can be torn apart in handfuls for convenience of handling. Planting material should be transported and used within shortest possible time after uprooting. It can be used for planting within 3 or 4 days of uprooting provided the material is handled carefully and kept covered. Occassional sprinkling of water during the period between removal and planting will help in checking mortality.

2. Cutting of Tops

Before transporting the materials to the filed, tops of slips should be cut off about 20 cm from the base. The job can be done by using a block of wood and a cane knife. Below the base, roots of 6 to 10 cm in length should be left on the plant.

3. Preparation of Planting Line

Field should be well ploughed and furrowed and rendered free of weeds. The contour line should be demarcated, just before planting of vetiver grass, with the help of desi plough.

4. Spacing

Within the row, spacing between the plants would be 10 cm.

5. Number of Slips per Hill

Slips planted singly will take a long time to form a clump. It is, therefore, advisable to use at least three slips per hill.

6. Care at the Time of Planting

In the planting furrow a small hold should be made with a wooden peg before lowering the plant in the ground. Three slips held together with the three writing fingers (thumb and two fingers) should be planted in the soft ground taking care that the thumb does not damage the stem above the root and the root and stem remain in straight line to avoid injury to the plant. After placing the plant in the field, a little earthing should be done and the soil around should be pressed firmly for proper union of plant with the soil.

7. Planting Time.

It should be coincide with Kharif sowing at the start of monsoon so that planting of vetiver would be part of kharif operation for the convenience of farmer and so that the planting gets established early in the rainy season.

8. After Care

The farmer should be advised to keep the vetiver rows free of weeds during the course of his working in the Kharif fields. In the first year farmer should do the gap filling by taking slips from the healthy plants around. Normal care, as applicable to field crops, for two seasons will make the plants healthy and strong enough to take care of themselves besides taking care of the field silt.

ANNEXURE – VIII.14

SPECIFICATIONS AND COST ESTIMATE FOR 100 m LENGTH PLANTATION OF VETIVER GRASS HEDGE IN SHIFTING CULTIVATION LAND

Length of Vegetative hedge	-	100 m
No.of hills per 100 m length 10 cm spacing	-	1,000
No. of slips @ 3 per hill required for planting 100 m length		3,000
No. of clump required to produce required slips	-	60
Cost of Clumps		
Cost of raising nursery / purchase price (Lump sum)	-	Rs.60.00
Cost of uprooting of clumps / cutting of tops	-	Rs.45.00
Pro rata cost of transportation of 60 clumps for an average	-	Rs.52.00
Distance of 60 km in hilly terrain, including loading /unloading		
Clearing and separation of slips from the clump (3,000)	-	Rs.25.00
Total	-	Rs.182.00
Plantation Cost		
Digging of 10 cm deep and 10 cm wide trench of 100 m length	-	Rs.23.00
Along the contour line		
Cost of planting 1,000 hills	-	Rs.90.00
Miscellaneous and contingencies	-	Rs.15.00
Total	-	Rs.128.00
Grand total	-	Rs.310.00 (per 100m)
Cost of planting of 500 m total length in the middle of 20 m (width) strips of mixed and cover crop proposed in the land Use model (unit of 2.20 ha)	-	Rs.1550.00

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Chapter - IX

LAND MANAGEMENT PLAN

INDIA
MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS
UMNGOT HYDRO-ELECTRIC PROJECT
(3 X 80 MW)

PART - II

ENVORINMENT MANAGEMENT PLAN (EMP)

IX

LAND MANAGEMENT

Preamble

9.01 A successful feasible and implementable Environment Management Plan (EMP) largely depends upon the accurate Environmental Impact Assessment of the various parameters necessary for working out the mitigative measures and subsequent formulation of relevant plans. The Environmental Impact Assessment of Umngot HEP was presented in the previous Part -I of the study report. The same brought to light the various aspects of the impact of the project on land, water, flora and fauna and in last but not the least, the human population including public health.

Land Management

9.02 The Umngot HEP area comprises vast areas of forests, hilly regions, undulating plains and series of valleys. The land management consists of formulation of plans towards mitigative measures identified in various fields as below –

<u>Catchment area treatment plan</u>: The plan has been discussed separately in Chapter – VIII of EMP including Compensatory Afforestation, Reservoir rim treatment plan and watershed management.

<u>Land Management</u>: Following aspects of land management not covered in the above captions has been dealt with in this chapter.

1. Muck Disposal Plan
2. Methods of tunneling using TBMs,
3. Conventional controlled blasting, Charge density, amount of delay.

Plan for Muck Disposal site management

9.03 For the Hydro Electric projects, the quantity of muck generated is quite considerable for the construction of dams across rivers, excavation of tunnels and construction of other associated structures. As already indicated under EIA, the muck generation and improper dumping leads to degradation of land and loss of biomass. About 1.09 Mm^3 muck is to be disposed at suitable locations in respect of project. The muck is to be disposed in a planned manner so that it occupies least possible space and is not hazardous to the environment. The muck disposal areas are to be identified carefully. A low level area which does not involve any additional land acquisition will be identified. The muck disposal areas need to be developed preferably quite away from the MWL line along the river course in a series of terraces of boulder crater walls and masonry walls wherever needed. This shall achieve the objectives (i) to protect the muck area from flood water during monsoon and (ii) to create inspection paths. In between the terraces catch water drains will be provided. The terraces of the muck disposal areas are ultimately covered with fertile soils obtained from excavations. Thereafter suitable plants will be planted adopting applicable bio-technical measures. The overall idea is to enhance / maintain aesthetic view in the environs of the project in the post construction period and avert any land or water sources contamination due to muck besides compensating the ecological loss due to construction of main structures to some extent. The various activities proposed as part of the muck management plan envisages the following:

1st Phase:

- Land acquisition (if required)
- Civil works (retaining walls such as boulder walls, masonry walls)
- Dumping muck
- Levelling the area, terracing and implementation of various engineering control measures
- Spreading of fertile soils
- Application of fertilizers

2nd Phase:

- Construction of drains, etc
- Digging pits for plantation
- Plantation, turfing etc.
- Fencing
- Watch and ward

❖ Maintenance upto 5 years in post project period.

9.04 The total cost required for management of muck disposal sites in respect of Umngot HEP works out to be Rs 118.58 lakh. The item-wise costs of management of muck disposal sites are presented in Table – 9.1.

Table – 9.1 Cost Estimate for Stabilization of Muck Disposal Management

Sl.No.	Details	Quantity	Unit	Unit Rate (Rs)	Cost (Rs lakhs)
A	Engineering Measures				
1	Boulder crater walls	3000	m^3	1208	36.24
2	Masonry wall	1500	m3	1889	28.34
3	Catch water drain	-	-	LS	8.00
4	Leveling including spreading of excavated soil including Transportation.	3000	m3	638	19.14
	Sub-total				**91.72**
B	Biological Measures				
1	Plant saplings procurement			LS	5.00
2	Plantation			LS	10.00
3	Fencing	1.50	Km	80000	1.20
4	Biological fertilizer procurement	-	-	LS	4.80
5	Watch & ward 2 Nos @ Rs. 4000/- month / person for 5 years with an escalation of 10% every year	24 Man Months Per Year	Month	Y1-96000 Y5-140553	5.86
	Sub-total				**26.86**
	Total A + B				**118.58**

Source : Computed by AFCL

Restoration Plan for Quarry Sites

9.05 Most of the aggregate required for the construction of dam, power houses and other head works would be obtained from the muck generated during foundation exploration and tunnels since the rock is found suitable as coarse aggregate in CC and other works. Additional quantities of coarse aggregate for concrete works is proposed to be obtained from the following quarries

9.06 Stone quarries are proposed in the nearby vicinity on the flanks of Umngot River on the upstream area which are likely to be submerged. The rock in the quarry area is hard and compact and erosion intensity will be low. Quarries will be proposed in Govt. lands. No major impact is anticipated from these excavations.

9.07 The quarries for fine aggregate are proposed from Myntdu river sand quarry in Jaintia hills district which is situated at about 55 km from the dam axis. Sand is already being quarried from that river to other projects and no mitigation measures are suggested.

Restoration of Quarries

9.08 The quarries need to be stabilized after extraction of required construction materials is completed. Following engineering and biological measures are suggested for the restoration of quarry sites stone.

- Construction of rough stone guards to check soil erosion in the area and prevent loss of land due to possible land slides.
- Pits formed after quarrying shall be filled with unuseful rock boulders, spalls, waste sand and finally with farm yard manure.
- Grass slabs will be placed to stabilize and check the erosion due to surface runoff.

9.09 The details of costs for the different measures are given in Table – 9.2.

Table 9.2 Details of Costs for Restoration of Quarry Sites

Sl.No.	Activities	Approx. Quantity m^3	Unit cost Rs/m^3	Total Cost Rs. in Lakhs
1	Construction of guard walls with dry rubble	15000	782	117.30
2	Filling up land with soil and debris	15000	255	38.25
	Total			**155.55**

9.10 Methods of Tunneling and Use of TBM

Umngot Hydro Electricity Project has been proposed on Umngot River in Meghalaya state. For generation of the required capacity of power is mainly the following tunnels have been proposed:

1. Low Pressure tunnel of 5588 m length and 3.60 m diameter comprising modified horseshoe in shape. The maximum elevation of ground along the line is 1334 m.
2. High pressure shaft tunnel of 2200m length and 2.75 m diameter trifurcating to 1.80 m diameter.
3. The outlet from the power house will be through a tail race tunnel of 41 m length modified horse shoe diameter 4.4 m and then connected to the rectangular channel of 120.00 meter length dimension of 6.6 m x 2.8 m.

9.11 The others include:

HRT – 5588 m long, Concrete lined modified horse shoe - Shaped Size 3.6 m dia with design discharge of 35.61cumec

Construction Adits

- ✓ Adit to Faces I and II – 300 m long of 3.5m dia located at about 200 m down stream of the dam axis.
- ✓ Adit to Faces III and IV - 1200 m long and 3.5 m dia at about midway of the HRT.
- ✓ Adit to Face V - 230 m long of 3.5 m dia.

Pressure Shaft & Access Adits

- Adit Specification : Internal Diameter 2.75 m, length – 2200 m, steel liner thickness varies from 10 mm to 32mm and Diameter after trifurcation 1.8 m Adit of 2 Numbers viz,. at (i). Midway of inclined limb of 3.5 m dia and 750 m long and (ii) Power house end with 3.5 m dia and 230 m long.

Geological formations encountered

9.12 The finalized alternative alignments of tunnels comprise the following Geological Formations at the bottom. The over burden in the case of HRT is laid over by Quartzite rock and sand stone at top while the rock met within the tunnel area is Granite. The High Pressure Shaft Tunnel area is laid over with Quartzite and Granite at top and Granite at bottom. The tunneling area below the ground in respect of Tail Race Tunnel also consists of Granite at the bottom.

Tunneling Techniques

9.13 Tunnels other than minor tunnels are to be used for transportation. The main objective of tunneling is to remove rock mass to create opening. In order to remove part of the rock mass, it is necessary to induce additional fracturing and fragmentation of the rock. The tensile strength of rock is about 1/10th of compressive strength and therefore breaking the rock requires only 1/100th of the energy as that in compression. The techniques of rock breakage using explosives involves drilling blast holes by percussion or rotary means, loading the bore holes with explosives and then detonating the explosive in each hole in sequence. Instead of deep cuts being constructed, tunnels are often used to conduct the line under a natural obstruction such as hill or ridge. Tunnels are used to carry underground railways, highways and also to carry fluids. The maintenance cost of a tunnel is low compared to that with deep cuts. Tunnels in solid rocks are self supporting and designed as circular, semi circular or horse shoe types of size depends upon the purpose for which the tunnel is proposed.

Conventional type of tunneling

9.14 The following sequence of operations generally take place in the tunneling of conventional types

a) Setting up and drilling

b) Putting explosives and firing

c) Ventilating and removing the dust of explosion

d) Loading and hauling muck

e) Removing ground water if required

f) Erection of support to the roof and sides

g) Placing reinforcement

h) Placing concrete lining

i) Curing and removing the shuttering

9.15 The general practice still followed in tunneling is Drill and Blast technique. This is used where the use of Mechanical tunneling is not economically feasible. In this explosive are loaded in holes that are drilled in a specific pattern chosen to produce the most economical and satisfactory breakage of rock. Drills may be maintained on bars or columns with an adjustable clamp permitting movement. This method is still effective in small tunnels. However, for large tunnels, drills are maintained on drill carriages known as "Jumbos" which is a portable carriage with one or more working platforms equipped with bars, columns or booms to support several drills. The supports allow the drills to accommodate any drilling pattern. The jumbo moves along the tunnel as excavation progresses.

After the holes are drilled they are loaded with explosives. Detonation using instantaneous and delay exposures, follows a specific sequence. Dynamite is used extensively for blasting, Ammonium nitrate explosives may also be used

Environmental disadvantages:

9.16 The drill and blast method poses severe safety hazards to tunnel workers. Undetonated explosives pose a risk, as do the dust, toxic fumes, air pollution, gases and noise associated with blasting. In addition, blasting disturbs and may fracture the rock around the tunnel, thus increasing the risk of falling rocks and debris. Following blasting, the tunnel is ventilated gases, fumes and dust created during the drill and blast operations are removed.

9.17 The following methods are commonly employed for tunneling in hard rock.

(i) Full face: Applicable for tunnels not more than 3.0 m in diameter. Whole section is attacked at the same time.

(ii) Heading and bench method involves driving of the top portion of the tunnel ahead of the bottom portion. This method is rarely used.

(iii) Drift Method: A small tunnel known as a drift is driven first for the full or part length, before excavating the full cross section of the tunnel.

9.18 **Mucking:** The operation of loading broken rock for removal from a tunnel is known as mucking. It may be performed by hand, mucking machines, power shovels or tractor loaders. Specially designed power shovels with short booms and dipper sticks are used for mucking in large tunnels. In case the exhaust fumes are objectionable, units powered with electric motors will be used. Muck is hauled from a tunnel in narrow gauge muck cars pulled by locomotives in trucks or by belt conveyors.

9.19 **Dust Control:** The various operations such as drilling, blasting, loading and hauling muck of the tunnel creates dust in the air. This may create a serious health hazards to the workers. This can be mitigated by using water instead of air for removal of cuttings from the drilled holes, arrangements of complete ventilation near the tunnel face, wetting muck piles during mucking operations.

9.20 Grouting rock tunnels to seal off leakages of water with cement will be done prior to placing concrete lining with necessary reinforcement.

Ventilation of tunnels

9.21 Dust and poisonous gases are largely collected in the conventional type of tunneling due to blasting, mucking and other operations. Ventilation is essential to remove such poisonous gases and to supply fresh air to workers. Mechanical ventilation becomes essential in the case of long tunnels.

Drainage of Tunnels

9.22 Water is likely to accumulate in the tunnel due to ground water and water from washings of bore holes. Ground water seepage may be checked to some extent by grounding with suitable materials. The water accumulated in the sump wells will be pumped out. After completion of tunneling, drainage ditches are provided along the length of the tunnel leading to sump wells and there from the water is pumped out.

9.23 The summary of conventional tunneling by drill and blast techniques are :

Controllable Variables

a) Drilling	:	Diameter of holes
	:	Drilled length
	:	Drill Pattern
	:	In correct drilling
b) Charging	:	Types of explosives
	:	Energy of explosives
	:	Charging method
	:	Design of charging
	:	Charged length
	:	Firing pattern
c) Blasting	:	Firing system
	:	Firing material
	:	Water (Partly)

Non Controllable Variables

Geology	:	Rock parameters
	:	Rock mass Joints
Others	:	Incline and decline
	:	Water (partly)

Mechanical Excavation in Rock

9.24 The technology of using Tunnel Boring Machine (TBM) was developed in 1960's. Compared to the drilling and blasting, a Tunnel Boring Machine (TBM),

- Can excavate rock at a greater rate almost ten times faster than the contemporary drill and blast method.
- Results in a smoother tunnel wall.

- Does not disturb the rock around and adjacent to the excavation. This allows for less supporting steal to safety anchor the surrounding excavation.
- Provides for less over break of rock resulting in the use of much less concrete in the lining process. A tunnel excavated by a TBM required 6.88cum per one meter length compared to 22.72cum per meter length using conventional methods.
- Requires much fewer personnel than the conventional techniques.

9.25 **TBM Excavation:** - India's need for the advantages of TBM excavation is immense. Not for the labour saving benefits but for speed and quality construction by which TMBs can excavate long tunnels for hydro, irrigation, road and rail tunnels. India's history with large scale TBM tunneling however is limited. Resorting India's appreciation and confidence in large scale TBM tunneling is a tough assignment and certain established companies such as Robbins etc have undertaken tunneling works to ensure success of the largest and largest diameter hard rock tunnels in the history. Infact the TBM is Tunnel Boring and muck extraction machine. With the TBMs about 400-500 meters length of the progress per month can be achieved. The rotating head shatters the rock effortlessly and the cutter heads fracture the hard rock into pieces. The TBM conveyor discharges the muck on to a transfer belt that crosses the backup and loads via a hopper, a large continuous conveyor. At the portal, muck transfers onto the stacking conveyor for discharging onto the stock piles. There are two basic types of machines for underground rock excavation viz., partial face machines and full face machines.

9.26 Partial face machines use a cutting head at the end of a movable bottom. Full face machines use a rotating head armed with cutters which fills the tunnel cross section completely and thus almost always excavates circular tunnels. The former are cheaper, smaller and much more flexible in operation. Full face machines are used for relatively straight and long tunnels (>2 km) permits high rates of advance in a smooth, automated construction operation. This may be suitable for the tunnels proposed for the Umngot HEP.

MECHANICS

9.27 In general, 1.5 hours are required for a single cutter change and if several cutters are changed at one time, each may require 30-40 minutes. Even higher down times can be expected with large water inflows, which make cutter change activities more difficult and time consuming. In tunneling terms, a TBM applies both thrust (F_n) and torque (F_t) during the cutting process Cutting involves a complex mixture of tensile, shear and compressive modes of failure. With thrust, the cutting dis penetrates the rock and generates extensive crack propagation to the free surface. Further, strain relief occurs as the disc edge rolls out of its cut, inducing further tensile cracking and stabbing at the rock surface.

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TBM Excavation and Design

9.28 TBMs will operate within certain ranges of rock deformability and strength, where with machine can be tailored to a specific range to achieve maximum efficiency.

Single and Double shield TBMs

9.29 Single shield TBMs are cheaper and are the performed machines for hard rock tunneling. Double shielded TBMs are normally used in unstable geology (as they offer more work protection) or where a high rate of advancement is required. For the Umngot HEP Single Shield TBM is most preferable in as much as it is cheaper and the geological conditions are quite suitable to it.

9.30 Impacts of Geotechnical conditions on TBM operations included (i) Loosening loads, blocks / slabby rock, over break, cave-ins and (ii) Ground water in flow.

The other major geotechnical conditions may be;

(iii) Squeezing ground

(iv) Ground gas / hazardous fluids / wastes

(v) Over stress, spalls, bursts.

(vi) Mixed strength rock

(vii) Hard abrasive rock

(viii) Variable weathering, soil like zones, faults

(ix) Weak rock at invert

9.31 Suitable measures required shall be pre-planned in the design of TBM. Through geological investigations are needed before the design to have full knowledge as to how the rock would react especially under the high stresses of TBM.

9.32 Benched excavations are used for large diameter tunnels in weak rock. Variations may involve sequences in which the inverts, top heading and bench are excavated in different order. Since the maximum diameter of tunnels of Umngot HEP is only 3.6 m., this type of excavation is not necessary.

TBM Tunneling

9.33 TBM tunneling in relation to the selection and dimensioning of the machine, the attention is posed on the limiting geological conditions which may be envisaged and on the importance of geological and geotechnical investigations in order to derive an appropriate understanding of the rock mass conditions along the line of the tunnel.

9.34 TBM excavation represents a big investment in an inflexible but potentially very fast method of excavating and supporting rock tunnel. When unfavorable conditions are encountered without warning then the time schedule and practical consequences are often far greater in a TBM driven tunnel than in a drill and blast tunnel. The unfavorable conditions can be produced by either a rock mass of very poor quality causing instability or a rock mass of very good quality (i.e., strong and massive rock mass) determining very low penetration rates. However, use of full face mechanized excavation method can overcome the limits imposed by the local geology. The influence factors will be the TBM type used and tunnel diameter. Even the economic challenges and schedule competitions of the drill and blast method and other methods can also be over come by the use of TBM. Use of large diameter TBM has been evaluated to be more expensive than the drill and blast methods. The average progress rate is 4.8 – 5.0 km per year with two faces against 2.3 – 4.8 km per year estimated for larger diameter TBM (Kovarietal., 1993). The diameter of tunnels proposed in the Umngot HEP are 3.60 m and below only for which use of TBM is well suited in respect of progress and financial involvement.

9.35 The practically infinite number of combinations of rock, soil and environmental conditions which may be encountered during tunnel excavation determine the types and characteristics of the suitable TBM. As easily perceived, the reasons for limiting the tunnel diameter are;

- The potential of a TBM in hard rock decreases with the increasing diameter (Kovarietal., 1993, Bruland, 1998)
- There are technological limits for the maximum dimensions of some major TBM components, for example, the bearing and head.
- The intensities of both the instability phenomena and the induced convergence also increase with increasing diameter of excavation (Tsengetal., 1998, Barla G and Barlam, 1998)

9.36 A positive and consolidated experience already exists in the use of TBMs in rocks of different qualities and strength for excavation diameters upto 12-12.5 m. A great help in the use of TBMs could possibly achieved through standardization of the section types for various usages. Generally speaking, the most reliable machines are the simple ones as they have the least amount of equipment that can break down (Foster 1997). Overall results of a TBM project depends on

- The type of TBM used and
- The design and special construction characteristics of the TBM adopted

Importance of Geological and Geotechnical Investigations

9.37 Despite the excellent performance of TBM's in favorable ground conditions, (more than 1 km advancement per month for some hydraulic / tunnels), in many cases the actual advancement rates have been below expectations and certainly less than claimed by the manufactures. It is, therefore, necessary to decide whether to optimize the choice of the construction method or the selection of the machine for a given tunnel, on the basis of understanding of site geology and geotechnical conditions or of the level of prediction about these conditions. It has infact been demonstrated that money spent on such investigations is greatly compensated by the savings made in terms of construction cost and time.

9.38 Relatively more important or frequent difficult ground conditions which can affect TBM performance will be considered:

- Borability limits
- Instability of excavation walls
- Instability of excavation face
- Fault zones
- Squeezing

9.39 It should be pointed out that tunnel excavation by a TBM may encounter other difficult ground conditions due to presence of clayey soil; soft ground resulting in settlement of TBM, strong inflow of groundwater and gas, rock bursting, rock and water at higher temperature and karstic cavities. Naturally, the theoretical performance of a TBM is affected by various activities strictly related to the functioning of the machine.

9.40 Positive Impacts in use of TBMs

- TBM often turns in a production rate of 400 m per month
- Automatic lining installers
- Can drill up to 12 m diameter tunnels
- Economically feasible considering the lesser time consumption

- Environment impacts minimized in terms of noise and air pollutions besides risks to workmen.
- Quantities of cement concrete lining can be saved due to the rock surface after drilling compared to the conventional techniques which results in savings in use of aggugates which indirectly cause less damage to quarry sites.
- Use of explosives is largely minimized, thus minimizing or avoiding the risk of thefts of explosives by miscreants or terrorists who try to create instability in the area.
- Reduction of hazardous fumes generation.
- Here the destruction work is minimum and cause large sized chips and a maximum drilling performance.

9.41 Negative (Adverse) Affects

- Power cuts hamper the entire operation
- Problems on the conveyors where blocky conditions of rock is met with. This can be resolved using extra grizzly bars across the cutter head openings.
- Water ingress up to 700 lit /min through the face cause difficult condition. Proper ring builds constructed in advance can avert this difficulty.
- Water ingress on the conveyor system
- Sharp edges of the granite blocks cause serious tears on the long horizontal conveyors.

9.42 Despite the interruptions and delaying factors, the progress of the excavation of the tunnels with TBM will not be hampered much and an advanced rate of about 100 m per week can be achieved. The negative effects can be easily overcome by proper design of TBM, through geological and geotechnical investigations before proceeding with the work and providing uninterrupted power supplies.

Conclusion

9.43 Considering the merits and demerits in the use of Tunnel Boring Machine for tunneling work the following are suggested.

- Tunnel Boring Machines may be resorted to for tunneling long tunnels above 10000 m and above 3.0 m duly allocating to suitable firms which are having much successful experiences of tunneling with TBM over the world.

- For short length tunnels with small over-heads and diameter below 3.0m conventional methods of drill and blast technique may be followed.
- However extensive geological and geotechnical surveys may be carried out before choosing the methods.
- On the basis of detailed geotechnical survey, the project proponent found that the use of TBM technique for tunneling is not feasible in view of the technical and economy reasons. The lengths of tunnels to be executed are too short. The TBM method may very expensive in such cases.

Conventional controlled blasting, charge density and amount of delay.
Ground Vibration:

9.44 at places along the dam alignment and tunnels which are proposed by conventional blasting rocky areas are met with where blasting is essential for construction works. When an explosive charge is fired in a hole stress waves propagate radically in all directions and cause the rock particles to oscillate. This oscillation is felt as ground vibration. The vibration intensity, experienced by structures can be characterized by three parameters viz., Amplitude, frequency, and practical velocity. Out of these, the Peak Particle Velocity (PPV) has been the damage criteria.

9.45 A detailed ground vibration study in the rock areas has to be made and relationship between the PPV and square root sealed distance applicable to that area has to be worked out. The 95% line is represented by the equation given below.

$$V= K (Q^{1/2} / D)^{1.312}$$

Where V= Ground PPV in mm /sec
K= Constant which is dependant upon local rock condition
Q= Charge per delay in Kg
D= Distance from blast point in meters.

9.46 The safe charge per delay is given in Table. 9.3

Table 9.3 Charge per delay for safe ground vibrations at different distances Umngot HEP

Sl. No	Distance in m	Safe change per delay (in Kgs) for different PPV			
		10 mm /sec	15 mm /sec	20 mm /sec	25 mm /sec
1	100	27.62	51.24	79.44	111.62
2	200	110.47	204.95	317.75	446.46
3	300	248.57	461.14	714.93	1004.54
4	400	441.86	819.81	1270.98	1784.86

Table 9.3 Charge per delay for safe ground vibrations at different distances Umngot HEP					
Sl. No	**Distance in m**	**Safe change per delay (in Kgs) for different PPV**			
		10 mm /sec	**15 mm /sec**	**20 mm /sec**	**25 mm /sec**
5	500	690.46	1280.95	1985.91	2790.40
6	600	994.26	1844.56	2859.81	4018.17
7	700	1353.30	2510.66	3892.38	5469.18
8	800	1767.58	3279.23	5083.92	7143.42
9	900	2237.09	4150.27	6434.34	9040.89
10	1000	2761.84	5123.79	7943.63	11161.60

9.47 It is concluded and recommended as follows.

1. Normal charge weight per delay should be below 40 Kg. The regulatory authorities insists for limiting PPV of 10 mm /sec having frequency between 8 to 25 HZ as a damage criteria for building belonging to people nearby to the alignment point. The estimated PPV at nearest village or habitation should be lower than threshold value.
2. The frequencies below 8 HZ area considered serious for potential structural damage. It has to be seen that the frequencies below 8 HZ should not be generated in this case.
3. The air over pressure (Sand level) due to blasting should be well within limits.
4. The vibrations due to blasting can further be minimized by adopting the following measures:

   * Ensure systematic burden and spacing
   * Ensure designed depth and including of blast hole, keeping the sub grade drilling to optimum.
   * Ensure proper free face for fist row of holes.

9.48 The recommendations of regulatory authority should be strictly followed. As the blasting patter shall be minimum there is no longer to any structures from ground vibration due to blasting in future. The project is located near Siangkhanai village of East Khasi Hills district which is 2 km away.

Annexure IX.1
P-1

Boulder Crater Walls

Description	Quantity	Unit	Rate (Rs.)	Per Unit	Unit	Amount (Rs.)
Random Rubble stone masonry, in CM (1:8) prop: including cost and conveyance of all materials and Labour Charges such as mixing, laying and curing etc.., complete						
RR Stone OG	1.10	cum	163.00	1.00	cum	**179.30**
1st Class Mason	0.54	No.	224.00	1.00	Each	**120.96**
2nd Class Mason	1.26	No.	206.00	1.00	Each	**259.56**
Man Mazdoor	1.40	No.	170.00	1.00	Each	**238.00**
Woman Mazdoor	1.40	No.	170.00	1.00	Each	**238.00**
Add sundries						**0.14**
					Total	**1035.96**
Over Head charges @6%(10%-VAT)						**62.16**
						1098.12
Add Contractors profit at 10%						**109.81**
				Total		**1207.93**
Rate for 1 cu.m.				**Rounding**		**1208.00**

Masonry Wall

Description	Quantity	Unit	Rate (Rs.)	Per Unit	Unit	Amount (Rs.)
CRS masonry, in CM (1:8) prop: including cost and conveyance of all materials and Labour Charges such as mixing,laying and curing etc.., complete						
CR Stone OG	0.60	cum	344.20	1.00	cum	**206.52**
RR Stone OG	0.50	cum	244.00	1.00	cum	**122.00**
CM (1:8)	0.32	cum	327.26	1.00	cum	**104.72**
1st Class Mason	0.75	No.	274.00	1.00	Each	**205.50**
2nd Class Mason	1.75	No.	256.00	1.00	Each	**448.00**
Man Mazdoor	1.40	No.	190.00	1.00	Each	**266.00**
Woman Mazdoor	1.40	No.	190.00	1.00	Each	**266.00**
Add sundries						**0.96**
					Total	**1619.70**
Over Head charges @6%(10%-VAT)						**97.18**
						1716.89
Add Contractors profit at 10%						**171.69**
					Grand Total	**1888.58**
Rate for 1 cu.m.						**1889.00**

Annexure IX.1
P-2

Leveling including spreading of excavated soil including Transportation.

	Unit =cum				
	Taking output = 360 cum				
Sl. No.	**Description**	**Quantity**		**Rate (Rs.)**	**Per Unit**
	Spreading and Levelling				
A	**Labour**				
a	Mate	Day	288.00	10.08	2,903.04
b	Mazdoor skilled	Day	193.40	2.00	386.80
c	Mazdoor	Day	250.00	250.00	62,500.00
				Total	65,789.84
B	**Machinery**				
a	Smooth wheeled roller 8 Ton	hours	840.00	24.00	20,160.00
b	Water Tanker 6 kl	hours	517.00	36.00	18,612.00
				Total	38,772.00
C	**Transportation Upto 20 km**				
	Total (A+B				104,561.84
D	**Over head charges@6%(10%-VAT)**				
	Add for Over head @6%on(A)+(B)+C				6273.71
E	**Total of (A)+(B)+(C)+(D)**				110,835.55
F	**Add Contractor profit at 10%on (E)**				11083.56
	Cost per 360cum(E)+(F)				121,919.11
	Rate per 1cum				338.66418
	Rate to be adopted per 1cum				**339**
C	**Loading and Transportation Upto 20 km**				
	Rs/ m3 through tipper				**214**
	Estimated at Rs 10.70 per km				
	Manual Loading				**62.75**
	Manual Unloading				**22.41**
					638.16
			Rounded off		**638.00**

Annexure IX.1
P-3

Guard Walls with Dry rubble

CRS masonry, in CM (1:8) prop: including cost and conveyance of all materials and Labour Charges such as mixing,laying and curing etc.., complete for super structure

Description	Quantity	Unit	Rate (Rs.)	Per Unit	Unit	Amount (Rs.)
CR Stone OG	0.60	cum	244.00	1.00	cum	**146.40**
RR Stone OG	0.50	cum	163.00	1.00	cum	**81.50**
1st Class Mason	0.75	No.	224.00	1.00	Each	**168.00**
Man Mazdoor	1.40	No.	170.00	1.00	Each	**238.00**
Add Scaffolding Charges						**36.00**
Add sundries						**0.96**
					Total	**670.86**
Over Head charges @6%(10%-VAT)						**40.25**
						711.11
Add Contractors profit at 10%						**71.11**
				Grand Total		**782.22**
Rate for 1 cu.m.						**782.00**

Filling-up Land with Soil and Debris

Description	Quantity	Unit	Rate (Rs.)	Per Unit	Unit	Amount (Rs.)
Rate as per SSR	1.00	cu.m.	109.00	1.00	cu.m.	**109.00**
Add 50% extra for narrow foundation	1.00	cu.m.	54.50	1.00	cu.m.	**54.50**
Mate	0.01	Day	188.00	1.00		**2.51**
Mazdoor skilled	0.07	Day	193.00	1.00		**12.87**
Mazdoor Un skilled	0.27	Day	146.00	1.00		**38.93**
Add sundries						**0.50**
Rate per 1 cu.m.					**Total**	**218.31**
Over Head charges @6%(10%-VAT)						**13.10**
						231.41
Add Contractors profit at 10%						**23.14**
				Grand Total		**254.55**
Rate for 1 cu.m.						**255.00**

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Chapter - X

BIO-DIVERSITY MANAGEMENT PLAN

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENT MANAGEMENT PLAN (EMP)

X

BIO-DIVERSITY MANAGEMENT PLAN

Green Belt Development

10.1 The study area of the project is having high bio-diversity and is related to the forest cover of the region. The area has more than 60 per cent of geographical area under forest cover. However, the submergence area is having only 23 per cent forest cover.

10.2 The entire reservoir along the course of the river is surrounded by small patches of forests of different types. A green belt is proposed along the periphery of the reservoir, along the roadsides and homestead plantations in the labour and staff colony. List of trees identified for avenue and homestead plantations is given in **Table 10.1**

Table 10.1 List of trees identified for avenue and homestead plantations

Local / common name	Latin name	Family
Austalian wattle	*Acacia auriculiformis*	Mimosaceae
Borpat	*Ailanthus grandis*	Simaroubaceae
Safed Siris	*Albizia procera*	Mimosaceae
Amari	*Amoora wallichii*	Meliaceae
Kadam	*Anthocephalus cadamba*	Rubiaceae
Chaplash	*Artocarpus chaplasha*	Moraceae
Mundani	*Artocarpus fraxinifolius*	Moraceae
Birch	*Betula alnoides*	Betulaceae
Semul	*Bombax ceiba*	Bombacaceae
Kurta	*Calophyllum polyanthum*	Clusiaceae
Dhoop	*Canarium resiniferum*	Burseraceae
Indian Horn Beam	*Carpinus viminea*	Betulaceae
Indian Chestnut	*Castanopsis speciosa*	Fagaceae
Gonsorai	*Cinnamomum cecicodaphne*	Lauraceae
Khokan	*Duabanga sonneratioides*	Lythraceae
Gamari	*Gmelina arborea*	Verbenaceae
Jacaranda	*Jacaranda acutifolia*	Bignoniaceae
Lagerstoemia	*Lagerstoemia parviflora*	Lythraceae

Table 10.1 List of trees identified for avenue and homestead plantations		
Local / common name	Latin name	Family
Badam	*Mansonia dipikai*	Sterculeaceae
Champ	*Michelia champaca*	Magnoliaceae
Bola	*Morus laevigata*	Moraceae
Khasi pine	*Pinus kesiya*	Pinaceae (Conifer)
Podocarpus	*Podocarpus neriifolia*	Podocarpaceae (Conifer)
Rhododendron	*Rhododendron arboreum*	Ericaceae
Chilauni	*Schima wallichii*	Theaceae
Sal	*Shorea robusta*	Dipterocarpaceae
Spathodia	*Spathodia companulata*	Bignoniaceae
Talauma	*Talauma phellocarpa*	Magnoliaceae
Teak	*Tectona grandis*	Verbenaceae
Bhelu	*Tetrameles nudiflora*	Tetramelaceae
Toon	*Toona ciliata*	Meliaceae
Ahoi	*Vitex peduncularis*	Verbenaceae

Plan for Green Belt Development

10.3 Loss of forest, agricultural and other lands is inevitable under submergence when ever large river valley projects are taken up. Although the forest loss due to submergence and various other project appurtenances would be compensated as a part of compensatory Afforestation, it is proposed to develop green belt, in areas other than catchment area to compensate the loss of vegetation outside the forests. Such green belt development shall be proposed along the periphery of the water spread area, along the sides of roads, near dam sites, and around the project staff colony and appurtenances locations. The general consideration involved while developing the green belt are;

- Local/native trees growing upto 10 m or above in height with perennial foliage should be planted around various appurtenances of the proposed project.
- Planting trees should be undertaken in appropriate encircling rows around the project site
- Generally fast growing trees should be planted

Since, the tree trunk area is normally devoid of foliage up to a height of 3 m it may be useful to have shrubbery in front of the trees so as to give coverage to this portion. The plantation should be at a spacing of 4 to 5m. about 500 plants per hectare should be planted. The plantation and maintenance of the plantation area should be done by project proponents. The selection of species recommended for green belt development shall be done in consultation with the state forest departments. For initial 2 years weeding and soil consolidation around the plants is recommended. Gap filling may be taken in third year. Watch and ward for 3 years to be ensured.

Advantages of Green Belt Development

1. The trees planted prevent soil erosion and movement of silt towards reservoir from the

catchment.

2. It prevents illegal encroachments
3. The trees will be useful as perches to the water birds for laying their eggs and help in their breeding.
4. The Green belt helps in maintaining ecological balance of the nature.

10.4 Planting stocks are readily available from the Social Forest Department as well as from the local private nurseries. All plants are locally adapted. Sufficient resources and man power for development and maintenance of the Green belt are provided in the plan.

Areas for Green belt Plantation

10.5 Greenbelt development is proposed in about 40% (55 ha) of the area around the earmarked (136.67 ha) for creating the infrastructure covered under the project. The approximate areas identified for green belt plantation are shown in Table 10.2.

Table 10.2 : Location of Green Belt Plantation

Sl. No.	**Location of Green Belt**	Area, ha	Rs/ha	Rs Lakh
1	Hydraulic Structures	12	41500	4.98
2	Roads (Both sides)	39	41500	16.19
3	Buildings Staff Colony	2	41500	0.83
4	Others	2	41500	0.83
	TOTAL	55		**22.83**

Cost of Green belt Plantation

10.6 About 500 plants per hectare are proposed to be planted for Green belt development in lieu of loss of Vegetation for various activities. The Green belt Afforestation activity comprises of various components such as demarcation and survey, planting material, transportation, planting and tilling and maintenance. The total cost for Green Belt plantation per hectare is estimated as Rs. 41500. The details are presented in Table 10.3.

Table 10.3 : Estimation of cost per hector per Green Belt plantation (500 plants)

Sl.No.	Particulars	Cost Rs. Per ha
1	Demarcation and survey	1000
2	Cost of Plant material @ Rs. 10 per plant	5000
3	Digging of trenches 1.0 m X 0.5m X 0.3m (0.15 cum)	3000
4	Transplantation of plants @ Rs. 4.00 and filling per plant	2000
5	Internal transport of plants @ Rs. 1.00 per plant	500
6	Maintenance, replacement of causalities, watch and ward	30000

	Rs. 1 per plant per month for 5 years	
	Total per hectare	**41500**

10.7 The total cost of Green belt plantation around the buildings, roads etc in an area of 55 ha works out to Rs. 22.83 lakhs which is provided under EMP. At the time of execution, this component will be implemented by the State Forest Department.

Biodiversity Conservation Plan:

10.8 Important Biorich sites in Meghalya are the Nokrek and Balpakram National Park. In addition, there are three protected areas known as Wildlife Sanctuaries. They are Siju WLS, Baghmara WLS and Nongkhyllem WLS. Further, a network of protected areas was identified with a view to developing them as National Park and WLSs. This network consist three area for developing National Parks and four areas for developing WLSs. None of these sites are in study area or in submergence area[1].

10.9 As stated earlier, the land tenancy system in the North East is different from the rest of the country. A study carried out by the concerned DFO indicated that the land through at the project area and catchment of Umngot River upto project site was private holding owned by either individual or communities. In view of the above, the project proponents plan to develop a biodiversity park in consultation with the forest department and the N.E.H. University, Shillong. Before the reservoir is filled up, the project proponents will sponsor a research project for detailed survey, collection and conservation of all REET species. Wherever in - situ conservation is not possible, ex-situ conservation will be undertaken. Thus it is planned to involve research institutions for getting the work done.

Wildlife Conservation Plan:

10.10 It is proposed to involve the Meghalaya State Wildlife Division, Shillong for any rescue and rehabilitation of REET fauna if found in the reservoir area. It is also proposed to constitute Umngot biodiversity conservation board with representatives from forest, wildlife, BSI and ZSI from time to time review and implementation of plans for conservation of wildlife and protection of REET species. A budgetary provision of **Rs. 50.00 lakh** will be made for establishing bio-diversity park and implementation of Bio-diversity Wildlife Conservation Plan.

Fishery Management Plan:

Scientific techniques of Fish Enhancement for the small multiple –use Reservoirs -

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1 For details see Sudipto Chatterjee, et. al 'Background paper on Biodiversity significance of North East India' WWF India Study on Natural Resources, Water and Environmental News for Development and Growth in North Eastern India, June 2006.

Estimated quantity of production.

10.11 Enhancement of culture based fisheries even in small reservoirs less than 1000 ha has been found to be highly lucrative. Enhancement (FAO 1997) is defined as technical interventions in the existing aquatic resource systems, "which can substantially alter the environment, institutional and economic attributes of the system ". Qualitative and quantitative improvement of the newly formed reservoir can be achieved by exercising specific management options. Some of these options are:

1. Stock enhancement
2. Species enhancement
3. Environmental enhancement
4. Management enhancement
5. Enhancement through new culture systems

10.12 The last option is the one mainly followed in India. This is expected to be one of the best options available under limited water intervention. Stocking of hatchery reared fish fingerlings of 8-10 cm in calculated quantities every year during the monsoon months can enhance production. The monsoon itself adds to the fish production of the rivers by way of fish eggs and larvae because flood flows initiate maturation process in fish, and spawning occurs.

10.13 Unlike the mainland, the administrative set up of the North East India is different. Except those under the direct control of the government, the rest of the areas are managed by the respective District Councils of Khasi Hills and Jaintia Hills as per provisions of the Sixth Schedule to the Constitution of India. The fisheries department of Meghalaya does not have any data regarding the catch composition, fish density, fish standing crop, and fish population dynamics in and around project area. It is mainly due to the following:

a) Fishing and fisheries in not a major economic activity. It is not an organized activity. Along the stretch of the river, the locals are allowed to catch fish from the river. There is no organized marketing activity also.

b) Neither the State government nor the Fisheries department is empowered to regulate any fishing activity.

10.14 Further, Umngot is a small river which flows towards South in to Bangladesh and it is not a tributary of Brahmaputra. A list of fish either caught by the fisherman engaged during the survey or reported by the ZSI is given in **Chapter V. (Annexure V.19)**. None of the species was endemic to the River. Since it is not a tributary of River Brahmaputra, its fish fauna is slightly different. Although many of the species were scarce, they do not come under the REET category.

10.15 The project may alter the physico- chemical parameters of the River water during construction which in turn can influence the food chain. As such the project has the potential to influence the fish species composition of the River. The impacts may last for a year or two. Subsequently, availability of water in the reservoir may stimulate fish production. Since the reservoir is the last on the River, no fish passage is planned. Migrations between down steam and upstream is possible along with the reservoir overflow. Further, the span of fish can safely pass though the water used for power generation. As such no fish ladder is planned. Seasonal variations in composition of aquatic insects, Phytoplankton and Zooplankton of the River and other water bodies within the study area are already indicated in **Chapter V (Annexure V.21, V.22 & V.23)**. The proposed biodiversity board of the Umngot Hydroelectric project will also have an expert in inland fisheries for monitoring.

10.16 Although large dams impede migration of certain varieties of fish, the lakes formed by the dams increase fish production enormously and provide livelihood to large number of fisherman. In general, high production of fish has been observed in reservoirs where commercial fishing has been encouraged[2]. Therefore, it is proposed that commercial stocking and fishing may be developed in the reservoir planned under the project with the following approach and infrastructure,

Organisation of Fisherman Cooperative Society and training Programme

10.17 The primary fisherman cooperative society of the tribal project affected families is to be organized. The membership should, as far as possible, be limited to 50 to avoid over fishing and to ensure a reasonable income per fisherman. If the production exceeds the stipulated yield on a sustainable basis, the membership could be increased proportionately.

10.18 As the tribals of the project area are not habitual to deepwater fishing, the PAFs pting fishing, as a vocation, will be imparted training in deep water fishing, transport of fish etc. The womenfolk will also be trained on sorting, grading (size-wise, species – wise, quality wise etc). and stacking in baskets, etc. Simple quality processing techniques such as sun drying (with or without salting) and also smoking under hygienic conditions could be demonstrated.

Stocking and Selection of Species

10.19 Stocking of fish seed from extraneous sources, is the most important management practice in reservoir development. Under the multi-species culture system, the indigenous Indian major carps, Catla, Rohu, and Mrigal are extensively stocked in India. Introduction of exotic fishes like Chinese carps Silver carp, Grass carp and Common carp is practiced for extensive commercial fisheries. Usually, the Indian major carps are stocked as they find environment more congenial for growth, reproduction and have high fecundity and breeding success. For better utilization of the available food, stocking of L, calbasu, L. fimbriatus, and L.bata, may also be considered. It is also necessary to maintain a viable prey – predator ratio in the reservoir, failing which it may result in

2 For details see S. Char, Future Approaches Towards Taking UP Dam Projects, A Thematic Paper submitted to World Commission on Dam and also see http://www/dams.org

increase in trash fish which may support predator fishes. Regular stocking of desired species of fish is necessary with initiation of reservoir operation.

Influence of stocking

10.20 Stocking is considered successful only when the stocked fish are recaptured. As the Indian reservoirs are developed on the basis of stocking-cum-capture, the stocked species should form a breeding population. To restore the stock, over fishing should be avoided and regular stocking should be done every year initially. Introduction of Bighead and Silver Carp should also be avoided before establishment of self-stocking capacity of indigenous carp species.

Stocking Density

10.21 The productive area for fishing is estimated about 125 ha i.e. 50% of submergence Area at FRL 1040 m and stocking rate of 200 advanced fingerlings per ha can be adopted.

Fish Seed Requirement

10.22 Based on the above stocking rate, the requirement of fish seed at different stages and the corresponding requirement of nursery, rearing area and advanced fingerling pond area have been worked out and are presented in Table – 10.4.

Table – 10.4 : Assessment of Fish Seed Requirement and Infrastructure for Fish Seed Production

Sl. No.	Activities	Nos	Unit
(i)	Production of advanced fingerlings for stocking (@ 200 fingerlings/ha for 125 ha i.e. 50% impounding at R.L 1042 m)	**0.25**	**Lakh**
(ii)	Requirement of early fingerlings	**0.42**	**Lakh**
	Assumption : 60 - 65 per cent survival from early fingerlings to advance fingerlings (80 - 100 mm)		
(iii)	Requirement of fry	**0.69**	**Lakh**
	Assumption : 60 per cent survival from fry to early fingerlings (30 - 40 mm)		
(iv)	Requirement of spawn	**1.74**	**Lakh**
	Assumption 40 per cent survival from spawn to fry (15 - 20 mm)		
	Requirement of rearing space		
(i)	* Nursery to raise spawns to fry (@ 50 lakhs spawn / ha)	**0.03**	
(ii)	* Rearing area for fry to early fingerlings (@ 5 lakhs fry / ha)	**0.14**	
(iii)	* Rearing area for early fingerlings to advanced fingerlings (@ 3 lakhs fry / ha)	**0.14**	
	Total area required for fish seed rearing (ha)	**0.31**	

10.23 For raising advanced fingerlings, a composite farm will be required. It is proposed to develop fish seed farm near project colony proposed.

Infrastructure facilities

Fishing Nets

10.24 It is proposed to rehabilitate 50 tribal PAFs through fishing activities. Every fisherman will be supplied with 20 kg of finished nylon nets with floats, etc. Nets can be supplied in a period of 2 years @ 10 / kg /year. Boat seines / drag nets can be operated in selected patches where tree stumps have been removed flush to the ground. While the gill nets will be the property of the individual members, the dragnets would be the property of the primary fishermen cooperative societies.

10.25 In the initial three years, more emphasis should be laid on operation of shore seines and long-lines with hooks to catch the native fish and the predators. Use of monofilament gill nets should be discouraged as these nets catch even the juveniles and undersized fish.

Fishing Boats

10.26 It is proposed to provide one fishing boat for every two fishermen. Water worthiness and speed are important considerations for selection of the boats. Plank built teak wood boats would be provided to the oustees. The type of boat would be left to the choice of the oustees. However, Bengal type dinghies, which proved to be a great success in other reservoirs, could be introduced after adequate training.

Fish Landing Centre

10.27 Cost estimate of Fisheries Development for Rehabilitation of PAP is shown in **Table – 10.5.**

Table 10.5
Cost Estimates of Fisheries Development

Sl.No.	Items	Amount (Rs. In lakhs)	
		Recurring cost / year	Capital cost
1	Training @ Rs. 2500/ individual	-	1.25
2	Fishing nets @ Rs 17500 / individual	-	8.75
3	FRP boat @ 1 boat / 2 fisherman 25 boats @ Rs. 2500 each	-	0.63
4	Survey / registration of fishermen and formation of society and infrastructure development	-	1.00
5	Development of composite farm and fingerlings production (cost includes construction of farm, farm	-	5.00

Table 10.5 Cost Estimates of Fisheries Development			
Sl.No.	Items	Amount (Rs. In lakhs)	
		Recurring cost / year	Capital cost
	equipment, approach road etc.		
6	Limnological studies on conservation and management of aquatic fauna	-	2.00
7	Post harvest management and transportation	-	2.00
8	Managerial staff and O & M	0.25	
	Sub-Total	**0.25**	**20.63**
Grand Total (Recurring cost for 10 years & Capital Cost)		**2.50**	**20.63**

10.28 Total cost of Fisheries Development for 50 families works out to be Rs 23.13 lakh. This provision consists of Rs 20.63 lakh towards capital Cost and Rs 2.50 lakh towards recurring costs (10 years at the rate of Rs 25,000 per year).

Project Benefits from Fisheries

10.39 Fish production from the reservoir will be increased steadily on a sustainable basis so as to attain a yield of 25 tonnes per year on full development. The estimated production rate is 200 kg/ha. The Project will generate employment to 50 tribal fishermen on regular basis. In addition, it will also provide employment to another 5-10 tribals on ancillary activities such as transport, packing, basket making etc. About 20% of the fish harvested will be consumed locally and the remaining 80% is exported to near by towns and villages. The project will provide engagement to the womenfolk in fish vending, net making, net mending, and basket making etc.

10.30 Thus a total of Rs. 95.95 lakh will be provided for bio-diversity management plan under the project as per Table 10.6.

Table 10.6 Biodiversity Management Plan		
SL No	**Management Measure**	**Rs Lakhs**
1	Green Belt Development	22.83
2	Wildlife Conservation Plan	50.00
3	Fishery Management Plan	23.13
	Total	**95.95**

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Chapter - XI

PUBLIC HEALTH MANAGEMENT PLAN

INDIA
MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS
UMNGOT HYDRO-ELECTRIC PROJECT
(3 X 80 MW)

PART - II
ENVORINMENT MANAGEMENT PLAN (EMP)

XI
PUBLIC HEALTH MANAGEMENT

Labour Camps:

11.01 The aggregation of labour population (1000) during construction phase is likely to put significant stress on various facts of environment. In due cause of time, the labour population is likely to increase to 2000. This increase in population is likely to increase pressure on the existing infrastructure facilities in the area. The connected issues will be

- Facilities in labour camps
- Sanitation and sewage treatment
- Solid waste management
- Provision of community kitchen

Facilities in Labour Camps

11.02 The spatial distribution concentration of construction activities ensures that labour population is likely to be concentrated at weir and the power house, contraction will be forced to make semi-permanent structures for their workers. The water requirements for domestic use may be collected from the river since this is generally good and can be used after chlorination.

Sanitation:

11.03 One common latrine for 20 persons and one septic tank for 500 people should be provided. The effluent from these septic tanks could be disposed off through soak pits. Drinking water sites will be located away from each other. Total construction time for the project is 5 years. At peak stage there will be increase in labour population to 2000. It has been estimated that about 100 community latrines and 4 septic tanks will need to be constructed. The total budget required for these facilities will be **Rs.40.00 lakh** as shown in Table 11.1

Table: 11.1 Cost Estimate for Sanitary Facilities for Labour Camps				
Sl. No.	**Unit**	**Rates Rs/ unit**	**Number**	**Total Cost (Rs) Lakhs**
1.	Community Latrine	20,000	100	20.00
2.	Septic Tanks including sewage system for labour camps	5,00,000	4	20.00
	Total			**40.00**

Solid Waste Management

11.04 As mentioned in para 11.01, the increase in population due to congregation of construction labour is expected to be about 2000. The average per capita solid waste generated would be of the order of 425 gm/day/person. The solid waste likely to be generated from labour camps shall be in the order of 0.85 tones/day.

11.05 Adequate facilities for collection, conveyance and disposal of solid waste need to be developed. For solid waste collection 8 numbers of masonry storage vats, each of 2 m^3 capacity should be constructed at appropriate locations in various labour camps. These vats should be emptied at regular intervals and the collected waste can be transported to land fill sites.

11.06 One fully covered truck to collect the solid waste from common collection point and transfer it to the disposed site should be put into service. A suitable land fill site should be identified and designed to certain municipal waste from various project townships, Labour colonies, etc. A total provision of **Rs.61.00 lakh** has been earmarked for the purpose. The details are given in Table 11.2:

Table: 11.2 Umngot HEP: Details of Expenditure Required for Solid Waste Management		
Sl. No	**Items**	**Cost Rs. Lakh**
1.	One covered truck for conveyance of solid waste to land full site @ Rs. 25 lakh / truck	25.00
2.	Manpower cost of 8 persons @ Rs. 5000 per month per person for five years including 20% escalation	36.00
	Total	**61.00**

11.07 Generally, from sanitary land fill sites, there is little risk of methane generation due to the decay of organic or degradable components; as it slowly diffuses at low concentration through the covering material which is likely to cause ground water pollution. To reduce this, disposal sites should be covered with impervious materials.

Sewage from Labour Camps

11.08 During project construction phase sufficient measures need to be implemented to ameliorate the problem of water pollution through various sources. The sewage generated from the labour camps after treatment in septic tanks will be disposed of discharging into the river. Septic tanks shall be located so as not to pollute drinking water. Settling tanks of appropriate size for treatment of effluents shall be provided. An amount of **Rs.5.00 lakh** shall be earmarked for construction of various settling tanks.

11.09 In the post project construction operation phase a planned colony with 100 quarters is likely to be set up. It is recommended to commission a suitable Sewage treatment plant to treat the sewage from the colony. The cost will be included in the construction of project colony.

Public Health Delivery System:

11.10 The increase in water fringe area provides suitable habitats for the growth of vectors of various diseases, and they are likely to increase the water-related diseases. Malaria is one such disease. Malaria control measures which aim at destroying the habitat and interrupting the life cycle of mosquitoes by using mechanical, biological or chemical s need to be implemented. The anti-malaria operations can be co-ordinate by various PHCs available at block headquarters in the area and hospitals at district headquarters in association with the project authorities. The integrated measures, are given in the following paragraphs.

- Site selected for habitation of workers should not be in the path of natural drainage
- Adequate drainage system to dispose store water drainage from the labour colonies should be provided
- Adequate vaccination & immunization facilities should be provided for workers at the construction site
- Labour camps and resettlement sites should be atleast 2km away from a main water body.

Development of Medical Facilities

11.11 A population about 2000 is likely to congregate during the construction phase. The labourers will be concentrated at two places. There will be no medical facilities available here or in the nearby vicinity of the project site. It is suggested that suitable medical facilities be developed at the project site. It is recommended that a dispensary should be established during project construction phase itself so that it can serve the labour population migrating in the area as well as the local population if any.

Proposed Health Facilities

11.12 It is possible that during the construction work, technical staff's operating different equipments are not only exposed to the physical strain but also to the physical effects of the environment in which they are working. The technical staff and labour may come up with common manifestations such as insect bites, fever, diarrhea and work exhaustion. In addition, invariably there may be some accidents at work site under all such circumstances workers will need immediate attention.

11.13 It is, therefore, considered necessary to have a first aid box at each of the major construction sites so that the affected get immediate attention in case of an injury or accident. The first aid box will have the following facilities:

- First aid box with essential medicines
- First aid appliance like splints and dressing material
- Stretchers, wheel chairs, etc.,

Health Extension Activities:

11.14 The health extension activities will have to be created in the villages situated in nearby area to the site. There would be possibilities of transmission of communicable diseases due to migration of labour population form other areas to the construction site. Occurrence of communicable diseases needs attention of qualified doctors and dispensary.

11.15 The doctors form the dispensary should make regular visits to the site/ villages and organize health promotional activities with active participation of the local village Panchayat and health functionaries. The health functionaries would undertake the following tasks as part of health promotional activities:

- Collect water samples to ascertain portability of water from different sources and regular disinfection of drinking water should be taken,
- Maintain close surveillance on incidence of communicable diseases in the area.
- Maintain close liaison with community leaders, and health functionaries of different Departments so that they can be mobilized in case of an emergency.

11.16 The Budgetary provision required for Public Heath Delivery System is given in Table 11.3 below:

Table 11.3 - Budgetary provision Public Heath Delivery System				
Sl. No	**Dispensary**	**Number**	**Monthly enrolments, Rs**	**Annual Expenditure, Rs**
A	**Administration and Man Power**			
1	Doctor	2	25000	600,000
2	Nurse	4	10000	480,000
3	Multi purpose Health Workers	2	8000	192,000
4	Attendants	2	6000	144,000
5	Drivers	2	5000	120,000
	Sub Total			**1,536,000**
	First Aid post			
1	Health Assistants	2	5000	120,000
2	Dressers	2	4000	96,000
	Sub Total			**216,000**
B	**Expenditure and Material Supplies Dispensary (Non recurring)**			
1	Vehicles	2	500000	1,000,000
2	Furniture	LS		100,000
	Sub Total			**1,100,000**
C	**Recurring expenses for One Year**			
1	Drugs and Medicines	LS		125,000
2	Contingencies	LS		50,000
3	First Aid Posts	LS		40,000
	Sub Total for One Year			**215,000**

C. Infrastructure

i) Dispensary

Considering the number of rooms, staff quarters, etc., it is estimated that 5000 Sq.ft plot (costs around Rs 1.00 lakh) will be required for dispensary out of which 3000 Sq.ft will be built up land which includes staff quarters. It is estimated about 1.5 times of built up Area that comes 4500 sq ft plint area of RCC building is to be constructed, including a provision for first floor to the extent of 1500 sq ft. The present cost norms for construction cost of RCC will be Rs. 900 per Sq.ft. Therefore the total cost of construction of dispensary will be **Rs. 41.50 lakh.**

ii) First Aid Posts

These shall be temporary construction and will be constructed with asbestos sheets/Tiles, bamboo etc., the total cost will be **Rs.2.00 lakh**.

D. Recurring Expenditure

11.17 As discussed above, the annual recurring expenditure includes general recurring expenditure like Administration and Man Power Expenses (Rs 15.36 lakhs), First Aid Posts Expenses (Rs 2.16 lakhs) and Drugs and Medicines, Contingencies and First Aid Posts (Rs 2.15 lakhs). Therefore the annual recurring expenses would be Rs 19.67 lakhs and maintenance for the next 5 year period it works out to Rs 98.35 lakh. (Refer table 11.4 for details). The total recurring expenses for six years are estimated to be Rs 118.02 lakhs.

E. Non- Recurring Expenditure

11.18 This includes capital costs on infrastructure and the same is amounting to Rs. 54.50 lakh comprising Rs. 11.00 lakh for Vehicles and Furniture and Rs 43.50 lakhs for dispensary and First Aid buildings. (Refer table 11.4 for details)

Total cost of Health Delivery

11.19 The total cost of health delivery system is estimated at **Rs. 278.52 lakhs** as summarized in Table 11.4 below:

Table 11.4 Total Cost of Public Health Management

Sl No	Particulars	Rs lakhs
I	**Sanitary Facilities for Labour Camps**	**40.00**
II	**Solid Waste Management**	**61.00**
III	**Sewage Treatment from Labour Camps**	**5.00**
IV	**Public Health Delivery System**	
A	**Recurring Expenses Per Year**	
1	Administration and Man Power Expenses	15.36
2	First Aid Posts Expenses	2.16
3	Drugs and Medicines, Contingencies and First Aid Posts	2.15
	Sub Total for One Year	***19.67***
	Sub Total for the next Five Years as Maintenance	***98.35***
B	**Non-Recurring (As Capital Cost during First Year)**	
1	Infrastructure for Dispensary like Vehicles and Furniture	11.00
2	Infrastructure for Dispensary Buildings	41.50
3	Infrastructure for First Aid Buildings	2.00
	Sub-Total	**54.50**
	Total Public Health Management	**278.52**

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Chapter - XII

ENVIRONMENT MONITORING PLAN

INDIA
MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVORINMENT MANAGEMENT PLAN (EMP)

XII

ENVIRONMENTAL MONITORING PROGRAMME

The Need

12.01 Environmental monitoring is an essential component for sustainability of any water resource project. It is an integral part of any environmental assessment process. Any water resources development project introduces complex inter-relationships in the project area between people, various natural resources, biota and the many developing forces. Thus, a new environment is created. It is very difficult to predict with complete certainty the exact post-project environmental scenario. Hence, monitoring of critical parameters is essential in the project operation phase. An Environmental Monitoring Programme has been designed with the following objectives:

- Assess the changes in environmental conditions, if any, during construction and operation of the project.
- Monitor the effective implementation of mitigatory measures.
- Warning of any significant deterioration in environmental quality so that additional mitigatory measures may be planned in advance.

Areas of Concern

12.02 From the monitoring point of view, the area of concern are water quality, land use, ecology, etc. An attempt is made to establish early warning of indicators of stress on the environment. Suggested monitoring details are outlined in the following sections.

WATER QUALITY

Construction Phase

Umngot Dam and Power House

12.03 It is proposed to monitor the effluents before and after treatment from septic tanks related to staff colony and labour colonies. One community latrine can be provided for 20 persons. The sewage from community latrines can be treated in septic tanks. For 500 persons one septic tank shall be provided. The effluents from these septic tanks can be disposed off through soak pits. Drinking water facilities and waste disposal site will be located away from each other. The total construction period for the project is 6 years excluding period for preliminary works. At the time of peak construction phase there will be a peak population of about 5000. To ensure that the sewage from the labour camps do not pollute the river water, it has been estimated that about 250 community latrines and 10 septic tanks need to be constructed. Project staff colony for 2000 including technical personnel has been proposed at near dam site and power house site for which about 4 septic tanks are required. The frequency of monitoring could be once in a month. Since 10 septic tanks have been proposed for labour camps and staff colony, a total of (10 septic tanks X 12 months x 2 samples, i.e. before and after treatment) 240 samples/year are needed to be analysed. The parameters to be monitored include pH, Bio-chemical Oxygen Demand, total Suspended Solids and total Dissolved Solids. The cost of testing of one sample is expected to be Rs. 2000. Thus, total cost for analysis of 240 samples is expected to be Rs. 4.80 lakh/year. Considering that the construction phase to last for a period of 6 years and an escalation cost of 10% every year, the total cost over the entire construction phase works out to **Rs 37.00 lakhs.** The analysis work can be done by a laboratory recognized by the State Pollution Control Board or by the State Pollution Control Board at Shillong it self.

Operation Phase

12.04 The surface water quality of the impounded water and river Umngot needs to be monitored thrice in a year. The proposed parameters to be monitored include pH, Temperature, Electrical Conductivity, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total hardness, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc and Manganese. The sampling sites shall be:

- Reservoir water upstream of Surge Shaft
- Reservoir water – Right flank near Amlarem
- End of Tail Race Tunnel (Umngot River)

12.05 The total cost of analysis will be 0.10 lakhs per year. This analysis shall be done throughout the entire life of the project. The analysis work can be conducted by a reputed external agency recognised by State Pollution Control Board in association with the project proponents. Under EMP the cost is provided for 10 years. (**Rs.1.00 lakh)**.

12.06 During project operation phase, a Sewage Treatment Plant (STP) is proposed to be set up to treat the effluent from the project colony. Once every week, it is envisaged to analyse a sample each before and after treatment from the STP. The parameters to be analysed include pH, Bio-chemical Oxygen Demand, Chemical Oxygen Demand, Total suspended Solids and Total Dissolved Solids. The cost of analysis of 50 samples @ Rs. 3000 per sample works out to Rs.1.50 lakhs per year. A provision of **Rs. 15.00 lakh** shall be made for analyzing the samples for 10 years.

The total cost of water quality monitoring is proposed as below:

1	Effluent samples (Construction period)	37.00 lakhs
2	Effluent samples (Operation period)	15.00 lakhs
3	Surface water samples (Operation)	1.00 lakhs
	Total	**53.00 lakhs**

AIR QUALITY AND METEOROLOGY

Construction Phase

12.07 The ambient air quality monitoring during construction phase can be carried out by an external agency, approved by State Pollution Control Board or the Board itself at major construction sites. Every year monitoring is to be done for the following three seasons.

- Pre-Monsoon (Spring March to April)
- Monsoon (May to September)
- Autumn (October to November)
- Winter (December to February)

12.08 The frequency of monitoring could be twice a week for four consecutive weeks at each station for each season. The parameters to be monitored are Respirable Particulate Matter (RPM) and Suspended Particulate Matter(SPM, Sulphur dioxide (SO_2) and Nitrogen Oxides (NOx).

12.09 Every year, ambient air quality is to be monitored at Umngot dam site and Power house. The total samples would be 64 per year. Total cost of Rs. 19.75 lakhs (with 10% escalation) at the rate of Rs. 4000 per sample will be required for the project construction phase of 6 years.

12.10 A meteorological laboratory can be setup at the ambient air quality monitoring stations for Umngot project. Automatic recorders for Temperature, Humidity, Wind speed & direction, rainfall needs to be commissioned at the site, an amount of Rs. 15.00 lakh can be earmarked for this purpose. The total cost for the monitoring of air quality and other meteorological parameters works out to **Rs. 34.75 lakh.**

Soil Erosion and Siltation

Project Operation Phase

12.11 Soil erosion rates in the catchment areas, of the dams, efficacy of soil conservation measures need to be closely monitored twice a year. The study can be done by the staff of the proposed Environment Management Cell or the Project proponents. The study should be undertaken throughout the life of the project so as to design the soil erosion prevention measures and also for the rehabilitation / decommissioning of the project. An amount of Rs. 5.00 lakhs per year may be provided totaling to **Rs. 50 lakhs** for 10 years. After 10 years the parameters will be reviewed and provisions continued if required from normal funds. In addition to the above, soil quality at various locations in the catchment area needs to be monitored once every year. The parameters to be monitored are pH, organic matter and texture.

Samplings

12.12 In view of the limited catchment of Umngot HEP mostly confined to the river portion, two samplings in each district may be selected in the two districts in which the catchment is covered namely, East Khasi Hills and Jantia Hills. Thus 4 samplings will be taken in an year till 10 years i.e., 40 samples. At the rate of Rs. 2000/- per sample including escalation of prices, for the total 40 samples in 10 years, the total cost would be **Rs. 1.27 lakh.** The samplings may be taken at different locations in each year so as to cover the entire area of the catchment.

ECOLOGY

Project Operation Phase

12.13 Monitoring of aquatic ecology will be essential for future programmes of fish development. Some of the parameters to be monitored are phytoplanktons, Zooplanktons, Benthic life and fish composition etc. The parameters can be monitored twice every year at the water sampling sites given below:

(i)	Umngot Reservoir	Left flank, Right flank,
(ii)	Power house site	

12.14 The monitoring can be conducted by a reputed external agency for which 1.00 lakhs / year can be earmarked upto 10 years totaling to **Rs 10.0 lakhs**. Status of afforestation programmes, green belt development, changes in migration patterns of the aquatic and terrestrial fauna species should be studied. The staff at the proposed unit of the Environment Management cell can undertake the work. A provision of Rs. 5 lakhs per year can be kept for this purpose upto 10 years totaling to **Rs 50.00 lakhs.** The total cost provision made for Ecology monitoring is **Rs 60.00 lakhs**.

NOISE

Construction Phase

12.15 Noise emissions from vehicular movement, operation of various construction equipment may be monitored during construction phase at the major construction sites as follows:

(i) Umngot dam site
(ii) Powerhouse site
(iii) HRT Site
(iv) High Pressure Shaft
(v) TRT

The frequency of monitoring could be once every month. For monitoring of noise generators, five integrating sound level meters will be required for which an amount of Rs. 3.0 lakhs needs to be earmarked.

INCIDENCE OF WATER-RELATED DISEASES

Project Construction Phase

12.16 Identification of water related diseases, adequacy of local vector control and curative measures, status of public health are some of the parameters which should be closely monitored three times a year with the help of data maintained in the government dispensaries/hospitals.

Implementation	:	Public Health Department & Dispensary constructed for labour camps.
Cost per annum	:	Rs. 5.00 lakh

12.17 The total cost required for monitoring over the entire project construction phase of 6 years shall be **Rs. 38.58 lakh** including escalation.

Project Operation Phase

12.18 Increased prevalence of various vector borne diseases and adequacy of local vector control and curative measures need to be monitored. The monitoring can be done three times in a year.

Implementation : Dispensaries at the project sites (1 No)
Cost per annum : Rs. 2.0 lakhs

The total cost required for monitoring for 10 years in the operation phase worksout to **Rs. 31.87 lakhs.**

Summary of Environmental Monitoring Programme

12.19 The details of environmental monitoring programme during construction and operation phases along with their costs are given Tables - 12.1 and 12.2 respectively. The cost required for implementation of the Environmental Monitoring Programme during project construction phase is of the order of Rs. 113.33 lakhs and it is Rs 159.15 lakhs during the operation phase. The total cost for the Environment Monitoring programme worked out to **Rs. 272.48 lakhs.**

Table 12.1
Summary of Environmental Monitoring Programme During Project Construction Phase

Sl. No	Item	Parameters	Frequency	Location	Cost (Rs Lakhs)
1	Effluent from septic tanks	pH, BOD, COD, TSS, TDS	Once every month	Before and after treatment from each septic tank	37.00
2	Air Quality	SPM, RPM, So_2 and NO_x	Once every month	At Major construction sties.	19.75
3	Meteorological aspects	Wind direction & velocity, temperature, humidity, rainfall	Once every month	At one of the ambient air quality sampling sites	15.00
4	Noise	Equivalent noise level (Leq)	Once in three months	At major construction sites.	3.00
5	Water-related diseases	Identification of water related diseases, adequacy of local vector control and curative measures, etc	Three times a year	Labour camps and colonies	38.58
				Total	**113.33**

Table 12.2 UMNGOT HEP
Summary of Environmental Monitoring Programme During Project Operation Phase

Sl. No	Item	Parameters	Frequency	Location	Cost (Rs Lakhs)
1	Water	pH, Temperature, EC, Turbidity, TDS, Calcium, Magnesium, Total hardness, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc and Manganese	Thrice a year		1.00
2	Effluent from sewage Treatment Plan (STP)	pH, BOD, COD, TSS, TDS	Once every week	-Before and after treatment from Sewage Treatment Plant (STP)	15.00
3	Water-related diseases	Identification of water-related diseases, sites, adequacy of local vector control measures, etc.	Three time a year	-Villages adjacent to project	31.87
4	Soil erosion and Siltation	pH, Organic matter, texture etc	Once an year of 50 years		51.28
5	Ecology a) Aquatic	Phytoplanktons, zoo plank tons benthic life.	Twice every year		10.00
	b) Afforestation green belt etc	Green belt development, Migration patterns changes etc.	Once every year for 10 years	Catchment areas	50.00
Total					**159.15**

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Chapter - XIII

DAM BREAK ANALYSIS AND DISASTER MANAGEMENT PLAN

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVORINMENT MANAGEMENT PLAN (EMP)

XIII

DAM BREAK ANALYSIS AND DISASTER MANAGEMENT PLAN

Introduction

13.01 Dams involving large investments of money are constructed for economic development of the country (Singh, 1996). Generally, dams serve multipurpose objectives. According to ICOLD (International Committee on Large Dams), there are more than 35000 large dams existing throughout the world' and many more are under construction. Every development has to pay a price, and so is with the dams in terms of their failures. There are many instances of dam break. Jansen (1980) has listed historical information on various dam break cases. Three major causes of dam failure are, overtopping failure (inadequate spillway, misuse of road embankment etc.), foundation failure (fault movement, settlement etc.), and piping and seepage of embankment dams. Due to the presence of a dam, there is a feeling of safety and the area becomes thickly populated, and thus, a dam becomes a potential source of disaster due to the risk of its failure. When a dam fails, the sudden release of the reservoir water forms a catastrophic flood and it results in the catastrophic loss of life and property. Therefore, dam-safety programs have been developed in most countries of the world as a result of safety against dam breaks.

13.02 The characteristics of a dam break flood are different from those of an ordinary natural flood. Very high peak discharges during a short time, occurrence of bores or shock waves, fast and violent flooding of the banks resulting in strong two-dimensional effects, presence of mixed flow regimes, flooding of dry land with abnormal dissipative effects, and transport of debris/solid materials accumulated in the reservoir are associated with a dam break flood. The behavior of the bed friction causing turbulence during such a flow is not well established, and so is with the dam failure. It leads to a difficulty in calibrating such models. Thus, the dam break flood analysis becomes a special problem to be dealt carefully.

13.03 Dam break flood analysis occupies a very important place in water resources engineering practices (Almeida and Franco, 1994). It is useful in (a) establishing the required dam spillway capacity, (b) environmental and safety impact evaluation of dams or other special structures built in a river valley, (c) valley planning and zoning, (d) implementation of operational emergency and safety procedures, such as warning systems and evacuation plans, and (e) solving special and unexpected problems arising from very high risk of a dam or other river obstruction failure.

13.04 The project main components relating to the dam are as below:

a) Main dam across Umngot river which is proposed as a concrete gravity dam of Homogeneous section. The maximum height (Bed of river) is 111.0 m. Length of the dam is 394 m.
b) Intake and Head Race Tunnel of 5588 m long and 3.60 m dia, modified horse shore type low pressure tunnel.
c) High pressure shaft 2200 m long with an internal diameter of 2.75 m trifurcating to 1.80 m.
d) Ground Level power house having machine wall size of 77.50 m x 22.00 m.
e) Surge shaft 75.75 m high and 10 m dia.

13.05 The gross reservoir storage at FRL of +1040.00 m is proposed as 38.59 Mm^3 and the live capacity of the reservoir is 32.95 Mm^3 only.

13.06 As per MOEF guidelines for preparation of Environment Impact Assessment and Environment Management Plan reports, it is mandatory for conducting Dam Break Analysis for dams with maximum height of 30.0 m and above. Since the present maximum height of the main dam is only of 110.0 m, the Dam Break Analysis is necessary. Therefore, the dam break analysis of the proposed Umngot dam is attempted in the following paragraphs.

Methodology

13.07 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.

13.08 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 times.

Breaching of the Dam

13.09 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.

13.10 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.

Hydraulic Computational Algorithm

13.11 The other important component of the model is its hydraulic computational algorithm. It computes the unsteady flow routing due to the dam beak taking the time-variation of breach size/shape and spillway characteristics into account. This part of the model also determines the extent and time of occurrence of flooding in the downstream region as determined by routing the outflow hydrograph through the downstream locations. The effects of bed roughness, valley storage, flow losses, downstream control structures on the flood wave movement result in modification of the outflow hydrographs. Flood routing methods are classified into hydrologic and hydraulic methods. In hydrologic methods, governing equations are simplified by approximating the flow characteristics. The simplified equations are solved using a suitable approach. However, the hydraulic methods employ the complete set of governing equations to obtain a solution though at a higher cost. The hydraulic method used in the model is described below.

Governing Equations: The governing equations constitute the expanded form of the one dimensional Saint Venant equations.

13.12 Dam Breach Analyses for Umngot Dam

From the Froelich Breach Predictor Equations

$b = 9.5 * K_0 (V_s H)^{0.25}$

$t = 0.59 (V_s^{0.47})/H^{0.91}$

b = Average Breach Width (ft),
K_0= 0.7 for Piping & 1.0 for Overtopping Failure
Vs = Storage Volume (ac-ft)
H = Selected Failure Depth (ft) above Breach Bottom
t = Time of Failure (hrs, ~H/120 or Minimum of 10 Min)

13.13 Assuming in this particular case the failure depth above breach bottom as the height of the dam and considering a piping failure or structural failure, the following values are taken for the variables from the salient features of dam:

H = 111.00 m = 360.89 ft
K_0 = 0.70
Vs = 38.59 Mm^3 = 31,272 ac-ft
(Note on Conversions : 1 ft = 0.3048 m ; 1 Mm^3 = 810.37 acre-ft = 0.1234 ha-m)

$b = 9.5 \times 0.70 \times (31272 \times 360.89)^{0.25}$ = 385.44 ft = 117.48 m
$t = 0.59\ (31272)_{0.47} / (360.89)^{0.91}$ = 0.36 hrs = 21.60 min

13.14 Average breach width 'b' is computed as 385 ft or 117.48 m which is equal to 1.07 H. But based on the river cross section at the dam site the existing base width 16 m is i.e. 0.15 H. Similarly time of failure't' computed from the above formula as 0.36 hrs. Therefore, the time of failure can be assumed as minimum of 10 min as per the governing equation.

Solution Technique

13.15 In the governing equations, x and t are the independent variables and h and Q are the dependent variables. Other terms in the equations are either functions of the variables or constant. Being non-linear partial differential equations, generalized analytical solutions of Eqa. 1 & 2 are not available in literature, and therefore, numerical methods are resorted to. The numerical methods available are: (i) Finite-difference, (ii) Finite-element, (iii) finite-volume, (iv) finite-analytic, (v) Characteristics and (vi) spectral. DAMBRK model uses the weighted four point Preissmann scheme, a finite-difference method, for the numerical solution of the governing equations. This particular scheme has several advantages over other schemes. The details of the numerical scheme are available elsewhere (Fread, 1992). However, for the sake of completeness, a short description follows:

13.16 The channel reach is divided into N number of computational nodes. This results in N-1 rectangular grids between the upstream and the downstream boundaries. At any time level, there exist two unknowns (flow depth h and discharge Q) at each node and two equations (continuity and momentum, Eqs 1 & 2) can be applied to each grid. Thus, there are 2N unknowns and 2N-2 equations. The system becomes determinate with two more equations obtained from boundary conditions. These non-linear equations (2N) are solved iteratively be a fast converging Newton-Rap son method.

13.17 Presence of any internal boundary (weir, bridge, or dam etc) requires special treatment as the governing equations are not valid at these locations. In such cases, momentum equation is replaced by established empirical relations. For example, a dam is treated as an internal boundary and the discharge through the spillway is obtained either by the stage- discharge relationship or by a broad-crested weir formula. Similarly, special treatment is provided for bridges and water falls.

13.18 The upstream boundary condition plays an important role in the solution of the governing equations and a correct specification of the same is essential. In most of the cases. This information is obtained from the specified time history of the discharge (hydrograph). The upstream flow should not be zero and the time specification should not be less than the required time of flood routing. If the flow in supercritical at the upstream end two boundary conditions should be prescribed at this location, one from discharge hydrograph and the other from normal flow conditions depending on the physical characteristics of this section (i) single value rating curve, (ii) generated dynamic loop-rating, (iii) critical flow rating, and (iv) water level time series. The flow conditions are also specified at the beginning of the unsteady flow computations. In the DAMBRK model the initial conditions (flow conditions at t=0) are specified by assuming a steady non-uniform flow. Thus, discharge at each node is specified by the steady state continuity equation and the flow depth by numerically integrating the steady state gradually-varied flow equation. The direction of computation depends on the flow conditions.

Data Requirement

13.19 The input data requirement for the DAMBRK model can be categorized into two groups. 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.

13.20 The second group of data pertains to cross-sectional features of the downstream river. The cross-sections are specified by location from the dam site. These are described in the form of a table reflecting variation of top widths with elevation. Other required data are bed roughness expansion-contraction coefficients and sinuosity.

13.21 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.

From the NWS Simple Dam Break Equation

$Q_b = Q_o + 3.1\ b_r\ (C/(t+C/(H^{0.5}))^3$
Q_b= Breach + Non-Breach Flow (cfs)
Q_o= Non-Breach Flow (cfs)
b_r= Final Average Breach Width (ft, ~ 1H to 5H)
C = 23.4 As/Br
As= Reservoir Surface Area (ac) at Failure Elevation
H = Selected Failure Depth (ft) above Final Breach Elevation
t = Time of Failure (hrs, ~H/120 or Minimum of 10 Min)

13.22 Considering non breach flow as zero and taking from the salient features A_s as 627 acres, final average breach width B_r as 117 m (1.07 H) and time of failure as 40 minutes breach flow Q_b is computed as 2,18,231 cusecs or 6179 cumec. The flood routing details and inundation map for the Umngot HEP dam are presented in Appendix –XIII.1.

Maximum Flood Elevations

13.23 As per the Dam Break Analysis conducted, the peak flood elevation and peak discharge at different locations below the dam are given below in Table.13.1. *(Also refer Appendix-1 page 20 and 21 for more details)*.

Table: 13.1 Peak flood elevations of Umngot River below the Dam in the event of Dam Break

Sl. No	Location in Km	Time, minutes	Peak Elevation (m)	Peak Discharge (cusec or ft^3/s)
1	0	6	989.06	218231
2	1.0	6	911.51	213078
3.	2.0	7	835.10	308127
4.	3.0	7	758.70	206237
5.	3.9	7	716.50	205666
6.	5.1	7	651.50	204298
7.	6.0	8	607.50	203228
8.	7.0	8	575.60	201859
9.	8.0	8	542.90	200476
10.	9.0	8	509.80	199354
11.	10.0	8	477.80	199555
12.	11.0	9	446.10	200508
13.	12.0	9	414.30	201379
14.	13.1	9	375.50	201918
15.	14.0	10	344.55	203375
16.	14.9	10	313.50	205213
17.	16.0	11	295.25	205305
18.	17.0	11	279.08	202263
19.	18.0	11	261.55	196773
20.	19.0	12	243.70	190406
21.	20.0	12	225.75	183322

13.24 The maximum time taken to reach the 20 km point would be 0.205 hrs or 12 minutes due to the rapid fall in the topography. The area is likely to be upto the maximum flood elevations at the different locations. The inundation map duly depicting the maximum flood elevations is shown in **Fig. 13.1. It was found that very small** extent of land is likely to be inundated outside the river flanks and also there no habitations within the inundation area. However, a suitable disaster management plan in the event of dam break and consequential floods is prepared.

Disaster Management Plan

13.25 The spill way of the dam of Umngot HEP should have adequate capacity to negotiate the probable maximum flood expected at the dam site, so that the dam does not get over topped due to impingement of PMF ensuring no chance of failure. The dam designed has to take into account all forces which are likely to act on them during its life time specifically is respect of seismic forces. Utmost quality control need to be taken during its construction ensuring no possibility of dam failure. The present chapter is focused on the strategy for Disaster Relief in the event of maximum flooding in the river against inundation even without dam failure.

Umngot River

13.26 Umngot river is one of the tributaries of Surma river in "Bangladesh". The river originates at an altitude of 1840 m at 11 km from Shillong near Nongkrem road junction. The catchment area comprises of about 57.14 per cent of forests inclusive of dense and open forests.

13.27 The modified Probable Maximum Flood (PMF) now computed and recommended to be adopted as designed flood is 8969.0 cumec. The project area falls within very heavy rainfall area and is nearer to Cherrapunji. It is necessary to adopt good management practice for release of water above the flood line gradually so that the villages downstream of dam are not affected. Necessary flood warnings shall be issued whenever warranted.

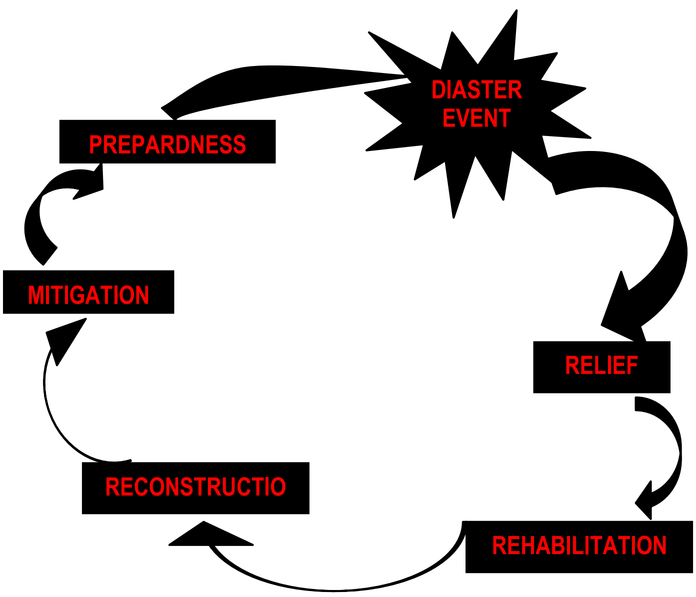
13.28 Generally, over flows into the reservoir occur during the monsoon periods i.e., from May to September. The rainfall in the catchment area will influence maximum surface water levels. The down pour and heavy rainfall can be taken as a signal for occurrence of heavy flows.

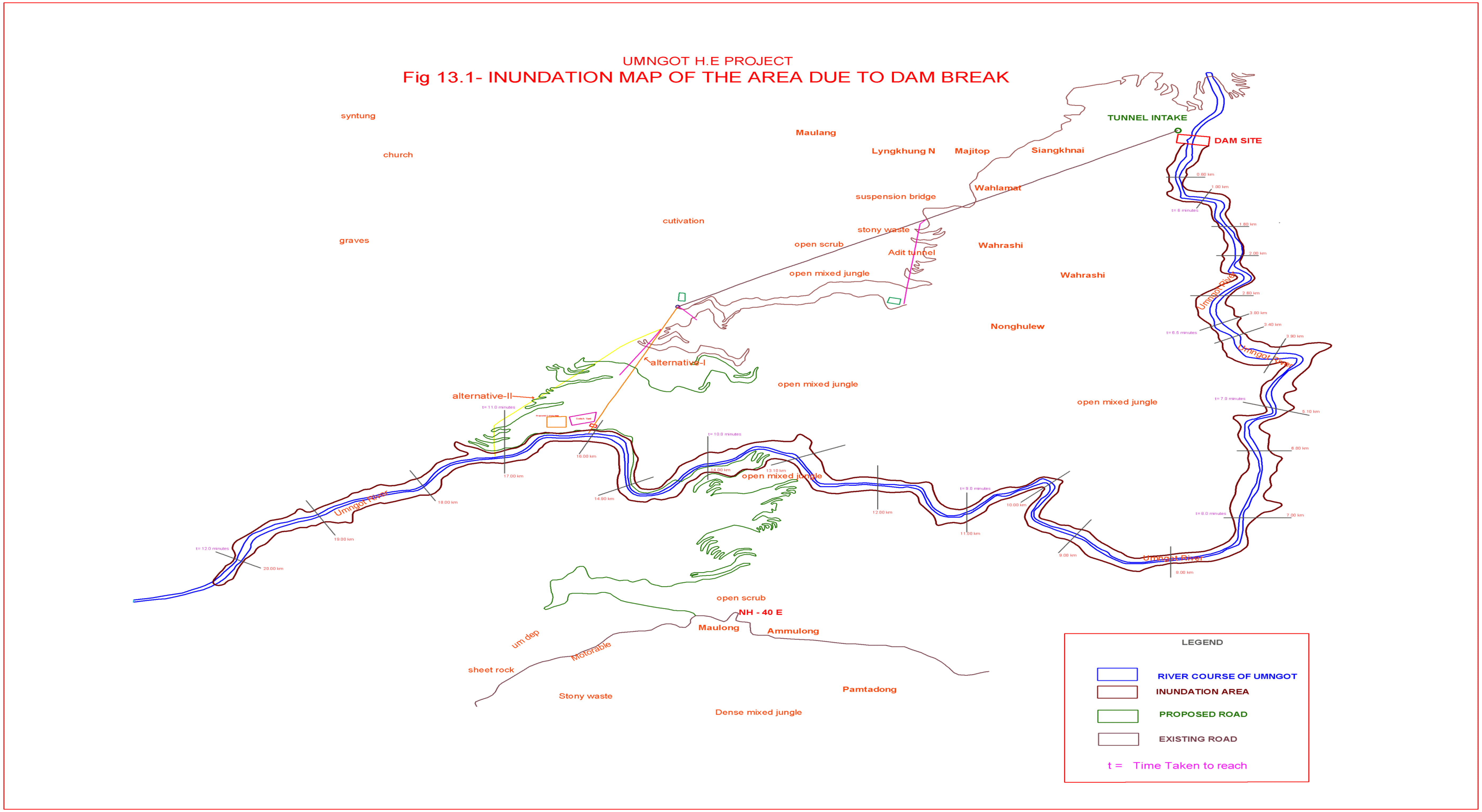
Disaster Management

13.29 The disaster is an example of failed or unsustainable development which can only be prevented or mitigated by adoption of more sustainable development practices. Therefore, a disaster can be defined as a serious destruction of economic and/or environmental system entailing widespread losses which exceed the ability of the affected society to cope using only its own resources (UNDP 1997).

13.30 This calls for better planning and development which can prepare for and prevent or mitigate every sudden onset of disaster. The risk of such disaster is part and parcel of the economic, technological and social organizations. There are no perfect solutions. Such is the nature of disaster. Therefore, planning phases of the disaster cycle (reconstruction and mitigative) have to be linked into the rest of the Cycle.

13.31The general conceptual framework for disaster management cycle is depicted overleaf




UMNGOT H.E PROJECT
Fig 13.1- INUNDATION MAP OF THE AREA DUE TO DAM BREAK
syntung
church
graves
cutivation
Maulang
Lyngkhung N
Majitop
Siangkhnai
TUNNEL INTAKE
DAM SITE
Wahlamat
suspension bridge
stony waste
open scrub
Adit tunnel
Wahrashi
Wahrashi
open mixed jungle
Nonghulew
alternative-I
alternative-II
open mixed jungle
open mixed jungle
open mixed jungle
Umngot River
Umngot River
Umngot River
Umngot River
open scrub
NH - 40 E
Maulong
Ammulong
um dep
motorable
sheet rock
Stony waste
Pamtadong
Dense mixed jungle
LEGEND
RIVER COURSE OF UMNGOT
INUNDATION AREA
PROPOSED ROAD
EXISTING ROAD
t = Time Taken to reach

Emergency

13.32 The word disaster will be synonyms with emergency either in the case of irrigation projects or hydro-electric projects. An emergency occurring in the electric plant is one that may affect one or several sections within it and or may cause serious injuries, loss of lives, extensive damage to property or serious disruption outside the works. It will require the best use of internal resources as well as outside resources to handle it effectively. Apart from the result of a malfunction of system, human errors, it may also be precipitated by the intervention of outside natural forces such as cyclones, floods causing damages to main structures. The disaster may occur due to deliberate acts of arson or sabotage. The different environment management plans for the above categories are discussed in the foregoing paras.

(A) Disasters in the Power plant

Objectives

13.33 The main hazards in the plant occur due to catching of fires because of explosions, chemicals or gasses. The objective of the major emergency or disaster management plan is to make use of the combined resources of the plant and the outside services to achieve the following:

1. Effect the rescue and medical treatment of causalities;
2. Safeguard other people;
3. Minimize damage to property and the environment;
4. Initially contain and ultimately bring the incident under control;
5. Identify any causalities;
6. Provide the need of relatives ;
7. Provide authoritative information to the news media;
8. Secure the safe rehabilitation of affected area;
9. Preserve relevant records and equipment for the subsequent enquiry into the cause & circumstances of the emergency.

Turbine Generator Explosion

13.34 H_2 gas explosion is a possible hazard in Generator. However, the Generator is designed to withstand explosion. Seal oil system is also provided for the Generator to prevent the leakage of H_2 gas. And also the H_2 purity is continuously monitored and maintained always above 98%. All the H_2 cylinders are checked for high purity.

Fires in Cable Galleries

13.35 The main hazard in cable galleries is fires. To control fires, heat sensors and smoke detectors are provided in the cable galleries to detect the fires at the inception stage itself. Also fire resistance barriers are provided at the cable intersections, intermittent places on cable trays, cable raisers and cable entry points.

Transformer Hazards

13.36 To take care of all the possible hazards adequate protection systems are available as per Engineering and in case of failure emulsifier system are provided to quench fires.

Sub-station Hazards

13.37 To take care of the problems relating to short circuits, supporting insulators, etc the following precautions are to be taken:

- Plugging of cable gland plates and breaker inspection plates against reptile entry and earthing to the cable gland.
- Periodical inspection / testing of switchgear equipment.
- Providing proper nomenclature of switchgear equipment with regards to voltage level, feeder description and panel numbering to avoid wrong identification.

Fuel oil Handling system hazards

13.38 The main hazard in fuel oil section is fires and storage tank explosion. However, to contain the chances of fires / explosions due to spillover, dyke walls are provided all around the fuel oil storage tanks. Apart from this, foam flooding system and MV water spray systems are provided on all Fuel Oil tanks. The level gauges and temperature monitors are also provided on the fuel oil tanks.

Storage / Godowns - hazards

13.39 The main hazards in stores/ godowns is fire and explosion due to stored gas cylinders. However to prevent the chances of fires and explosions, gas cylinders and flammable materials are to be stored safely with utmost care and precautions. Fire hydrant / portable fire extinguishers systems are to be made available all around the materials storage.

Fire Fighting

13.40 The plant shall be protected against fire hazards and shall be equipped with minimum fire protection systems. Main source of water supply for fire fighting is raw water which is drawn through pumps from River Umngot from both banks. The nearest fire station is situated at Jowai about 25 km. The fire station shall be made well equipped to meet any contingency. Minimum requirement of fire fighting equipment such as CO_2, foam and Dry Chemical Powder (DCP) may be maintained at the project location.

Fixed Fire Detection and Protection systems

13.41 The systems for protection and detection shall be kept at the project site as given Table – 13.2

Table - 13.2 : UMNGOT HYDRO-ELECTRIC PROJECT FIXED FIRE DETECTION AND PROTECTION SYSTEM			
Sl. No.	**Type & Nomenclature**	**Approximate capacity**	**Premises**
1	Water sprinkler system and Emulsifier	5 kgs pressure	On all transformers
2	Foam pourer	5 kgs pressure	On all fuel oil tanks
3	Medium velocity water spray system	5 kgs pressure	At LDO tanks
4	Smoke detectors	5 kgs pressure	At all control rooms switch gear rooms, cable galleries, etc.

Portable Fire Extinguishers

13.42 In addition to above fire fighting equipments, portable and mobile fire extinguishers have to be installed at all locations of the plant including Main Plants, Control rooms, Switch Gear rooms, Laboratories, Off sites, Administration building etc. Details are tabulated below:

DETAILS OF PORTABLE FIRE EXTINGUISHERS		
Sl No.	**Type of Extinguishers**	**Capacity**
1	CO_2 Type	6.8 kg
		22.5 kg
2	Foam type	9.0 Lt
		50 Lt
3	DCP type	5 kg
		75 kg
4	ABC Power Type	5 kg

Hospital Facility

13.43 Dispensary is already proposed at the camp colony (i.e. in public health management plan) situated at near surface power house with fully equipped separate disaster ward and burns ward shall be made available. First Aid centre also be made available inside the plant premises and manned round the clock. Ambulance facility may also be provided at the project dispensary.

Communication Facilities

13.44 Telephone and Inter-communication facilities shall be provided at all required desks or with officials. Audio Visual Emergency alarm to be provided in Control Room. P & T (STD) Divisional Engineers office and in Unit Control Board to contact nearby industries to ask for assistance. The facility can also be used to contact district authorities for information and help.

Emergency Power Supply

13.45 Emergency lights are to be provided at all vulnerable areas for lighting arrangements as well as to operate basic minimum equipment for operating the plant safely. All units are to be provided with DG sets as well as DC Battery System which come on auto in case of power failure. More than one supply through different transmission systems are also to be provided to ensure electric supply without fail.

Emergency Safety Equipment

13.46 The following emergency safety equipments shall be made available in Unit Control Board, where there may be a need including UCBs, Fuel Oil Pump Houses, Shift charge engineer's office and Safety Office.

- Self contained breathing apparatus
- Gas masks
- Gum boots
- Hand gloves
- Aprons etc.
- Fire Resisting suits

Emergency Control Centre

13.47 Emergency Control Centre is proposed in the Divisional Engineer's office chamber. It shall be equipped with all communication facilities to contact, the outside agencies and corporate offices. It is centrally located and from here the Unit Control Board, the switch yard control room and other wings are nearer to contact and to give suitable instruction to the officers. The emergency control room will be manned by ADE. The officials nominated as key personnel and Sr. Officers only shall have the access to the centre. The ECC will also contain the following data.

a. Safety data pertaining to all hazardous material, likely to cause emergency
b. Procedure of major and special fire fighting, rescue operations, first aid etc.
c. Emergency callout list of persons drafted for emergency control. Key personnel, fire, safety, first aid, medical, personnel & industrial relations, security, police and district administration authorities.

Emergency Alarms

13.48 The emergency siren will be sounded by the Security personnel as and when necessity arises with the instructions of the Divisional Engineer from the control room. Two sirens may be installed at the following places.

1. At Emergency Control room
2. At MeECL Housing colony at Security gate

13.49 They shall be manned round the clock. The alarm shall consist of repeated long and short blast for continuous period of 2 minutes. The alarm will be sounded such that the nature of emergency can be easily distinguished.

Summary of Fire Disaster Prevention

13.50 The detection and monitoring of fires in the quickest possible time helps the emergency management agencies to prevent large scale damage to life and property. Also, the residence in an area can be notified in advance so that they may have sufficient time to vacate the places. The frequency of fire incidents, loss pattern and extinction techniques vary vastly. This necessitates compilation and analysis of fire data.

13.51 The generation of electricity in Umngot Hydro-Electric project is through adjustable blades, bulbs turbines. During construction stage itself automatic tripping and other technical systems have been in force to avoid any fire accidents in the project site. However, fire prevention, mitigation plans should be kept ready to meet any eventually in case of fire accident. The important fire prevention measures should be:

- There should not be any storage of inflammable materials like petrol, diesel and explosives of any type near / close to the turbine or other machine rooms including nearby storeroom.
- Suitable fire extinguishing equipment should be kept ready always at the plant site.
- The watch / security staff of the plant should have the training in the operation of fire extinguishing equipment
- There should be time to time check up / inspection regarding the fitness / upkeep of fire extinguishing kits.
- Ones in a while mock drills to be conducted by involving the watch & ward / security staff of the plant under the supervision of senior officials.
- Smoke detectors should be installed at suitable points for detection of fire. The smoke detectors shall be designed that the operation of any detectors shall actuate an alarm device to give indication and alarm in the control room. The equipment shall be simple in design, easily operated - inspected and maintained. The equipment shall comply in all respects with the appropriate regulations of Insurance Association of India and similar approved organisation.

- Automatic alarm devices should be installed on the machine control panels, main control desks / panels and causing shutdown in case of serious trouble.
- Some of the alarms of unit control panels to be grouped and repeated in the control room. Similarly some control room alarms may have to be grouped and repeated in machine control panels.
- Location of instruments, indications recording controls and safety devices shall be based on recommendations of the manufacturer.
- In respect of fire fighting system, the contractor shall design, supply, testing and commissioning of fire protection equipment along with necessary control and annunciation arrangements comprising of :
- Fire Hydrant System
- Mulsifyre System
- Portable fire extinguishers

- Generator transformers shall be protected with mulsifyre type of fire protection system.
- Fire Hydrant system with fire hydrants to be located at the specified locations all over the power house. The system shall be complete with piping, fire hose cabinets, fire hose and all other accessories required (Note: This particular devise may be arranged as per the requirement in the plant).
- Portable Fire Extinguishers both well mounting type and tyre mounting type like (a) CO_2 type and (b) Foam type may be arranged.
- Smoke / Heat detectors to be placed in the specified area to generate automatic alarm in case of fire
- Linear Heat Sensing cable shall be laid in the control cable - duct to reuse the zone under fire
- In the event of fire on the transformer the Mulsifyre installation of the particular Transformer / equipment shall come into operation to open the corresponding deluge valve.
- Suitable fire guards shall be provided for protection of personnel. These include selective steel helmets, fire resistance / suits coats, hand gloves and gumboots.
- A 2.5 kg CO_2 gas type fire extinguisher bearing the under-writers table shall be provided in the cabin.

Action Plan

13.52 In the event of Emergency, Action plan is prepared for effective Central Management. The action plant consists of

1. First information from the site
2. Responsibilities of Divisional Engineer / O & M concerned
3. Responsibilities of Superintending Engineer / O & M
4. Responsibilities for declaration of Emergency
5. Responsibilities of Emergency communication officer (ADE / Peshi)
6. Responsibilities of Key personnel
7. Responsibilities and action to be taken by essential staff and various teams during emergency.

First Information from the Site

13.53 The first person who observes / identifies the hazardous incident shall inform by shouting, through public addressing system and by telephoning to the Divisional Engineer (O&M) available in Unit Control Board about the hazard. The observer also telephones to Fire station in case of fire hazard. Then the Divisional Engineer / will inform to concerned Superintending Engineer / O & M (According to the area of hazard) and also to Chief Engineer / O & M and communicate it to all key personnel about the incident.

Responsibilities of Superintending Engineer / O & M

13.54 The Superintending Engineer / O & M on knowing about hazardous incident, immediately will rush to the incident site and take overall charge and inform the same to Chief Engineer / O & M. On arrival, he will assess the extent of emergency and decade if major emergency exists and inform the Emergency Communications Officer (A.DE / Peshi) accordingly. His responsibilities will be:-

1. To direct all operations to within the affected area taking into consideration priorities for safety of personnel, minimize damage to the plant, property, environment and minimize loss of materials.
2. To provide advice and information to the fire & security officers and the local fire service.
3. To ensure that all non-essential workers / staff on the areas affected are evacuated to the appropriate assembly points and the areas are searched for causalities.
4. To setup communication points and establish contact with Emergency Control Centre in the event of failure of electric supply and thereby Public Address System (PAS) and internal telephones failure.
5. To report on all significant developments to the Chief Engineer / O & M.
6. To have regard to the need to preserve the evidence so as to facilitate any enquiry into the cause and circumstances which have caused or escalated the emergency

Responsibilities of the Chief Incident Controller (CE / O&M)

13.55 The Chief Engineer / O & M assume overall responsibilities for the plant and its personnel in case of any emergency. His responsibilities are: -

1. To assess the magnitude of the situation and decide if staff needs to be evacuated from their assembly points to identified safer places.
2. To undertake a continuous review of possible developments and assess in consultation with key personnel as to whether shutdown of the plant or any section of the plant and evacuation of personnel are required.
3. To co-ordinate with senior officials of Police, Fire brigade, Medical, Factories inspectorate and provide advice on possible effects on areas outside the plant premises.
4. To look after rehabilitation of affected persons and discontinuation of emergency
5. To issue authorised statements to news media, and ensure that evidence is preserved for enquires to be conducted by the Statutory Authorities

Responsibility for Declaration of Major Emergency

13.56 The Superintending Engineer / O & M on hearing the hazardous incident shall go to the scene of the incident make an informal assessment of the situation and decide whether a major emergency exists or is likely to develop. On his decision he will inform the Chief Engineer / O & M and activate the major emergency procedure. Superintending Engineer / O & M, who have knowledge and experience to recognize the fact of major emergency or the potential for it, in consultation with Chief Engineer a Major Emergency. Once the Emergency alarm is raised the works Emergency procedures will be activated.

Making the Emergency known inside the Plant

13.57 The major emergency will be made known to every one inside the plant by resounding the alarm. Separate alarms are sounded to warn different types of major emergency such as Fire and Explosion or Toxic gas escape. Same alarm can be used with different number of times as given and Public Address System also available throughout the Plant at every location.

Responsibilities of Emergency Communication Officer (ADE / Peshi)

13.58On hearing the emergency alarm he will proceed to Emergency control centre. He will:

a) Report to Chief Engineer and Superintending Engineer and maintain contact with them
b) On the information received from the Superintending Engineer of the situation recommending, if necessary, evacuate the staff from assembly points.
c) Identify suitable staff to act as runners or messengers who are listed in the Essential staff, between and the Superintending Engineer / O & M if the telephone and other system of communication fail due to any reason.
d) Maintain inventory of items in the Emergency Control Centre.
e) Maintain a log of incidents
f) Liaise with neighborhood fire brigades, hospitals, civil and police authorities on advice from Chief Engineer.

Key Personnel

13.59 Apart from Superintending Engineer / O & M and Chief Engineer other works personnel will have key role to play in providing advice and in implementing the decisions made by the Chief Engineer.

The key personnel include:

A. Divisional Engineer in charge responsible for
   a) Generation
   b) Electrical Maintenance
   c) Mechanical Maintenance
   d) C & I
   e) Chemical
   f) E & P

B. Head of personnel and officers connected with IR and Labour Welfare
C. SE (Admin. & Purchase)
D. Safety Officer
E. Chief Medical Officer
F. Security Officer / Security Inspector
G. Fire Officer

13.60 A list of key personnel and their phone numbers shall be informed to all concerned suitably. If necessary, they will decide the actions needed to shut down plants, evacuate personnel, carryout emergency engineering works, arrange for supplies of equipment personnel etc. carryout atmosphere tests, provide catering facilities , liaison with local bodies, state government authorities, inform relatives of the victims, press media etc.

Responsibilities of Key Personnel:

A) Departmental Heads

13.61 The departmental heads will provide assistance as required by Superintending Engineer / O & M. They will decide which members of their departments are required at the incident site.

B) Superintending Engineer / ADM

He will:-

a) Report to Chief Engineer / APGENCO O & M
b) Ensure that all non-essential workers in the affected areas are evacuated to assembly points in consultation with the Chief Engineer / O & M.
c) Receive reports from nominated persons from assembly points and pass on the absence information service.
d) Keep liaison with other coordinators to meet the requirements of services such as materials, security management, transportation, medical, canteen facilities etc., as required during emergency.
e) Be in constant touch with Chief Engineer / O & M and feed him correct information of the situation
f) Give information to press, public and authorities concerned on instructions from the Superintending Engineer / O & M and Chief Engineer / O & M.
g) Ensure that causalities received adequate attention at medical centre and arrange required additional help and inform relatives of the injured.
h) Arrange to inform public on Radio and T V about evacuation etc.
i) Arrange a TV coverage on handling emergency

C) Chief Medical Officer

13.62 Chief Medical Officer will render medical treatment to the injured and if necessary will shift the injured to nearby hospitals. He will mobilize extra medical help from outside if necessary. HE will keep a list of qualified first aiders.

D) Head of Safety

13.63 On hearing the emergency alarm, he will proceed to the site.

He will: -

a) Make sure that all safety equipments are made available to the emergency teams.
b) Participate in rescue operations
c) Co-ordinate to transfer the insured persons to medical centre and arrange for first aid.
d) Keep in contact with the DE / O & M and the Superintending Engineer / O & M and advise them on the condition of injured persons.

E) Security Officer

13.64 On hearing the Emergency alarm, he will proceed to main entrance / main gate. He will:-

a) Arrange to control the traffic at the gate and the incident area.
b) Direct the security staff to the incident site to take part in the emergency operations under his guidance and supervision.
c) Evacuate the people in the plant or in the nearby areas as advised by Superintending Engineer / O & M after arranging the transport through Transport In-charge.
d) Allow only those people who are associated with handling emergency.
e) Maintain law and order in the area, if necessary with handling emergency.
f) Maintain communication with chief Engineer / O & M, Superintending Engineer / O & M and Asst. Divisional Engineer / Peshi. O/o CE / O & M.

F) Officer Emergency Control Centre (ECC)

13.65 On hearing the emergency, he will arrange to sound the alarm as per the type of emergency in consultation with Superintending Engineer / O & M. He will:-

a. Inform the nearest fire stations; arrange to operate the fire fighting equipment available in the plant.
b. Take guidance of the Superintending Engineer / O & M for fire fighting as well as assessing the requirement of outside help.
c. Maintain communication with Superintending Engineer / O & M, Chief Engineer/ O & M and ADE / Peshi.

Essential Staff

13.66 In plants, immediately affected or likely to be as decided by the Chief Engineer O & M and Superintending O & M and Superintending Engineer / O & M, efforts will be needed to make shut down and make process units safe. This work will be carried out by plant supervisors and essential operators provided. They can do without exposing themselves to undue risk. The following employees will also be required to help the above works.

1. Attendants
2. First Aiders
3. Personnel for emergency work engineering, such as for providing extra lighting or replacement of lighting, providing temporary by pass of the works
4. Personnel for transporting equipment to the incident site from other parts of the works
5. Personnel for moving tankers or vessels from area of risk.
6. Personnel for acting as runners in case of communication difficulties
7. Personnel for manning plant entrance, in liaison with the Police to direct emergency vehicles entering the plant, to control traffic leaving the plant and to turn away or make alternate arrangement for visitors and other traffic arriving at the gate.

13.67 It is the responsibility of the Superintending Engineer / O & M to identify the above essential staff and form a Task Force which report at defined plant control centers so that they can be readily contacted. It is the responsibility of the Superintending Engineer O&M to remove all non-essential staff to assembly points.

Responsibilities of Teams

A. Task Force

- To identify source of hazard and try to neutralise / contain it.
- To isolate remaining plant and keep that if safe condition.
- To organise safe shutdown of plant, if necessary
- To organise all support service like operation of fire pumps, sprinkler system etc.

B. Maintenance Team

- Attend to all emergency maintenance jobs on top priority
- To take steps to contain or reduce the level of hazard created due to disaster.
- To organise additional facilities as desired.

C. Fire Fighting Team

In case fire erupts and emergency is due to fire the fire fighting team is responsible

- To rush to fire spot and extinguish the fire.
- To seek help form outside fire fighting agencies through notified officers.
- To evacuate persons affected due to whatever reasons.

D. Communication Team

- To maintain the communication network in working condition
- To attend urgent repairs in the communication system, if required
- If arrange messengers for conveying urgent messages when needed so.
- To help Electricity authorities to communicate with external or internal authorities / officials.

E. Security Team

- To man all gates
- To bar entry of unauthorised persons
- To permit with minimum delay, the entry of authorised personnel and outside agencies, vehicles, etc. who have come to help.
- To allow the ambulance / evacuation vehicles etc. to go through the gates with security escort.

F. Administration Team

- To rescue the casualties on priority basis
- To transport casualties to first aid post, safe places, or medical centres.
- To account the personnel
- To help in search for missing personnel
- To pass information to the kith and kin of fatal or seriously injured persons.

G. Safety Team

- To arrange required safety equipment
- To guide authorities on all safety related issues.
- To record accident details
- To collect and preserve evidences in connection with accident inquires.
- To report the accidents to statutory authorities and Chief Engineer / O & M.

H. Medical Team

- To arrange first aid material / stretchers immediately and reach to site of incident.
- To arrange for immediate medical attention.
- To arrange for sending the casualties to various hospitals and nursing homes etc.
- To ask specific medical assistance from outside including specialists in consultation with Chief Engineer / O & M and Superintending Engineer / O & M.

Support Teams

13.68 In addition to the teams already mentioned there will be two additional teams known as support teams.

A. **Support Team to Chief Engineer / O & M**

13.69 This team assists Chief Engineer / O & M during the emergency to execute his functioning in consultation with him. The members of the team and their responsibilities are given below:

a) Head of Personnel (Superintending Engineer / Admin)

- Contacting statutory authorities
- Arranging for relievers and catering facilities
- Giving information to News India
- Arranging shelters for affected persons
- Contacting medical centers and nursing homes
- Providing all other support, as necessary

b) Head of Materials (Asst. Divisional Engineer / Stores)

- Arranging for urgently required materials through cash purchase or whatever means.

c) Head of Finance (Sr. Accounts Officer)

- Arranging funds for various relief measures as well as emergency purchase of materials and sending his representative for emergency purchase.

B. Support team to Superintending Engineer / ADM

- Asst. Divisional Engineer / Technical
- Divisional Engineer / General
- Divisional Engineer / Electrical Maintenance

13.70 The team may call any more persons depending upon the need. The team will assist the Superintending Engineer / Admin. in manning communication and passing instructions to the team. One Asst. Engineer / Technical shall always be available with the Superintending Engineer / Admin. for recording all information coming in and instructions going out.

B. DISASTER DUE TO NATURAL CALAMITIES

Floods, Earthquakes, Dam break, etc

13.71 The dam across the River Umngot relating to the HEP is designed for a Probable Maximum Flood (PMF) for 1000 years return period. The location as well as the impounding area of the dam extend in the gorge portion of the river and do not submerge many private lands on both sides of the banks. Thus the dam does not get over topped due to impingement of PMF ensuring no chance of failure of the dam due to over topping. The dam is designed duly taking into account of all forces including seismic effects which are likely to act on it during its life time and utmost quality control still need to be taken during its construction, ensuring no possibility of the dam failure. The dam break study is mandatory since the height of the dam at the deepest portion is 122.80 m. The present chapter is hence focused on the strategy of Disaster preparedness only in the event of failure of the proposed Gravity dam for the maximum floods due to the break as per the analysis conducted by IIT, Roorkee.

Disaster Preparedness against Floods

13.72 The Natural Flood Commission (NFC) was set up in July 1976 by the Government of India. The NFC in its 1981 report laid great stress on proper flood plan management without diluting the importance of structural measures for specific situation.

Training in Disaster Preparedness

13.73 The success of disaster preparedness operations depends ultimately on public awareness and cooperation. This calls training at several levels. To begin with, the public servants who administer relief needs be trained. Some institutions like Human Settlement Management Institute (HSMI), Asian Disaster Preparedness Centre (ADPC) and National Institute of Rural Development (NIRD). More effort is necessary at the state level to train up field officers and staff in disaster preparedness.

13.74 The warning and forecasting systems need to be modernized and expanded. Geographical Information system (GIS) and Remote Sensing (RS) can be used in carrying out search and rescue operations in a more effective manner by identifying areas that are disaster prone, zoning them according to risk magnitudes, making inventory of population and assets at risk and simulating damage scenarios. Finally, the importance of public education and community preparedness should be fully recognized.

13.75 The disasters due to dam break cause heavy loss of life and property. Due to recent advances in science and technology, it is now possible to forecast the occurrence of extreme events and the nature of devastation that may cause with a greater degree of occurrence and with longer lead time. Availability of such crucial information in advance greatly helps in taking effective measures for prevention and mitigation of loss of life and property and avoids human suffering.

13.76 Awareness of the need to give greater attention to disaster mitigation, preparedness and management has been growing among decision-makers. Pre-disaster preparedness now formed an integral part of development planning. The team was invited to provide guidance on the strategies to reduce the destructive effects of the extreme events to stimulating data acquisition for forecasting and early warning systems, and by making improvements in disaster preparedness.

Disaster Management Plan - Floods

13.77 In case of extreme flood all of a sudden due to meteorological, topological and / or dam break cause disaster. The mighty flood water does not affect any residential areas as there are no residential areas down stream of the Umngot HEP which is proposed in deep gorge. The entire flood water however, partly affects the agriculture land on either side of river and major quantum of flood water flows down stream through the dam.

13.78 The on-site-emergency plan is aimed at ensuring safety of personnel, protection of environment, protection of plant installations, restoration of production and salvage operations in the same order of priorities. For effective implementation of such plan, it should be widely circulated and personnel are trained through mock drills. The objective of major emergency plan is to make use of the combined resources of the plant and outside services to achieve the following:

* Effect the rescue and medical treatment of casualties
* Minimize damage to the plant property and environment
* Initially contain and ultimately bring the incident under control
* Secure the safe rehabilitation of affected area.

Emergency Power Supply

13.79 In case of power failure due to some fire accidents, emergency lights are provided at all vulnerable areas for lighting arrangements as well as to operate basic minimum equipment. All units are provided with DG sets as well as DC Battery system which come on auto in case of power failure. More than one supply through different transmission system is also provided to ensure electric without fail.

Disaster Mitigation through Education and Training Programmes

13.80 The personnel / Engineers and other staff of the project should be exposed to short duration training on disaster management related issues. In case of extreme un-expected floods or dam break type of measures to be taken shall be taught in such training programmes.

Delineation of Vulnerable Areas

13.81 The Talukas / villages in the low lying areas below the dam which are prone to submergence due to maximum flood levels warrant special attention and requires relief and rescue operations. The Talukas situated in the down stream of the project area where the river spreads and where there are no flood banks on either side are prone to high inundation. The vulnerable areas likely to get affected due to heavy flood discharge need to be identified and delineated.

Transportation _Diversion Routes

13.82 In such a situation there is every possibility of interruption to transportation during the floods when it reaches flood warning levels and the more the water level raises the more inundation of roads may take place. The regular traffic will be interrupted due to raising water level and total transportation system by road will be cut off. Whenever such emergency arises men and material are to be transported immediately for relief operations. There is an imminent occurrence of traffic interruption of road due to inundation. Hence, it is necessary to take experience of the past about the levels of such obstruction and how the situation should be overcome. Identifying the diversion routes is a pre-requisite to organize conveyance by tanks or available mini vans - diversion can be taken if the water level is high. Particulars of diversion routes have to be obtained from the concerned departments and the authorities concerned shall plan out sending men and material and to take up rescue operations during high levels of floods.

Use of Generators

13.83 During the disaster there is also a possibility of power failure due to which the batteries connected to the HAM sets & Motorola sets will be discharged and the communication systems will be affected. Charging of batteries for use by HAM sets and Motorola sets can be done by using the generators available locally in the power plant or with the Revenue Officers.

Monitoring Relief Operations

13.84 It was the practice that senior officers from State level were sent by the Government to over-see and monitor the arrangements and effective implementation of the relief operations. The Officers having experience in disaster management in the past and having knowledge of environmental conditions and acquaintance of the areas are to be deputed. Therefore, it is necessary to have the data of the Officers deployed from other districts who have worked during the past disasters and to suggest the Government and request for their services in the hour of need. It is also necessary to plan out deployment of the staff of Electricity Dept., and goods available with them and outside the district for effective and quick management of situations.

Air dropping Food Packets

13.85 Air dropping of food packets, medicines may have to be resorted to the marooned villages during inundation. As such, the places where air dropping of food packets has to be dropped need to be identified and listed in advance. There will be sale and consumption of dead fish and meat of dead animals during floods. Sufficient propaganda should be made not to consume such fish or meat during floods season as they may lead to spread of epidemics.

Supply of Drinking Water

13.86 Adequate arrangements are also to be made well in advance for supply of drinking water sachets and milk packets by the related department.

Post -flood Operations

13.87 Flood relief operation in the affected areas has to continue for longer periods. Post flood operations also should be taken up for rehabilitating the evacuated people, restoration of power supply, telecommunications and improving sanitary conditions by way of spraying bleaching power, lime, phenol etc. To save the lives of the cattle, awareness should be created among the villagers that they should not tie the cattle and they should leave the cattle free.

Role of Participant Agencies

13.88 During pre or post inundation periods various agencies both government line departments and private agencies are involved in relief operations the main agency being the Electricity department. Each one agency has to perform their duties and responsibilities as given below:

1. ELECTRICITY (POWER DEPARTMENT)

13.89 The Divisional Engineer should take steps for disconnection of power supply to the villages likely to be affected. After receding of water, officers should visit the affected areas, clear path of power line / telephone poles, inspect damages caused and restore public utilities as quickly as possible. The Emergency Control Centre (ECC) in the plant premises shall be made alert for communicating with all the concerned line departments and other non-officials

2. POLICE DEPARTMENT

13.90 The Police Department shall be kept on “ALERT” from the time of level of reading first working to. It must instill public confidence that their properties and belonging are properly guarded in the event of evacuation. It should also install VHF sets in all the earmarked places by deputing personnel for operation of sets/passing of messages. In addition to this, two constables to each Mobile Team should be deputed for rescue and relief operations. They should have in regular touch with the Emergency Control Centre of the Umngot HEP. During post disaster operation, the monetary relief released for disbursement to the victims should be escorted.

3. FIRE SERVICES

13.91 The Fire Service Department during disaster has to evacuate the people who are trapped on building tops on the trees and also on hillocks. People can be shifted to safer places where water cannot enter. People can be resettled from collapsed buildings etc., with the help of their staff. In special case the Department has also to take up supply of Drinking water to the relief camps. They have to keep in regular contact with ECC of Umngot HEP in the plant premises.

4. MEDICAL & HEALTH DEPARTMENT

13.92 The Medical & Health Department has to play a very vital role during the disaster. All the activities will be taken up under the over-all supervision of the District Medical & Health Officer (D.M & H.Os). During floods season the Department shall ensure that all ambulances and other vehicles are road worthy, all vacant posts shall be filled up in the vulnerable mandals either by transfer or by deputation from other mandals. They shall procure and stock sufficient quantities of required medicines by indenting the same and shall be able to supply the same to all the concerned PHCs by the end of June. The Department shall constitute and provide medical staff to the Village Teams, Zonal Teams and the Mobile Teams and the orders for the same shall be issued well in advance.

13.93 They shall also organize Medical Teams to be posted at all the relief camps. During the month of June itself the department shall take up health education in all the vulnerable villages and ensure that general sanitation in these areas is maintained effectively. During disaster they shall ensure that the teams shall be available in all the vulnerable villages and take up the detection and treatment for Gastro-enteritis, Diarrhea and fever cases. Distribution of ORS Packets, Chlorine tablets for pot chlorination, checking of public water supply systems, spraying of bleaching powder as disinfectant, sanitary disposal of wastes shall be taken up by the medical teams. Mobile Medical Teams shall move by any means of transportation to render medical aid to the marooned villages.

13.94 Post disaster relief measures include surveillance of Gastro-enteritis, Diarrhea and Dysentery and spraying of disinfectant to prevent epidemics. Maintenance of Public Water supplies, erecting temporary lavatories and urinals shall be organized at relief camps to prevent epidemics.

<u>Village team</u> shall consist of the village Leaders, Panchayat members, teachers and paramedical personnel i.e. ANM’s for undertaking medical relief measures.

ZONAL TEAMS will consist of 3 to 4 para-medical personnel covering a group of villages to undertake the medical relief.

5. ANIMAL HUSBANDRY

13.95 The Animal Husbandry Department should stock sufficient quantities of medicines and fodder in advance to swing into emergency during menace besides chalking-out detailed programme for precautionary measures by constituting teams to prevent cattle diseases, epidemics and estimation of loss to the live-stock. The Animal Husbandry Department shall ensure that all the Veterinary Doctors at Block Level are available at headquarters and shall ensure that there is no spread of animal diseases and ensure that precautionary vaccination shall be taken up well in advance. They also shall conduct survey on cattle loss and submit report in the Detailed Data Sheet.

6. AGRICULTURE DEPARTMENT

13.96 One of the major tasks after the disaster will be assessment of damage to standing crops. Besides preliminary survey by the Revenue Department, the Agriculture Department shall conduct comprehensive survey on the crop losses and land damages due to sand-cast. It shall distribute seeds for next transplantation and educate farmers on methods for reclaiming eroded lands.

7. PUBLIC WORKS DEPARTMENT

13.97 Immediately after receding of floods, the Engineering personnel of Public Works Department shall visit the entire area, estimate damages caused to Roads, Culverts and Buildings etc. besides removal of fallen trees/collapsed tenements. Whenever necessary, immediate repairs have to be taken on war-footing basis to restore vehicular traffic. Further, toposheets have to be kept ready with Sub-Collectors to coordinate air dropping of food packets by the Pilots.

13.98 The Public Works Department shall ensure that the alternative routes shall be in roadworthy condition and if needed, to take up urgent repairs in advance. They have also to ensure that in the areas inundated with water all the buildings are still livable and certify the same before evacuated people return back to these areas. The villagers shall be allowed to go back to their houses only after certification about the livability of the houses and buildings by the Public Works Department. The Department shall properly maintain all Government buildings and ensure that none of the building shall be damaged beyond a point for all these buildings would be inhabited by a lot of Government staff who will be monitoring the flood.

8. COMMUNITY AND RURAL DEVELOPMENT DEPARTMENT

13.99 Similarly, the Engineering personnel of the Department should visit the affected area, inspect losses to their department infrastructure like school buildings, roads, tanks, drinking water sources and estimate the loss to submit to the concerned authorities. It should also take up immediate repairs to restore public utilities, wherever necessary.

9. PUBLIC HEALTH ENGINEERING

13.100 In each District there are district administrative councils and under this there are village councils/durbars. Each Village Council shall ensure a minimum stock of 5 bags of bleaching powder, 50 bags of lime and all others shall maintain a stock of 25 bags of bleaching powder and 100 bags of lime for the purpose of sanitation. Similarly District Council shall also maintain 100 bags of Bleaching Powder and 1000 bags of lime and around 20,000 chlorine tablets. This stock shall be maintained since July onwards.

13.101 During post disaster, the affected areas will be full of debris and slush scattered all over the houses as well as roads and drains. At this juncture, the village councils have to swing into action for cleaning up and spraying of Bleaching powder in the entire area to prevent out-break of epidemics.

13.102 The Public Health Department also shall ensure supply of protected water to the victims in relief centers. They shall also take up the supply of water in sealed polythene sachets of 250 ml, 500 ml or any other convenient capacity. The sachets can be packed into cartons and transported to the places where relief camps are being run.

10. WELFARE DEPARTMENTS

13.103 The Social Welfare / Tribal Welfare Departments have to reserve three months advance stocks of essential commodities in their Hostels functioning in the vulnerable areas. During the disaster, they are responsible for preparation of food and water packets and to load them in to the Helicopters for air dropping.

11. NCC / SCOUTS & GUIDES

13.104 The services of NCC / Scouts and Guides can also be utilized as the victims will have to face much difficulty in shifting their household goods and other belongings to the safer places. Their services will be of great utility in terms of providing man power support to the administration for running relief camps and providing other services.

12. TREASURES & ACCOUNTS DEPARTMENT

13.105 As financial constraints may hamper the disaster management efforts, it is inevitable to relax the Treasury Rules during emergency. The Sub-Treasury Officers concerned should take immediate action to release monetary relief on the basis of requisition.

13. ROLE OF PRESS & MEDIA

13.106 The role of Press & Media is of prime importance as it helps in allaying fears of public. The Press & Media should be in close touch with the administration from the commencement of season for flashing of news items in the daily news papers / Radio & TV about the impeding disaster situation. This would help educate the people about the possible hazards; steps to mitigate the distress and role Government / NGOs are playing. This at times may be in the form of interviews / short lectures and be broadcasted periodically through AIR / TV.

14. ROLE OF NGOs

13.107 As and when any catastrophe takes place, the service oriented NGOs will take part in the relief operations. At this point, it is very important to avoid duplication of relief being extended by them. Hence, to avoid this, the Sub-Collectors involved in relief operations shall make a request inviting them to contribute their help in cash, so that the same can be utilized for purchasing the needy items to the flood victims after assessed at the Main Control Room from time to time. The NGOs have to consider this and to come forward with their succor. This will also help in money being used in the optimum manner basing on the local needs, instead of NGOs preferences and their experiences in milieu that might be different and might not be replicable in the present arena. NGOs help should be sought also in terms of providing Counseling to get over distress and also providing manpower support to the administration. During post disaster, the Sub Collectors shall convene a meeting of all NGOs and request them to adopt a particular village or affected area for concentrated efforts. Role of NGOs is quite crucial in terms of smooth running of Relief camps also.

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Chapter - XIV

REHABILITATION AND RESETTLEMENT PLAN

INDIA
MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVORINMENT MANAGEMENT PLAN (EMP)

XIV

REHABILITATION & RESETTLEMENT PLAN

Background

14.01 Irrigation and hydro electric projects are the stepping stones for increasing the food production and leads to all-round development of the farming community. Yet, these projects lead to submergence of houses and house sites rendering the people homeless. In addition, cause loss of agricultural land affecting the overall social fabric of the affected people. It goes without saying that such adverse social impacts are unavoidable but there is a great need to minimize or completely avoid such impacts by way of providing alternative sites for resettlement, through provision of housing, infrastructure and allied facilities related to education , road, drinking water, electricity, hospital, etc., as well as extending suitable rehabilitation support. This way it will help affected people to regain at least their former levels of living standards. To achieve success, it requires careful planning and implementation of the resettlement and rehabilitation management plan with in-built monitoring system, both by the Project administrators / managers and of course the affected lot as well.

14.02 The Ministry of Environment and Forests, the Central Water Commission and CEA of the Government of India has been identified as the nodal agencies for scrutinizing and according sanction for the HE projects in particular. These organizations are very keen on minimizing and / or if possible avoiding both direct and indirect adverse impacts while according sanctions to such projects. The Meghalaya Energy Corporation Limited (MeECL) is equally interested in keeping the negative / adverse impacts of the project at the bare minimum or if possible prevent these adverse impacts both on ground as well as on population before sanctioning budgetary provisions for implementation of the Project. It is, therefore, evident that it requires a detailed study.

14.03 Implementation of Resettlement and Rehabilitation Plan is for minimizing the Socio - Economic Environmental impacts and making necessary provision for alternatives for reducing or avoiding such adverse effects, if any. Therefore, the present study is in line with the above needs for environmental clearance by the concerned authorities.

The Study Area

14.04 The Umngot HE project has been identified as a diversion project with storage on the Umngot River in East Khasi hills district for hydro power generation. The Umngot HE scheme is located near Siangkhanai village of East Khasi Hills district. The catchment area and storage lies in the districts of East Khasi hills and Jaintia hills. Short stretch of about 20 km. between the proposed Dam site and the Powerhouse site is encountered by a number of rapids and falls to drop from an elevation of 940 to 210 m, offering a good scope for harnessing Hydro power potential from the river. The drop between the proposed dam site and power house is about 774 m. The dam site is located at a longitude of 92° 06' 45" and latitude 25° 21 '38". The drainage area at the proposed dam site is about 304sq.km.

14.05 The Gross and Live storage of the Umngot storage reservoir is 38.59 Mm^3 and 32.95 Mm^3 at FRL EL 1040.0 m and MDDL at EL 1010.0 m respectively. By the construction of a 111 m high diversion dam the water will be diverted from the right bank through a 5588 m long Head Race Tunnel (low pressure tunnel) upto the Surge Shaft. An underground High pressure Shaft of length 1200 m long would then connect it to a surface level Power house at EL 230.5 m which is located in the mountain formation at a place near the village of Syntung. The water would be discharged back to the river through a Tail Race Tunnel/channel. The installed capacity is proposed as 240 MW to be generated through 3 numbers of Pelton Turbines of 80 MW each.

14.06 The Umngot Hydro-Electric Project is expected to generate 240 MW in a dependable year. The power from this project would be very much useful in mitigating the hardships of power crisis in the state as well as in the region besides providing employment in two districts of East Khasi hills and Jaintia hills. The project when completed will comprise the following components:

a) Concrete gravity dam in the gorge portion across Umngot River of 111 m high and 420 m long to impound on effective storage of 3900 Ha-m.

b) Intake and Head Race Tunnel (HRT) of 5588 m long and 3.6 m diameter modified horse shoe low pressure tunnel.
c) A pressure shaft of 2200 m long with internal diameter of 2.75 m trifurcating to 1.80m dia.
d) Surface power house with machine hall size of 77.5m x 22.0 m
e) Free Flowing Tail Race Tunnel/channel to lead the effluents back to Umngot River.

14.07 The implementation of the project with Installed capacity of 3 X 80 MW Hydel power generation would result 856.35 Million units of Annual Energy in a 90% dependable rainfall year. While the area within 10 km radius of the dam site and submergence area is treated as the study area for EIA study, the area under submergence is the study area for R & R study.

Involuntary Displacement

14.08 The Umngot Hydro-Electric Project (3 X 80 MW) affects only private lands due to submergence and construction of power houses and such aspects are required to be assessed as per the provisions of National Policy 2007.

14.09 The Project affected families / displaced families are required to be resettled nearest to the project area or in the same village if partially affected and are resettled as per the provision of National R & R policy 2007. Therefore, there is need for a detailed Socio-Economic Survey of the affected households and identification of the households eligible for resettlement and rehabilitation as per the National Policy leading to formulation of a detailed resettlement and rehabilitation action plan for the project affected families. But during the study it was found that the affected families are losing only full or part of their lands and not losing any structures, houses, cattle sheds etc,. The present report, therefore, is intended for the preparation of Project Affected Families Economic Rehabilitation Plan (PAFERP) on the basis of the socio-economic survey already conducted by AFC, Guwahati.

Approach and Methodology

14.10 The Socio- Economic Environmental impact assessment and formulation of necessary Resettlement and Rehabilitation plan forms an integral part of the HE projects where the large scale inundation of land due to submergence under reservoir cause problems in the Socio-Economic Environment. Subsequent, suggesting suitable mitigative measures in the study area forms part of PAFERP.

Definitions

14.11 The relevant definitions for formulation of Project Affected families Economic Rehabilitation Plan (PAFERP) are as follows:

i) Project Affected Village (PAV): The village/ settlement either fully or partly likely to get affected due to submergence under the reservoir, other infrastructure, etc, is defined as PAV.

ii) Displaced person: A person who is losing his house or house site by way acquisition under the project due to submergence will be deemed to be a displaced person.

iii) Project affected person is a person according to NPRR-2007 who is living in the affected village for a minimum period of three years or is doing some business or work or has been cultivating on his own land for the last three years before the notification of the project.

iv) Resettlement: Allocation of land and provision of assistance for construction of houses with provision of minimum infrastructure facilities like health, education, transport, communication, electricity, etc., in the new location is termed as Resettlement.

v) Rehabilitation: Provision of Economic Support Programmes either on individual household basis or for group of individuals for generating adequate income is called Rehabilitation.

Socio-Economic Survey

14.12 The Project and its related activities result in the submergence of lands. Some people of the area are likely to be affected and require economic resettlement and re-habilitation measures to enable them to restore at least to their levels of living of the pre-project stage. As such, resettlement and economic rehabilitation has now been considered as an integral part of any development programme. It is, therefore, necessary to plan out strategies for the smooth resettlement and rehabilitation of the affected persons. A Socio-Economic Survey of the affected families under the project was carried out in the affected areas of East Khasi Hills and Jaintia Hills district affected villages. The Socio-Economic Survey indicated that the people affected due to the construction of the project are of Families losing only land due to construction of the dam other infrastructure

14.13 Based on the Socio-Economic survey conducted in the affected villages, a detailed Rehabilitation and Resettlement plan is designed suggesting the line of action for implementation, monitoring and evaluation of the resettlement and rehabilitation programme.

Aims and Objectives

14.14 The main aims of the Socio-Economic study are to:

a) Assess the Socio-Economic impact of the affected persons belonging to different castes and categories, viz, Scheduled tribes, Scheduled Castes, Backward classes and other classes who will be losing only land

b) Formulate a Resettlement and Economic Rehabilitation programme for the project Affected Families (PAFs)

SOCIO ECONOMIC ENVIRONMENT

Background

14.15 The construction of the dam results in sub mergence of 56.60 ha of private lands out of the total submergence of 253.85 ha. In all 228 PAFs speared in 12 villages are affected due to land acquisition / submergence. Out of the total area of 56.60 ha coming under submergence, an area of 28.60 ha fall in East Khasi Hills district and the remaining 28.00 ha in Jaintia Hills district. The district, block and village wise distribution of PAFs and corresponding submerged land due to reservoir is given in Table 14.1.

Table 14.1: The district, block and village wise list of PAFs and corresponding submerged land							
I No	District	Block	Village	No. of Families (All are ST)	Extent of Total Land Cultivated, ha	Extent of Land Submerged, ha	Land Left with, ha
1	East Khasi Hills	Mawkynrew	KSANGRNGI	30	20.90	7.40	13.50
2	East Khasi Hills	Mawkynrew	MAWDULOP	16	7.60	3.29	4.31
3	East Khasi Hills	Mawkynrew	MAWJATAP	6	2.40	1.23	1.17
4	East Khasi Hills	Mawkynrew	MAWLANG	3	1.50	0.75	0.75
5	East Khasi Hills	Mawkynrew	MAWSIR	15	6.00	2.13	3.87
6	East Khasi Hills	Mawkynrew	MYNSANG	18	8.60	2.97	5.63
7	East Khasi Hills	Mawkynrew	PASHANG	21	12.70	3.83	8.87
8	East Khasi Hills	Mawkynrew	SIANGKHANAI.	5	1.80	0.98	0.82
9	East Khasi Hills	Mawkynrew	UMSAW-WAR	25	18.10	6.02	12.08
10	Jaintia Hills	Amlarem	MOSAKHIA	29	20.82	9.14	11.68
11	Jaintia Hills	Amlarem	SOHMANONG	37	25.54	12.01	13.53
12	Jaintia Hills	Thadlaskein	SOHMYNTING	23	16.07	6.85	9.22
			Total	**228**	**142.03**	**56.60**	**85.43**

Project Affected Villages

14.16 The Project Affected Villages are those villages where farmers own land or Government land or forest land get submerged under the proposed dam or have to be acquired for the execution of the project work. As a result of involuntary land acquisition for the project, a number of families living in the Project Affected Villages (PAVs) will be affected by the loss of land or house/house site or both. There are 12 PAVs where there is only land is to be acquired and no houses are to be acquired in any of the 12 villages.

Project Affected Community

14.17 The socio-economic details of the affected villages were collected. All such affected households who are losing lands are to be compensated for the losses suffered by each of the household head as per the prevailing market rates for land in the project area.

Demography

14.18 The construction of Umngot HE Project and development of infrastructure in the project area in all affects part households in 12 Villages affected due to submergence. The population details of the entire 12 villages are presented below in Table 14.2. As seen from the tables there are 881 households with a total population of 5225. The total male population is 2609 and female population is 2616.

Table 14.2: The district, block and village wise Population							
Sl No	District	Block	Name of Village	Number of households	Total population (including institutional and houseless population)		
					Persons	Males	Females
1	East Khasi Hills	Mawkynrew	Ksangrngi	31	203	112	91
2	East Khasi Hills	Mawkynrew	Mawdulop	19	123	71	52
3	East Khasi Hills	Mawkynrew	Mawjatap	82	448	219	229
4	East Khasi Hills	Mawkynrew	Mawlang	39	194	101	93
5	East Khasi Hills	Mawkynrew	Mawsir	21	106	51	55
6	East Khasi Hills	Mawkynrew	Mynsang	110	630	323	307
7	East Khasi Hills	Mawkynrew	Pashang	32	196	99	97
8	East Khasi Hills	Mawkynrew	Siangkhanai	31	138	68	70
9	East Khasi Hills	Mawkynrew	Umsawwar	55	294	158	136
10	Jaintia Hills	Amlarem	Mosakhia	68	324	148	176
11	Jaintia Hills	Amlarem	Sohmanong	25	148	73	75
12	Jaintia Hills	Thadlaskein	Sohmynting	368	2421	1186	1235
			Total	**881**	**5225**	**2609**	**2616**

Family Size and Sex Ratio

14.19 The average family size among the affected households in all 12 villages is 6 members and it is same for the households losing land. The size is less (4 persons per family) in East Khasi Hills-Mawkynrew-Siangkhnai Village and more in Jaintia Hills-Thadlaskein-Sohmynting (7 persons per family). The average sex Ratio i.e. Female to Male ratio is around 1003 females per every 1000 males indicating female dominancy. The female dominancy is as high as 1189 in Mosakhia village and low of 732 in Mawdulop village. The district, block and village wise Family Size and Sex Ratio is presented in Table 14.3

Table 14.3 : . The district, block and village wise Family Size and Sex Ratio					
Sl No	District	Block	Name of Village	Family Size	Female to Male ratio
1	East Khasi Hills	Mawkynrew	Ksangrngi	7	813
2	East Khasi Hills	Mawkynrew	Mawdulop	6	732
3	East Khasi Hills	Mawkynrew	Mawjatap	5	1046
4	East Khasi Hills	Mawkynrew	Mawlang	5	921
5	East Khasi Hills	Mawkynrew	Mawsir	5	1078
6	East Khasi Hills	Mawkynrew	Mynsang	6	950
7	East Khasi Hills	Mawkynrew	Pashang	6	980
8	East Khasi Hills	Mawkynrew	Siangkhanai	4	1029
9	East Khasi Hills	Mawkynrew	Umsawwar	5	861
10	Jaintia Hills	Amlarem	Mosakhia	5	1189
11	Jaintia Hills	Amlarem	Sohmanong	6	1027
12	Jaintia Hills	Thadlaskein	Sohmynting	7	1041
			Total	**6**	**1003**

Scheduled Castes (SC) and Scheduled Tribes (ST) population

14.20 The total population of the 12 PAVs is 5225, out which the STs accounted for over 99.85 per cent with 5217. There are no SC households in these villages. The village-wise details of SC and ST population are given in Table-14.4.

Table 14.4 : Details of SC and ST Population in Affected villages

Sl No	Name of Village	Total population			Scheduled Tribes population		
		Persons	Males	Females	Persons	Males	Females
1	Ksangrngi	203	112	91	203	112	91
2	Mawdulop	123	71	52	123	71	52
3	Mawjatap	448	219	229	448	219	229
4	Mawlang	194	101	93	194	101	93
5	Mawsir	106	51	55	106	51	55
6	Mynsang	630	323	307	630	323	307
7	Pashang	196	99	97	196	99	97
8	Siangkhanai	138	68	70	138	68	70
9	Umsawwar	294	158	136	294	158	136
10	Mosakhia	324	148	176	323	147	176
11	Sohmanong	148	73	75	148	73	75
12	Sohmynting	2421	1186	1235	2414	1183	1231
	Total	**5225**	**2609**	**2616**	**5217**	**2605**	**2612**

Literacy

14.21 The literacy rate of the study area is around 48%. The female literacy rate (55.4%) is 15 percent higher than the male literacy rate of 40.2%. Among all the villages, Sohmanong of Jaintia Hills has the highest rate of literacy at 84.5%. The lowest literacy rate was found to be in Mynsang village of East Khasi Hills at 12.3%. The Village-wise particulars are furnished in Table - 14.5.

Table 14.5 : Village wise Literacy rate in the PAVs

Sl No	Name of Village	Total population above 6 Years of age			Literates			% Literacy		
		Persons	Males	Females	Persons	Males	Females	Persons	Males	Females
1	Ksangrngi	155	83	72	43	14	29	27.7	16.9	40.3
2	Mawdulop	94	54	40	25	15	10	26.6	27.8	25.0
3	Mawjatap	346	175	171	81	26	55	23.4	14.9	32.2
4	Mawlang	142	73	69	42	14	28	29.6	19.2	40.6
5	Mawsir	80	38	42	14	4	10	17.5	10.5	23.8
6	Mynsang	471	240	231	58	26	32	12.3	10.8	13.9
7	Pashang	145	76	69	82	44	38	56.6	57.9	55.1
8	Siangkhanai	111	58	53	42	16	26	37.8	27.6	49.1
9	Umsawwar	208	114	94	137	70	67	65.9	61.4	71.3
10	Mosakhia	233	109	124	188	90	98	80.7	82.6	79.0
11	Sohmanong	110	58	52	93	46	47	84.5	79.3	90.4
12	Sohmynting	1837	899	938	1073	430	643	58.4	47.8	68.6
	Total	**3932**	**1977**	**1955**	**1878**	**795**	**1083**	**47.8**	**40.2**	**55.4**

Occupation:

14.22 The working community was dominated by Main workers (77%) both in case of Male and Female workers and it about 80 and 73% respectively compared to Marginal workers which stood at 23%. The village wise classification of workers is given in Table 14.6.

Table 14.6 : Village wise classification workers

Sl No	Name of Village	Total workers, Nos			Main workers, Nos			Marginal workers, Nos		
		Persons	Males	Females	Persons	Males	Females	Persons	Males	Females
1	Ksangrngi	96	59	37	96	59	37	0	0	0
2	Mawdulop	55	40	15	47	38	9	8	2	6
3	Mawjatap	257	130	127	4	0	4	253	130	123
4	Mawlang	103	55	48	3	3	0	100	52	48
5	Mawsir	41	24	17	36	23	13	5	1	4
6	Mynsang	257	168	89	229	153	76	28	15	13
7	Pashang	121	63	58	93	54	39	28	9	19
8	Siangkhanai	68	41	27	26	12	14	42	29	13
9	Umsawwar	167	91	76	123	84	39	44	7	37
10	Mosakhia	195	90	105	115	57	58	80	33	47
11	Sohmanong	70	41	29	70	41	29	0	0	0
12	Sohmynting	1203	614	589	1180	612	568	23	2	21
	Total	**2633**	**1416**	**1217**	**2022**	**1136**	**886**	**611**	**280**	**331**

Percentage of Workers

Sl No	Name of Village	Total workers			Main workers			Marginal workers		
		Persons	Males	Females	Persons	Males	Females	Persons	Males	Females
1	Ksangrngi	100.0	61.5	38.5	100.0	61.5	38.5	-	-	-
2	Mawdulop	100.0	72.7	27.3	100.0	80.9	19.1	100.0	25.0	75.0
3	Mawjatap	100.0	50.6	49.4	100.0	0.0	100.0	100.0	51.4	48.6
4	Mawlang	100.0	53.4	46.6	100.0	100.0	0.0	100.0	52.0	48.0
5	Mawsir	100.0	58.5	41.5	100.0	63.9	36.1	100.0	20.0	80.0
6	Mynsang	100.0	65.4	34.6	100.0	66.8	33.2	100.0	53.6	46.4
7	Pashang	100.0	52.1	47.9	100.0	58.1	41.9	100.0	32.1	67.9
8	Siangkhanai	100.0	60.3	39.7	100.0	46.2	53.8	100.0	69.0	31.0
9	Umsawwar	100.0	54.5	45.5	100.0	68.3	31.7	100.0	15.9	84.1
10	Mosakhia	100.0	46.2	53.8	100.0	49.6	50.4	100.0	41.3	58.8
11	Sohmanong	100.0	58.6	41.4	100.0	58.6	41.4	-	-	-
12	Sohmynting	100.0	51.0	49.0	100.0	51.9	48.1	100.0	8.7	91.3
	Total	**100.0**	**53.8**	**46.2**	**100.0**	**56.2**	**43.8**	**100.0**	**45.8**	**54.2**

Occupational Distribution

14.23 The occupational distribution of the workers indicated that the prominent occupation is cultivators which accounted for about 65.13% of total workers and is followed by Agril labourers (31.33%). All other services account for 3.53 %.(Table 14.7)

Table 14.7 : Distribution of Occupational Pattern in Project Affected Villages							
Sl No	**Occupation**	**Persons**			**Percentage to total**		
		Total	**Main**	**Marginal**	**Total**	**Main**	**Marginal**
1	Cultivators	1715	1280	435	65.1	63.3	71.2
2	Agril Labourers	825	653	172	31.3	32.3	28.2
3	Household industry workers	10	9	1	0.4	0.4	0.2
4	Other workers	83	80	3	3.2	4.0	0.5
	Total	2633	2022	611	100.0	100.0	100.0

Resettlement & Economic Rehabilitation Plan

14.24 The Department of Land Resources (DLR), Ministry of Rural Development (MORD), Government of India (GOI) formulated a policy entitled “National Policy on Resettlement and Rehabilitation for Project Affected Families-2007". No separate state policies existed in the State of Meghalaya. The socio-economic survey identified 229 households to be PAFs due to in the reservoir submergence and requires land to be acquired from them. No houses/structures are required for the proposed Umngot project. Thus, the total project affected families are 229 households, who are losing lands only. The Total Affected Persons have been identified to be 229 under the reservoir system on the basis of following criteria.

i) Families who lost substantial i.e. more than 50 per cent of land holding and left with less than 5.0 acres (2.0 ha) of dry land or 2.5 acres (1.0 ha) wet land;

ii) Families rendered land less after land acquisition for construction of reservoir; and

iii) Families whose land loss was less than 50 per cent of total land holding and left with less than 0.2 ha of land i.e. deemed to be functionally landless.

IDENTIFIED PAFs

14.25 On careful study of the data generated from the household survey carried out in the Project area, it is found that there were 229 PAFs (all belong to ST only) identified as per the criteria indicated above and could be classified under the following categories.

i) Families who are likely to lose more than 50 per cent of land and left with less than 2.0 ha of dry or 1.0 ha of wet;
ii) Rendered landless due to complete acquisition of their holdings; and
iii) Functionally landless who are left with 0.2 ha after land acquisition.
iv) No family get displaced due to submergence under reservoir.

14.26 Keeping in view the above criteria, the affected households who come within the preview of PAFs have been identified. The village wise distribution of the PAFs and their total holdings in the reservoir affected area is given in Table - 14.8. It can be observed that all the PAFs are ST households.

Table – 14.8 : The village wise distribution of the PAFs and their total holdings										
District	Village	No.of Families (All are ST)	No. of PAFs				Total Area of PAFs, ha			
			Marginal	Small	Medium	Big	Marginal	Small	Medium	Big
EAST KHASI HILLS	KSANGRNGI	30	30				20.90			
	MAWDULOP	16	16				7.60			
	MAWJATAP	6	6				2.40			
	MAWLANG	3	3				1.50			
	MAWSIR	15	15				6.00			
	MYNSANG	18	18				8.60			
	PASHANG	21	21				12.70			
	SIANGKHANAI.	5	5				1.80			
	UMSAW-WAR	25	25				18.10			
JAINTIA HILLS	MOSAKHIA	29	29				20.82			
	SOHMANONG	37	34	2	1	0	20.53	2.93	2.08	
	SOHMYNTING	23	23				16.07			
	Total	**228**	**225**	**2**	**1**	**0**	**137.02**	**2.93**	**2.08**	**0**

14.27 Further, it could thus be concluded that majority of the PAFs who are going to loose their lands are Marginal Farmers in the study area. The action plan is prepared for these households for payment of land compensation for the land acquired. Further an economic rehabilitation plan for the identified PAFs of reservoir system indicating the various entitlements as per National Policy for Resettlement & Rehabilitation of Project Affected Families i.e. National Rehabilitation Policy (NRRP- 2007) is also prepared.

14.28 The Economic Rehabilitation of the PAFs is made as per the rehabilitation provisions indicated in Table 14.9 accordance with the National Policy NRRP-2007.

Table 14.9 : The Applicable Entitlements as per National Policy-2007		
Sl.No.	**Entitlement Zone**	**Amount, Rs**
I	**Compensation To The Loss Of House -**	**Not applicable**
II	**Compensation To The Loss Of Land**	
1	After land acquisition if the farmer becomes The Prevailing minimum agricultural wage is considered at Rs 100 per man day	
1	Landless (750 days of MAW)	75,000
2	Marginal farmers (500 days of MAW)	50,000
3	Small farmers (375 days of MAW)	37,500
III	**Exclusive Tribal Benefits**	
1	Financial Assistance for each ST PAF (500 MAW days)	37,500
2	Provision of land to land compensation for each ST PAF who lost his land under acquisition	
3	25% higher R & R benefits if the Tribal PAF resettled out of the district or out side tribal area	
IV	**Rehabilitation Equivalent (750 MAW)**	75,000
V	**Occupations Grants**	
	Financial Assistance for each PAF whose primary occupation is	

Table 14.9 : The Applicable Entitlements as per National Policy-2007		
Sl.No.	**Entitlement Zone**	**Amount, Rs**
1	Agricultural labour (equivalent to 25 days minimum agricultural wages per month for period of one year i.e. 300 days)	30,000
2	Non agricultural labour (625 MAW days)	Not applicable
3	Rural artisans / Self employed PAFs	Not applicable
VI	**Other Benefits**	
1	Transportation charges	Not applicable
2	Compensation for Cattle sheds	Not applicable
3	Compensation for Productive trees @ 20 tree per family and Rs. 1500/- per tree	30,000
4	Compensation for Farm houses	Not applicable
VII	SC/ST Grant (500 days of MAW)	50,000

14.29 All the above entitlements have been worked out on the basis of the guidelines issued by the MORD, at the prevailing minimum agricultural wage of Rs. 100/- per day per person.

Project Affected Family Economic Rehabilitation Plan (PAFERP)

14.30 The cost of relief, resettlement and rehabilitation of the affected households under the Umngot HE project has been worked out in accordance with the National Policy guidelines-2007. Broadly, the issue has two components only namely i) land compensation and ii) economic rehabilitation of PAFs who have lost only land but not house / house site.

Land Acquisition

14.31 According to the Socio-Economic Survey, a total of 56.60 ha of land have to be acquired in the reservoir areas from 228 families residing in 12 villages under the scheme. In addition, land to the extent of 103.70 ha may need to be acquired from village / district councils for reservoir submergence. This land consisted of 60.00 ha of forest land and 43.70 ha of barren and uncultivable land. The submergence area consisted 93.55 ha of Land River and under water bodies. Thus, the total submergence area of reservoir is assessed to be 253.85 ha. The land required for hydrologic structures, roads, buildings and other purposes is assessed to be 136.67 ha. Thus, the total land required for the project is 390.52 ha. As per clause 7.4 of "NRRP-207", In the case of irrigation or hydel projects, the state Government may formulate suitable schemes for providing land to the affected families in the command areas of the projects by way of pooling of the lands that may be available or, otherwise, could be made available in the command areas of such projects. Since most of the PAFs prefer to be rehabilitated in same location, this may not be possible. Therefore, only cash compensation is proposed for the entire land loss. Therefore, the land acquisition required for the project is 296.97 ha. The compensation for acquisition of this land may need to be paid as per the provisions contained in Land Acquisition Act 1894 and prevailing market rates. The total cost of involuntary acquisition of 296.07 ha of arable, broom, forest and other community land at differential rates, loss of standing crop, tress, interest, demarcation, legal and establishment charges, solatium etc., are given in Table-14.10. The total compensation for land acquisition is estimated to be **Rs. 2,331.07 lakh.**

Table 14.10 : COMPENSATION FOR LAND ACQUISITION

Sl. No	Particulars	Costs, Rs Lakh			
		Private Arable Lands	Forest Lands	Community Lands	Total
1	Total Land to be acquired, ha	56.60	93.53	146.84	**296.97**
a	Reservoir submergence	56.60	60.00	43.70	160.30
b	Hydraulic Structures		4.92	25.18	30.10
c	Roads		28.00	69.17	97.17
d	Buildings		0.61	2.47	3.07
e	Others		0.00	6.33	6.33
f	River Water Bodies (Acquisition Not Considered in submergence)			93.55	93.55
	Total Required for the Project	**56.60**	**93.53**	**240.39**	**390.52**
2	Cost of land acquisition @ Rs. 4.90 lakh per ha Private Lands, Rs 4.30 lakhs per ha of Community Land and Barren land. The Forest Lands @ Rs 5.18 lakhs per ha and also will be Taken with Compensatory Afforestation as per Forest Dept. Guidelines	277.34	484.49	631.42	**1,393.25**
3	Solatium charges @ 30% of cost of land acquisition	83.20	145.35	189.43	417.98
4	Interest charges for time lag in taking possession of land for 2 years @ 9% p.a. for 25% item 2 and 3	21.63	37.79	49.25	108.67
5	Legal charges @ 1% of items 2+3	3.61	6.30	8.21	18.12
6	Demarcation charges @ 1% of items 2+3	3.61	6.30	8.21	18.12
7	Unforeseen and miscellaneous charges @ 5% on 2+3	18.03	31.49	41.04	90.56
8	Establishment and Contingency charges @ 10% (including relocation of roads, power lines, etc) of items 2+3	36.05	62.98	82.09	181.12
9	Compensation forTress falling in 56.60 ha for 228 families (Estimated at Rs 1,12,500 per ha having 25 trees at the rate of Rs 4500 perTree)	63.68			63.68
10	Compensation for Standing Crop (Broom stick) Loss @ Rs 32000 per ha (40 kg/ha x Rs 80/kg)	18.11			18.11
11	Rent for use of Land of 8.76 ha at Rs 49000 per year per ha i.e 10% Cost of land (Temporary for five years)	21.46			21.46
	Total	**546.72**	**774.70**	**1,009.65**	**2,331.07**

No indicative budget has been proposed as land acquisition is not likely to increase any further.

Economic Rehabilitation

14.32 It may be pointed out here that a 5 per cent margin has been allowed in the indicative budget to meet additional claims that could arise at the time of project execution. The Economic Rehabilitation package for 228 PAF households identified under the SES is estimated to cost about **Rs. 524.59 lakh.** Further, a margin of 5% is allowed in the indicative budget to meet any additional claims that might arise when the actual implementation of R & R Programme is taken up. Thus the total cost of economic rehabilitation programme of PAF households would be about **Rs 550.82 lakh** including an indicative budget of Rs 26.23 lakh. The details of the economic rehabilitation programme are presented in **Table- 14.11**. Household wise economic rehabilitation package for PAFs under reservoir system is presented in *Appendix-2*

Table 14.11 : ECONOMIC REHABILITATION OF PAF HOUSEHOLDS

Sl. No	Particulars	Costs, Rs Lakh		
		As per SES	Indicative Budget (5%)	Total
1	Rehabilitation grant for 228 families equivalent to 750 days of minimum agricultural wage of Rs 100/day i.e. Rs 75,000 per Family	171.00	8.55	**179.55**
2	Occupational grant (Subsistence Allowance) equivalent to 25 days minimum agricultural wages per month for period of one year i.e 300 days @ Rs100/day Rs 30,000 per family	68.40	3.42	**71.82**
3	Each PAF whose entire land has not been acquired and consequently becomes a Landless (38) and Marginal (190) will get one time financial assistance equivalent to 750, and 500 MAW respectively	123.50	6.18	**129.68**
4	ST grant equivalent to 500 days i.e. Rs. 50000 /- for each of 228 ST PAFs	114.00	5.70	**119.70**
5	Establishment and Contingency Charges at 10% on all items	47.69	2.38	50.07
Total		**524.59**	**26.23**	**550.82**

Access to on-going Programmes

14.33 While the above are the resettlement and economic rehabilitation support provided, the PAFs may also be provided with access to benefits from the ongoing development programmes and welfare oriented schemes.

Linkages with other Development Programmes

14.34 The District Rural Development Agency (DRDA) will provide adequate support in implementation of Economic Rehabilitation Programme. The concerned Sub-Collector will be the nodal agency for implementation of the R & R Action Plan. Formation of village committees and village action plans through involvement of local NGOs are some of the crucial aspects in the implementation process of ERP Action plan.

Livelihood Training

14.35 With the acquiring of land all the PAFs loose their sole source of income. The rehabilitation will be undertaken in the same village. Since the families are not provided for land to land compensation, they need to be trained to take up available or possible livelihood activities within the same village. The identification of possible livelihood activities in the affected villages needs to be undertaken with help of local Non-Government Organisation (NGOs). Further, the officials responsible for implementing the R & R Plan need to be provided with adequate training to identify the livelihood activities for PAFs. A lumpsum amount of Rs. 5.00 lakh will be earmarked for this activity. In addition, all the PAFs need to be provided with adequate training to take up new livelihood activities identified for their rehabilitation. A training budget at the rate of Rs. 5000 per family is provided towards training of PAF member. Thus, the total amount to be provided for training of PAF members to take up new livelihood activities is Rs. 11.40 lakh. The total amount provided for training of officials and PAFs is Rs. 16.40 lakh.

Total Financial Requirement

14.36 The total financial requirement for the implementation of Resettlement and Economic Rehabilitation Plan including cost of land acquisition would be about **Rs 2,886 lakh** as per details given in Table – 14.12

Table – 14.12 : TOTAL COST OF RESETTLEMENT AND REHABILITATION

Rs lakhs

Sl.No.	Particulars	SES	Indicative Budget (for 5%)	Total
1	Land Compensation	2,331.07	-	2,331.07
2	Economic Rehabilitation	524.59	26.23	550.82
3	Training	16.40	-	16.40
	Total	**2,872.06**	**26.23**	**2,898.29**

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Chapter - XV

EMP IMPLEMENTATION PLAN

INDIA
MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS
UMNGOT HYDRO-ELECTRIC PROJECT
(3 X 80 MW)

PART - II
ENVORINMENT MANAGEMENT PLAN (EMP)

XV

ENVIRONMENTAL MANAGEMENT PLAN IMPLEMENTAION SCHEDULE

Introduction

15.01 Timely completion of a project is of utmost importance for channelizing the anticipated benefits out of the project. Any delay in implementation of the power development projects in particular would abnormally escalate the project cost resulting in delayed benefits and the cost of the project could ultimately overtake the benefits accruing from the project. Therefore, proper implementation planning is most essential for periodic monitoring; taking corrective and timely measures with a view to complete the work within the stipulated time frame. The implementation of Environmental Management Plan comprising the components related to Catchment Area Treatment compensatory afforestation, flora and fauna development, on-farm development in the command area and land acquisition disbursal of compensation and rehabilitation to project affected persons requires to be attended to within the given time frame.

Time Frame

15.02 The Umngot Hydro Electric Project is scheduled to be completed over a period of 6 years excluding Pre-construction year but including the concurrent implementation of the Environmental Management Plan (EMP). Considering the various components under Environmental Management Plan for implementation, the following is the schedule of implementation of the proposed components related to Umngot, dam, Tunnels and Power house etc.

Pre-Construction year

1. Environmental clearance from MOEF
2. Forest and wild life clearance
3. Surveys for identification of catchment area treatment components

First Year

1. Start land acquisition proceedings for the submergence area, dam, surge shaft, tunnels and power house.
2. Starting afforestation work including engineering works in the prioritized sub-watersheds of catchment area.
3. Handing over land to Forest department towards compensatory Afforestation.
4. Monitoring sanitation facilities in the staff colonies and labour colonies.
5. Commencement of compensatory Afforestation programme.
6. Establishing laboratory for testing of parameters like Air, Noise, effluents etc., and commissioning.

Second Year

1. Land acquisition for the submergence area, Power house and other components.
2. Monitoring foreshore plantations, soil and moisture conservation treatment measures in the catchment area.
3. Monitoring Air and Noise parameters during construction of dam, tunneling and Power house etc.
4. Establishing and monitoring of medical facilities and health services for labour camps and staff colonies.
5. Monitoring water supply and sanitary arrangements in the labour and staff colonies.
6. Deforestation in the water spread area
7. Monitoring environment parameters like effluents from septic tanks, water samples water related diseases.
8. Monitoring of compensatory afforestation plantations and maintenance.

Third Year

1 Monitoring Compensatory Afforestation work, plantations and maintenance.
2 Deforestation of the area of submergence
3 Afforestation, soil and moisture construction works in the prioritized areas of Catchment and maintenance of plantations.
4 Monitoring foreshore plantations / reservoir rim treatment and maintenance.
5 Monitoring parameters related to Air, Noise, Water and effluents from project colonies and construction sites like dam, head works, tunnels and power house.
6 Surveillance of diseases medical and health facilities

Fourth Year

1. Monitoring of compensatory afforestation work and maintenance.
2. Afforestation soil and moisture conservation works in the prioritized areas in the Catchment.

3. Foreshore plantations / reservoir rim treatment completion including maintenance.
4. Evacuation of Private lands up to FRL+1040.
5. Monitoring parameters related to Air quality, Noise levels during construction works like dam, tunnels, head works, and Power house, Water samples and effluents from staff & labour colonies and testing.
6. Surveillance of diseases, medical and health facilities

Fifth Year

1. Compensatory Afforestation with plantation monitoring including maintenance.
2. Completion of deforestation in the submergence area.
3. Afforestation in the degraded areas, soil and moisture conservation works in the prioritized area of the catchment including maintenance of plants.
4. Evacuation of the lands likely to be submerged upto +1040.00 m.
5. Monitoring parameters related to Air quality, Noise levels at construction sites like main dam, Link canal, tunnel works, power house etc. Monitoring water samples, effluents from staff and labour colonies for the parameters prescribed.
6. Surveillance of diseases, medical and health facilities to be monitored in the labour camps and staff colonies.
7. Construction works of approach roads for tourism development.

Sixth Year

1. Compensatory Afforestation with plantation to be completed.
2. Soil and moisture conservation measures in the prioritized sub watersheds in the catchment to be completed.
3. Monitoring parameters related to Air quality and Noise levels at the construction sites of main dam, structures, power house works. Monitoring water samples, effluents from staff and labour colonies for the proposed parameters.
4. Surveillance of diseases medical and health facilities to be monitored in the labour camps and staff colonies.
5. Construction works like approach roads, guest houses and project houses for tourism development.

15.03 A bar chart showing the proposals for implementation under different components of EMP is presented below:

15.04 Continuation of monitoring of parameters for surface water quality, sewage water samples, soil erosion and siltation, ecology, water diseases in the operation period up to ten years as suggested in chapter XII.

.

UMNGOT HEP							
Implementation Schedule –Bar Chart							
Dam, Tunnels, Power house etc.,							
Sl. No	Item of work	1st year	2nd year	3rd year	4th year	5th year	6th year
1	Mateorological Monitoring (Air & Noise)						
2	Afforestation / reforestation in proritised areas (degraded_						
3	Environment monitoring (water, effluents)						
4	Land acquisition – submergence area						
5	Compensatory afforestation (plantation)						
6.	Surveillance of diseases, medical and health facilities						
7	Soil and moisture conservation works in prioritized areas						
8	Deforestation in the submerged area						
9	Foreshore plantation / reservoir rim treatment						
10	Evacuation of submergence lands						
11	Tourism development						
12	Landscapes / parks / View points						

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

PART - II

ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Chapter - XVI

EMP PROJECT COST

INDIA
MEGHALAYA
EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT (3 X 80 MW)

PART – II
ENVIRONMENTAL MANAGEMENT PLAN (EMP)

XVI

PROJECT COST

Introduction

16.01 Based on the assessment of environment impacts on land, water, flora and fauna, a detailed Environmental Management Plan (EMP) including Rehabilitation and Resettlement (R&R) has been formulated for protecting the environment and ecology in the core influence zone. Thus the EMP proposed in the present study covers land environment including catchment area treatment, biological conservation, public health management plan, air & noise pollution management plan and R & R Plan in the pre and post project periods. The present chapter is, therefore, focused on the financial requirements for implementation of the proposed EMP as envisaged in this report. The salient features of the EMP outlay under different components are discussed in the following paragraphs.

Land Environment

(A) Catchment Area Treatment measures

16.02 Necessary engineering measures are proposed for the treatment of the catchment for soil conservation as well as water harvesting structures.

16.03 The cost estimate of the proposed structures is given in Table - 16.1. The total cost of catchment area treatment of the project is assessed to be **Rs. 2,901.96 lakh.**

Table - 16.1 COST ESTIMATES FOR CATCHMENT AERA TREATMENT			
Sl.No.	**Recommended Treatment**	**Area to be treated / No. of structures**	**Total cost Rs lakh**
I	**Vegetative recommended treatment**		
	Afforestation and Silvi Pasture Development	1200 ha	385.20
II	**Soil and Water conservation measures**		
a)	Engineering and Mechanical measures	456 nos	48.69
b)	Staggered trenches	2230 ha	316.68
c)	Bench Terracing	3011 ha	1,422.55
III	Shifting cultivation		
a)	Control of shifting cultivation	788 ha	44.15
b)	Vegetative Barriers	162 ha	2.51
IV	Reservoir Rim Treatment	60 km or 60 ha	19.26
V	Compensatory Afforestation	93.53 ha	662.92
	Grand Total		**2,901.96**

Treatment of Muck Disposal sites

16.04 The total cost for the engineering measures proposed at the muck disposal sites works out to be **Rs. 118.58 lakhs** as given in chapter - IX.

C Restoration of quarry sites and dumping areas

16.05 Cost estimate for the restoration of the quarry sites has been worked out to **Rs. 155.55 lakhs** as given in chapter - IX.

Total Cost of Land Management

16.06 The total cost of management plan under land environment consisting of muck disposal sites' treatment, and restoration of quarry sites and dumping sites works out to be **Rs. 274.13 lakhs.** In addition, an amount of Rs. 2,239.04 lakh is needed for catchment area treatment and Rs. 662.95 lakh for compensatory afforestation. Thus, the total cost for management of land environment is **Rs. 3,176.12 lakh.**

Biological Conservation Plan

16.07 The biological conservation plan worked under the EMP consisted fisheries development, greenbelt establishing and restoration. It is suggested to establish a bio-diversity park near the project site as part of Wildlife Conservation Plan in EMP.

16.08 The cost of various sub-heads under this plan are indicated in Table 16.2

Table 16.2 Biodiversity Management Plan		
SL No	Management Measure	Rs Lakhs
1	Green Belt Development	22.83
2	Wildlife Conservation Plan	50.00
3	Fishery Management Plan	23.13
	Total	**95.95**

16.09 A total budgetary provision of Rs. 95.95 lakh is necessary for implementation of EMP under this component.

Public Health Management Plan

16.10 The plan covers providing sanitation facilities to labour and staff colonies, solid waste management including effluent management, public health delivery system and provision of safe drinking water to project colony and labour colonies. The item wise cost for implementation of Public Health Management Plan as discussed in Chapter XI is summarized in Table 16.3

Table 16.3 : Cost of Public Health Delivery System		
Sl No	**Particulars**	**Rs lakhs**
I	**Sanitary Facilities for Labour Camps**	**40.00**
II	**Solid Waste Management**	**61.00**
III	**Sewage Treatment from Labour Camps**	**5.00**
IV	**Public Health Delivery System**	
A	**Recurring Expenses Per Year**	
1	Administration and Man Power Expenses	15.36
2	First Aid Posts Expenses	2.16
3	Drugs and Medicines, Contingencies and First Aid Posts	2.15
	Sub Total for One Year	***19.67***
	Sub Total for the next Five Years as Maintenance	***98.35***
B	**Non-Recurring (As Capital Cost during First Year)**	
1	Infrastructure for Dispensary like Vehicles and Furniture	11.00
2	Infrastructure for Dispensary Buildings	41.50
3	Infrastructure for First Aid Buildings	2.00
	Sub-Total	**54.50**
	Total Public Health Management	**278.52**

16.11 The total funds to be provided for implementation of EMP under this component are assessed to be **Rs. 278.52 lakh.**

Environmental Monitoring Programme

16.12 Environmental monitoring is an essential component for sustainability of any water resources project. Water resources development project introduces complex interrelationships in the area between people, various natural resources and many developing forces. Hence monitoring of critical parameters is essential in the project operation phase. The objects of this programme are:

- ✓ Assess the changes in environmental conditions, if any during construction and operation of the project
- ✓ Monitor the effective implementation of mitigatory measures
- ✓ Warning of any significant deterioration in environment quality.

16.13 The areas of concern and the anticipated costs for monitoring during the construction and operation phases are summarized in Table 16.4.

Table 16.4
Cost of Environmental Management Programme

SI. NO	Particulars	Construction phase	Operation Phase	Total
1	Water quality and effluents	37.00	16.00	**53.00**
2	Air quality	19.75	-	**19.75**
3	Meteorological aspects	15.00	-	**15.00**
4	Noise levels	3.00	-	**3.00**
5	Water related diseases	38.58	31.87	**70.45**
6	Soil erosion and siltation	-	51.27	**51.28**
7	Ecology	-	60.00	**60.00**
	Total	**113.33**	**159.15**	**272.48**

16.14 The total financial requirement for environmental monitoring under the project during both construction and operation phases is assessed to be **Rs. 272.48 lakh**, out of which Rs. 173.33 lakh is required during construction phase and balance (Rs. 159.15 lakh) is required during operation phase.

Resettlement and Rehabilitation Plan

16.15 The project envisages only submersion of land. Land is required for the construction of power house besides for establishment of a project colony and submergences. For the above components 56.60 ha of private land is proposed to be acquired besides 93.53 ha o forest land and 146.84 ha of community lands. The total cost of involuntary acquisition of private agricultural land at

Rs. 4,90,000/- per ha and Rs. 4,30,000/- per ha for community lands, loss of tress, loss of standing crop, interest, demarcation, legal and establishment charges is estimated to be **Rs. 2,331.07 lakh.**

16.16 The Economic Rehabilitation package for 228 PAF households identified under the SES is estimated to cost about *Rs. 524.59 lakh.* Further, a margin of 5% is allowed in the indicative budget to meet any additional claims that might arise when the actual implementation of R & R Programme is taken up. Thus the total cost of economic rehabilitation programme of PAF households would be about **Rs 550.82 lakh** including an indicative budget of *Rs 26.23 lakh. All the benefits from the package was estimated by considering present wage rate of Rs 100 per man day.*

Training

16.17 A lumpsum amount of Rs. 5.00 lakh will be earmarked for this activity. In addition, all the PAFs need to be provided with adequate training to take up new livelihood activities identified for their rehabilitation. A training budget at the rate of Rs. 5000 per family is provided towards training of 228 PAF members. Thus, the total amount to be provided for training of PAF members to take up new livelihood activities is Rs. 11.40 lakh. The total amount provided for training of officials and PAFs is **Rs. 16.40 lakh.**

Total Financial Requirement for R & R

16.18 The total financial requirement for the implementation of Resettlement and Economic Rehabilitation Plan including cost of land acquisition would be about **Rs 2,898.29 lakh** as per details given in Table – 16.5

Table - 16.5
TOTAL COST OF RESETTLEMENT AND REHABILITATION

Rs lakhs

Sl. No.	Particulars	SES	Indicative Budget (for 5%)	Total
1	Land Compensation	2,331.07	-	2,331.07
2	Economic Rehabilitation	524.59	26.23	550.82
3	Training	16.40	-	16.40
	Total	**2,872.06**	**26.23**	**2,898.29**

Total Project Outlay for EMP and R &R

16.19 The total implementation cost of environmental Management plan and Resettlement & Rehabilitation Plan is estimated at **Rs 3,823.04 and Rs 2,898.29 lakhs** respectively. The total financial provision required for implementation of EMP under the project is assessed to be about **Rs. 67.22 crore** including R & R costs and **Rs 38.23 crore excluding R & R costs**. The item-wise total project cost is presented below in Table 16.6

Table 16.6 Total Project of EMP and R&R		
Sl. No	**Particulars**	**Amount Rs lakhs**
A	**Environmental Management Plan**	
1	Catchment area treatment including reservoir rim treatment and Compensatory Afforestation	2,901.96
2	Land Management	274.13
3	Biological Conservation plan	95.95
4	Public Health Management Plan	278.52
5	Environmental Monitoring Plan	272.48
	Sub-Total of EMP	**3,823.04**
B	**Resettlement and Rehabilitation Plan**	
1	Land Acquisition	2,331.07
2	Economic Rehabilitation	550.82
3	Training	16.40
	Sub-Total of R & R	**2,898.29**
	Total Project cost Including R & R	**6,721.33**

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

APPENDIX - 1

OUTPUT OF DAM BREAK ANALYSIS

PMP DISTRIBUTION

	PMP VALUE CMS.			**140**	**DESIGN LOSS RATE CM./HR.**				**0.36**				
	TEMPORAL DISTRIBUTION IN %												
HOUR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**TOTAL**
BELL I	13	23	32	40	47	53	58	63	66	70	73	75	
RAINFALL INCREMENT	13	10	9	8	7	6	5	5	3	4	3	2	**75**
EFFECTIVE HOURLY RAIN FALL	17.84	13.64	12.24	10.84	9.44	8.04	6.64	6.64	3.84	5.24	3.84	2.44	
BELL II	4.33	7.67	10.67	13.33	15.67	17.67	19.33	21.00	22.00	23.33	24.33	25.00	
RAINFALL INCREMENT	4.33	3.33	3.00	2.67	2.33	2.00	1.67	1.67	1.00	1.33	1.00	0.67	**25**
EFFECTIVE HOURLY RAIN FALL	5.71	4.31	3.84	3.37	2.91	2.44	1.97	1.97	1.04	1.51	1.04	0.57	
													100

CRITICAL EFFECTIVE RAINFALL

SUG ORDINATE (CUMECS)	1 HR. EFFECTIVE RAINFALL (CMS)		CRITICAL 1 HR. EFFECTIVE RAINGALL (CMS.)	
	BELL I	BELL II	BELL I	BELL II
11	2.44	0.57	3.84	1.04
28	6.64	1.97	3.84	1.04
64	9.44	2.91	5.24	1.51
126	12.24	3.84	6.64	1.97
196	17.84	5.71	8.04	2.44
136	13.64	4.31	10.84	3.37
84	10.84	3.37	13.64	4.31
54	8.04	2.44	17.84	5.71
38	6.64	1.97	12.24	3.84
24	5.24	1.51	9.44	2.91
18	3.84	1.04	6.64	1.97
14	3.84	1.04	2.44	0.57

ESTIMATION OF DIRECT RUNOFF HYDROGRAPH

		CRITICAL 1 HR. EFFECTIVE RAINFALL (CMS.)																											
TIME	ORDINATE	BELL I												ORDINATE	BELL II												RUNOFF	FLOW	FLOOD
(HRS.)	(CUMECS)	3.84	3.84	5.24	6.64	8.04	10.84	13.64	17.84	12.24	9.44	6.64	2.44	(CUMECS)	1.04	1.04	1.51	1.97	2.44	3.37	4.31	5.71	3.84	2.91	1.97	0.57	ORDINATE	(CUME	ORDINATE
0	0	0.00																									0.00	200	200.00
1	4	15.36	0.00																								15.36	200	215.36
2	11	42.24	15.36	0.00																							57.60	200	257.60
3	28	107.52	42.24	20.96	0.00																						170.72	200	370.72
4	64	245.76	107.52	57.64	26.56	0.00																					437.48	200	637.48
5	126	483.84	245.76	146.72	73.04	32.16	0.00																				981.52	200	1181.52
6	196	752.64	483.84	335.36	185.92	88.44	43.36	0.00																			1,889.56	200	2089.56
7	136	522.24	752.64	660.24	424.96	225.12	119.24	54.56	0.00																		2,759.00	200	2959.00
8	84	322.56	522.24	1027	836.64	514.56	303.52	150.04	71.36	0.00																	3,747.96	200	3947.96
9	54	207.36	322.56	712.64	1301.4	1013	693.76	381.92	196.24	48.96	0.00				BELL II												4,877.92	200	5077.92
10	38	145.92	207.36	440.16	903.04	1575.8	1365.8	872.96	499.52	134.64	37.76	0.00			1.04	1.04	1.51	1.97	2.44	3.37	4.31	5.71	3.84	2.91	1.97	0.57	6,183.04	200	6383.04
11	24	92.16	145.92	282.96	557.76	1093.4	2124.6	1718.6	1141.8	342.72	103.84	26.56	0.00														7,630.40	200	7830.4
12	18	69.12	92.16	199.12	358.56	675.36	1474.2	2673.4	2247.8	783.36	264.32	73.04	9.76	0	0.00												8,920.32	200	9120.32
13	**14**	**53.76**	**69.12**	**125.76**	**252.32**	**434.16**	**910.56**	**1855**	**3496.6**	**1542.2**	**604.16**	**185.9**	**26.84**	**4**	**4.16**	**0.00**											**9,560.68**	**200**	**9760.68**
14	11	42.24	53.76	94.32	159.36	305.52	585.36	1145.8	2426.2	2399	1189.4	425	68.32	11	11.44	4.16	0.00										8,909.92	200	9109.92
15	8.5	32.64	42.24	73.36	119.52	192.96	411.92	736.56	1498.6	1664.6	1850.2	836.6	156.2	28	29.12	11.44	6.04	0.00									7,662.04	200	7862.04
16	7	26.88	32.64	57.64	92.96	144.72	260.16	518.32	963.36	1028.2	1283.8	1301	307.4	64	66.58	29.12	16.61	7.88	0.00								6,137.75	200	6337.75
17	6	23.04	26.88	44.54	73.04	112.56	195.12	327.36	677.92	660.96	792.96	903	478.2	126	131.04	66.58	42.28	21.67	9.76	0.00							4,586.99	200	4786.99
18	5	19.20	23.04	36.68	56.44	88.44	151.76	245.52	428.16	465.12	509.76	557.8	331.8	196	203.84	131.04	96.64	55.16	28.84	13.48	0.00						3,442.72	200	3642.72
19	4	15.36	19.20	31.44	46.48	68.34	119.24	190.96	321.12	293.76	358.72	358.6	205	136	141.44	203.84	190.26	126.08	68.32	37.07	17.24	0.00					2,812.39	200	3012.39
20	3	11.52	15.36	26.20	39.84	56.28	92.14	150.04	249.76	220.32	226.56	252.3	131.8	84	87.36	141.44	295.96	248.22	156.16	94.36	47.41	22.84	0.00				2,565.85	200	2765.85
21	2	7.68	11.52	20.96	33.2	48.24	75.88	115.94	196.24	171.36	169.92	159.4	92.72	54	56.16	87.36	205.36	386.12	307.44	215.68	120.68	62.81	15.36	0.00			2,559.99	200	2759.99
22	1	3.84	7.68	15.72	26.56	40.20	65.04	95.48	151.64	134.64	132.16	119.5	58.56	38	33.52	56.16	126.84	267.92	478.24	424.62	275.84	159.88	42.24	11.54	0.00		2,727.84	200	2927.84
23	0	0.00	3.84	10.48	19.92	32.16	54.20	81.84	124.88	104.04	103.84	92.96	43.92	24	24.96	33.52	81.54	165.48	331.84	660.52	543.06	365.44	107.52	32.01	7.88	0.00	3,025.85	200	3225.85
24			0.00	5.24	13.28	24.12	43.63	68.20	107.04	85.68	80.24	73.04	34.16	18	18.72	24.96	57.38	106.38	204.96	458.32	844.76	719.46	245.76	81.48	21.67	2.28	3,320.76	200	3520.76
25				0.00	6.64	16.08	32.52	54.58	89.20	73.44	66.08	56.44	26.84	14	14.56	18.72	36.24	74.86	131.76	283.08	586.16	1119.2	483.84	186.24	55.16	6.27	3,417.87	200	3617.87
26					0.00	8.04	21.68	40.92	71.36	61.2	56.64	46.48	20.74	11	11.44	14.56	27.18	47.28	92.72	181.98	362.04	775.56	752.64	366.66	126.08	15.96	3,101.16	200	3301.16
27						0.00	10.84	27.28	53.52	48.96	47.20	39.84	17.08	8.5	8.84	11.44	21.14	35.46	58.56	128.06	232.74	479.64	522.24	570.36	248.22	36.48	2,597.90	200	2797.90
28							0.00	13.64	35.68	36.72	37.76	33.20	14.64	7	7.28	8.84	16.61	27.58	43.92	80.88	163.78	308.34	322.56	395.76	386.12	71.82	2,005.13	200	2205.13
29								0.00	17.84	24.48	28.32	26.56	12.20	6	6.24	7.28	12.84	21.67	34.16	60.66	103.44	216.98	207.36	244.44	267.92	111.72	1,404.11	200	1604.11
30									0.00	12.24	18.88	19.92	9.76	5	5.20	6.24	10.57	16.75	26.84	47.18	77.58	137.04	145.92	157.14	165.48	77.52	934.26	200	1134.26
31										0.00	9.44	13.28	7.32	4	4.16	5.20	9.06	13.79	20.74	37.07	60.34	102.78	92.16	110.58	106.38	47.88	640.18	200	840.18
32											0.00	6.64	4.88	3	3.12	4.16	7.55	11.82	17.08	28.65	47.41	79.94	69.12	69.84	74.86	30.78	455.85	200	655.85
33												0.00	2.44	2	2.08	3.12	6.04	9.85	14.54	23.59	36.64	62.81	53.76	52.38	47.28	21.66	336.19	200	536.19
34													0.00	1	1.04	2.08	4.56	7.88	12.20	20.22	30.17	48.54	42.24	40.74	35.46	13.68	258.81	200	458.81
35														0	0.00	1.04	3.02	5.91	9.76	16.85	25.86	39.97	32.64	32.01	27.58	10.26	204.90	200	404.90
36																0.00	1.51	3.94	7.32	13.48	21.55	34.26	26.88	24.74	21.67	7.98	163.33	200	363.33
37																	0.00	1.97	4.88	10.11	17.24	28.55	23.04	20.37	16.75	6.27	129.18	200	329.18
38																		0.00	2.44	6.74	12.93	22.84	19.20	17.46	13.79	4.85	100.25	200	300.25
39																			0.00	3.37	8.62	17.13	15.36	14.55	11.82	3.99	74.84	200	274.84
40																				0.00	4.31	11.42	11.52	11.64	9.85	3.42	52.16	200	252.16
41																					0.00	5.71	7.68	8.73	7.88	2.85	32.85	200	232.85
42																						0.00	3.84	5.82	5.31	2.28	17.25	200	217.25
43																							0.00	2.91	3.94	1.71	8.56	200	208.56
44																								0.00	1.97	1.14	3.11	200	203.11
45																									0.00	0.57	0.57	200	200.57
46																										0.00	0.00	200	200.00

ANALYSIS OF THE DOWNSTREAM FLOOD HYDROGRAPH

PRODUCED BY THE DAM BREAK OF

UMNGOT DAM

ON

UMNGOT RIVER (MEGHALAYA)

BASED ON PROCEDURE DEVELOPED BY
DANNY L. FREAD, PH.D., SR. RESEARCH HYDROLOGIST

QUALITY CONTROL TESTING AND OTHER SUPPORT BY
JANICE M. LEWIS, RESEARCH HYDROLOGIST

HYDROLOGIC RESEARCH LABORATORY
W23, OFFICE OF HYDROLOGY
NOAA, NATIONAL WEATHER SERVICE
SILVER SPRING, MARYLAND 20910

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***                         ***
***  SUMMARY OF INPUT DATA  ***
***                         ***
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INPUT CONTROL PARAMETERS FOR UMNGOT DAM

PARAMETER	VARIABLE	VALUE
NUMBER OF DYNAMIC ROUTING REACHES	KKN	1
TYPE OF RESERVOIR ROUTING	KUI	0
MULTIPLE DAM INDICATOR	MULDAM	0

```
PRINTING INSTRUCTIONS FOR INPUT SUMMARY              KDMP          3

NO. OF RESERVOIR INFLOW HYDROGRAPH POINTS            ITEH         34

INTERVAL OF CROSS-SECTION INFO PRINTED OUT WHEN JNK=9  NPRT        0

FLOOD-PLAIN MODEL PARAMETER                          KFLP          0

METRIC INPUT/OUTPUT OPTION                           METRIC        1


                     UMNGOT DAM          RESERVOIR

                   TABLE OF ELEVATION VS SURFACE AREA

              SURFACE AREA (SQ KM)   ELEVATION (M)
                      SA(K)                HSA(K)
             ************************* ****************

                          2.8           1042.50
                          1.8           1030.00
                          1.4           1020.00
                          1.0           1010.00
                           .8           1000.00
                           .3            980.00
                           .1            960.00
                           .0            940.00
1


         UMNGOT DAM           RESERVOIR AND BREACH PARAMETERS
```

PARAMETER	UNITS	VARIABLE	VALUE
**	*******	******	***********
LENGTH OF RESERVOIR	KM	RLM	3.00
ELEVATION OF WATER SURFACE	M	YO	1042.00
SIDE SLOPE OF BREACH		Z	1.67
ELEVATION OF BOTTOM OF BREACH	M	YBMIN	935.26
WIDTH OF BASE OF BREACH	M	BB	.00
TIME TO MAXIMUM BREACH SIZE	HOUR	TFH	.10
ELEVATION (MSL) OF BOTTOM OF DAM	M	DATUM	935.26
VOLUME-SURFACE AREA PARAMETER		VOL	.00
ELEVATION OF WATER WHEN BREACHED	M	HF	1042.00
ELEVATION OF TOP OF DAM	M	HD	1042.00
ELEVATION OF UNCONTROLLED SPILLWAY CREST	M	HSP	995.00
ELEVATION OF CENTER OF GATE OPENINGS	M	HGT	.00
DISCHARGE COEF. FOR UNCONTROLLED SPILLWAY		CS	.00
DISCHARGE COEF. FOR GATE FLOW		CG	.00
DISCHARGE COEF. FOR UNCONTROLLED WEIR FLOW		CDO	580.80
DISCHARGE THRU TURBINES	CMS	QT	.00

QSPILL(K,1) CMS	HEAD(K,1) M
0.	.0
954.	1.0
2831.	3.0
4663.	5.0
6451.	7.0
8194.	9.0
9048.	10.0
11050.	12.4

DHF(INTERVAL BETWEEN INPUT HYDROGRAPH ORDINATES) = 1.00 HRS.

TEH(TIME AT WHICH COMPUTATIONS TERMINATE)= 19.0000 HRS.

BREX(BREACH EXPONENT) = .000

MUD(MUD FLOW OPTION) = 0

IWF(TYPE OF WAVE FRONT TRACKING) = 0

KPRES(WETTED PERIMETER OPTION) = 0

KSL(LANDSLIDE PARAMETER) = 0

DFR(WINDOW FOR CRITICAL FROUDE NO. IN MIX FLOW ALGORITHM)= .050

INFLOW HYDROGRAPH TO UMNGOT DAM

****

9760.68	9109.92	7862.04	6337.75	4786.99	3642.72	3012.39	2765.85
2759.99	2927.84	3225.85	3520.76	3617.87	3301.16	2797.90	2205.13
1604.11	1134.26	840.18	655.85	536.19	458.81	404.90	363.33
329.18	300.25	274.84	252.16	232.85	217.25	208.56	203.11

```
      200.57    200.00


TIME OF INFLOW HYDROGRAPH ORDINATES

         .0000    1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000
        8.0000    9.0000   10.0000   11.0000   12.0000   13.0000   14.0000   15.0000
       16.0000   17.0000   18.0000   19.0000   20.0000   21.0000   22.0000   23.0000
       24.0000   25.0000   26.0000   27.0000   28.0000   29.0000   30.0000   31.0000
       32.0000   33.0000
1
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          CROSS-SECTIONAL PARAMETERS FOR   UMNGOT RIVER (MEGH
                       BELOW UMNGOT DAM

PARAMETER                                              VARIABLE      VALUE
***************************************************  ******      *******

NUMBER OF CROSS-SECTIONS                                NS              7

MAXIMUM NUMBER OF TOP WIDTHS                            NCS             6

NUMBER OF CROSS-SECTIONAL HYDROGRAPHS TO PLOT           NTT             6

TYPE OF OUTPUT OTHER THAN HYDROGRAPH PLOTS              JNK             1

CROSS-SECTIONAL SMOOTHING PARAMETER                     KSA             0

DOWNSTREAM SUPERCRITICAL OR NOT                         KSUPC           1

NO. OF LATERAL INFLOW HYDROGRAPHS                       LQ              0

NO. OF POINTS IN GATE CONTROL CURVE                     KCG             0
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```
 NUMBER OF CROSS-SECTION WHERE HYDROGRAPH DESIRED
          (MAX NUMBER OF HYDROGRAPHS = 6)
**************************************************

              1    2    3    4    6    7



      CROSS-SECTIONAL VARIABLES FOR   UMNGOT RIVER (MEGH
                  BELOW UMNGOT DAM

 PARAMETER                                    UNITS  VARIABLE
******************************************  *******  ******

 LOCATION OF CROSS-SECTION                      KM      XS(I)
 ELEVATION(MSL) OF FLOODING AT CROSS-SECTION    M       FSTG(I)
 ELEV CORRESPONDING TO EACH TOP WIDTH           M       HS(K,I)
 TOP WIDTH CORRESPONDING TO EACH ELEV           M       BS(K,I)
      (ACTIVE FLOW PORTION)
 TOP WIDTH CORRESPONDING TO EACH ELEV           M       BSS(K,I)
      (OFF-CHANNEL PORTION)
 NUMBER OF CROSS-SECTION                                I
 NUMBER OF ELEVATION LEVEL                              K
1



 CROSS-SECTION NUMBER  1
*************************

 XS(I) =      .000   FSTG(I) =     .00
```

```
HS  ...    935.3   935.8   936.6   985.6   987.7  1045.0
BS  ...       .0     8.8    17.1   137.7   141.7   450.0
BSS ...       .0      .0      .0      .0      .0      .0
```

```
 CROSS-SECTION NUMBER  2
*************************

 XS(I) =     3.000   FSTG(I) =     .00

 HS  ...    713.4   714.0   718.2   743.5   752.3  1000.0
 BS  ...       .0    11.4    29.0   118.8   149.9   450.0
 BSS ...       .0      .0      .0      .0      .0      .0
```

```
 CROSS-SECTION NUMBER  3
*************************

 XS(I) =     6.000   FSTG(I) =     .00

 HS  ...    559.2   560.3   562.4   592.4   595.3   950.0
 BS  ...       .0    24.1    38.7   122.6   129.6   450.0
 BSS ...       .0      .0      .0      .0      .0      .0
```

```
 CROSS-SECTION NUMBER  4
************************

 XS(I) =      9.000   FSTG(I) =     .00


 HS  ...    454.6   456.5   457.8   483.3   486.4   850.0
 BS  ...       .0    29.1    37.3    97.8   105.3   450.0
 BSS ...       .0      .0      .0      .0      .0      .0
1



 CROSS-SECTION NUMBER  5
************************

 XS(I) =     12.000   FSTG(I) =     .00


 HS  ...    358.3   362.0   364.4   393.8   403.3   800.0
 BS  ...       .0    23.5    45.1   113.8   135.2   450.0
 BSS ...       .0      .0      .0      .0      .0      .0



 CROSS-SECTION NUMBER  6
************************

 XS(I) =     15.000   FSTG(I) =     .00


 HS  ...    261.0   261.5   262.6   288.4   295.1   700.0
 BS  ...       .0    13.1    27.4   131.7   154.4   450.0
 BSS ...       .0      .0      .0      .0      .0      .0
```

```
 CROSS-SECTION NUMBER  7
*************************

 XS(I) =    20.000   FSTG(I) =     .00


 HS  ...    159.6   161.9   164.1   192.5   192.8   600.0
 BS  ...       .0    27.1    37.9    91.8    92.4   450.0
 BSS ...       .0      .0      .0      .0      .0      .0
1



 MANNING N ROUGHNESS COEFFICIENTS FOR THE GIVEN REACHES
        (CM(K,I),K=1,NCS) WHERE I = REACH NUMBER
********************************************************

 REACH  1 ...  .050   .050   .050   .050   .050   .050

 REACH  2 ...  .050   .050   .050   .050   .050   .050

 REACH  3 ...  .050   .050   .050   .050   .050   .050

 REACH  4 ...  .050   .050   .050   .050   .050   .050

 REACH  5 ...  .050   .050   .050   .050   .050   .050

 REACH  6 ...  .050   .050   .050   .050   .050   .050



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     CROSS-SECTIONAL VARIABLES FOR   UMNGOT RIVER (MEGH
                BELOW UMNGOT DAM

 PARAMETER                                    UNITS  VARIABLE
******************************************  *******  ******

 MINIMUM COMPUTATIONAL DISTANCE USED          KM      DXM(I)
      BETWEEN CROSS-SECTIONS

 CONTRACTION - EXPANSION COEFFICIENTS                 FKC(I)
      BETWEEN CROSS-SECTIONS


            REACH NUMBER        DXM(I)    FKC(I)
           **************      ********  ********

                  1               .200      .200

                  2               .400      .100

                  3               .100      .100

                  4               .250     -.500

                  5               .100     -.500

                  6               .250      .300

1
```

DOWNSTREAM FLOW PARAMETERS FOR UMNGOT RIVER (MEGH
BELOW UMNGOT DAM

PARAMETER	UNITS	VARIABLE	VALUE
MAX DISCHARGE AT DOWNSTREAM EXTREMITY	CMS	QMAXD	.0
MAX LATERAL OUTFLOW PRODUCING LOSSES	CMS /M	QLL	.000
INITIAL SIZE OF TIME STEP	HOUR	DTHM	.0000
DOWNSTREAM BOUNDARY PARAMETER	M	YDN	.000000
SLOPE OF CHANNEL DOWNSTREAM OF DAM	%	SOM	7.40
THETA WEIGHTING FACTOR		THETA	.00
CONVERGENCE CRITERION FOR STAGE	M	EPSY	.000000
TIME AT WHICH DAM STARTS TO FAIL	HOUR	TFI	.00

COMPUTATIONS WILL USE THE FOLLOWING DXM VALUES

.200 .400 .100 .250 .100 .250

TOTAL NUMBER OF CROSS SECTIONS (ORIGINAL+INTERPOLATED) (N) = 115 (MAXIMUM ALLOWABLE = 200

1

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***                          ***
***  SUMMARY OF OUTPUT DATA  ***
***                          ***
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1

CROSS-SECTION NO.	KM	BOTTOM ELEVATION M	REACH NO.	REACH LENGTH KM	SLOPE %	MESAGE
1	.00	935.26				
2	3.00	713.41	1	3.00	7.40	
3	6.00	559.17	2	3.00	5.14	
4	9.00	454.58	3	3.00	3.49	
5	12.00	358.27	4	3.00	3.21	
6	15.00	261.02	5	3.00	3.24	
7	20.00	159.61	6	5.00	2.03	

TOTAL VOLUME IN RESERVOIR BEHIND
UMNGOT DAM = 79.2 CU. M (MILLION)

DEFINITION OF VARIABLES IN RESERVOIR DEPLETION TABLE

PARAMETER	UNITS	VARIABLE
**	*******	******
TIME STEP FROM START OF ANALYSIS		I
ITERATIONS NECESSARY TO SOLVE FLOW EQUATIONS		K
ELAPSED TIME FROM START OF ANALYSIS	HOUR	TTP(I)
TOTAL OUTFLOW FROM DAM	CMS	Q(I)
ELEVATION OF WATER SURFACE AT DAM	M	H2
ELEVATION OF BOTTOM OF BREACH	M	YB
EST DEPTH OF FLOW IMMEDIATELY DOWNSTREAM	M	D
SUBMERGENCE COEFFICIENT		SUB
VELOCITY CORRECTION		VCOR
TOTAL VOLUME DISCHARGED FROM TIME OF BREACH	MILLION CU M	OUTVOL
BREACH WIDTH	M	BB
RECTANGULAR BREACH DISCHARGE COEFFICIENT		COFR
INFLOW TO RESERVOIR	CMS	QI(I)
BREACH OUTFLOW	CMS	QBRECH
SPILLWAY OUTFLOW	CMS	QSPIL

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	*****	*******	*******	******	*****	****	****	*********	****	****	*****	******	*****
01	0	.000	39913	1042.00	1042.00	961.32	1.00	1.00	.0	.0	3.10	9761.	0.	39913.
02	2	.002	39850	1041.91	1039.87	961.28	1.00	1.15	.3	.0	3.10	9759.	13.	39837.
03	2	.004	39859	1041.83	1037.73	961.29	1.00	1.08	.6	.0	3.10	9758.	88.	39771.
04	1	.006	39932	1041.75	1035.60	961.31	1.00	1.05	.9	.0	3.10	9757.	228.	39704.
05	1	.008	40095	1041.67	1033.46	961.35	1.00	1.04	1.1	.0	3.10	9755.	458.	39637.
06	1	.010	40361	1041.59	1031.33	961.43	1.00	1.03	1.4	.0	3.10	9754.	791.	39570.
07	1	.012	40741	1041.51	1029.19	961.54	1.00	1.03	1.7	.0	3.10	9753.	1240.	39502.
08	1	.014	41246	1041.42	1027.06	961.68	1.00	1.02	2.0	.0	3.10	9752.	1814.	39432.
09	1	.016	41886	1041.34	1024.92	961.85	1.00	1.02	2.3	.0	3.10	9750.	2525.	39361.
10	1	.018	42668	1041.25	1022.79	962.07	1.00	1.02	2.6	.0	3.10	9749.	3380.	39289.
11	1	.020	43602	1041.16	1020.65	962.32	1.00	1.02	2.9	.0	3.10	9748.	4388.	39214.
12	1	.022	44694	1041.07	1018.52	962.61	1.00	1.02	3.3	.0	3.10	9746.	5557.	39137.
13	2	.024	45951	1040.97	1016.38	962.94	1.00	1.02	3.6	.0	3.10	9745.	6895.	39057.
14	2	.026	47380	1040.87	1014.25	963.31	1.00	1.02	3.9	.0	3.10	9744.	8407.	38973.
15	2	.028	48986	1040.77	1012.11	963.72	1.00	1.02	4.3	.0	3.10	9742.	10100.	38886.
16	2	.030	50775	1040.66	1009.98	964.16	1.00	1.02	4.6	.0	3.10	9741.	11980.	38795.
17	2	.032	52751	1040.55	1007.84	964.64	1.00	1.02	5.0	.0	3.10	9740.	14052.	38699.
18	2	.034	54920	1040.42	1005.71	965.15	1.00	1.02	5.4	.0	3.10	9739.	16322.	38599.
19	2	.036	57285	1040.30	1003.57	965.70	1.00	1.02	5.8	.0	3.10	9737.	18793.	38492.
20	2	.038	59850	1040.16	1001.44	966.27	1.00	1.02	6.2	.0	3.10	9736.	21470.	38380.
21	2	.040	62618	1040.02	999.30	966.88	1.00	1.02	6.7	.0	3.10	9735.	24357.	38261.
22	2	.042	65592	1039.87	997.17	967.51	1.00	1.02	7.1	.0	3.10	9733.	27458.	38135.
23	2	.044	68776	1039.71	995.03	968.17	1.00	1.02	7.6	.0	3.10	9732.	30776.	38001.
24	2	.046	72171	1039.54	992.90	968.85	1.00	1.02	8.1	.0	3.10	9731.	34313.	37858.
25	2	.048	75779	1039.35	990.76	969.55	1.00	1.03	8.6	.0	3.10	9729.	38073.	37707.
26	2	.050	79602	1039.16	988.63	970.27	1.00	1.03	9.2	.0	3.10	9728.	42057.	37546.
27	2	.052	83643	1038.96	986.50	971.01	1.00	1.03	9.8	.0	3.10	9727.	46269.	37374.
28	2	.054	87901	1038.74	984.36	971.77	1.00	1.03	10.4	.0	3.10	9726.	50710.	37192.
29	2	.056	92379	1038.51	982.23	972.54	1.00	1.03	11.1	.0	3.10	9724.	55382.	36998.
30	2	.058	97077	1038.26	980.09	973.33	1.00	1.04	11.7	.0	3.10	9723.	60287.	36791.
31	2	.060	101997	1037.99	977.96	974.12	1.00	1.04	12.5	.0	3.10	9722.	65427.	36571.
32	2	.062	107138	1037.71	975.82	974.93	1.00	1.04	13.2	.0	3.10	9720.	70802.	36336.
33	2	.064	112502	1037.41	973.69	975.75	1.00	1.04	14.0	.0	3.10	9719.	76416.	36086.

34	2	.066	117832	1037.09	971.55	976.54	1.00	1.04	14.8	.0	3.10	9718.	82012.	35820.

RESERVOIR DEPLETION TABLE

I	K	TTP(I)	Q(I)	H2	YB	D	SUB	VCOR	OUTVOL	BB	COFR	QI(I)	QBRECH	QSPIL
***	**	*****	*******	*******	******	*****	****	****	*********	****	****	*****	******	*****
35	2	.068	123183	1036.76	969.42	977.31	1.00	1.04	15.7	.0	3.10	9716.	87646.	35538.
36	2	.070	128675	1036.40	967.28	978.08	1.00	1.04	16.6	.0	3.10	9715.	93437.	35239.
37	2	.072	134297	1036.02	965.15	978.85	1.00	1.04	17.5	.0	3.10	9714.	99376.	34921.
38	2	.074	140039	1035.61	963.01	979.62	1.00	1.04	18.5	.0	3.10	9713.	105455.	34585.
39	2	.076	145889	1035.18	960.88	980.37	1.00	1.04	19.6	.0	3.10	9711.	111662.	34228.
40	2	.078	151833	1034.73	958.74	981.13	1.00	1.04	20.6	.0	3.10	9710.	117984.	33849.
41	2	.080	157857	1034.25	956.61	981.87	1.00	1.04	21.7	.0	3.10	9709.	124409.	33448.
42	2	.082	163945	1033.74	954.47	982.60	1.00	1.04	22.9	.0	3.10	9707.	130923.	33023.
43	2	.084	170079	1033.20	952.34	983.33	1.00	1.03	24.1	.0	3.10	9706.	137507.	32572.
44	2	.086	176240	1032.63	950.20	984.04	1.00	1.03	25.4	.0	3.10	9705.	144146.	32094.
45	2	.088	182406	1032.02	948.07	984.73	1.00	1.03	26.6	.0	3.10	9703.	150819.	31587.
46	2	.090	188552	1031.37	945.93	985.41	1.00	1.03	28.0	.0	3.10	9702.	157504.	31049.
47	2	.092	194653	1030.69	943.80	986.05	1.00	1.03	29.4	.0	3.10	9701.	164177.	30477.
48	2	.094	200679	1029.96	941.66	986.66	1.00	1.03	30.8	.0	3.10	9700.	170810.	29869.
49	2	.096	206623	1029.19	939.53	987.25	1.00	1.03	32.3	.0	3.10	9698.	177397.	29227.
50	2	.098	212482	1028.38	937.39	987.91	1.00	1.03	33.8	.0	3.10	9697.	183932.	28550.

KTIME= 447 ALLOWABLE KTIME= 699 TT= 19.0

PROFILE OF CRESTS AND TIMES FOR UMNGOT RIVER (MEGH
BELOW UMNGOT DAM

DISTANCE FROM DAM KM	MAX ELEV M	MAX FLOW CMS	TIME MAX ELEV-HRS	MAX VEL M/S	FLOOD ELEV M	TIME FLOOD ELEV-HRS
********	********	********	********	********	**********	**********
.000	989.06	218231	.110	52.86	.00	.00
.200	972.40	215678	.100	52.74	.00	.00
.400	956.97	213337	.100	52.55	.00	.00
.600	941.87	212829	.105	52.30	.00	.00
.800	926.72	213234	.105	52.09	.00	.00
1.000	911.51	213078	.105	51.97	.00	.00
1.200	896.25	212443	.105	51.81	.00	.00
1.400	880.95	211416	.105	51.62	.00	.00
1.600	865.62	210086	.105	51.41	.00	.00
1.800	850.29	208519	.110	51.17	.00	.00
2.000	835.11	208127	.110	50.91	.00	.00
2.200	819.90	208454	.110	50.71	.00	.00
2.399	804.64	208381	.110	50.60	.00	.00
2.599	789.34	207958	.110	50.47	.00	.00
2.799	774.01	207229	.110	50.31	.00	.00
2.999	758.65	206237	.110	50.12	.00	.00
3.428	737.70	205629	.115	48.09	.00	.00
3.856	716.46	205666	.115	46.85	.00	.00
4.285	694.89	204441	.115	45.94	.00	.00
4.713	673.23	204184	.120	45.43	.00	.00
5.142	651.46	204298	.120	45.20	.00	.00
5.570	629.43	203056	.120	45.04	.00	.00
5.999	607.46	203228	.125	45.11	.00	.00
6.099	604.34	203295	.125	44.78	.00	.00
6.199	601.20	203287	.125	44.47	.00	.00
6.299	598.04	203206	.125	44.18	.00	.00
6.399	594.86	203052	.125	43.90	.00	.00
6.499	591.67	202827	.125	43.64	.00	.00
6.599	588.45	202531	.125	43.40	.00	.00
6.699	585.22	202165	.125	43.16	.00	.00
6.799	581.97	201728	.125	42.94	.00	.00
6.899	578.78	201623	.130	42.73	.00	.00
6.998	575.58	201859	.130	42.59	.00	.00
7.098	572.37	202027	.130	42.46	.00	.00
7.198	569.15	202125	.130	42.33	.00	.00
7.298	565.91	202153	.130	42.22	.00	.00
7.398	562.66	202109	.130	42.11	.00	.00
7.498	559.40	201993	.130	42.00	.00	.00
7.598	556.11	201803	.130	41.90	.00	.00
7.698	552.82	201538	.130	41.81	.00	.00
7.798	549.51	201198	.130	41.72	.00	.00
7.898	546.18	200782	.130	41.63	.00	.00
7.998	542.91	200476	.135	41.55	.00	.00
8.098	539.66	200704	.135	41.48	.00	.00
8.198	536.39	200862	.135	41.45	.00	.00
8.298	533.10	200946	.135	41.43	.00	.00
8.398	529.81	200955	.135	41.41	.00	.00
8.498	526.50	200886	.135	41.39	.00	.00
8.598	523.18	200739	.135	41.38	.00	.00
8.698	519.84	200513	.135	41.36	.00	.00
8.798	516.49	200207	.135	41.35	.00	.00
8.898	513.12	199821	.135	41.33	.00	.00
8.998	509.81	199354	.140	41.32	.00	.00
9.248	501.64	199549	.140	41.23	.00	.00
9.498	493.66	199899	.140	41.03	.00	.00
9.748	485.75	199927	.140	40.73	.00	.00

DISTANCE FROM DAM KM ********	MAX ELEV M ********	MAX FLOW CMS ********	TIME MAX ELEV-HRS ********	MAX VEL M/S ********	FLOOD ELEV M **********	TIME FLOOD ELEV-HRS **********
9.998	477.82	199555	.140	40.53	.00	.00
10.248	469.83	199945	.140	40.28	.00	.00
10.498	461.95	200645	.145	40.03	.00	.00
10.748	454.05	200845	.145	39.83	.00	.00
10.998	446.07	200508	.145	39.68	.00	.00
11.248	438.03	200838	.145	39.52	.00	.00
11.498	430.14	201513	.150	39.33	.00	.00
11.747	422.26	201709	.150	39.15	.00	.00
11.997	414.32	201379	.150	39.01	.00	.00
12.097	410.68	201104	.150	39.14	.00	.00
12.197	407.05	201539	.150	39.23	.00	.00
12.297	403.46	201898	.155	39.29	.00	.00
12.397	399.96	202179	.155	39.32	.00	.00
12.497	396.47	202376	.155	39.34	.00	.00
12.597	392.98	202486	.155	39.33	.00	.00
12.697	389.49	202511	.155	39.30	.00	.00
12.797	386.00	202453	.155	39.30	.00	.00
12.897	382.51	202315	.155	39.28	.00	.00
12.997	379.03	202101	.155	39.26	.00	.00
13.097	375.55	201917	.155	39.22	.00	.00
13.197	372.06	202354	.155	39.16	.00	.00
13.297	368.57	202727	.155	39.10	.00	.00
13.397	365.16	203033	.160	39.02	.00	.00
13.497	361.74	203271	.160	38.94	.00	.00
13.597	358.32	203440	.160	38.85	.00	.00
13.697	354.90	203536	.160	38.80	.00	.00
13.797	351.46	203559	.160	38.75	.00	.00
13.897	348.02	203506	.160	38.69	.00	.00
13.997	344.57	203375	.160	38.63	.00	.00
14.097	341.11	203163	.160	38.57	.00	.00
14.197	337.64	203583	.160	38.50	.00	.00
14.297	334.16	204023	.160	38.42	.00	.00
14.397	330.68	204398	.165	38.34	.00	.00
14.497	327.27	204706	.165	38.26	.00	.00
14.597	323.85	204944	.165	38.19	.00	.00
14.697	320.42	205110	.165	38.15	.00	.00
14.797	316.99	205201	.165	38.10	.00	.00
14.897	313.55	205213	.165	38.05	.00	.00
14.997	310.09	205143	.165	37.99	.00	.00
15.247	306.48	205409	.165	37.03	.00	.00
15.497	302.90	206234	.170	36.23	.00	.00
15.747	299.22	206291	.170	35.56	.00	.00
15.997	295.26	205305	.175	35.03	.00	.00
16.246	291.48	205371	.175	34.63	.00	.00
16.496	287.39	204927	.175	34.33	.00	.00
16.746	283.28	203366	.180	34.14	.00	.00
16.996	279.09	202263	.180	34.06	.00	.00
17.246	274.71	201336	.185	33.99	.00	.00
17.496	270.44	199639	.185	33.92	.00	.00
17.746	266.00	197731	.185	33.84	.00	.00
17.996	261.57	196773	.190	33.90	.00	.00
18.246	257.16	195235	.190	33.96	.00	.00
18.496	252.64	193081	.190	34.01	.00	.00
18.746	248.20	191877	.195	34.04	.00	.00
18.996	243.73	190406	.195	34.13	.00	.00
19.246	239.18	188360	.200	34.28	.00	.00
19.496	234.76	186763	.200	34.41	.00	.00
19.746	230.25	185293	.200	34.49	.00	.00
19.996	225.77	183322	.205	34.58	.00	.00

INDIA

MEGHALAYA

EAST KHASI HILLS AND JAINTIA HILLS DISTRICTS

UMNGOT HYDRO-ELECTRIC PROJECT

(3 X 80 MW)

APPENDIX - 2

HOUSEHOLD WISE RESETTLEMENT AND ECONOMIC REHABILITATION PACKAGE

Household wise Resettlement and Economic Rehabilitation Package

SL No	District	Village	Name of Head of Household	Caste	SL No	Extent of Total Land Cultivated, ha	Farmer Class Before Acquisition, ha	Extent of Land Submergence, ha	Land Compensation, Rs lakhs	Rehabilitation grant, Rs	Occupation grant, Rs	Land Left with,ha	Farmer Class After Acquisition	One time financial assistance, Rs	ST Grant, Rs
1	EAST KHASI HILLS	KSANRNGI	SMTI. SHITAMON NONGBRI	ST	1	0.50	1-Marginal	0.18	0.90	75,000	30,000	0.32	1-Marginal	50,000	50,000
2	EAST KHASI HILLS	KSANRNGI	SHRI.MAIT WAR	ST	2	0.70	1-Marginal	0.26	1.30	75,000	30,000	0.44	1-Marginal	50,000	50,000
3	EAST KHASI HILLS	KSANRNGI	SHRI.JWENG NONGRUM	ST	3	0.90	1-Marginal	0.30	1.50	75,000	30,000	0.60	1-Marginal	50,000	50,000
4	EAST KHASI HILLS	KSANRNGI	SMT.TRIA NONGBRI	ST	4	0.80	1-Marginal	0.25	1.25	75,000	30,000	0.55	1-Marginal	50,000	50,000
5	EAST KHASI HILLS	KSANRNGI	SHRI.POREN LYNSHIANG	ST	5	0.80	1-Marginal	0.40	2.00	75,000	30,000	0.40	1-Marginal	50,000	50,000
6	EAST KHASI HILLS	KSANRNGI	SHRI.DENGTON NONGRUM	ST	6	0.80	1-Marginal	0.23	1.15	75,000	30,000	0.57	1-Marginal	50,000	50,000
7	EAST KHASI HILLS	KSANRNGI	SMTI.LO WAR	ST	7	0.80	1-Marginal	0.19	0.95	75,000	30,000	0.61	1-Marginal	50,000	50,000
8	EAST KHASI HILLS	KSANRNGI	SMTI.KSHOIT WAR	ST	8	0.80	1-Marginal	0.24	1.20	75,000	30,000	0.56	1-Marginal	50,000	50,000
9	EAST KHASI HILLS	KSANRNGI	SHRI.SHUTOM NONGRUM	ST	9	0.60	1-Marginal	0.20	1.00	75,000	30,000	0.40	1-Marginal	50,000	50,000
10	EAST KHASI HILLS	KSANRNGI	SMTI.THWAIN WAR	ST	10	0.70	1-Marginal	0.23	1.15	75,000	30,000	0.47	1-Marginal	50,000	50,000
11	EAST KHASI HILLS	KSANRNGI	SMTI.THRIA LYNSHIANG	ST	11	0.70	1-Marginal	0.22	1.10	75,000	30,000	0.48	1-Marginal	50,000	50,000
12	EAST KHASI HILLS	KSANRNGI	SMTI.KHEN NONGBRI	ST	12	0.70	1-Marginal	0.20	1.00	75,000	30,000	0.50	1-Marginal	50,000	50,000
13	EAST KHASI HILLS	KSANRNGI	SMTI.BUD NONGRUM	ST	13	0.60	1-Marginal	0.19	0.95	75,000	30,000	0.41	1-Marginal	50,000	50,000
14	EAST KHASI HILLS	KSANRNGI	SMTI.DIAPLIN NONGBRI	ST	14	0.70	1-Marginal	0.21	1.05	75,000	30,000	0.49	1-Marginal	50,000	50,000
15	EAST KHASI HILLS	KSANRNGI	SHRI.HEROD WARLARPIH	ST	15	0.60	1-Marginal	0.30	1.50	75,000	30,000	0.30	1-Marginal	50,000	50,000
16	EAST KHASI HILLS	KSANRNGI	SHRI.WELSON NONGBRI	ST	16	0.60	1-Marginal	0.24	1.20	75,000	30,000	0.36	1-Marginal	50,000	50,000
17	EAST KHASI HILLS	KSANRNGI	SHRI.KLEIN LYNSHIANG	ST	17	0.70	1-Marginal	0.30	1.50	75,000	30,000	0.40	1-Marginal	50,000	50,000
18	EAST KHASI HILLS	KSANRNGI	SHRI.STAN SOHTUN	ST	18	0.80	1-Marginal	0.30	1.50	75,000	30,000	0.50	1-Marginal	50,000	50,000
19	EAST KHASI HILLS	KSANRNGI	SHRI.EM WAR	ST	19	0.80	1-Marginal	0.25	1.25	75,000	30,000	0.55	1-Marginal	50,000	50,000
20	EAST KHASI HILLS	KSANRNGI	SHRI.RAIDMAR DKHAR	ST	20	0.80	1-Marginal	0.15	0.75	75,000	30,000	0.65	1-Marginal	50,000	50,000
21	EAST KHASI HILLS	KSANRNGI	SHRI LET MARBOH	ST	21	0.70	1-Marginal	0.20	1.00	75,000	30,000	0.50	1-Marginal	50,000	50,000
22	EAST KHASI HILLS	KSANRNGI	SHRI.KESLOVELY KHARNAIOR	ST	22	0.60	1-Marginal	0.18	0.90	75,000	30,000	0.42	1-Marginal	50,000	50,000
23	EAST KHASI HILLS	KSANRNGI	SHRI.SBIN NONGBRI	ST	23	0.70	1-Marginal	0.40	2.00	75,000	30,000	0.30	1-Marginal	50,000	50,000
24	EAST KHASI HILLS	KSANRNGI	SHRI.LIEH WAR	ST	24	0.40	1-Marginal	0.20	1.00	75,000	30,000	0.20	0-Landless	75,000	50,000
25	EAST KHASI HILLS	KSANRNGI	SHRI.THRIAT LYNSHIANG	ST	25	0.70	1-Marginal	0.20	1.00	75,000	30,000	0.50	1-Marginal	50,000	50,000
26	EAST KHASI HILLS	KSANRNGI	SHRI.THRET MUKHIM	ST	26	0.70	1-Marginal	0.30	1.50	75,000	30,000	0.40	1-Marginal	50,000	50,000
27	EAST KHASI HILLS	KSANRNGI	SMTI.NGIAP MUKHIM	ST	27	0.70	1-Marginal	0.40	2.00	75,000	30,000	0.30	1-Marginal	50,000	50,000
28	EAST KHASI HILLS	KSANRNGI	SMTI.IIAP LYNSHIANG	ST	28	0.70	1-Marginal	0.30	1.50	75,000	30,000	0.40	1-Marginal	50,000	50,000
29	EAST KHASI HILLS	KSANRNGI	SHRI.BRING NONGRUM	ST	29	0.70	1-Marginal	0.20	1.00	75,000	30,000	0.50	1-Marginal	50,000	50,000
30	EAST KHASI HILLS	KSANRNGI	SMTI.PHOK NONGRUM	ST	30	0.60	1-Marginal	0.18	0.90	75,000	30,000	0.42	1-Marginal	50,000	50,000
		KSANRNGI Total			**30**	**20.90**		**7.40**	**37.00**	**2,250,000**	**900,000**	**13.50**		**1,525,000**	**1,500,000**

Household wise Resettlement and Economic Rehabilitation Package

SL No	District	Village	Name of Head of Household	Caste	SL No	Extent of Total Land Cultivated, ha	Farmer Class Before Acquisition, ha	Extent of Land Submergence, ha	Land Compensation, Rs lakhs	Rehabilitation grant, Rs	Occupation grant, Rs	Land Left with,ha	Farmer Class After Acquisition	One time financial assistance, Rs	ST Grant, Rs
31	EAST KHASI HILLS	MAWDULOP	SMTI.KSHIAR MUKHIM	ST	31	0.40	1-Marginal	0.25	1.25	75,000	30,000	0.15	0-Landless	75,000	50,000
32	EAST KHASI HILLS	MAWDULOP	SMTI.IAISHAHLANG MUKHIM	ST	32	0.50	1-Marginal	0.25	1.25	75,000	30,000	0.25	1-Marginal	50,000	50,000
33	EAST KHASI HILLS	MAWDULOP	SHRI.KYIUN NONGBRI	ST	33	0.30	1-Marginal	0.20	1.00	75,000	30,000	0.10	0-Landless	75,000	50,000
34	EAST KHASI HILLS	MAWDULOP	SHRI.THRING WAR	ST	34	0.40	1-Marginal	0.20	1.00	75,000	30,000	0.20	0-Landless	75,000	50,000
35	EAST KHASI HILLS	MAWDULOP	SHRI.HERMON SUTING	ST	35	0.50	1-Marginal	0.30	1.50	75,000	30,000	0.20	0-Landless	75,000	50,000
36	EAST KHASI HILLS	MAWDULOP	SHRI.LONSING MUKHIM	ST	36	0.60	1-Marginal	0.40	2.00	75,000	30,000	0.20	0-Landless	75,000	50,000
37	EAST KHASI HILLS	MAWDULOP	SHRI.SHAM MUKHIM	ST	37	0.50	1-Marginal	0.13	0.65	75,000	30,000	0.37	1-Marginal	50,000	50,000
38	EAST KHASI HILLS	MAWDULOP	SHRI.STIAR SUTING	ST	38	0.70	1-Marginal	0.12	0.60	75,000	30,000	0.58	1-Marginal	50,000	50,000
39	EAST KHASI HILLS	MAWDULOP	SMTI.THABA MUKHIM	ST	39	0.60	1-Marginal	0.13	0.65	75,000	30,000	0.47	1-Marginal	50,000	50,000
40	EAST KHASI HILLS	MAWDULOP	SHRI.STIAN LYNGSHIANG	ST	40	0.50	1-Marginal	0.12	0.60	75,000	30,000	0.38	1-Marginal	50,000	50,000
41	EAST KHASI HILLS	MAWDULOP	SHRI.IOHBOR SUTING	ST	41	0.50	1-Marginal	0.30	1.50	75,000	30,000	0.20	0-Landless	75,000	50,000
42	EAST KHASI HILLS	MAWDULOP	SHRI.ONLY WARLARPIH	ST	42	0.40	1-Marginal	0.12	0.60	75,000	30,000	0.28	1-Marginal	50,000	50,000
43	EAST KHASI HILLS	MAWDULOP	SHRI.NIAI SUMER	ST	43	0.40	1-Marginal	0.20	1.00	75,000	30,000	0.20	0-Landless	75,000	50,000
44	EAST KHASI HILLS	MAWDULOP	SHRI.JRIE MUKHIM	ST	44	0.50	1-Marginal	0.15	0.75	75,000	30,000	0.35	1-Marginal	50,000	50,000
45	EAST KHASI HILLS	MAWDULOP	SHRI.STIEN MUKHIM	ST	45	0.30	1-Marginal	0.12	0.60	75,000	30,000	0.18	0-Landless	75,000	50,000
46	EAST KHASI HILLS	MAWDULOP	SHRI.BET MUKHIM	ST	46	0.50	1-Marginal	0.30	1.50	75,000	30,000	0.20	0-Landless	75,000	50,000
		MAWDULOP Total			**16**	**7.60**		**3.29**	**16.45**	**1,200,000**	**480,000**	**4.31**		**1,025,000**	**800,000**
47	EAST KHASI HILLS	MAWJATAP	SABIN SUTING	ST	47	0.30	1-Marginal	0.12	0.60	75,000	30,000	0.18	0-Landless	75,000	50,000
48	EAST KHASI HILLS	MAWJATAP	KYRMAN SUTING	ST	48	0.20	1-Marginal	0.11	0.55	75,000	30,000	0.09	0-Landless	75,000	50,000
49	EAST KHASI HILLS	MAWJATAP	VANG SUTING	ST	49	0.40	1-Marginal	0.25	1.25	75,000	30,000	0.15	0-Landless	75,000	50,000
50	EAST KHASI HILLS	MAWJATAP	MARTI SHADAP	ST	50	0.40	1-Marginal	0.2	1.00	75,000	30,000	0.20	0-Landless	75,000	50,000
51	EAST KHASI HILLS	MAWJATAP	OREN SUTING	ST	51	0.50	1-Marginal	0.3	1.50	75,000	30,000	0.20	0-Landless	75,000	50,000
52	EAST KHASI HILLS	MAWJATAP	STIAD KHONGIONG	ST	52	0.60	1-Marginal	0.25	1.25	75,000	30,000	0.35	1-Marginal	50,000	50,000
		MAWJATAP Total			**6**	**2.40**		**1.23**	**6.15**	**450,000**	**180,000**	**1.17**		**425,000**	**300,000**
53	EAST KHASI HILLS	MAWLANG	SHRI DRISHON MUKHIM	ST	53	0.50	1-Marginal	0.25	1.25	75,000	30,000	0.25	1-Marginal	50,000	50,000
54	EAST KHASI HILLS	MAWLANG	SHRI PHLIM MUKHIM	ST	54	0.40	1-Marginal	0.20	1.00	75,000	30,000	0.20	0-Landless	75,000	50,000
55	EAST KHASI HILLS	MAWLANG	SHRI STOLY LYNSHIANG	ST	55	0.60	1-Marginal	0.30	1.50	75,000	30,000	0.30	1-Marginal	50,000	50,000
		MAWLANG Total			**3**	**1.50**		**0.75**	**3.75**	**225,000**	**90,000**	**0.75**		**175,000**	**150,000**

Household wise Resettlement and Economic Rehabilitation Package

SL No	District	Village	Name of Head of Household	Caste	SL No	Extent of Total Land Cultivated, ha	Farmer Class Before Acquisition, ha	Extent of Land Submergence , ha	Land Compensation, Rs lakhs	Rehabilitation grant, Rs	Occupation grant, Rs	Land Left with,ha	Farmer Class After Acquisition	One time financial assistance, Rs	ST Grant, Rs
56	EAST KHASI HILLS	MAWSIR	SMTI.LISIA LYTING	ST	56	0.20	1-Marginal	0.15	0.75	75,000	30,000	0.05	0-Landless	75,000	50,000
57	EAST KHASI HILLS	MAWSIR	SHRI.TOILY LYNSHIANG	ST	57	0.50	1-Marginal	0.15	0.75	75,000	30,000	0.35	1-Marginal	50,000	50,000
58	EAST KHASI HILLS	MAWSIR	SHRI.DIE MUKHIM	ST	58	0.40	1-Marginal	0.13	0.65	75,000	30,000	0.27	1-Marginal	50,000	50,000
59	EAST KHASI HILLS	MAWSIR	SHRI.POTSUTING	ST	59	0.80	1-Marginal	0.25	1.25	75,000	30,000	0.55	1-Marginal	50,000	50,000
60	EAST KHASI HILLS	MAWSIR	SHRI.JLIR NONGBRI	ST	60	0.30	1-Marginal	0.12	0.60	75,000	30,000	0.18	0-Landless	75,000	50,000
61	EAST KHASI HILLS	MAWSIR	SHRI.STIN LYNSHIANG	ST	61	0.40	1-Marginal	0.14	0.70	75,000	30,000	0.26	1-Marginal	50,000	50,000
62	EAST KHASI HILLS	MAWSIR	SHRI.MOON NONGBRI	ST	62	0.20	1-Marginal	0.07	0.35	75,000	30,000	0.13	0-Landless	75,000	50,000
63	EAST KHASI HILLS	MAWSIR	SHRI.KEL MUKHIM	ST	63	0.40	1-Marginal	0.12	0.60	75,000	30,000	0.28	1-Marginal	50,000	50,000
64	EAST KHASI HILLS	MAWSIR	SHRI.DRUN PYNGROPE	ST	64	0.50	1-Marginal	0.13	0.65	75,000	30,000	0.37	1-Marginal	50,000	50,000
65	EAST KHASI HILLS	MAWSIR	SHRI.BRIAK LYNSHIANG	ST	65	0.60	1-Marginal	0.22	1.10	75,000	30,000	0.38	1-Marginal	50,000	50,000
66	EAST KHASI HILLS	MAWSIR	SHRI.SYNDIAH LYTING	ST	66	0.30	1-Marginal	0.12	0.60	75,000	30,000	0.18	0-Landless	75,000	50,000
67	EAST KHASI HILLS	MAWSIR	SHRI.KHOIT SUTING	ST	67	0.20	1-Marginal	0.08	0.40	75,000	30,000	0.12	0-Landless	75,000	50,000
68	EAST KHASI HILLS	MAWSIR	SHRI.ALBAN KHARKONOR	ST	68	0.30	1-Marginal	0.15	0.75	75,000	30,000	0.15	0-Landless	75,000	50,000
69	EAST KHASI HILLS	MAWSIR	SHRI.DLEID MUKHIM	ST	69	0.50	1-Marginal	0.18	0.90	75,000	30,000	0.32	1-Marginal	50,000	50,000
70	EAST KHASI HILLS	MAWSIR	SHRI.WILING SUTING	ST	70	0.40	1-Marginal	0.12	0.60	75,000	30,000	0.28	1-Marginal	50,000	50,000
		MAWSIR Total			**15**	**6.00**		**2.13**	**10.65**	**1,125,000**	**450,000**	**3.87**		**900,000**	**750,000**
71	EAST KHASI HILLS	MYNSANG	SMTI.BLOSIBON MARBOH	ST	71	0.60	1-Marginal	0.16	0.80	75,000	30,000	0.44	1-Marginal	50,000	50,000
72	EAST KHASI HILLS	MYNSANG	SHRI.KOBRET MYRMEIN	ST	72	0.50	1-Marginal	0.15	0.75	75,000	30,000	0.35	1-Marginal	50,000	50,000
73	EAST KHASI HILLS	MYNSANG	SHRI.KRIN KHARBANGER	ST	73	0.60	1-Marginal	0.14	0.70	75,000	30,000	0.46	1-Marginal	50,000	50,000
74	EAST KHASI HILLS	MYNSANG	SMTI.RIENDA MARBOH	ST	74	0.50	1-Marginal	0.13	0.65	75,000	30,000	0.37	1-Marginal	50,000	50,000
75	EAST KHASI HILLS	MYNSANG	SHRI.DRIAN MARBOH	ST	75	0.20	1-Marginal	0.10	0.50	75,000	30,000	0.10	0-Landless	75,000	50,000
76	EAST KHASI HILLS	MYNSANG	SMTI.SILON NONGRUM	ST	76	0.70	1-Marginal	0.20	1.00	75,000	30,000	0.50	1-Marginal	50,000	50,000
77	EAST KHASI HILLS	MYNSANG	SMTI. KHIAR SUTING	ST	77	0.50	1-Marginal	0.18	0.90	75,000	30,000	0.32	1-Marginal	50,000	50,000
78	EAST KHASI HILLS	MYNSANG	SHRI.DHON SUTING	ST	78	0.60	1-Marginal	0.24	1.20	75,000	30,000	0.36	1-Marginal	50,000	50,000
79	EAST KHASI HILLS	MYNSANG	SHRI. PO MUKHIM	ST	79	0.50	1-Marginal	0.18	0.90	75,000	30,000	0.32	1-Marginal	50,000	50,000
80	EAST KHASI HILLS	MYNSANG	SHRI.KYIED K.KONGOR	ST	80	0.40	1-Marginal	0.18	0.90	75,000	30,000	0.22	1-Marginal	50,000	50,000
81	EAST KHASI HILLS	MYNSANG	SHRI.PHER K.KONGOR	ST	81	0.60	1-Marginal	0.20	1.00	75,000	30,000	0.40	1-Marginal	50,000	50,000
82	EAST KHASI HILLS	MYNSANG	SHRI.RIIA K.KONGOR	ST	82	0.50	1-Marginal	0.20	1.00	75,000	30,000	0.30	1-Marginal	50,000	50,000
83	EAST KHASI HILLS	MYNSANG	SHRI.PHRANSHON K.KONGOR	ST	83	0.20	1-Marginal	0.06	0.30	75,000	30,000	0.14	0-Landless	75,000	50,000
84	EAST KHASI HILLS	MYNSANG	SHRI.DIMAI SUTING	ST	84	0.10	1-Marginal	0.05	0.25	75,000	30,000	0.05	0-Landless	75,000	50,000
85	EAST KHASI HILLS	MYNSANG	SMTI.SMIR SUTING	ST	85	0.20	1-Marginal	0.09	0.45	75,000	30,000	0.11	0-Landless	75,000	50,000
86	EAST KHASI HILLS	MYNSANG	SMTI.PHYRNAI SUTING	ST	86	0.50	1-Marginal	0.25	1.25	75,000	30,000	0.25	1-Marginal	50,000	50,000
87	EAST KHASI HILLS	MYNSANG	SMTI.PLO MUKHIM	ST	87	0.70	1-Marginal	0.24	1.20	75,000	30,000	0.46	1-Marginal	50,000	50,000
88	EAST KHASI HILLS	MYNSANG	SMTI.RITI MARBOH	ST	88	0.70	1-Marginal	0.22	1.10	75,000	30,000	0.48	1-Marginal	50,000	50,000
		MYNSANG Total			**18**	**8.60**		**2.97**	**14.85**	**1,350,000**	**540,000**	**5.63**		**1,000,000**	**900,000**

Household wise Resettlement and Economic Rehabilitation Package

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89	EAST KHASI HILLS	PASHANG	SHRI.LINLIS LATING	ST	89	0.50	1-Marginal	0.16	0.80	75,000	30,000	0.34	1-Marginal	50,000	50,000
90	EAST KHASI HILLS	PASHANG	SMTI.IOLINA NONGRUM	ST	90	0.70	1-Marginal	0.25	1.25	75,000	30,000	0.45	1-Marginal	50,000	50,000
91	EAST KHASI HILLS	PASHANG	SHRI.KIN SUTING	ST	91	0.80	1-Marginal	0.24	1.20	75,000	30,000	0.56	1-Marginal	50,000	50,000
92	EAST KHASI HILLS	PASHANG	SHRI.KYRSHAN BINA	ST	92	0.90	1-Marginal	0.36	1.80	75,000	30,000	0.54	1-Marginal	50,000	50,000
93	EAST KHASI HILLS	PASHANG	SMTI. KRAMON NONGRUM	ST	93	0.70	1-Marginal	0.26	1.30	75,000	30,000	0.44	1-Marginal	50,000	50,000
94	EAST KHASI HILLS	PASHANG	SMTI.KMEN NONGRUM	ST	94	0.50	1-Marginal	0.15	0.75	75,000	30,000	0.35	1-Marginal	50,000	50,000
95	EAST KHASI HILLS	PASHANG	SMTI.BLI MYNSONG	ST	95	0.70	1-Marginal	0.18	0.90	75,000	30,000	0.52	1-Marginal	50,000	50,000
96	EAST KHASI HILLS	PASHANG	SHRI.SIREN NONGRUM	ST	96	0.70	1-Marginal	0.19	0.95	75,000	30,000	0.51	1-Marginal	50,000	50,000
97	EAST KHASI HILLS	PASHANG	SMTI.BIAKSILA NONGRUM	ST	97	0.30	1-Marginal	0.15	0.75	75,000	30,000	0.15	0-Landless	75,000	50,000
98	EAST KHASI HILLS	PASHANG	SHRI.PHLIMON LATING	ST	98	0.30	1-Marginal	0.12	0.60	75,000	30,000	0.18	0-Landless	75,000	50,000
99	EAST KHASI HILLS	PASHANG	SMTI.AIDA NONGRUM	ST	99	0.50	1-Marginal	0.14	0.70	75,000	30,000	0.36	1-Marginal	50,000	50,000
100	EAST KHASI HILLS	PASHANG	SMTI.JANAI MYNSONG	ST	100	0.40	1-Marginal	0.12	0.60	75,000	30,000	0.28	1-Marginal	50,000	50,000
101	EAST KHASI HILLS	PASHANG	SMTI.ROSI NONGRUM	ST	101	0.60	1-Marginal	0.15	0.75	75,000	30,000	0.45	1-Marginal	50,000	50,000
102	EAST KHASI HILLS	PASHANG	SMTI.DOLORIT NONGRUM	ST	102	0.70	1-Marginal	0.15	0.75	75,000	30,000	0.55	1-Marginal	50,000	50,000
103	EAST KHASI HILLS	PASHANG	SMTI.OLIN NONGRUM	ST	103	0.40	1-Marginal	0.12	0.60	75,000	30,000	0.28	1-Marginal	50,000	50,000
104	EAST KHASI HILLS	PASHANG	SHRI.DOMINIC NONGRUM	ST	104	0.70	1-Marginal	0.15	0.75	75,000	30,000	0.55	1-Marginal	50,000	50,000
105	EAST KHASI HILLS	PASHANG	SHRI IENG BINA	ST	105	0.80	1-Marginal	0.19	0.95	75,000	30,000	0.61	1-Marginal	50,000	50,000
106	EAST KHASI HILLS	PASHANG	SMTI.ROMILIN LATING	ST	106	0.70	1-Marginal	0.2	1.00	75,000	30,000	0.50	1-Marginal	50,000	50,000
107	EAST KHASI HILLS	PASHANG	SMTI.JNGIAR NONGRUM	ST	107	0.40	1-Marginal	0.15	0.75	75,000	30,000	0.25	1-Marginal	50,000	50,000
108	EAST KHASI HILLS	PASHANG	SMTI.ITA NONGRUM	ST	108	0.60	1-Marginal	0.14	0.70	75,000	30,000	0.46	1-Marginal	50,000	50,000
109	EAST KHASI HILLS	PASHANG	SMTI.SINO NONGRUM	ST	109	0.80	1-Marginal	0.26	1.30	75,000	30,000	0.54	1-Marginal	50,000	50,000
		PASHANG Total			**21**	**12.70**		**3.83**	**19.15**	**1,575,000**	**630,000**	**8.87**		**1,100,000**	**1,050,000**
110	EAST KHASI HILLS	SIANGKHNAI	SMT KWAT KHONGIONG	ST	110	0.40	1-Marginal	0.20	1.00	75,000	30,000	0.20	0-Landless	75,000	50,000
111	EAST KHASI HILLS	SIANGKHNAI	SHRI. TRE KHONGIONG	ST	111	0.30	1-Marginal	0.20	1.00	75,000	30,000	0.10	0-Landless	75,000	50,000
112	EAST KHASI HILLS	SIANGKHNAI	SMTI. TRI KHONGIONG	ST	112	0.30	1-Marginal	0.13	0.65	75,000	30,000	0.17	0-Landless	75,000	50,000
113	EAST KHASI HILLS	SIANGKHNAI	SMIT DREI KHONGIONG	ST	113	0.40	1-Marginal	0.20	1.00	75,000	30,000	0.20	0-Landless	75,000	50,000
114	EAST KHASI HILLS	SIANGKHNAI	SMIT.KWAN KHONGIONG	ST	114	0.40	1-Marginal	0.25	1.25	75,000	30,000	0.15	0-Landless	75,000	50,000
		SIANGKHNAI Total			**5**	**1.80**		**0.98**	**4.90**	**375,000**	**150,000**	**0.82**		**375,000**	**250,000**

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115	EAST KHASI HILLS	UMSAW-WAR	SMTI. SOPHINA SUTING	ST	115	0.80	1-Marginal	0.25	1.25	75,000	30,000	0.55	1-Marginal	50,000	50,000
116	EAST KHASI HILLS	UMSAW-WAR	SHRI SAMUEL SUTING	ST	116	0.70	1-Marginal	0.25	1.25	75,000	30,000	0.45	1-Marginal	50,000	50,000
117	EAST KHASI HILLS	UMSAW-WAR	SHRI PHIR NONRUM	ST	117	0.80	1-Marginal	0.3	1.50	75,000	30,000	0.50	1-Marginal	50,000	50,000
118	EAST KHASI HILLS	UMSAW-WAR	SMTI KSANTINA SUTING	ST	118	0.80	1-Marginal	0.27	1.35	75,000	30,000	0.53	1-Marginal	50,000	50,000
119	EAST KHASI HILLS	UMSAW-WAR	SMTI KHIE SUTING	ST	119	0.80	1-Marginal	0.3	1.50	75,000	30,000	0.50	1-Marginal	50,000	50,000
120	EAST KHASI HILLS	UMSAW-WAR	SMTI BHINDA NONGRUM	ST	120	0.60	1-Marginal	0.21	1.05	75,000	30,000	0.39	1-Marginal	50,000	50,000
121	EAST KHASI HILLS	UMSAW-WAR	SMTI BISLIN NONGRUM	ST	121	0.70	1-Marginal	0.25	1.25	75,000	30,000	0.45	1-Marginal	50,000	50,000
122	EAST KHASI HILLS	UMSAW-WAR	SMTI THIM SUTING	ST	122	0.70	1-Marginal	0.24	1.20	75,000	30,000	0.46	1-Marginal	50,000	50,000
123	EAST KHASI HILLS	UMSAW-WAR	SMTI BIHRIT NONGRUM	ST	123	0.60	1-Marginal	0.18	0.90	75,000	30,000	0.42	1-Marginal	50,000	50,000
124	EAST KHASI HILLS	UMSAW-WAR	SMTI.RIT NONGRUM	ST	124	0.70	1-Marginal	0.26	1.30	75,000	30,000	0.44	1-Marginal	50,000	50,000
125	EAST KHASI HILLS	UMSAW-WAR	SMTI.PITROLINA NONGRUM	ST	125	0.80	1-Marginal	0.3	1.50	75,000	30,000	0.50	1-Marginal	50,000	50,000
126	EAST KHASI HILLS	UMSAW-WAR	SMTI.REGINA NONGRUM	ST	126	0.70	1-Marginal	0.24	1.20	75,000	30,000	0.46	1-Marginal	50,000	50,000
127	EAST KHASI HILLS	UMSAW-WAR	SMTI.DROLIAN SUTING	ST	127	0.80	1-Marginal	0.26	1.30	75,000	30,000	0.54	1-Marginal	50,000	50,000
128	EAST KHASI HILLS	UMSAW-WAR	SMTI.KSHIAR SUTING	ST	128	0.70	1-Marginal	0.27	1.35	75,000	30,000	0.43	1-Marginal	50,000	50,000
129	EAST KHASI HILLS	UMSAW-WAR	SMTI.RONA NONGRUM	ST	129	0.80	1-Marginal	0.25	1.25	75,000	30,000	0.55	1-Marginal	50,000	50,000
130	EAST KHASI HILLS	UMSAW-WAR	SMTI.THERIN NONGRUM	ST	130	0.60	1-Marginal	0.22	1.10	75,000	30,000	0.38	1-Marginal	50,000	50,000
131	EAST KHASI HILLS	UMSAW-WAR	SMTI.ALIN NONGRUM	ST	131	0.70	1-Marginal	0.15	0.75	75,000	30,000	0.55	1-Marginal	50,000	50,000
132	EAST KHASI HILLS	UMSAW-WAR	SMTI.KWIRINA NONGRUM	ST	132	0.70	1-Marginal	0.17	0.85	75,000	30,000	0.53	1-Marginal	50,000	50,000
133	EAST KHASI HILLS	UMSAW-WAR	SMTI.RILIN SUTING	ST	133	0.80	1-Marginal	0.26	1.30	75,000	30,000	0.54	1-Marginal	50,000	50,000
134	EAST KHASI HILLS	UMSAW-WAR	SMTI.JNGIAR SUTING	ST	134	0.80	1-Marginal	0.22	1.10	75,000	30,000	0.58	1-Marginal	50,000	50,000
135	EAST KHASI HILLS	UMSAW-WAR	SMTI.ROPHINA NONGRUM	ST	135	0.70	1-Marginal	0.25	1.25	75,000	30,000	0.45	1-Marginal	50,000	50,000
136	EAST KHASI HILLS	UMSAW-WAR	SMTI.STIAN SUTING	ST	136	0.80	1-Marginal	0.23	1.15	75,000	30,000	0.57	1-Marginal	50,000	50,000
137	EAST KHASI HILLS	UMSAW-WAR	SMTI.THEH NONGRUM	ST	137	0.70	1-Marginal	0.26	1.30	75,000	30,000	0.44	1-Marginal	50,000	50,000
138	EAST KHASI HILLS	UMSAW-WAR	SMTI.SYUR SUTING	ST	138	0.60	1-Marginal	0.19	0.95	75,000	30,000	0.41	1-Marginal	50,000	50,000
139	EAST KHASI HILLS	UMSAW-WAR	SMTI.MOLIN SUTING	ST	139	0.70	1-Marginal	0.24	1.20	75,000	30,000	0.46	1-Marginal	50,000	50,000
		UMSAW-WAR Total			**25**	**18.10**		**6.02**	**30.10**	**1,875,000**	**750,000**	**12.08**		**1,250,000**	**1,250,000**

Household wise Resettlement and Economic Rehabilitation Package

6

SL No	District	Village	Name of Head of Household	Caste	SL No	Extent of Total Land Cultivated, ha	Farmer Class Before Acquisition, ha	Extent of Land Submergence, ha	Land Compensation, Rs lakhs	Rehabilitation grant, Rs	Occupation grant, Rs	Land Left with,ha	Farmer Class After Acquisition	One time financial assistance, Rs	ST Grant, Rs
140	JAINTIA HILLS	MASOKHIA	REAL SING MOSKAR	ST	140	0.91	1-Marginal	0.09	0.45	75,000	30,000	0.82	1-Marginal	50,000	50,000
141	JAINTIA HILLS	MASOKHIA	WOM KHYRIEM	ST	141	0.70	1-Marginal	0.30	1.50	75,000	30,000	0.40	1-Marginal	50,000	50,000
142	JAINTIA HILLS	MASOKHIA	INDIRA PAWA	ST	142	0.80	1-Marginal	0.20	1.00	75,000	30,000	0.60	1-Marginal	50,000	50,000
143	JAINTIA HILLS	MASOKHIA	TNGEN SHYRMANG	ST	143	0.80	1-Marginal	0.20	1.00	75,000	30,000	0.60	1-Marginal	50,000	50,000
144	JAINTIA HILLS	MASOKHIA	LORENT POHKSENG	ST	144	0.85	1-Marginal	0.25	1.25	75,000	30,000	0.60	1-Marginal	50,000	50,000
145	JAINTIA HILLS	MASOKHIA	PHUL PAWA	ST	145	0.80	1-Marginal	0.30	1.50	75,000	30,000	0.50	1-Marginal	50,000	50,000
146	JAINTIA HILLS	MASOKHIA	BRID PAWA	ST	146	0.80	1-Marginal	0.30	1.50	75,000	30,000	0.50	1-Marginal	50,000	50,000
147	JAINTIA HILLS	MASOKHIA	SARI SHYRMANG	ST	147	0.75	1-Marginal	0.40	2.00	75,000	30,000	0.35	1-Marginal	50,000	50,000
148	JAINTIA HILLS	MASOKHIA	SHYMA KASAR	ST	148	0.60	1-Marginal	0.30	1.50	75,000	30,000	0.30	1-Marginal	50,000	50,000
149	JAINTIA HILLS	MASOKHIA	SAROT SUTING	ST	149	0.70	1-Marginal	0.20	1.00	75,000	30,000	0.50	1-Marginal	50,000	50,000
150	JAINTIA HILLS	MASOKHIA	KROSWEL KHYRIEM	ST	150	0.70	1-Marginal	0.40	2.00	75,000	30,000	0.30	1-Marginal	50,000	50,000
151	JAINTIA HILLS	MASOKHIA	HIL PAWA	ST	151	0.90	1-Marginal	0.60	3.00	75,000	30,000	0.30	1-Marginal	50,000	50,000
152	JAINTIA HILLS	MASOKHIA	ANSWER KYNDIAH	ST	152	0.60	1-Marginal	0.40	2.00	75,000	30,000	0.20	0-Landless	75,000	50,000
153	JAINTIA HILLS	MASOKHIA	WEN SHYRMANG	ST	153	0.70	1-Marginal	0.30	1.50	75,000	30,000	0.40	1-Marginal	50,000	50,000
154	JAINTIA HILLS	MASOKHIA	SUK PAKSANG	ST	154	0.60	1-Marginal	0.40	2.00	75,000	30,000	0.20	0-Landless	75,000	50,000
155	JAINTIA HILLS	MASOKHIA	THAL PAWA	ST	155	0.52	1-Marginal	0.30	1.50	75,000	30,000	0.22	1-Marginal	50,000	50,000
156	JAINTIA HILLS	MASOKHIA	STIAD KHONGIONG	ST	156	0.65	1-Marginal	0.40	2.00	75,000	30,000	0.25	1-Marginal	50,000	50,000
157	JAINTIA HILLS	MASOKHIA	DIANG KHONGIONG	ST	157	0.78	1-Marginal	0.20	1.00	75,000	30,000	0.58	1-Marginal	50,000	50,000
158	JAINTIA HILLS	MASOKHIA	PHIL SHYRMANG	ST	158	0.78	1-Marginal	0.30	1.50	75,000	30,000	0.48	1-Marginal	50,000	50,000
159	JAINTIA HILLS	MASOKHIA	PHER POHSIEJ	ST	159	0.65	1-Marginal	0.35	1.75	75,000	30,000	0.30	1-Marginal	50,000	50,000
160	JAINTIA HILLS	MASOKHIA	MOT KYNDIAP	ST	160	0.70	1-Marginal	0.25	1.25	75,000	30,000	0.45	1-Marginal	50,000	50,000
161	JAINTIA HILLS	MASOKHIA	JAN KYNDAIT	ST	161	0.65	1-Marginal	0.35	1.75	75,000	30,000	0.30	1-Marginal	50,000	50,000
162	JAINTIA HILLS	MASOKHIA	WAN PDE	ST	162	0.65	1-Marginal	0.40	2.00	75,000	30,000	0.25	1-Marginal	50,000	50,000
163	JAINTIA HILLS	MASOKHIA	KUIT KYNDIAP	ST	163	0.78	1-Marginal	0.50	2.50	75,000	30,000	0.28	1-Marginal	50,000	50,000
164	JAINTIA HILLS	MASOKHIA	RISING PAWA	ST	164	0.70	1-Marginal	0.20	1.00	75,000	30,000	0.50	1-Marginal	50,000	50,000
165	JAINTIA HILLS	MASOKHIA	KAMAI SHYRMANG	ST	165	0.70	1-Marginal	0.30	1.50	75,000	30,000	0.40	1-Marginal	50,000	50,000
166	JAINTIA HILLS	MASOKHIA	STAN KHYRIEM	ST	166	0.70	1-Marginal	0.40	2.00	75,000	30,000	0.30	1-Marginal	50,000	50,000
167	JAINTIA HILLS	MASOKHIA	PHING KYNDIAP	ST	167	0.70	1-Marginal	0.15	0.75	75,000	30,000	0.55	1-Marginal	50,000	50,000
168	JAINTIA HILLS	MASOKHIA	BINI PHAWA	ST	168	0.65	1-Marginal	0.40	2.00	75,000	30,000	0.25	1-Marginal	50,000	50,000
		MASOKHIA Total			**29**	**20.82**		**9.14**	**45.70**	**2,175,000**	**870,000**	**11.68**		**1,500,000**	**1,450,000**

Household wise Resettlement and Economic Rehabilitation Package

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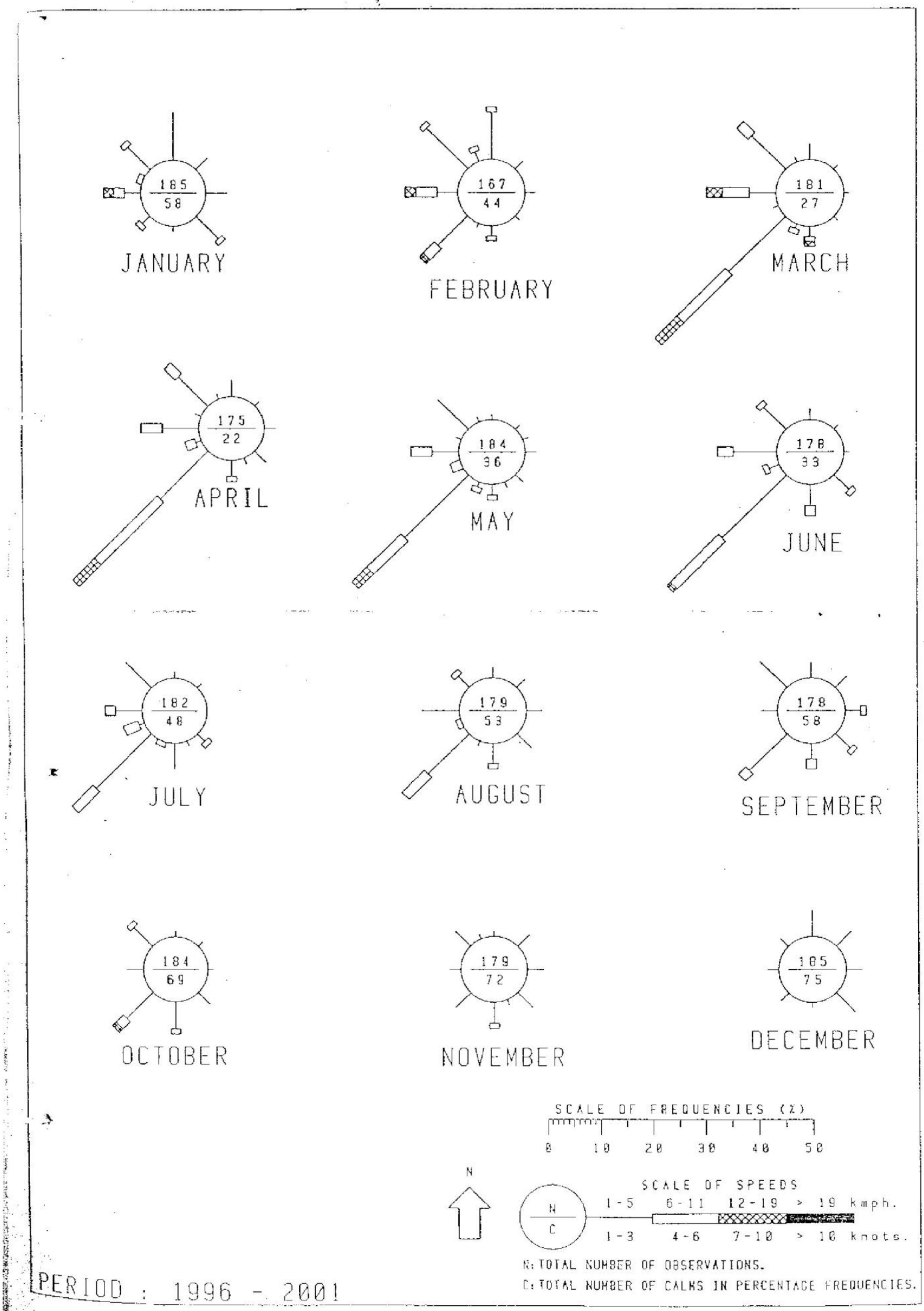
SL No	District	Village	Name of Head of Household	Caste	SL No	Extent of Total Land Cultivated, ha	Farmer Class Before Acquisition, ha	Extent of Land Submergence, ha	Land Compensation, Rs lakhs	Rehabilitation grant, Rs	Occupation grant, Rs	Land Left with,ha	Farmer Class After Acquisition	One time financial assistance, Rs	ST Grant, Rs
169	JAINTIA HILLS	SOHMANONG	SMT.ELBI BAREH	ST	169	0.80	1-Marginal	0.40	2.00	75,000	30,000	0.40	1-Marginal	50,000	50,000
170	JAINTIA HILLS	SOHMANONG	SMT.RIBHA SUTING	ST	170	0.26	1-Marginal	0.09	0.45	75,000	30,000	0.17	0-Landless	75,000	50,000
171	JAINTIA HILLS	SOHMANONG	LAMBOR BAREH	ST	171	0.78	1-Marginal	0.40	2.00	75,000	30,000	0.38	1-Marginal	50,000	50,000
172	JAINTIA HILLS	SOHMANONG	SMT.SYNTU POSHNA	ST	172	0.26	1-Marginal	0.09	0.45	75,000	30,000	0.17	0-Landless	75,000	50,000
173	JAINTIA HILLS	SOHMANONG	SMT.WANBHA BAREH	ST	173	0.39	1-Marginal	0.18	0.90	75,000	30,000	0.21	1-Marginal	50,000	50,000 228
174	JAINTIA HILLS	SOHMANONG	SMT.SIL SUTING	ST	174	0.65	1-Marginal	0.27	1.35	75,000	30,000	0.38	1-Marginal	50,000	50,000
175	JAINTIA HILLS	SOHMANONG	SMT.THAILDA BAREH	ST	175	0.80	1-Marginal	0.40	2.00	75,000	30,000	0.40	1-Marginal	50,000	50,000
176	JAINTIA HILLS	SOHMANONG	PHYRNAI BAREH	ST	176	0.44	1-Marginal	0.18	0.90	75,000	30,000	0.26	1-Marginal	50,000	50,000
177	JAINTIA HILLS	SOHMANONG	SMT.ROSE BAREH	ST	177	0.78	1-Marginal	0.40	2.00	75,000	30,000	0.38	1-Marginal	50,000	50,000
178	JAINTIA HILLS	SOHMANONG	SMT. RUM SUTING	ST	178	1.56	2-Small	0.74	3.70	75,000	30,000	0.82	1-Marginal	50,000	50,000
179	JAINTIA HILLS	SOHMANONG	SMT.KRIAL BAREH	ST	179	0.83	1-Marginal	0.40	2.00	75,000	30,000	0.43	1-Marginal	50,000	50,000
180	JAINTIA HILLS	SOHMANONG	SMT.LAID LYNSHING	ST	180	0.52	1-Marginal	0.23	1.13	75,000	30,000	0.30	1-Marginal	50,000	50,000
181	JAINTIA HILLS	SOHMANONG	SMT.MEBI BAREH	ST	181	0.65	1-Marginal	0.40	2.00	75,000	30,000	0.25	1-Marginal	50,000	50,000
182	JAINTIA HILLS	SOHMANONG	SMT.SERIT BAREH	ST	182	2.08	3-Medium	1.60	8.00	75,000	30,000	0.48	1-Marginal	50,000	50,000
183	JAINTIA HILLS	SOHMANONG	SHNGAIN BAREH	ST	183	0.52	1-Marginal	0.14	0.68	75,000	30,000	0.39	1-Marginal	50,000	50,000
184	JAINTIA HILLS	SOHMANONG	HADI MUKHIM	ST	184	0.78	1-Marginal	0.40	2.00	75,000	30,000	0.38	1-Marginal	50,000	50,000
185	JAINTIA HILLS	SOHMANONG	SMT.HEL BAREH	ST	185	0.78	1-Marginal	0.40	2.00	75,000	30,000	0.38	1-Marginal	50,000	50,000
186	JAINTIA HILLS	SOHMANONG	SMT.MARI LYNSHIANG	ST	186	0.65	1-Marginal	0.27	1.35	75,000	30,000	0.38	1-Marginal	50,000	50,000
187	JAINTIA HILLS	SOHMANONG	WOL BAREH	ST	187	0.84	1-Marginal	0.40	2.00	75,000	30,000	0.44	1-Marginal	50,000	50,000
188	JAINTIA HILLS	SOHMANONG	SMT.PHULBIANG BAREH	ST	188	0.39	1-Marginal	0.09	0.45	75,000	30,000	0.30	1-Marginal	50,000	50,000
189	JAINTIA HILLS	SOHMANONG	SMT.DIW LANGSHIANG	ST	189	0.39	1-Marginal	0.09	0.45	75,000	30,000	0.30	1-Marginal	50,000	50,000
190	JAINTIA HILLS	SOHMANONG	SMT.MEL BAREH	ST	190	0.29	1-Marginal	0.09	0.45	75,000	30,000	0.20	0-Landless	75,000	50,000
191	JAINTIA HILLS	SOHMANONG	SMT.RODA BAREH	ST	191	0.80	1-Marginal	0.40	2.00	75,000	30,000	0.40	1-Marginal	50,000	50,000
192	JAINTIA HILLS	SOHMANONG	TNGEN LYNSHIANG	ST	192	0.52	1-Marginal	0.18	0.90	75,000	30,000	0.34	1-Marginal	50,000	50,000
193	JAINTIA HILLS	SOHMANONG	TIPSNGI LYNSHIANG	ST	193	0.39	1-Marginal	0.18	0.90	75,000	30,000	0.21	1-Marginal	50,000	50,000
194	JAINTIA HILLS	SOHMANONG	SMT.SHIMTI BAREH	ST	194	0.52	1-Marginal	0.18	0.90	75,000	30,000	0.34	1-Marginal	50,000	50,000
195	JAINTIA HILLS	SOHMANONG	SAKLING MUKSOR	ST	195	0.83	1-Marginal	0.36	1.80	75,000	30,000	0.47	1-Marginal	50,000	50,000
196	JAINTIA HILLS	SOHMANONG	SMT.MERIS BAREH	ST	196	0.65	1-Marginal	0.18	0.90	75,000	30,000	0.47	1-Marginal	50,000	50,000
197	JAINTIA HILLS	SOHMANONG	LANG PYRTUH	ST	197	0.45	1-Marginal	0.18	0.90	75,000	30,000	0.27	1-Marginal	50,000	50,000
198	JAINTIA HILLS	SOHMANONG	SMT. SINA BAREH	ST	198	0.45	1-Marginal	0.18	0.90	75,000	30,000	0.27	1-Marginal	50,000	50,000
199	JAINTIA HILLS	SOHMANONG	SMT.ENIT BAREH	ST	199	1.37	2-Small	0.60	3.00	75,000	30,000	0.77	1-Marginal	50,000	50,000
200	JAINTIA HILLS	SOHMANONG	SMT RIT SUTING	ST	200	0.52	1-Marginal	0.18	0.90	75,000	30,000	0.34	1-Marginal	50,000	50,000
201	JAINTIA HILLS	SOHMANONG	MANGKARA BAREH	ST	201	0.80	1-Marginal	0.40	2.00	75,000	30,000	0.40	1-Marginal	50,000	50,000
202	JAINTIA HILLS	SOHMANONG	SMT.TRILI PAKSANG	ST	202	0.83	1-Marginal	0.40	2.00	75,000	30,000	0.43	1-Marginal	50,000	50,000
203	JAINTIA HILLS	SOHMANONG	RAJEN BAREH	ST	203	0.80	1-Marginal	0.40	2.00	75,000	30,000	0.40	1-Marginal	50,000	50,000
204	JAINTIA HILLS	SOHMANONG	SMT.MERILY PAKSANG	ST	204	0.39	1-Marginal	0.18	0.90	75,000	30,000	0.21	1-Marginal	50,000	50,000
205	JAINTIA HILLS	SOHMANONG	SMT DIAMMON BAREH	ST	205	0.78	1-Marginal	0.36	1.80	75,000	30,000	0.42	1-Marginal	50,000	50,000
		SOHMANONG Total			**37**	**25.54**		**12.01**	**60.05**	**2,775,000**	**1,110,000**	**13.53**		**1,925,000**	**1,850,000**

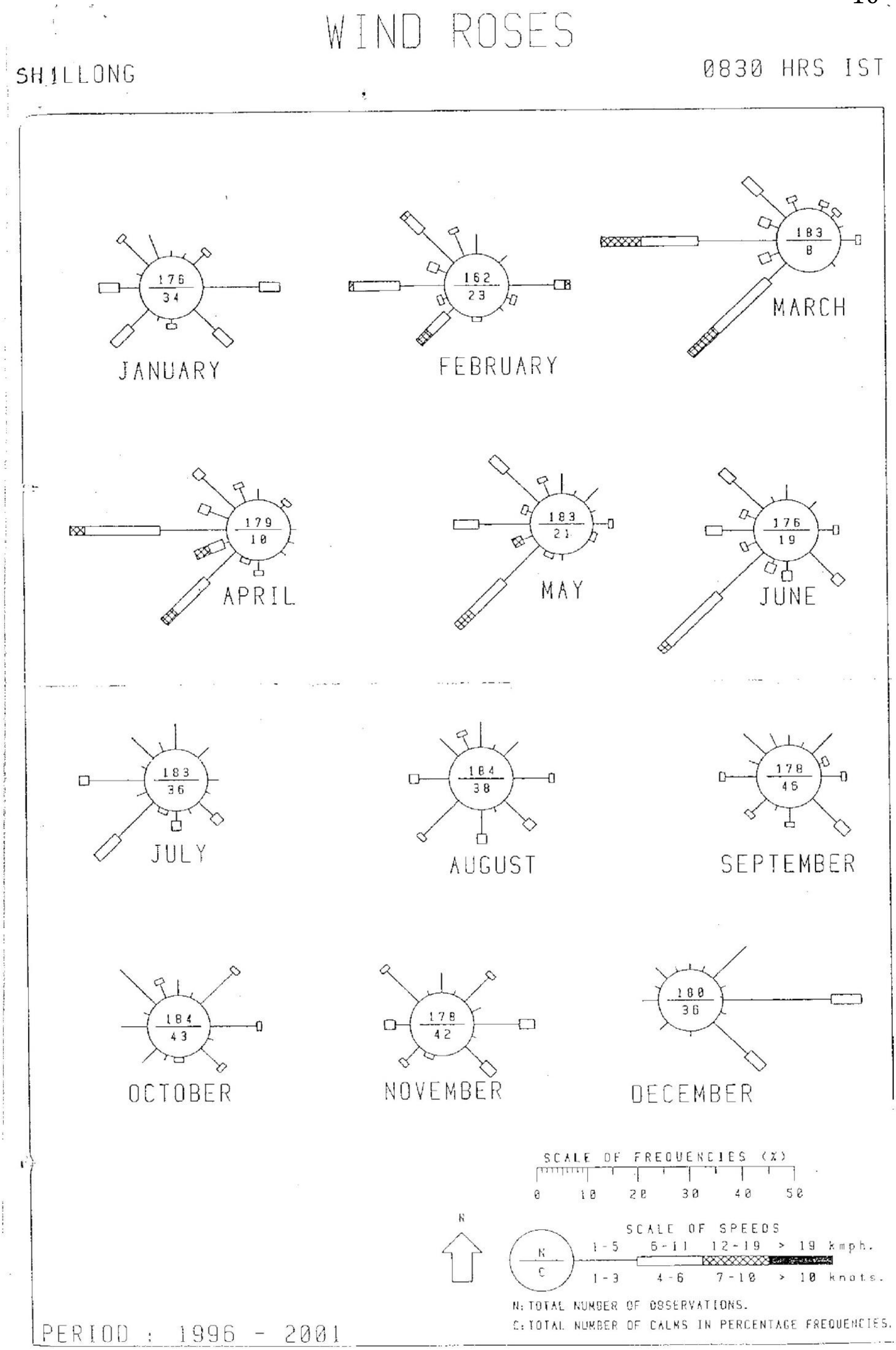
Household wise Resettlement and Economic Rehabilitation Package

SL No	District	Village	Name of Head of Household	Caste	SL No	Extent of Total Land Cultivated, ha	Farmer Class Before Acquisition, ha	Extent of Land Submergence, ha	Land Compensation, Rs lakhs	Rehabilitation grant, Rs	Occupation grant, Rs	Land Left with,ha	Farmer Class After Acquisition	One time financial assistance, Rs	ST Grant, Rs
206	JAINTIA HILLS	SOHMYNTING	SANTI DKHAR	ST	206	0.52	1-Marginal	0.25	1.25	75,000	30,000	0.27	1-Marginal	50,000	50,000
207	JAINTIA HILLS	SOHMYNTING	CHAIR PYRTUH	ST	207	0.70	1-Marginal	0.40	2.00	75,000	30,000	0.30	1-Marginal	50,000	50,000
208	JAINTIA HILLS	SOHMYNTING	SUKMON LYNGKOT	ST	208	0.80	1-Marginal	0.20	1.00	75,000	30,000	0.60	1-Marginal	50,000	50,000
209	JAINTIA HILLS	SOHMYNTING	SMT.KWALSI SHYLLA	ST	209	0.80	1-Marginal	0.30	1.50	75,000	30,000	0.50	1-Marginal	50,000	50,000
210	JAINTIA HILLS	SOHMYNTING	SMT SAH PYRTUH	ST	210	0.65	1-Marginal	0.20	1.00	75,000	30,000	0.45	1-Marginal	50,000	50,000
211	JAINTIA HILLS	SOHMYNTING	SMT.BILORIS PYRTUH	ST	211	0.80	1-Marginal	0.30	1.50	75,000	30,000	0.50	1-Marginal	50,000	50,000
212	JAINTIA HILLS	SOHMYNTING	SMT.SAH PYRTUH	ST	212	0.80	1-Marginal	0.40	2.00	75,000	30,000	0.40	1-Marginal	50,000	50,000
213	JAINTIA HILLS	SOHMYNTING	BINO LYNGDOH	ST	213	0.45	1-Marginal	0.10	0.50	75,000	30,000	0.35	1-Marginal	50,000	50,000
214	JAINTIA HILLS	SOHMYNTING	KRINA PYRTUH	ST	214	0.60	1-Marginal	0.15	0.75	75,000	30,000	0.45	1-Marginal	50,000	50,000
215	JAINTIA HILLS	SOHMYNTING	SAILIN PYRTUH	ST	215	0.70	1-Marginal	0.25	1.25	75,000	30,000	0.45	1-Marginal	50,000	50,000
216	JAINTIA HILLS	SOHMYNTING	LEPHING PYRTUH	ST	216	0.70	1-Marginal	0.30	1.50	75,000	30,000	0.40	1-Marginal	50,000	50,000
217	JAINTIA HILLS	SOHMYNTING	PYNSHAIN PYRTUH	ST	217	0.90	1-Marginal	0.45	2.25	75,000	30,000	0.45	1-Marginal	50,000	50,000
218	JAINTIA HILLS	SOHMYNTING	RADIO LYNGDOH	ST	218	0.91	1-Marginal	0.50	2.50	75,000	30,000	0.41	1-Marginal	50,000	50,000
219	JAINTIA HILLS	SOHMYNTING	ANGELINA PYRTUH	ST	219	0.70	1-Marginal	0.24	1.20	75,000	30,000	0.46	1-Marginal	50,000	50,000
220	JAINTIA HILLS	SOHMYNTING	SANI PYRTUH	ST	220	0.60	1-Marginal	0.31	1.55	75,000	30,000	0.29	1-Marginal	50,000	50,000
221	JAINTIA HILLS	SOHMYNTING	FRIDAY PYRTUH	ST	221	0.52	1-Marginal	0.30	1.50	75,000	30,000	0.22	1-Marginal	50,000	50,000
222	JAINTIA HILLS	SOHMYNTING	LOVEFREECA PYRTUH	ST	222	0.65	1-Marginal	0.20	1.00	75,000	30,000	0.45	1-Marginal	50,000	50,000
223	JAINTIA HILLS	SOHMYNTING	BILIN PYRTUH	ST	223	0.84	1-Marginal	0.60	3.00	75,000	30,000	0.24	1-Marginal	50,000	50,000
224	JAINTIA HILLS	SOHMYNTING	LET PYRTUH	ST	224	0.78	1-Marginal	0.20	1.00	75,000	30,000	0.58	1-Marginal	50,000	50,000
225	JAINTIA HILLS	SOHMYNTING	LONG PYRTUH	ST	225	0.65	1-Marginal	0.25	1.25	75,000	30,000	0.40	1-Marginal	50,000	50,000
226	JAINTIA HILLS	SOHMYNTING	SYNTU LANGSHIANG	ST	226	0.70	1-Marginal	0.30	1.50	75,000	30,000	0.40	1-Marginal	50,000	50,000
227	JAINTIA HILLS	SOHMYNTING	LEPHING PYRTUH LYNGKOT	ST	227	0.65	1-Marginal	0.40	2.00	75,000	30,000	0.25	1-Marginal	50,000	50,000
228	JAINTIA HILLS	SOHMYNTING	SOSILI PHAWA	ST	228	0.65	1-Marginal	0.25	1.25	75,000	30,000	0.40	1-Marginal	50,000	50,000
		SOHMYNTING Total			**23**	**16.07**		**6.85**	**34.25**	**1,725,000**	**690,000**	**9.22**		**1,150,000**	**1,150,000**
		Grand Total			**228**	**142.03**		**56.60**	**283.00**	**17,100,000**	**6,840,000**	**85.43**		**12,350,000**	**11,400,000**

WIND ROSES 17 30 HRS IST

SHILLONG




WIND ROSES
SHILLONG
0830 HRS IST
176
34
JANUARY
162
23
FEBRUARY
183
8
MARCH
179
10
APRIL
183
21
MAY
176
19
JUNE
183
36
JULY
184
38
AUGUST
178
46
SEPTEMBER
184
43
OCTOBER
178
42
NOVEMBER
180
36
DECEMBER
SCALE OF FREQUENCIES (%)
0 10 20 30 40 50
N
SCALE OF SPEEDS
N
C
1-5 6-11 12-19 > 19 kmph.
1-3 4-6 7-10 > 10 knots.
N: TOTAL NUMBER OF OBSERVATIONS.
C: TOTAL NUMBER OF CALMS IN PERCENTAGE FREQUENCIES.
PERIOD : 1996 - 2001