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## ENVIRONMENTAL MANAGEMENT PLAN

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### 5.1 Purpose and Objectives of the Environmental Management Plan

An EMP provides a delivery mechanism to address the adverse environmental impacts of a project during its execution, to enhance project benefits, and to introduce standards of good practice to be adopted for all project related work. The primary objectives of the EMP are to:

- a) Facilitate the implementation of the mitigation measures for the identified adverse impacts.
- b) Define the responsibilities of the project proponents and contractors in order to ensure the implementation of the Environmental Management Plan.
- c) Define a monitoring mechanism and identify monitoring parameters in order to:
  - i) Ensure the complete implementation of all mitigation measures.
  - ii) Ensure the effectiveness of the mitigation measures.
  - iii) Provide a mechanism for taking timely action in the face of unanticipated environmental situations.

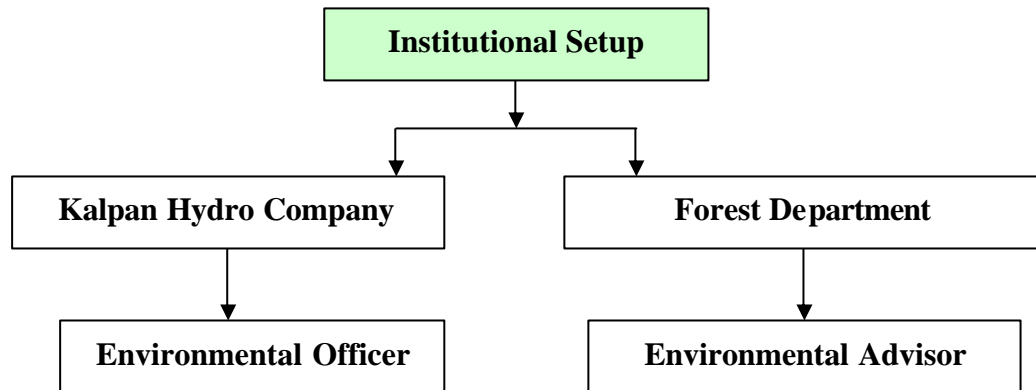
#### 5.1.1 Responsibilities of the Contractor

The contractor will be responsible for implementation of measures to avoid or minimize environmental impacts during construction. These will include protection measures relating to:

- a) Proper siting of the construction work camps.
- b) Development of supporting infrastructures
- c) Meeting effluent standards and water quality requirements for discharges into surface water or land from workers camp ;
- d) Managing onsite solid wastes;
- e) Controlling soil erosion and sedimentation;
- f) Controlling noise emissions, dust and other air pollution;
- i) Protection of local flora and fauna
- g) Managing onsite traffic;
- h) Implementing a health program for all persons engaged in construction work.
- i) Managing, preventing and developing emergency plans for chemical pollution incidents
- j) Providing physical cultural protection and relocation to the labour population as necessary

#### 5.1.2 Institutional Setup

Kalpan Hydro Company (KHC) will be solely responsible to implement the EMP. As the project is located in close vicinity of KNB, therefore, they will consult with Forest department before implementing any measure. KHC will ensure that Contractors engaged in the construction work or any other purposes will follow the EMP. The institutional set up suggested for implementation of EMP is delineated in **Figure 5.1**.



**Figure 5.1 – Institutional Setup of Environmental Cell**

The provisions of the contract of the construction contractor will include clear descriptions of the Contractor's obligations for undertaking measures to minimize and/or to mitigate impacts on the existing environment and social situation. The primary reference document for this will be the Construction Contractor's Environment Management and Monitoring Plan (CCEMMP). The CCEMMP will cover all the protection measures listed above and will be required to contain an over view of the project impacts that the contractor's work will have on the physical, biological and social environment , which will include:

- a) Details of environmental management plan, which to be implemented;
- b) Statutory requirements including approvals and licenses;
- c) Location and timing of environmental control activities;
- d) Assignment of responsibility to implement, maintain, asses and monitor each environmental control;
- e) Procedures and instructions to implement, maintain, asses and monitor each environmental control;
- f) Reporting and Emergency procedures;
- g) Corrective action requirement and verification.

## **5.2 Environmental Management Action for Lethang HEP**

The most reliable way to ensure implementation of the management plan is to integrate the management measures in the overall project planning, design, construction and operation work. In the Lethang HEP, the environmental management actions will be integrated into the civil work contracts and other project planning and design activities. The EMP measures include mitigation or enhancement measures as appropriate to the nature of impacts, and are explained in the following sections. These include:

- a) Air quality and noise quality control.
- b) Control of water pollution.
- c) Actions to conserve and protect biodiversity and implement compensatory afforestation.
- d) Fisheries conservation and management.
- e) Actions related to manage river flow in the project stretch of Rathang Chu.
- f) Reservoir rim treatment plan.
- g) Mitigation of all construction related impacts including control of pollution from labour camps.
- h) Restoration and landscaping of areas disturbed by construction and quarrying;
- i) Muck disposal plan and reinstatement of muck disposal areas.
- j) Resettlement and Rehabilitation Plan.
- k) Delivery of public health services

### 5.3 Biodiversity Management and Conservation Plan

#### Introduction

The Lethang HEP project is not dealing with any forest product or involved in any trade or research of biological resources or involved in exchange of information related to biological resources; therefore, the project does not attract 'Biodiversity Conservation Act 2002'. But the project is in close proximity of the KNP/KNB and will need 9.63 ha of forests land. Hence, a biodiversity management plan is prepared as an enhancement measures as well as making it as an environmental benign development.

The main purpose of biodiversity management and conservation plan is to protect the biodiversity of the surrounding area from adverse environmental and social impacts caused by the project by implementing various mitigation and enhancement measures. Significant adverse impacts on land and biological environment are anticipated due to road construction, blasting, excavation for tunnels, quarrying, dumping of excavated materials and influx of human population. In view of the foreseen disturbance and degradation of natural ecosystems, a biodiversity conservation and management plan (BMP) is proposed herewith. This plan applies to an area within 10 km radius of the project site. Responsibility of implementation and monitoring of this BMP in the project influenced area will lie with State Forest Department of Sikkim. Local people will be involved by the forest department on its discretion, for encouraging community participation.

Biodiversity Management Action Plans suggested for Project's Immediate Influence Area (PIIA) and the Directly Affected Area are delineated below:

#### Surveillance and Campaign against Illegal Felling of Trees

To prevent the chance of illegal cutting of trees adequate security measures as well as campaign to create public awareness against illegal felling of trees are suggested.

#### Compensatory Afforestation Plan

The total forest land involved in this project is **9.63 ha**, in this 8.001 ha for surface components and 1.6278 ha for underground components. As per the Indian Forest Conservation Act, 1980, if the Forest Department agrees to divert the forest land for non forest purpose, a Compensatory Afforestation Plan need to be prepared and implemented as per the guidelines and forest protection measures stipulated in the act.

As per this act,

- i) Compensatory forest plantations are to be made over an area equivalent to the affected or lost forest area, in non-forest land.
- ii) If non-forest land is not available, compensatory forest plantations are to be established on degraded forest lands, to the extent twice the forests area affected or lost.

As per the provisions of Forest Conservation Act, 1980, Compensatory Afforestation is not applicable for activity carried out in the forests land below three meter depth. In this project the total surface land proposed for the diversion is 9.63 ha. Thus, a total of 19.26 ha rounded to 20 ha of land is required to be afforested. The location for Compensatory Afforestation is selected in West Sikkim District, namely, Chung Reserve Forests and Yuksam Reserve Forests falling within Yuksam Forest Range are selected for compensatory afforestation by the State Forest Department. They allotted about 10 ha of area in each of these reserve forests adding up to 20 ha area for plantation purposes. The plantation activities will be carried out in aforesaid reserve forests. The cost of afforestation of this 20 ha of forests land is Rs.24, 528/ha (@1600 seedlings/ ha). The implementation Strategies of the Compensatory Afforestation is described below:

### Strategies adopted for Compensatory Afforestation:

An integrated approach will be adopted for taking up the plantation with soil enhancement measures, details are described below:

- a. The plantation will be done during (April – June) season. Planting pits of 30 cm x 30 cm x 30 cm will be dug at 2.5 m spacing in a triangular pattern. About 1600 seedlings will be planted on per hectare basis.
- b. The seedlings will be procured from the existing nearby forest nursery on payment basis as per norms, or if required a new nursery may be created or a suitable existing nursery of the State Forest Department may be adopted.
- c. Site specific species of mixed indigenous nature like *Michelia sp.*, *Cedrella toona*, *Castanopsis sp.*, *Juglans regia etc.* will be planted in the middle hill forests and species like *Terminalia tomentosa*, *Chikrasia tubularis*, *Duabanga grandiflora etc.* will be planted in the lower hill forests as block plantation.
- d. Soil enhancement measures will be taken up @ 25 % of the entire plantation areas supported by appropriate engineering and vegetation measures.
- e. The block plantation will be fenced with stone wall fencing of the required dimension to protect from wildlife interference. In addition to this, required number of watch and ward will also be engaged for protection of the plantation to ensure better establishment of the plantation.
- f. Maintenance of block plantation for a period of five years, followed by annual monitoring and evaluation by forest department officials will be taken care.

### Wildlife Management Plan:

The project area is located in close proximity to Kanchendzonga Biosphere Reserve and National Park. The barrage axis is proposed at about 300 m. downstream of the boundary of the Kanchendzonga National Park. The barrage site falls in outer periphery of Kanchendzonga Biosphere Reserve. It is the highest altitude protected wildlife area in India. The wildlife in the area is likely to move away from the area of increased human activity due to presence of large no of labour population and noise during construction phase. But eventually will return to the area once construction is completed. However, construction work will be done with appropriate due diligence for minimising the noise levels and human interference to non project areas. To protect wildlife surrounding forests patches following protection and conservation measures will be adopted:

- a) Regulating movement of floating population and settlement of camps away from forests area (wildlife habitat).
- b) Controlling grazing activity, poaching, encroachment and illicit felling of timbers.
- c) Construction of Watchtowers and Check posts
- d) Making wildlife protection mobile squad comprising Forest Guards in each group.
- e) Patrolling and Surveillance by Forest Guards and Range officer
- f) Appointing 'Watch and Wards' for special threatened animals.
- g) Strengthening and creation of wireless communication network.
- h) Arranging campaign against illicit tree cutting, poaching of wild animals and birds, nature education and awareness programmes.

- i) Organising activity like Eco-development through community participation.
- j) Recovery and improvement of wildlife habitat by plantation and fencing
- k) Improvement of existing waterholes and springs
- l) Control and management of forest fires
- m) Special Conservation of habitat vulnerable species and identification of decimating factors
- n) Enforcement of Law
- o) Recruitment of Field Staff
- p) Trans-location of displaced wildlife to KNP with the help of forests department.

To control adverse impacts due to human interferences (labourers), Kalpan Hydro Company will establish two check posts and watchtowers at the construction site. At present, there are two forests check posts recently constructed, one in Yuksam village and other is at Darap-Nambu, where entry fees for KNP is collected and trekkers checking is done. Also, the defaulters are apprehended and fined for non-compliance with regulations on the spot. The location of the additional check posts may be at Labour Camps; or on the right bank at upstream of Nallah -1 or at any other suitable sites near proposed barrage or wherever construction will take place. The location may be decided in consultation of State Forest officials. These check post will be watched over by forest guards under the supervision of Forests block officers. The guards will be provided adequate communication equipment and other facilities. The guards will carry out patrolling and surveillance at regular intervals. In addition to this, special task force will be deployed along with watch and wards for regular patrolling and surveillance to protect rare, endangered and threatened wildlife in the area. Local residents of nearby buffer zone (only those interested and dedicated) may be involved in this task. This will also encourage participation of the locals in conservation of forests and also create new job opportunities for them.

#### **Biodiversity Enhancement Measures:**

Following are the biodiversity enhancement measures to be adopted by KHC :

##### **a) Boundary Demarcation :**

This is one of the imperative tasks to be done before carrying out any constructional activity; boundary pillars need to be fixed all along the boundary of the acquired forest land for the project after conducting proper survey for boundary line with KBR/KNP/ West Territorial Forests Division. The concrete pillar along with iron angel to give distinct identification and strong foundation, which can not be uprooted or displaced easily.

##### **b) Habitat Improvement Work:**

The habitat improvement measures will primarily aim to restoring the habitat and food base for all the wild animal species. Some supplementary work under KBR management will be carried out on yearly basis without disturbing the existing flora and fauna of the KNP or KBR. For this the measures like development of pasture land in the open forests, Bamboo plantation, aided natural regeneration in degraded forest areas, grassland maintenance, and soil and moisture conservation will be adopted.

##### **c) Control of Grazing, Poaching, Encroachment and Illicit Felling of Timber:**

Under these measures activities like building up of a protection network, development of infrastructure facilities for better implementation of the rules and regulations, building up of information network and social fencing around the park through eco-development activities are suggested.

**d) Extensive Patrolling and Surveillance:**

Regular patrolling and maintaining constant vigil during construction phase of the project is suggested for prevention of poaching and illicit felling of timber from near by forests. For this, block level forests officer will be responsible for daily and intensive combining of forest areas. The irregular patrolling in criss-crossing the lower reaches and also in the higher reaches at least once in a week is suggested. While patrolling, the staff will look for any visible sign of unfamiliar scenes or movement and also try to locate any sign of carcass, suspicious looking mounds of earth/ salt licks, unauthorised activities inside forests.

**e) Maintenance of Special Habitats:**

The maintenance of special habitats is proposed as follows:

- i) Retention a number of hollow, top broken, top dried partially dead, or fully dead (snag) standing trees particularly trees >20 cm GBH and >5m height. Such trees are used by variety of wild species, particularly wood pecker, barbets, nuthatches and smaller mammals.
- ii) Retention and preservation of fallen trees and logs of any diameter and allow them to decompose “as is where is basis”, so that the decomposed trees and logs serves as habitat/ niches used by different organisms ranging from soil bacteria to fungi, mollusca, anthropods, amphibians and small mammals.
- iii) Retention and plantation of fruit and seed bearing trees and dwarf bamboo clumps, as these trees provide food for different animals including birds, butterflies, bees, moths etc.
- iv) Retention of trees with deeply twisted boles, furrowed barks or peeling bark, with natural cavities because bats, shrews, snakes etc. are often use such natural crevices and cavities as hiding, resting and nesting sites. These trees will be identified and preserved carefully.
- v) A garden for native medicinal and other rear-endangered plant species is proposed to establish in consultation with forests department.
- vi) Programme for identification of invasive and susceptible species will be initiated to ensure the conservation of the native species.
- vii) Peoples Biodiversity Register (PBR) will be created and maintained.
- viii) Existing Nature Interpretation Centre will be strengthen for awareness generation for conservation of nature among the local inhabitant as well as visiting population.
- ix) Surrounding forests, i.e., Yuksam-Dzongri-Goecha La trekking trail, Tashiding, Rabdentse, Dubbdi, Khecheopalri are all are known for birds. At least birds from four biomes are present in these forests. But there is no proper bird inventory is available in the area. Therefore, it is proposed to initiate preparation of scientific bird inventory, which will include all the resident and seasonal visitor birds to the area.

For effective implementation of afforestation as well as biodiversity conservation and wild life protection/management plan, an amount of **INR. 12.387 million (Rs. 123.87 Lakh)** is earmarked in the project cost. The break up of costs is delineated in **Table 5.1** below:



**Table 5.1: Budget for Biodiversity Management /Conservation and Afforestation**

Elaboration of Costs	Capital Costs (INR millions)	Working Costs (INR millions)
<b>A - Wildlife Management ( Construction Period)</b>		
a) Salary		
Four guards @ Rs. 8000 per month = Rs.3,84,000 / year		
Two Block Officer forests @ Rs. 10,000/- = Rs.2,40,000/ year		
One Range Officers @ Rs 20,000 per month = Rs.2,40,000 / year		
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Total Cost for one year = Rs.8,64,000 / year		
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Cost for four years = Rs.40,09,824 / -	-	<b>4.009</b>
(Assuming 10% increase per year) = Rs. 4.009 million		
b) Construction of Check Posts = Rs. 1.50 million	<b>1.5</b>	-
with provisions for ammunicions and communication system		
c) Construction of two watch towers = Rs. 0.45 million	<b>0.45</b>	-
d) Awareness, training and education of workers = Rs 0.45 million	<b>0.45</b>	-
and local people		
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<b>Total Cost A) = 6.309 million</b>	<b>2.4</b>	<b>4.009</b>
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<b>B - Compensatory Afforestation (CA)</b>		
Total Forest Land to be acquired = 9.629 ha		
CA @ 2 times of the forest area to be acquired = 19.258 ha ~ 20 ha		



Elaboration of Costs				Capital Costs (INR millions)	Working Costs (INR millions)
<b>a) Advance Work &amp; Creation</b>					
<b>Work</b>	<b>Area</b>	<b>Rate</b>	<b>Amount</b>		
i) Block plantation @1600 seedlings per ha	20 ha	24528	490560.00		
ii) Cost of stone wall fencing	5 ha	450000	2250000.00		
iii) Soil & Moisture Conservation measures (25% plantation area)	5 ha	27,005	135025.00		
iv) Biodiversity conservation of flora/fauna/rare and endangered & threatened species and related Activities (L.S)	1 ha	10,50000	1050000.00		
v) Eco restoration of site specific threatened species (LS)	1 ha	250000	250000.00		
vi) Awareness/extension/training/ publicity and documentation etc.	1 ha	200000	200000.00		
<b>SUBTOTAL (a)</b>			<b>46,25,585.00</b>	<b>4.625</b>	<b>-</b>
<b>b) Maintenance for 5 years</b>					
i) Two weedings including casualty feeding of block plantation in 2 <sup>nd</sup> & 3 <sup>rd</sup> year.					

Elaboration of Costs				Capital Costs (INR millions)	Working Costs (INR millions)
I weeding	20 ha	3828	76560.00		
II weeding	20ha	1800	36000.00		
<b>Total</b>			<b>1, 12,560. 00</b>	-	<b>0.125</b>
<b>Work</b>					
	<b>Area</b>	<b>Rate</b>	<b>Amount</b>		
ii) One weeding block plantation in 4 <sup>th</sup> and 5 <sup>th</sup> year 2 x 20 ha x @Rs 1800 /- per ha	20ha	1800	72,000		
iii ) Two watch & ward for looking after the plantation areas and protection for 5 years 2 x 5 year x 365 days @ Rs. 100 /- per day	20ha	-	3,65,000		
iv) Repair of fencing in 5 years	5ha	40000	40,000		
<b>Sub Total (b)</b>			<b>6,37,000</b>	-	<b>0.637</b>
<b>c) Overhead expenses / monitoring &amp; evaluation and contingencies</b>					
	<b>Area</b>	<b>Rate</b>	<b>Amount</b>		
i) Office expenses, stationary, TA/DA repair of vehicle, typewriter, computer Xerox machine, fax machine etc @ 5 %	5 %		2,68,760 /-		

Elaboration of Costs	Capital Costs (INR millions)	Working Costs (INR millions)
ii)Monitoring & Evaluation of scheme project by the Central Govt. as well as by the state govt. @ 2 %	2 %	1,07,502 /-
iii) Contingencies & unforeseen expenditure @ 4%	4%	215005 /-
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<b>SUBTOTAL (c)</b>	Rs. 5,91,267 / -	
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<b>TOTAL COST B)</b>	<b>Rs. 59,66,412 /-</b>	<b>0.591</b>
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<b>Total Cost (A + B)</b>	<b>7.025</b>	<b>5.362</b>
<b>Total Budgeted Costs = INR 12.387 millions</b>		

## 5.4 Public Health Delivery System

During construction the labour population will be concentrated at two or three sites. Workers will be vulnerable to be affected by diseases associated with the local conditions and camp/ temporary living conditions. There will be chance of infectious diseases outbreak particularly communicable diseases like tuberculosis, stomach infection, Malaria, Dengue, Hepatitis, HIV/AIDS etc. among the local communities. KHC will strive to ensure that the health of the construction workforce is maintained, and that the local communities are not exposed to increased health risks, or increased HIV/AIDS risks due to the presence of the large number of migrant workforce.

The skeletal health services, which are present in the area (detail of present status described in chapter 3) will be insufficient to cater such an influx of outside labour in this area. Therefore, the project authorities and the contractors will mandatory ensure that all the labourers including their family members are registered and quarantined, vaccinated against common ailments like Malaria, T.B. etc. The project authorities will hold screening camps for the labourers and blood tests will be conducted for diseases like AIDS, T.B., malaria etc. Only after valid certification, a labour or his family members will be registered with a contractor. KHC will ensure that the contractors follow this strict quarantine procedure and the contract terms will include the clause. Sufficient medical facilities will be provided by the KHC. KHC will also ensure that disease control measures are implemented by the contractor at the time the construction camps are built and during the construction period while the camps are inhabited.

As the Lethang Hydro Electric project is a run-of-the-river scheme will not inundate vast area (only 0.8 ha will be submerged) and aggravate the problem of vector born diseases. The reservoir basin will be cleared and prepared prior to filling so that it does not provide mosquito breeding sites. In addition, adequate precautionary arrangements will be made in public health delivery system to control vector born diseases.

Construction camp sitting will be made considering good drainage, water supply, sewage disposal and disease transmission potential, especially malaria. An adequately staffed clinic will be sited at the base camp. The contractors will establish all required linkages with the State AIDS Control Society (SACS), and will implement all measures including referral system advised by the SACS. The contractor will be responsible for these activities. KHC will monitor the contractor's activities and compliance.

The contractor will prepare and enforce the Staff Health Program in respect to matters regarding the health and safety of the construction workforce as a part of the contractor's Health and Safety Plan. The contractor's 'Staff Health Program' will also provide some assistance to nearby communities for emergency matters, if space and resources become intermittently available.

Similarly, the contractors can coordinate, as an additional facility but not replacing its own obligations under this EMP, with all other functioning medical facilities in the locality.

Contractor will take the following measures:

### At Construction Camps:

- a) In general, anti-malaria measures following current accepted practice will be instituted at campsites and facilities established for early diagnosis and treatment of patients with the diseases.
- b) Disease control measures are to be implemented by the contractors at the time the construction camps are built.
- c) Decisions regarding sitting of camps will be made with regard to good drainage, water supply, sewage disposal and disease transmission potential, especially malaria, dengue etc.
- d) Mosquito nets will be provided to the worker families.

### **For Overall Workforce:**

With regard to providing high quality health services to the contractor's employees, the program will include:

- a) Appropriate measures to address mosquito control, including malaria and dengue fever control.
- b) A medical centre will be sited at the main construction camps for the diagnosis and treatment of communicable diseases, attending general medical complaints and also handling the medical emergencies and accidents. It will have adequate number of doctors, trained nurses and other associated staff. Subsidiary treatment or first aid posts will be present at each construction camps, which will be headed by either a trained nurse or locally trained personnel.
- c) Suitable workers will be selected from the workforce and additional training will be given in occupational health and first aid. Thus a team of two or three personnel will be deployed at each work site. They will do this as part of their normal work and will be under the supervision of the person responsible for occupation health and of the medical officer.
- d) One ambulance will also be stationed at a suitable place to provide emergency medical facilities in the project area and carry patients to the nearby hospital, in case of emergency. It is also proposed to extend these facilities to the local public.
- e) For the control of communicable diseases and other public health issues, contractors will employ services of a sanitation officer and a disease control officer.
- f) Provision will be made for periodical health checks of employees, including checking will be done for drug abuse and sexually transmittable diseases in accordance with Indian Labours Laws resolutions, recommendations, guidelines for construction workers where ever required,.
- g) The contractor will deploy a team for sanitation management and control, whose responsibility will be to (i) control vector borne and other diseases, (ii) ensure the continued safe disposal of all solid wastes and sewage, (iii) implement fly and other insect control in the project area, specifically at the construction camp sites and its surrounding area, (iv) implement and monitor the sanitation management measures throughout the project area including construction camps and spontaneous resettlement areas, (v) provide appropriate information and education to the workforce on prevention of diseases, including malaria, diarrhoea, STD and HIV/AIDS, and (vi) investigate and document diseases outbreaks within the contractor's workforce.

### **For Construction sites**

At least two first aid posts will be provided at the construction site to attend the workers on immediate basis in case of an injury or accident. This first-aid post will have the following facilities:

- a) First aid box with essential medicines including ORS packets.
- b) First aid appliances-splints and dressing materials.
- c) Stretcher, wheel chair, etc.

The first aid post will be housed in temporarily erected structure and managed by one Health Assistant and one attendant. The doctor from the medical centre established by KHC may visit the first aid centre once daily at fixed time. The first aid centers will have adequate communication facility to link with the nearest health centre/hospital in case of an emergency.

### **Additional Malaria Control Measures:**

To reduce the risks of workers contracting malaria, the following measures will be taken for mosquito control at construction site:

- a) Educating the workers about problems and preventive measures.

- b) Provide protective clothing.
- c) Provide mosquito repellents.
- d) Minimize presence of open containers with water.
- e) Removal of discarded items that may contain water.
- f) Keeping storm water drains and borrow pits free of vegetation.
- g) Insecticide control in all probable locations of mosquito breeding.

#### HIV/AIDS Prevention Measures:

To effectively address the HIV/AIDS issues and the associated risks, the contractors will associate with the State Aid Control Society (SACS) fully and without any failure or excuse. KHC will insist that the contractors implement all advice from the SACS. In addition, the contractors will be obliged to implement regular and periodical awareness campaign on HIV/AIDS, provide for all awareness materials and their dissemination, including erecting large signage in prominent areas; and to provide for and maintain condom vending machines in all work areas including construction camps, public toilet booths, and work sites.

#### Budget on First Aid

The capital costs estimated for development of first-aid posts is estimated as **INR.50.50 Lakh**. The working costs estimated as **INR 60 Lakh**. The details are given below in **Table 5.2** :

**Table 5.2 : Budget for Public Health Delivery System**

Working Costs			
Particulars	Monthly Emoluments (INR)	No.	Annual Expenditure (INR)
<b>A) EXPENDITURE ON SALARIES</b>			
i) Doctor	30,000 / -	1	3,60,000 / -
ii) Nurses	15,000 / -	2	3,60,000 / -
iii) Attendants	8,000 / -	1	96,000 / -
v) Driver	6,000 / -	1	72,000 / -
<b>SUB – TOTAL A)</b>			<b>8,88,000 / -</b>
<b>B) MATERIAL AND SUPPLIES</b>			
i) Medicines and Drugs	-	-	3,00,000 / -
ii) Contingencies	-	-	1,00,000 / -
<b>SUB – TOTAL B)</b>			<b>4,00,000 / -</b>
<b>TOTAL EXPENDITURE ( A + B )</b>			<b>12,88,000 / -</b>
<b>Total Expenditure for 3 years ( @ 10 % Escalation per year)</b>			
<b>2<sup>nd</sup> Year</b>			<b>14,16,800 / -</b>
<b>3<sup>rd</sup> Year</b>			<b>15,58,480 / -</b>
<b>4<sup>th</sup> Year</b>			<b>17,14,328 / -</b>
<b>Total Costs after escalation @ 10 %</b>			<b>59,77,608 / -</b>
Capital Costs			
S.No.	Particulars	Amount (INR)	
1.	Infrastructural Facilities		
	a) Medical Camp for Construction Camps	15,00,000 / -	
	b) Setting up of First Aid centers	4,00,000 / -	
2.	Materials & Supplies		
	a) Furniture	2,50,000 / -	
	b) Clinical Equipments	5,00,000 / -	
	c) One Ambulance & One Additional Vehicle	24,00,000 / -	
<b>Total Estimated Cost (1 + 2)</b>			<b>50,50,000 / -</b>

## 5.5 Environment Management in Labour Camps

The involvement of large labour population and technical staff is likely to put significant pressure as a result of increase in discharge of sewage, quantity of solid wastes generated and other pollutants. The construction activity will engage different categories of manpower like officials, service providers, technical and non-technical workers. Total population estimated are to be about 3445 during peak construction phase.

The environmental management in the labour as well as officers camp mainly will be focused on

- Sewage Treatment and Sanitation facilities
- Solid waste management
- Free Fuel

### Sewage Treatment and Sanitation Facilities

Potable water requirements for the construction camps and the labourer's camps will be met from nearby rivers or natural springs, strictly without affecting any existing community sources of water. A complete water treatment system with chemical dosing, pressure filter will be installed by the project proponent to treat the raw water before using for drinking and domestic uses. The water can be transported to the point of consumption under gravitational flow. However, it is recommended that bacteriological analysis of water will be done on regular basis for avoiding spread of water born diseases like typhoid, dysentery, cholera, diarrhoea etc. due to bacteriological contamination. Also, the chlorine dose will be fixed so that there is adequate residual chlorine is available in water that is being consumed. There will be proper and stable water supply for domestic uses for all the inhabitants of the colony.

Common toilets will be provided to the camp sites including all work sites. Total sixty toilets will be provided in different strategic locations including work places and camp site. These sanitary facilities will be of standard municipal design as per the requirements. The wastewater generated from the colonies will not be allowed to flow into the Rathang Chu or any other natural drainage system of the area. The wastewater will be collected safely and disposed off in specifically designed septic tank. It is estimated that about sixty toilets will be constructed in different locations and approximately 372 KLD of waste water will be generated in the peak phase of construction. The estimated budget for sanitation and drinking water supply system is presented in **Table 5.3**

**Table 5.3: Estimated Budget for Sanitation and Drinking Water Facilities**

Unit	No.	Unit cost (Rs.)	Total cost (Rs.)
Community toilets	60	10,000	6,00,000
Septic tanks (one for each site)	6	5,00,000	30,00,000
Drinking water supply system	1	15,00,000	15,00,000
Sewage treatment plant (Primary & secondary settling tank including sewerage system)	1	12,00,000	12,00,000
Total Costs			63,00,000

### Solid Waste Management Plan

It is estimated that during construction phase 532.854 tonnes municipal solid wastes will be generation. In addition considerable quantity of construction wastes will be generated. The project developer will ensure proper management of solid waste generated by project activities.

- a) A secured land fill site will be developed in a suitable location within the project acquired land following the protocol due the absence of municipal solid wastes dumping ground in Yuksam or Lethang or any other near by places.



- b) Garbage bins will be provided in the labour camps and also in the construction site, which will be regularly emptied and disposed off in a hygienic manner.
- c) Degradable and non-degradable solid wastes will be separated.
- d) Common container will be taken to the dumping ground, which need to be developed for the the project.
- e) Biodegradable solid wastes will be covered with soil on daily basis to avoid any odor nuisance due to purification and check any contact with the flies or insects.
- f) Non biodegradable wastes will be segregated and saleable material will be sold through the project office to authorized vendor, non saleable wastes will be dumped in the secured land filling area.

The disposal site will be identified and developed by the project proponent in coordination with local authority and Sikkim Pollution Control Board. The disposal site will be lined with impervious materials so as to ensure that leachate does not lead to soil and water pollution. An incineration facility will be installed at a location where maximum garbage is dumped. One covered truck with adequate capacity will be put to service for collection of garbage from common collection point and transfer it to disposal site.

When parts of the waste disposal sites are full, the wastes will be covered by a depth of 1.5 m of soil, and then re-vegetated according to relevant requirements included in the landscaping and re-vegetation plan or as per the requirements of the Sikkim Pollution Control Board (SPCB). The cost estimated for solid wastes management is given in **Table 5.4**

**Table 5.4: Cost Estimates for Solid Waste Management**

Item	Cost (INR Lakh)
Preparation for Landfill site (lumpsum)	<b>5.00</b>
Landfill site (Running & Maintenance) Lumpsum @ Rs 50,000/- per year for 3 years	<b>1.50</b>
Salaries of two workers @ Rs 6000/month for 3 years @10% escalation per year	<b>4.80</b>
Construction of Vats and Waste collection (Handcarts and Bins) equipments	<b>3.00</b>
Truck for conveying solid wastes to site (one)	<b>15.00</b>
Running & Maintenance Cost of truck for 3 years @ Rs. 1.50 lakh per annum	<b>4.50</b>
Salaries of drivers @Rs 6000/month for 3 years escalation @ 10% per year	<b>3.60</b>
One incinerator	<b>10.00</b>

A separate collection and storage procedure will be developed for hazardous or toxic wastes, such as unused blasting materials, batteries, unused paint thinners and hydrocarbons, disused electronic equipment, etc. These wastes will be stockpiled in accordance with the requirement of the applicable laws and subsequently transported to special solid wastes treatment plant capable of proper disposal of such hazardous or toxic wastes as approved by Sikkim Pollution Control Board (SPCB).

#### **Provision of Free Fuel for Workers**

As a part of EMP, the project developer will ensure adequate supply of fuel to labour population as well as technical staff workers to avoided illegal cutting of trees to supply the fuel wood to the influx population for meeting their fuel demands. It will also include establishment of LPG godowns within the project area for

providing LPG cylinder to run community kitchens. Establishment of oil depot near project area to ensure adequate supply of kerosene oil.

Assuming, 15 litres of kerosene requirement per family per month, for 1000 families the total demand will be around 1,80,000 litres per year. The total costs for kerosene @Rs 25/litre will be around **INR 45 Lakh per year.**

Assuming, annual demand of one cylinder per family per month, for 100 employees the total demand will escalate to around 1200 cylinders per year. The total costs for distribution of cylinder @ Rs. 350 per cylinder per family will be around **INR 4.2 Lakh per year.**

The cost of establishment of Kerosene and LPG depot and security for 1200 cylinders will be beard by contractors.

The total budget for free fuel to labours is estimated around **49.2 Lakh per year.**

The total budget earmarked for environmental management in labour camps with provision of fuel is about **INR 159.60 Lakh.** The Budget for Environmental Management in Labour Camps including fuel provisions is given in **Table 5.5**

**Table 5.5: Budget for Environmental Management in Labour Camps**

Particulars				Non- Recurring (INR millions)	Recurring (INR millions)
<b>A – Sewage Treatment / Water Supply System in Labour Camps</b>					
<b>Non Recurring Costs</b>					
-----					
Components	No.	Unit Cost	Costs		
-----					
a) Community Toilets	60	Rs. 10,000 /-	= Rs. 6,00,000 /-		
b) Septic Tanks	6	Rs. 5,00,000 /-	= Rs. 30,00,000 /-		
c) Drinking water supply system	1	Rs. 15,00,000 /-	= Rs. 15,00,000 /-		
d) STP construction (Primary & Secondary settling tanks including sewerage system)	1	Rs.12,00,000 /-	= Rs.12,00,000/		
<b>Total Costs A)</b>			<b>= Rs. 63,00,000 /-</b>	<b>6.3</b>	<b>-</b>
-----					
<b>Recurring Cost</b>					
Maintenance and Operation of STP & Water Supply System @ Rs.1,50,000 / - per year					
<b>Total Cost</b>			<b>= Rs. 1,50,000 per year</b>	<b>-</b>	<b>0.1</b>
-----					
<b>B - Solid Waste Management Plan</b>					
<b>Non – Recurring Costs</b>					

Particulars		Non- Recurring (INR millions)	Recurring (INR millions)
----- Components			
----- Costs			
-----			
Preparation for Landfill site	= Rs. 5.00 Lakh		
One incinerator	= Rs. 10.00 Lakh		
Waste collection (Handcarts and Bins)	= Rs. 2.00 Lakh		
Truck for conveying solid waste to site (one)	= Rs. 15.00 Lakh		
-----			
<b>Total Costs</b>	<b>= Rs. 32,00,000 / -</b>	<b>3.2</b>	<b>-</b>
-----			
<b>Recurring Costs</b>			
-----			
Components			
-----			
Costs			
-----			
Landfill site (Running & Maintainence) Lumpsum @ Rs 50,000/- per year for 3 years	= Rs. 1.50 Lakh		
Salaries of two workers @ Rs 6000/month For 3 years @ 10% escalation per year	= Rs. 4.80 Lakh		
Running & Maintainence Cost of truck For 3 years @ Rs. 1.50 Lakh per annum	= Rs. 4.50 Lakh		
Salaries of drivers @Rs 6000/month For 3 years escalation @ 10% per year	= Rs. 3.60 Lakh		
-----			
<b>Total Costs</b>	<b>= Rs. 14,40,000 / -</b>	<b>-</b>	<b>1.44</b>
-----			
<b>C - Free Fuel Provision</b>			
-----			
<b>Recurring Costs</b>			
-----			
Fuel	No. of Persons	Total Costs	
-----			
a) LPG for technical staff	100	Rs. 4,20,000 / -	
b) Kerosene for labours	1000	Rs. 45,00,000 / -	
-----			
<b>Total Costs</b>		<b>= Rs. 49,20,000 / -</b>	<b>4.92</b>
-----			
<b>Total Costs (A+B+C)</b>		<b>9.5</b>	<b>6.46</b>
<b>TOTAL BUDGETED COSTS ~ INR 15.96 Million.</b>			

## 5.6 Muck Disposal Plan

### Introduction

In this project a large quantum of material will be excavated from the river water diversion tunnel. In addition to this, the construction of de-silting basin, intake structure, surge shaft, access adits as well as the excavation for the barrage will also generate a large amount of material. With an aim to protect the disposal areas from further soil erosion, and develop these areas in harmony with the environment the muck disposal plan is formulated. The muck disposal plan detailed in this report gives the quantification of muck, identifies

locations and activities where muck is generated (excavation and blasting operation), quantifies the muck generated from various sources with relevance to disposal plan.

The disposal locations/sites of muck is done in conjunction with various factors such as landscape, nearness to source of generation, obstruction in flow of surface water, relief and scope of afforestation, erosion control/sediment arrest and cost effectiveness. The plan identifies the landscaping measures for disposal of muck, modes of transportation for muck disposal and species selection for use of biofertilizer method for vegetative growth of muck spreads, delineates the muck disposal options for each site, manpower requirements, and feasibility of implementation and development of landscape. The plan includes administrative guidance for identifying and feasibility of muck disposal activities within KHC (Kalpan Hydro Company) or sub contractors. Delineating monitoring mechanism for implementation of Muck Disposal Plan, institutional analysis for reorienting activity within the administrative setup, payment schedule, and appraisal of Muck Disposal Plan are some of the elements covered in the plan.

### Quantity of Muck and Disposal Areas:

The total muck likely to be generated from the project is estimated 8, 85,000 cubic meters with 40 percent swelling factor from both upstream work, which includes pondage area, barrage, river diversion, intake, desanders, leveling of roads, associated muck dumping areas and other facilities and downstream work, which includes power house complex, tunnel, related muck dumping areas, access roads, surge shaft, pressure shaft, colony and facilities of surface and underground.

About 4 20,000 cubic meters of muck with 40 percent swelling factor will be generated from upstream work. Out of this, about 1, 40,000 cubic meters of muck will be used in construction/protection work. The remaining net quantity of about 2, 80,000 cubic meters muck volume will be disposed off suitably 4, 65,000 cubic meters of muck with 40 percent swelling factor will be generated from downstream work. In this about 1, 53,000 cubic meters of muck volume will be used in construction/protection work. The remaining quantity of about 3, 12,000 cubic meters of muck volume will be disposed of suitably.

For this purpose, six sites namely MD – 1, MD - 2, MD – 3, MD – 4, MD -5 and MD -6 are identified. The MD -1 is located near barrage on the right bank of Rathang Chu, MD-2 and MD -3 sites are upstream from Yuksam near left bank of Rathang Chu, MD – 4 is located on the left bank downstream Yuksam Village. MD -5 and MD-6 sites are near downstream from TRT (MD-5 on left bank and MD -6 on right bank). A total of 5.283 ha of private land is envisaged to be taken on lease basis for muck disposal. The muck disposal sites are shown in **Figure 5.2** and detailed calculations of average area, length and volume are delineated below and **Table 5.6**.

**Table 5.6: Muck Dumping Area Calculations**

S.No.	Description of Muck Dumping Area	Average Area (m <sup>2</sup> )	Average Length (m)	Average Volume (m <sup>3</sup> )
<b>A</b>	<b>Upstream Work</b>			
1	MD-1 (Plan Area = 2350 m <sup>2</sup> )	180	65	11720
2	MD-2 (Plan Area = 5400 m <sup>2</sup> )	125	185	23125
3	MD-3 (Plan Area = 8000 m <sup>2</sup> )	600	65	39000
4	MD-4 (Plan Area = 27000 m <sup>2</sup> )	1600	130	216000
<b>B</b>	<b>Downstream Work</b>			
1	MD-5 (Plan Area = 24000 m <sup>2</sup> )	950	215	200000
2	MD-6 (Plan Area = 14000 m <sup>2</sup> )	565	200	113000

## Restoration of Muck Disposal Sites

The unused material will be piled at an angle of repose (26 degree) at the proposed dumping sites. For stabilisation of spoil/dumped materials various engineering and biological measures are being proposed in the management plan. This will be done to provide stability to the slopes and also to provide ample space for planting of trees, which will further help in holding and consolidating the material stacked at different sites. The efforts will be made to relocate and rehabilitate the material within short distances from sites of its generation. Proposed engineering and biological measures are described below:

### a) Engineering Measures

Individual plans and cross sections of disposal areas, including protection measures such as seven meter high retaining wall made up of RR Masonary and dry Masonary with weep holes of 15cm. x 15cm. @1.5 m. centre to centre staggered is proposed for preventing sliding of spoil material/ dumped materials. The details of muck dumping sectional areas are given in **Table 5.7** Cross section of the retaining wall is shown in **Figure 5.3** and the cross sections of each muck dumping site is presented in **Figure 5.4a, Figure 5.4b.**

### b) Biological Measures :

The work plan formulated for re-vegetation of the muck disposal areas through various available biological measures, which includes:

- a) Formulation of appropriate blends of organic wastes and soil depending upon the quality of mucks to enhance the nutrient status of rhizosphere.
- b) Evaluation of spoil tips for their physical and chemical properties to ensure supportive and nutritive capacity.
- c) Screening and isolation of specialized strains of mycorrhizal fungi, rhizobium, azotobacter and phosphate solubizers (biofertilizer inoculum) in accordance with suitability for the spoil tips at the site.
- d) Mass culture of plant specific biofertilizer and mycorrhizal fungi. This is will be procured from different institutions/organizations, which are engaged in phytoremediation activity of degraded areas.
- e) Plantation of spoil tips under flat areas using identified blend and biofertilizer inoculum.



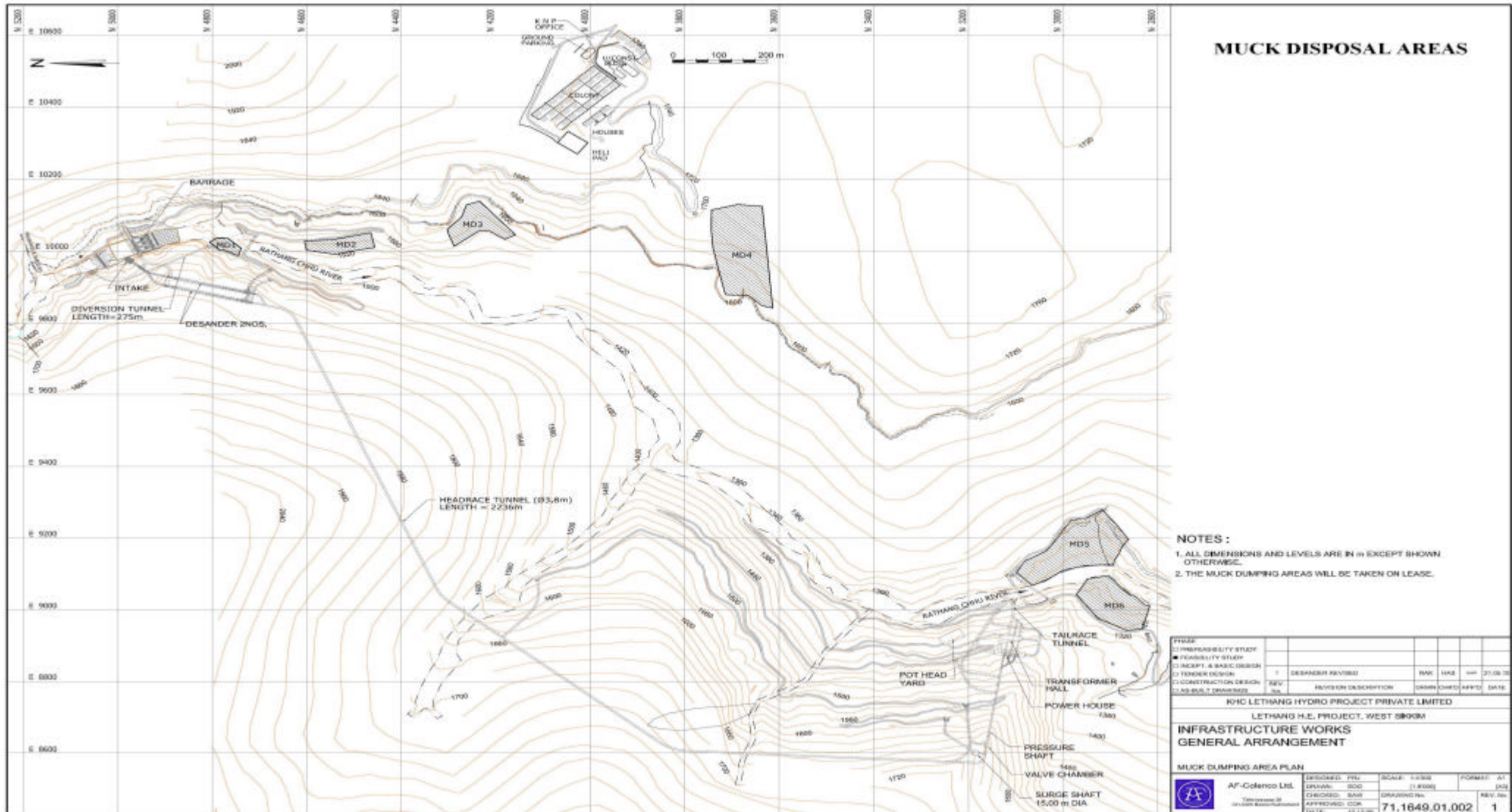
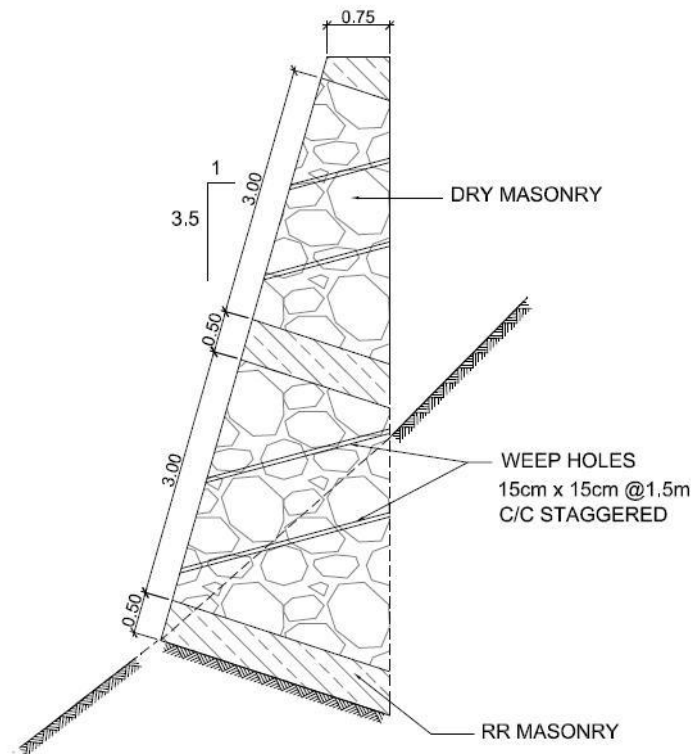


Figure 5.2: Muck Disposal Areas

**Table 5.7: Muck Dumping Cross Sections**

Muck Dumping Areas	Average Sectional Areas ( m <sup>2</sup> )	Sectional Area ( m <sup>2</sup> )		
		1	2	3
<b>UPSTREAM WORK</b>				
MD – 1	180	150	260	130
MD – 2	125	110	140	125
MD – 3	600	304	1206	290
MD – 4	1600			
<b>DOWNSTREAM WORK</b>				
MD – 5	950	490	890	1470
MD – 6	565	350	635	710



**Figure 5.3 : Retaining Wall Cross Section**

Proper dumping will be done over the designated dumping sites. The waste material dumped at spoil tips will comprise mainly of loose rock fragments that will be mechanically compacted and properly leveled with suitable safe slopes and retaining walls/crate walls will be constructed so that in no case the dumped material is washed away into the river. Construction material like stones, sand, etc. required for the construction of road will be obtained mostly from the excavated material to minimize the environmental damage. The efforts will be made to utilize maximum dumped material for the project activities and backfilling. In the streams, box culverts will be provided to prevent the erosion of stream bed.

- a. **Revegetation of Spoil tips:** After proper dumping of the muck all three dumping sites will be rejuvenated using bio-technological approach. The area will be restored through plantation and turfing on the slope.



- b. Soil Work and Plantation Technique :** Isolation and screening of specialised strains of mycorrhizal fungi, rhizobia, azotobacters and phosphate solubilizers (biofertilizer inoculum) in accordance with the suitability for the spoil tips will be done at site, based on following:
- (i) Periodical evaluation of rhizosphere development for physical, chemical and microbiological parameters.
  - (ii) Inoculation of plants with specific biofertilizers and mycorrhizal strains.
  - (iii) Monitoring of growth response in different plant species periodically and identification of corrective measures, if necessary.

Mass culture of plant specific biofertilizers and mycorrhizal fungi will be done. Plantation of saplings will be carried out in pits in plain area of spoil tips, using identified blend and biofertilizer inoculum. The pitting details are delineated in **Table 5.8** below:

**Table 5.8: Pitting for Plantation of Saplings**

Total No of pits	1600 per hectare
Size of each pit	60 cm x 60 cm x 60 cm
Spacing between pits	250 cm x 200 cm

The excavated material from the pits will be mixed with external soil, vegetable peels and farmyard manure, and some vermi-compost. The pit will be refilled with the mixture; mycorrhizal inoculum near the root system will be added. After this, plant saplings already inoculated with biofertilizers (Rhizobium and Azotobacter bacteria) will be planted and refilling will be done to cover the entire plant root system. Turfing (sodding) and suitable shrubs will be grown at slopes. About 6 cm of thick layer external soil will be spread on the slope area. Sod patches (40 cm x 20 cm) will be grown per square meter. Before sowing, the area will be properly amended with the manure.

**c. Species for Plantation:**

Afforestation with suitable plant species of high ecological and economic value and adaptable to local conditions will be undertaken at the rate of 1600 per hectare in accordance with canopy cover requirement. It is proposed that:

- a) Two percent of the total plant population will comprise horticulture plants and
- b) One site will be kept for other plantations depending upon its suitability.
- c) Development of Nursery.

The vegetative measures will be used for redevelopment of muck disposal areas. Plantation will be done extensively for slope stabilization. Plantation of grass species along with plants of *Alnus nepalensis*, *Shorea robust*, *Bombax malabarica*, *Albeizzia procera*, *Ailanthus grandis*, *Dendrocalmus hemiltonii*, *Terminalia chebula* etc. will be done.

**d. Irrigation Facilities**

Generally, forestation programme in the vicinity of forests is not supplemented with any irrigation methods and depends on rains. Trenches will be dug for facilitating irrigation.

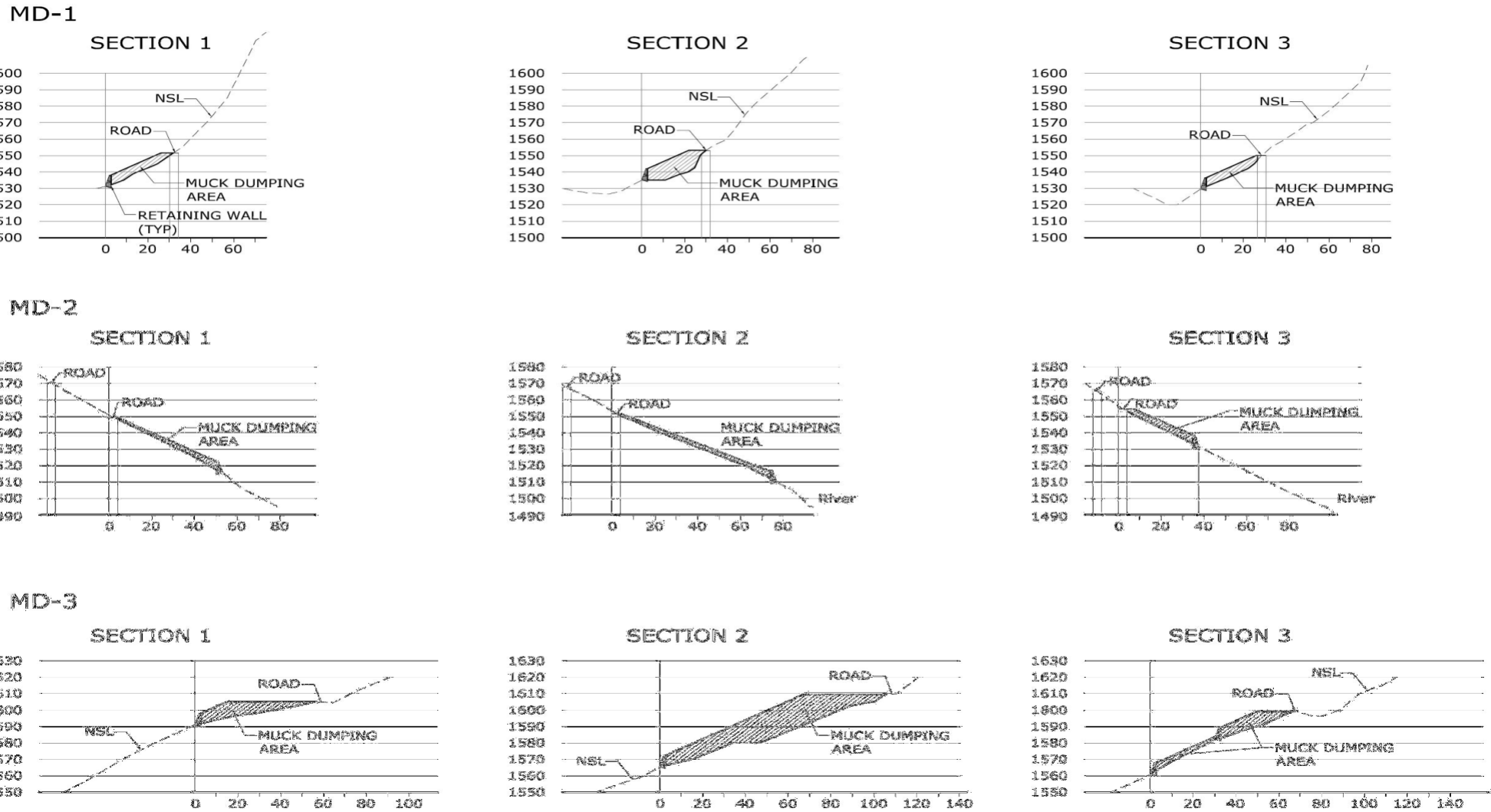
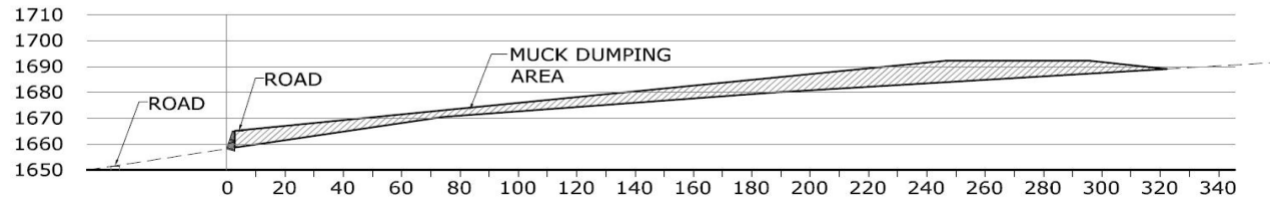


Fig 5.4 a): Muck Dumping Sections (MD1, MD2, MD3)

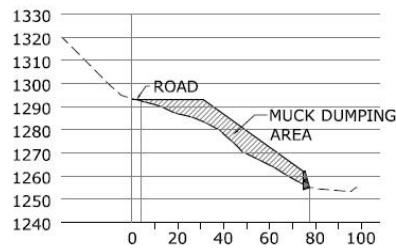
MD-4

SECTION 1

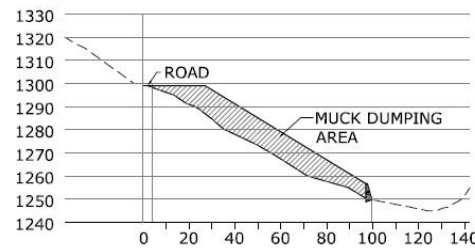


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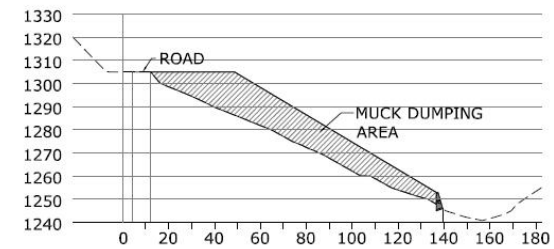
SECTION 1



SECTION 2



SECTION 3



MD-6

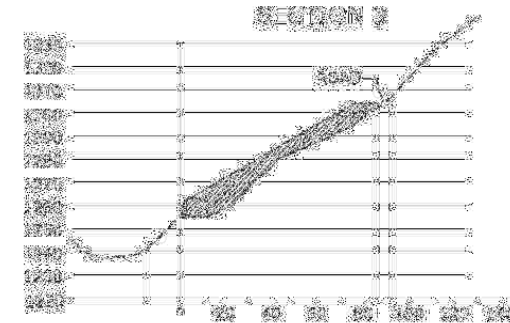
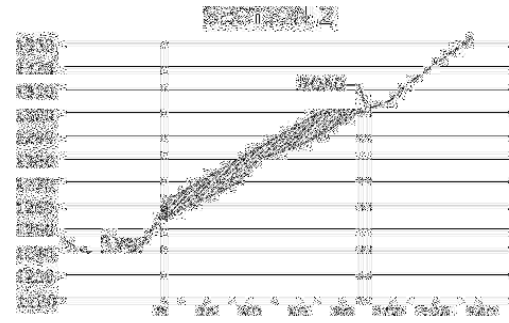
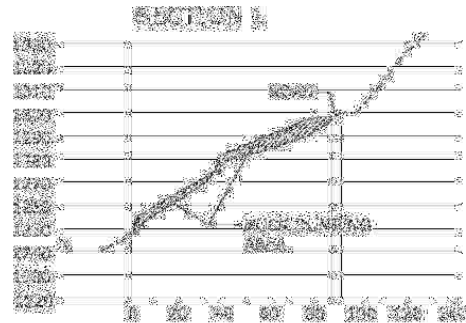


Fig 5.4 b): Muck Dumping Sections (MD4, MD5,MD6)

**e. Fencing**

All the sites will be properly fenced to protect the area from human and animals interference. Total about 2000 m. of fence will be required or all the sites.

**f. Watch and Ward**

It is proposed that five guards will be deployed for protection and maintenance of the sites for five years. The duties will include replacement of casualties, weeding, watering, repair of fence line etc.

For smooth implementation of Muck Disposal Plan following measures will be adopted:

- a) Selection of species having faster growth, and helpful in stabilizing the dump sites.
- b) Project authorities will ensure frequent meetings with the project team to enable smooth implementation of the Plan.

**Budget for Implementation of Muck Disposal Plan:**

The costs for the proposed scheme comprise capital investments, annual recurring and maintenance costs. Annual recurring costs include purchase of seed, manure, salary, wages, and miscellaneous expenditure. The unit costs are used to determine total cost. Recurring costs are determined based on annual basis. The details of estimated cost are given in **Table 5.9** below:

**Table 5.9: Budget for Muck Disposal Plan**

S.No.	Particulars	Capital (INR Lakh)	Working Costs (INR Lakh)
<b>Muck Disposal Measures</b>			
a)	Plantation on spoil tips including biofertilizers	15.00	-
b)	Turfing on slopes @ Rs.25,000 per ha taking into account 40 % of the total area of muck disposal i.e. 8.0750 ha (40 % = 3.23 ha) to be earmarked for turfing.	0.80	-
c)	Cost of Nursery Creation	5.00	-
d)	Fencing Costs for 2000 m (@ Rs. 250 /- per running meter	5.00	-
e)	Construction of Retaining Walls	0.00	-
f)	Maintenance for 5 years @ Rs. 100000 /- per year	-	5.00
<b>SUB - TOTAL</b>		<b>75.8</b>	<b>5.00</b>
<b>Salaries of Watch n Wards</b>			
g)	Watch & Wards	-	10.00
h)	Contingencies @ 10 % costs of muck disposal measures	-	7.58
<b>Total Costs</b>		<b>75.8</b>	<b>22.58</b>
<b>TOTAL BUDGETED COSTS - 98.38 Lakh</b>			

Therefore, total estimated costs for implementation of Muck Disposal Plan are **Rs. 98.38 Lakh**.

## 5.7 Reservoir Rim Treatment Plan

The construction of the barrage will result in creation of a small reservoir upstream of barrage. An area of about 0.844 ha will be submerged. The effects on the barrage and reservoir area due to geo-environment, impoundment, and other project related activities is assessed keeping in view the physiography, drainage pattern, slope aspect, land use/ land cover etc. in and around the reservoir. Accordingly, the 'Reservoir Rim Treatment Action Plan for protection of the Reservoir Rim is formulated. This is prepared to check the sedimentation in the reservoir caused by the loose debris on critical slopes, landslides etc. A generalized scheme of Reservoir Rim is adopted. Accordingly, a green belt is suggested, which will be kept in the immediate vicinity of the Reservoir Rim; wherever feasible taking into account the geomorphology, physiographic features, landuse/landcover and other related aspects. The width of the green belt will be minimum 500 m (slope length). Main objectives of this for Reservoir Rim Treatment Plan are:

- a) Prevent land degradation / soil erosion.
- b) Prevent the structure from subsidence and to provide stability.
- c) Augment the life on the reservoir by reducing siltation, and
- d) Stabilize the landslides and landslip zones around the reservoir.

### Remedial Measures

Development of a green belt around the reservoir periphery is suggested as remedial measures natural processes and anthropogenic activities envisaged during and after the project construction around the barrage site, The following measures are proposed for the green belt and related constructive activities

- a) Stabilisation of old landslide prone areas.
- b) Stabilisation of slopes adjoining the crushed zones
- c) River Training work of nallahs joining the reservoir at the tail end.

Following bioengineering and biological measures are suggested on the basis of topography, vegetation, soil types, climate and requirement of protection for the slides, structures:

#### a) Bioengineering measures:

- a) Retaining Walls
- b) Bunds with boulder crates
- c) Nallah Treatment/ Training Work
- d) R.R Masonary

All these bioengineering work are to be followed as per need at the specific sites and budgetary provisions for the purpose.

#### b) Biological Measures

Development of green belt of indigenous tree species is suggested under this measure. Other plant species, suitable for the area may also be planted as suggested in the CAT Plan. In addition to the suitable plantation as proposed in the CAT Plan, the mixed plantation with soil binding tree may be planted in the Reservoir Rim are given below:

- a) Plantation of Creepers/ Orchids/Ornamental Plants.
- b) Flowering Plants.
- c) Sowing and broadcasting of seeds.

## **Protection Measures:**

### **Fencing**

For protection of plants from human interference and grazing by cattle, it is proposed to fence all the open areas around the Reservoir Rim.

### **Budgetary Provisions for Reservoir Rim Treatment**

The costs of reservoir rim treatment including biological measures and bio engineering measures will cost about **INR 60 Lakh**.

## **5.8 Fisheries Conservation and Management Plan**

### **Introduction**

Due to the construction of barrage across the river will reduce the flow, which may lead to modification of natural habitat and obstruction in the way of fish movement. This necessitates development of a suitable fisheries management and conservation plan.

Mitigation measures suggested focusing on the fact that fish species like snow trouts i.e., *Schizopyge progastus* (Chuchay Asala), *Schizothorax richardisonni* (Dothay Asala) and *Garra annandalei* (Budune) are reported from the project stretch, which are most common fishes in the Rathang Chu. Investigation revealed that these species travel upstream mainly for breeding purposes, however no breeding grounds are found in the project stretch. Catch of *Garra annandalei* (Budune) is common in downstream near Dosthang village, where river take turn towards east near Ting Ting village but no fishing point is reported from project stretch.

Suggested Mitigation Measures are:

### **Construction Phase:**

- i) The construction work across the Rathang Chu will be restricted only in the lean season. Construction site, inside the river bed will be guarded to avoid the contamination of river water with construction materials. Construction debris will be collected and disposed to the designated disposal site away from river course.
- ii) Silt fencing will be constructed at the base of the embankment/ construction area near to river channel specifically at site of barrage and construction of access road adjacent to the river /nalla and around the stockpiles at the construction sites close to the any part of Rathang chu, Pau khola nalla, nalla 1 and nalla 2 or any other water channel to prevent the soil erosion thereby increase in turbidity and its adverse affect. The fencing will be provided prior to commencement of earthwork and continue till the stabilization of the embankment slopes, on the particular stretch particularly during the construction of access road to the barrage.
- iii) Any construction materials containing fine particles will be stored in an enclosure and away from water channel so that sediment-laden water does not drain into Rathang Chu or any nalla joining it, this will prevent localized turbidity.
- iv) Sedimentation cum grease traps will be constructed at the outer mouth of the drains of construction vehicle garage/ stop near the barrage, power house and any other construction site near to river or any natural nalla and will be provided with a lead channel minimum 1.5 m. before it enters into main water channels.



### Operation Phase:

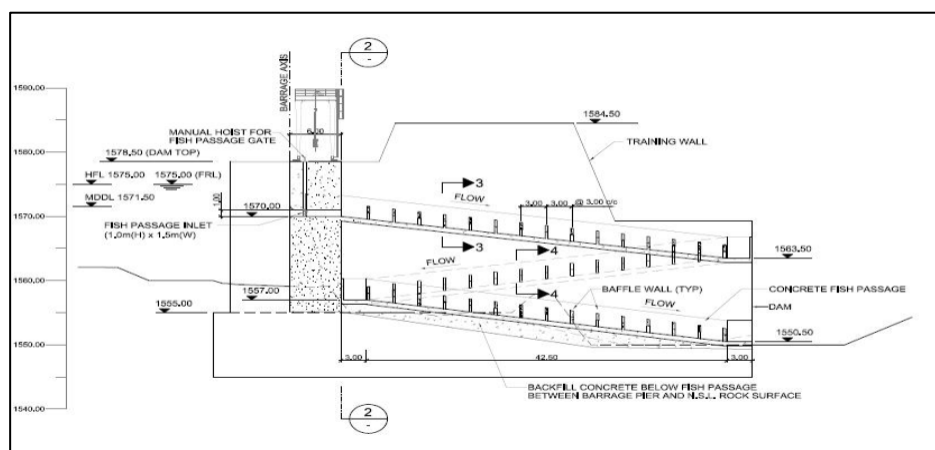
a) **Maintaining Environmental Flow:** The minimum environmental flow needed to sustain the existing ecological setup in the project affected stretch will be maintained through out the year. The measure of minimum environmental flow study is conducted by IIT Delhi along with EIA consultant using mathematical model considering existing hydrology and ecological aspects like species specific requirement of velocity, flow, depth etc. The minimal discharge for maintaining the environmental flow worked out by considering the species available in the project stretch is 1 m<sup>3</sup>/sec. However, two perennial nallas are joining Rathang Chu in this 2.5 km long project stretch, which also will supplement the discharge to certain extent and minimize the adverse impact. About 0.3 cumecs/sec of discharge from Nallah -1 and 0.03 cumecs/sec of discharge from Nallah -2 will be added up to the minimal discharge as computed by the study.

### b) Construction of Fish Ladder

Pool and weir type fish ladder is suggested along the end pier of right bank to facilitate the to and fro movement across the barrage. Details are described below:

- i) The fish ladder is of pool and weir type, a slot (1m X 1m) is also foreseen in each of baffle wall. The pool size is considered as 1.5(W) X 3.0(L), the baffle wall is of 2.00m height.
- ii) The ladder starts from downstream end of pier from EL 1550.50 m a.s.l will have two landing at EL 1557.00m a.s.l and 1563.50m a.s.l.
- iii) The inlet of fish passage will be in front of intake as water will always be in motion at front of intake.
- iv) The inlet will have a size of 1.0m (H) X 1.5m (W) the flow will be controlled by gate.
- v) The trash rack at intake will be guarded with fish screens.

The design of fish ladder is shown in **Figure 5.5**.



**Figure 5.5 : Fish Ladder**

### Enhancement/ Conservation Measures

The main objective of fisheries management is conservation of indigenous and threatened species as well as generation of employment opportunities for locals. Species, which are reported from the project stretch are *Schizopyge progastus* (Chuchay Asala), *Schizothorax richardsonni* (Dothay Asala), and *Garra annandalei* (Budune) are common native species of Himalayan region but these species are highly stressed, they are facing problem of habitat fragmentation and shrinkage due to rapid development of hydro power



projects as well as melting of glaciers at rapid pace. These species are prevailing in the lower temperature and comparatively fast current condition. These species are found in Rathang Chu waters in further down stream stretches (below Dosthang village) as per the interrogations with local fishermen and fisheries department. Hence, keeping in view of the above factors, the conservation measures for such indigenous species and sustenance of fishery following enhancement measures are suggested:

1. Development of Fish Farm including Trout Hatchery
2. Fish Stocking in Pondage area.

### 1. Development of Fish Farm including Trout Hatchery:

There is a great demand of fish in the area by the local people as well as Tourists. Main demand is of trout. At present about 14 no of licenses are issued to local fishermen. The construction of barrage across the river may have adverse impact even on down stream fish fauna. To supplement the natural fish stock in the river, supplementary stocking of trout in the up and down stream stretch of Rathang Chu is suggested. To have continuous supply of fish seed for this purpose a trout hatchery is proposed, which can be developed as hatchery cum production farm. This may be constructed and developed in Lethang or Yuksam village. The proposed farm will have a hatchery unit consisting hatching channel, each channel will have 4-5 hatching trays; cemented nursery tanks, cemented rearing tanks, cemented stock race ways, storage tanks and other associated infrastructures like, office room, lab room, material storage rooms, generator, water pump and accessories like dragnet, hand net, happa, bucket, food trays, and trays for handling of fish seeds.

A hatchery of indigenous species of snow trout *Schizothorax spp.* and the exotic trout *Salmo trutta fario* (Brown trout, as it is successfully reared, breed and stocked in upper reaches of many Himalyan river and reservoirs) are suggested to develop for stocking in pondage area and for river ranching.

### 2. Fish Stocking in Pondage Area and River Ranching :

Construction of barrage area will inundate 0.844 ha of area, which will create a reservoir of 23.5 m dip. This pondage area may be stocked with fish. The fingerlings produced in the proposed hatchery thus will provide continuous supply for such stock. It is proposed to stock the fingerlings size fish (above 30 mm size) @ 1000 -2000 /ha both indigenous and exotic *spp.* in the pondage area. Beside this, it is also suggested to release fingerlings size (above 30 mm) fish mainly indigenous sp. @ 1000- 1500 /ha in the down stream stretches of Rathang Chu. The excess seed produced in house in the hatchery may be reared in rearing tanks of proposed farm/ hatchery and can be sold to the locals for their consumptions and also can be supplied to the tourists' hotels. This will also help in revenue generation for self sufficiency of the proposed hatchery-farm.

### Budget for Fisheries Conservation:

The budgetary provisions for Fisheries Conservation and Management Plan are delineated in **Table 5.10** below:

**Table 5.10: Budget for Fisheries Conservation and Management**

S.No	Particulars	Quantity	Amount (INR Lakh)
<b>A) Capital Costs</b>			
1.	Nursery Tanks @ size : 3m x 0.75m x 0.5 m	7	2,50,000 /-
2.	Rearing Tanks @ size : 10m x 1.5m x 1 m	7	5,00,000 /-
3.	Hatching Trenches 2m x 0.5m x 5 m x 4 trays	15	3,50,000 /-
4.	Race Ways (Stocking Tanks)	2	5,00,000 /-

	@ size : 30m x 6m x 1.5 m		
5.	Storage Tanks @ size : 4m x 4m	2	2,50,000 /-
6.	Other miscellaneous accessories i.e happa, casnet, trays, buckets, mug etc.	-	2,00,000 /-
7.	Infrastructure for Office and Storage Room	-	8,00,000 /-
8.	Pumps	2	1,00,000 /-
9.	Vehicle	2	8,50,000 /-
10.	Generators	2	12,00,000 /-
<b>Total Capital Cost</b>			<b>50,00,000 /-</b>
<b>B) Working Costs</b>			
1.	Salary & Wages		
	Fisheries Inspector @ Rs. 25,000 /- per month	1	3,00,000 /-
	Fisheries Assis tant @ Rs. 15,000 /- per month	1	1,80,000 /-
	Fisheries Attendant @ Rs. 10,000 /- per month	1	1,00,000 /-
	Fisheries Guard @ Rs. 8,000 /- per month	1	1,00,000 /-
2.	Brooder Fish	200 Kg	4,00,000 /-
3.	Fish Food	Lumpsum	1,50,000 /-
4.	Fertilizer, manure, lime and medicine	Lumpsum	3,00,000 /-
5.	Electricity and other maintenance charges including vehicle maintenance and running costs	Lumpsum	1,00,000 /-
6.	Training to fisheries staff	Lumpsum	50,000 /-
7.	Contingency Measures	Lumpsum	50,000 /-
<b>Total Annual Costs</b>			<b>17,30,000 /-</b>
<b>Total Annual Cost @ 10 % escalation for 4 years</b>			
<b>1 year</b>			17,30,000/-
<b>2 year</b>			19,03,000 /-
<b>3 year</b>			20,93,300 /-
<b>4 year</b>			23,02,630 /-
<b>Total Working Cost after escalation @ 10 %</b>			<b>80,28,930 /-</b>

The total capital costs for fisheries conservation and management plan is estimated as **INR 50.00 Lakh** and the working cost is estimated as **INR 80 Lakh** for four years. The total budget costs of **INR 135 Lakh** is earmarked for fisheries conservation and management. The construction and maintenance costs for fish ladder are included in civil costs.

## 5.9 Mitigation of Impacts – Construction Phase

The mitigation measures aimed to mitigate and manage the construction induced impacts are categorized following headings and each of these groups of actions is described in the following sub-sections:

- Landslide Treatment
- Erosion and sediment control measures
- Quality management measures
- Water quality management and monitoring measures

- e) Chemical disaster/ spillage management measures
- f) Emergency measures for hazardous materials
- g) Emissions and dust control measures
- h) Noise control measures
- i) Enhancement measures for physical cultural resources
- j) Landscaping and re-vegetation measures
- k) Vegetation clearing measures
- l) Environmental training for construction workers
- m) On-site traffic and access management measures
- n) Site hygiene measures for construction work camps and resettlement areas

### 5.9.1 Landslide Treatment

The proposed project area is influenced by several landslide prone areas, therefore it becomes imperative to adopt certain engineering measures to avoid any landslides during operational phase of the project. Following practices are suggested for the contractor to adopt for treatment of potential landslides prone area falling in the project area:

- a) Construction of retaining walls structure using boulders with a steel wire along the landslides dominant areas.
- b) Soil mulching method, which includes covering the surface layer of soil with mulches of leaves, stubbles, straw etc. this prevents the organic top layer being washed away by rainfall. Mulches decay afterwards due to the microbial activities, which enhance the organic content of soil and also help in the retention of moisture in soil.
- c) Contour bunding by constructing earthen embankments at intervals across the slope and along the contour line of the many landslide areas. Such bund is useful in dividing the area into strips and act as barrier to the flow of water. As a result the amount and velocity of run-off are reduced, resulting reducing the soil erosion. This will be done where soil is fairly permeable and slope is not too steep. These are also called as level terraces, absorption type terrace or ridge type terrace.
- d) Contour trenching - constructing a series of deep pits (two feet wide and one feet deep) or trenches across the slope at convenient distance within the landslide prone area. The excavated soil will be deposited on the lower edges of the trenches where forest trees are planted.
- e) Channel terrace - construction of wide but willow channels across the slopes of the landslides either exactly on contour line or with a slight grade. The excavated soil will be deposited on the lower edges of the trenches where forest trees are planted.
- f) Bench terracing method to cover and level relatively steep land running across the slopes. The soil material that are excavated from the upper part of the terrace are used in filling the lower part and a small bund is also raised along the outer edge of the terrace to check the downward flow of rainwater and also soil erosion.
- g) Bally Benching: The landslides and mass movement of earth in some places are common features in and around the KNP and buffer zone, so to stabilize these areas bally benching in a staggered manner across the slopes will control the sliding soil and stone. The bally will be of *Erithrina indica*, *Viburnum*, *Kadam*, *bamboo rhizomes* etc. which will grow from bally itself and resultantly area will have green cover within 2 -3 years. Further, the space left in between the bally benching can be used for the plantation of soil binding species of fodder trees like *Ficus spp*, *Viverrnum spp* etc.

## 5.9.2 Erosion and Sediment Control

There is the possibility of site erosion and sedimentation of downstream waterways, if the site activities are not carefully managed. Erosion and sedimentation will be controlled during the construction of the work. Areas of the site not disturbed by the construction activities will be maintained in their existing condition. A principal effort at the construction areas will be management of erosion of excavated surfaces especially during the wet season when the volume of the runoff is expected to be high. Contractors will prepare an Environmental Monitoring and Management Plan that will include environmental management and pollution control techniques for all these areas of activity including drainage measures for underground work.

The Contractor will prepare an erosion and sediment control plan in conjunction with the contractor's Environmental Monitoring and Management Plan which will be prepared in accordance with the Landscaping and Re-vegetation Plan. It will detail all site-specific measures the contractor will implement during the construction phase to prevent an increase in pollution loads being exported from the site. It will cover site drainage, especially related to storm water management. In particular it will include:

- a) An assessment of the potential for water pollutants to be generated.
- b) Measures to be taken to collect, store and treat storm water prior to any discharges from the site, (considering options for water re-use on site)
- c) Management of material storage areas, including raw materials, chemicals, fuels, and oils;
- d) Measures to prevent litter entering water courses and details of permanent pollutant treatment measures or other water pollution control devices proposed for the operational stage
- e) Identification of any significant effects on hydrological condition and appropriate hydrological studies;
- f) An inspection and maintenance program to maintain the effectiveness of erosion and sediment control measures

Examples of activities, requirements, and practices that will be included in the contractor's Environmental Monitoring and Management Plan include the following:

- a) Maintenance of areas within the construction areas not disturbed by construction activities in their existing conditions.
- b) Soil erosion and sediment control practices, which will be implemented prior to any major soil disturbance, or in their proper sequence, and maintained until permanent protection is established. Only approved areas due for construction activity according to the programme will be cleared of vegetation and topsoil in accordance with sub-section on vegetation clearance
- c) Prior to wet season, implementation of appropriate measures by the contractor to ensure that erosion is minimized from work where the permanent drainage and erosion control measures, if any, are completed.
- d) Disposal of materials excavated by the contractor from open and underground excavation, which are unsuitable for incorporation into the permanent work or are surplus to such requirements, as spoil dumps in the spoil disposal areas. Materials suitable for roads, saddle damage, slope protection, resettlement area fills etc. will be stockpiled separately from spoil disposal areas, at agreed locations for later use.
- e) Stockpiling separately the soil excavated during construction. These soils will be used for landscaping and restoration of work areas. All stockpiles and spoil dumps will be constructed and stabilized, including provision of drainage and erosion control measures in accordance with the Landscaping and Re-vegetation Plan. The height of stockpiles and spoil dumps in spoil disposal areas will be limited to 3 m. for topsoil and materials for future use. The height of spoil dumps will be determined by the locations occupied, but generally will be not more than 6m, with a 2m berm at 3m. Topsoil stockpiles will be deep ripped to provide for moisture

retention and re-growth. Drainage and erosion from the stockpiles will be controlled by locating them in areas away from drainage lines. The erosion of the base of the dump will be prevented by providing a silt fence to contain any sediment in any runoff resulting from stockpile or spoil dump

- f) Stockpiles and spoil disposal areas will not be located on drainage lines or in floodway zones or other areas important for the conveyance of floodwaters during major floods. Flooded area behind spoil disposal areas will be allowed to drain to the downstream channel.
- g) Plans for water management during construction in accordance with the best practices, and include development of drainage work, sediment traps, diversion, culverts and other structures designed to treat water to the water quality requirements of this Sub Section and Water Quality Management Plan before discharge into natural watercourses. All these structure will be constructed progressively prior to commencement of construction work and areas will be directed to the sediment settling areas.
- h) Regular inspection of damage caused by scouring, sediment deposition, channel obstruction, and loss of vegetation cover as the drainage work may direct site runoff to established watercourses. Establishing non-erodible segments along the slope lengths. These outlets will be located along the natural drainage lines.
- i) Control of sedimentation, which will be implemented in the form of silt trap fences and sedimentation ponds where appropriate depending upon the size of the catchment, and other physical and environmental constraints. The silt trap fences will control flows along minor drainage lines, whereas the sedimentation ponds will be utilized for removing sediment-laden runoff from the construction areas. These will be built prior to the start of the activity and will be maintained until the completion of that activity. The ponds will be designed in accordance with the best practices.

### **5.9.3 Quarry and Borrow Area Management**

According to the DPR, coarse aggregate and stones will be quarried from nearby the riverbeds of Rathang Chu and by crushing available boulder. Also, a part of the sand will be quarried from the riverbeds. Therefore, during construction there is potential for noise, dust and sedimentation of waterways, and increased traffic hazards, if the development and operation are not carefully managed. Suitable mitigation and closure measures will be adopted for management of these sites.

The requirements of considerations and specifications for the use of quarry and borrow areas will be incorporated into the construction contracts.

The contractor will be responsible for use of the quarries and borrow areas in accordance with the provisions of the EMP. KHC will ensure that the specifications are incorporated into the construction contracts. KHC will develop a monitoring program to ensure that the operations are in accordance with the requirements of quarry management.

The contractor will have the right to quarry construction materials such as soil, sandstone, limestone, stone, sand, gravel and any other materials from the quarry areas subject to the requirements of the EMP and the conditions of contract.

The contractor will prepare an overall Quarry Management Plan for the total work in conjunction with the contractor's Environmental and Management Plan.

At least three months prior to commencing any activities in a particular quarry area, the contractor will submit a separate Quarry Management Plan to KHC for no-objection for the proposed quarrying activities. The Plans will include the following consideration:

- a) An assessment of the following impacts at all quarry sites will be identified and assessed for their magnitude and importance:
  - (i) Erosion and sedimentation
  - (ii) Road damage
  - (iii) Spoil and other wastes generation
  - (iv) Noise and dust generation.
- b) A plan showing the extent of the area to be developed.
- c) A method statement defining the proposed working method.
- d) The proposed access and haulage routes between the quarry and the destination for the extracted material.
- e) A justification for the quantities of material to be extracted, an estimate of the waste materials to be generated and disposal details for such waste materials.
- f) Details of the measures taken to minimize the quarry area and its visual impact on the surrounding area.
- g) Measures recommended minimizing the significance of each identified impact.

The plan will also describe details of the measures to be taken for the long-term rehabilitation of the quarry and borrow workings. These will include re-establishment of vegetation, restoration of natural courses, avoidance of flooding of the excavated area wherever possible, achievement of stable slopes, and avoidance of features which will otherwise constitute a risk to health and safety or a source of environmental pollution.

Where the excavated quarry and borrow areas cannot be reasonably drained, the contractor will minimize their number and consult with the local population as to that population's preferences for their location for reuse or other community purposes.

Quarry faces and excavations will be made safe and buildings, plant, equipment and debris and miscellaneous stockpiles of material will be removed from the areas

Materials, other than waste materials, extracted from quarrying operations will be used exclusively for the construction work.

#### **5.9.4 Water Quality Monitoring**

Construction activities may impact water quality in areas downstream of the construction activity. KHC will monitor water quality in Rathang Chu, and some of the tributaries. KHC's water quality program will start before the main civil work contract is initiated to determine baseline conditions in Rathang Chu. The information obtained during this period will be used to improve the water quality modelling and to compare water quality conditions during construction and operation of the project. The monitoring program will assess whether KHC is fulfilling its goal of beneficial use of water within the project area.

KHC will be responsible for implementing the water quality monitoring program from the pre-construction phase through construction and the operating period. The water quality monitoring plan will be designed to monitor the effects of surface water runoff from areas disturbed by all construction related activities.

KHC will prepare a Water Quality Monitoring Plan. The Water Quality Monitoring Plan will be designed to monitor the effects of surface water runoff from areas disturbed by all construction related activities. The plan will include the following:



- a) Detailed plans regarding monitoring the effects of surface water runoff from all construction areas, including cleared land, roads, construction camps, quarry areas, which may affect water quality in natural waterways. The plans will include the locations of the sampling water in waterways upstream and downstream of the entry points of the surface water runoff from the construction areas. The frequency and method of testing will be in accordance with internationally recognized standards.
- b) The contractor will ensure all construction related activities will not pollute waterways, in accordance with application standards. The Water Quality Monitoring Plan will include the applicable standards for water quality parameters.
- c) The water quality monitoring program will also monitor the quality of potable water supplied to the construction work camps, work sites.

As and when any water quality impact is identified, KHC will take immediate actions to control pollution of water, including provision of all corrective measures at site.

### **Management of Water Quality, Chemical Disaster and Spillage**

During construction phase there will be possibilities of the pollution of adjacent habitat areas and downstream waterways, if the site activities are not carefully managed. KHC will strive to reduce the potential impacts to surface water and ground water within the vicinity of the construction areas. This includes waste water management and discharges from the construction areas.

Construction camps will be equipped with waste water treatment facilities to prevent adverse impacts to the surrounding water bodies. To ensure that the waste water treatment facilities at each camp are effective, KHC will implement a water quality monitoring programme, as described in sub-section above.

Responsibility for providing waste water treatment facilities at the construction camps will be the construction contractors. KHC will be responsible for monitoring of the waste water treatment facilities.

The contractor will prepare a Chemical Waste/Spillage Management Plan. The Plan will include proposed actions for the following situations, and any other situations that could involve similar products:

- a) All refuelling of heavy equipment and machinery will be undertaken with appropriate safeguards and protection measures to prevent any spillage or contamination by chemical wastes or maintenance oils, lubricants etc.
- b) All fuel and hazardous material storage will be adequately banded to prevent any spillage problems
- c) Storm water runoff from open workshop servicing and repair areas and banded storage areas will be collected and treated before discharge to drains or waterways
- d) Suitable sanitary sewage and solid waste disposal facilities or systems will be provided at all long term work sites, workshops stores and offices; all explosives will be transported, stored and handled in accordance with the applicable laws and good design engineering, and construction practice. The contractor will provide details of proposed storage and security arrangements.

### **5.9.5 Emergency Measures for Hazardous Materials**

During construction there will be a potential for the pollution of adjacent habitat areas and downstream waterways if site activities are not carefully managed, and there is uncontrolled disposal and/or leaching of hazardous chemicals. KHC will minimize the potential for impacts associated with chemical wastes and spills of oil, diesel and grease from the construction area.



The contractor will be responsible for the preparation of the chemical waste and spillage management plan which will be approved and monitored by KHC. This plan will incorporate measures and processes to handle situations resulting from accidental spills of hazardous materials, including chemicals and hydrocarbons or other similar incidents.

KHC will be informed immediately of any accidental spill or incident in accordance with the plan and the contractor will immediately initiate remedial action.

This plan will be coordinated with the Disaster Management Plan, and will include provision of trained personnel, specialized plant and equipment, and defined and approved treatment and disposal methods for the known range of hazardous materials.

The contractor will subsequently provide a report detailing the reason for the spill or incident, remediation action taken, consequences/ damage from the spill, and proposed corrective actions.

The Emergency Plan for Hazardous Materials will be subsequently updated and submitted to KHC for no objection, every time such an accidental spill happens.

### **5.9.6 Emissions and Dust Control**

Fugitive dust from the site disturbances and emissions from the vehicles and plant have the potential to negatively affect air quality in the vicinity of the construction sites and access roads.

KHC will minimize emissions from vehicles and equipment used for construction activities and minimizes fugitive dust from construction areas and from unpaved roads within the construction areas.

Responsibility for incorporating specifications for regular maintenance of vehicles and equipment used will be with construction contractor. KHC will review the contracts to ensure that these specifications are incorporated. The contractor will also prepare an Emissions and Dust Control Plan. KHC will develop a monitoring program to ensure that specifications within the construction contracts are respected.

The contractor's Emissions and Dust Control Plan will include the following:

- a) Proposed methods and action to control dust resulting from construction related activities, including quarry sites, crushing and concrete batching plants, earthwork including road construction, embankments and channel construction, haulage of materials and construction work camps. As a minimum, dust will be controlled by water spraying or any other similar measures. These are to be applied as necessary to reduce to a minimum the spread of dust from unsealed construction roads and public roads when construction equipment is active, in areas of major earth excavation, and any other areas, which produces dust.
- b) The exhaust gases from the construction machinery and vehicles are accepted. However the engines will be inspected and adjusted as required to minimize pollution levels.
- c) The emission and dust control plan will include an Indian air quality standard 2009 which will be applied to designing, monitoring and controlling air quality/ pollution in the underground work.

For all underground work, for all activities and type of material excavated, the contractor will install mechanical/ forced ventilation systems which will provide air pollution concentration that comply with the requirements of the Indian air quality standard included in this sub plan. When internal combustion engines are operated in the underground work only diesel engines will be used.

The burning of waste and/or garbage will be done in designated areas at a distance of at least two kilometres downwind from the nearby villages and in accordance with applicable law and the contractor's

Environmental Monitoring and Management Plan. Burning of any material which produces toxic gases will not be allowed.

### 5.9.7 Noise Control Mitigation Plan

Noise Pollution can be mitigated at source itself. The ambient noise levels expected to increase gradually upto 1000 m. from the major construction sites. During construction, major sources of noise pollution will be movement of vehicles, blasting and drilling operations, concreting and mixing. Construction activities are expected to produce noise levels in the range of 80 – 130 dB (A), which will decrease gradually with increase in distance from source. During excavation, cutting of rocks, crushing, loading and transportation activities, the noise generated will be in the range of 90 – 130 dB (A), if all the above activities are carried out simultaneously. The expected noise levels during operation of construction machinery at site are presented in **Table 5.11**

**Table 5.11: Noise levels of construction equipments**

S.No.	Machine	Noise Level in dB(A)
1.	Drilling Machine	120 – 130
2.	Motor Scraper	85 – 95
3.	Face Shovel	80 – 90
4.	Dumping Trucks	80 – 90
5.	Compactors	81 – 85
6.	Dozers	80 – 85
7.	DG set	80 – 110
8.	Pumps	80 – 100
9.	Grouting machine	100 – 120

Humans can tolerate noise levels upto 60 – 65 dB(A) without any hearing damages. The silence zone noise levels are 10 – 40 dB(A) in addition to the baseline noise. Higher levels in the range of 100 dB(A) and above are susceptible to cause high risks of heart attacks, annoyance, anxiety, high blood pressure and hearing loss. However, studies reveal that harmful effects of noise levels on wild animals and birds are very few. Since, the project area is surrounded by forest cover, vegetation cover will act as a potential noise absorber to some extent. During the blasting activities, the noise levels may exceed above the critical limits, however, the activity is proposed to be regulated and scheduled considering the potential impact on animal behaviour. Also, the noise generated due to blasting activities can be reduced to some extent using electronic detonators and by adopting controlled blasting regime under strict and constant surveillance conditions. The other measures to control noise will be as follows:

- a) Regular maintenance of equipments and machineries to keep the noise generation at the designed level.
- b) High noise generating machines will be equipped/fitted with silencers to reduce the noise levels.
- c) The equipments that need to be placed still like generators will be kept under isolation using some enclosing structures to cut off noise levels.
- d) Heavy equipments like rotating or impacting machines will be damped by mounting them on anti-vibrations mountings.
- e) Only well maintained and new equipments that produce lesser noise than the old one will be installed at work sites.
- f) During the vegetation clearing process, the KHC will ensure that the working areas will be covered sufficient layers of trees around the periphery of working site, as these will act as effective noise absorbers.

- g) Effective traffic management will be undertaken to avoid significant delays and accumulation of noise levels in and around the project area. Necessary training/ orientation will be provided to the traffic operators/ drivers to make them aware of the environmental aspects of the traffic movement in the forest areas. Sounding of loud horns, etc. in the forested areas will be banned.
- h) It will be responsibility of KHC to monitor the noise at critical sites from time to time under the Environmental Monitoring Programme. The maximum exposure period specified by OSHA is tabulated in **Table 5.12**. The budget for noise monitoring is given in Chapter 6 – Environmental Monitoring Programme.

**Table 5.12: Maximum Exposure Periods Specified by OSHA**

Maximum Equivalent Continuous Noise level db (A)	Unprotected Exposure Period Per Day for hrs/ day and 5 days/ week
90	8
95	4
100	2
110	1/2
120	1/4
<b>No exposure permitted at or above this level</b>	

### 5.9.8 Enhancement and Conservation of Physical Cultural Properties

There is no physical cultural resource, including items having archaeological, historical, religious, sacred and or unique nature values such monument or structure is present near the actual project site.

Prior to commencement of work by the contractor in any portion of the construction areas, KHC will have:

- a) Completed a physical cultural resources survey for the particular portion of the construction area.
- b) Informed the contractor of any known objects and sites of physical cultural resources within the particular portion of the construction area.
- c) In accordance with conditions of the contract, required actions to be implemented by the contractor for any such known objects and sites of physical cultural resources.

To ensure the proper management action following management plan is suggested.

1. The contractor will prepare a physical cultural resources conservation plan for dealing with any chance found objects and sites of physical cultural resources notified by KHC or encountered by the contractor within the construction area in construction period. Such physical cultural resources plan will include proposed methodologies for:
  - a. Documentation and identification of any location of any objects or sites of physical cultural resources notified by KHC or encountered by the contractor within the construction areas.
  - b. Notification to the construction workforce of the need to be vigilant in the detection and reporting of, and the prevention of disturbance and damage to, objects and sites of physical cultural resources.
  - c. Notifications to KHC of any objects or sites of physical cultural resources encountered by the contractor within the construction areas.
2. Stopping work and securing the area adjacent to the objects and sites of physical cultural resources to prevent damage to such objects and sites.
3. KHC in coordination and consultations with Government Authorities, will be responsible for the appropriate overall management, protection and preservation of all objects and sites of physical cultural resources encountered within the construction area and will, in accordance with the conditions

of contract, instruct the contractor on the actions to be taken by the contractor in relation to avoiding or minimizing disturbance and damage to such objects and sites of physical cultural resources, including:

- a. Protection and preservation measures are to be taken by the contractor
  - b. Additional mitigation, management, notification and reporting measures are to be taken by the contractor to enable the construction activities to proceed
  - c. Changes to the work and the construction methods, if any, required to be taken by the contractor.
4. Additionally, KHC will retain the support of the Archaeological Survey of India, Sikkim office to periodically inspect the site, and the physical cultural properties identified by the survey, to verify that these properties are not damaged, and are being protected adequately. The experts from the Archaeological Survey of India, Sikkim office will also advise on the enhancement and protection measures that might be required from time to time.

#### **Archaeological Chance Found Procedure:**

Sites and properties that are buried or not identified by the survey undertaken by KHC may be discovered during project implementation, especially in the course of construction or excavation. Such unanticipated discoveries of remains of an archaeological and/or historical nature are termed archaeological chance finds. Most often they are concentrations of pottery, worked stone, and human and animal bones, without commercial value, but of significance to archaeologists, historians, anthropologists, and palaeontologists.

The following archaeological chance find procedures will be adopted in project design and construction contracts:

- a) The responsibility for preservation, maintenance and assessment of historical and cultural monuments rests with the Department of Archaeology, Government of Sikkim, and in specific cases, with the Archaeological Survey of India.
- b) Whenever chance finds of cultural or historical artefacts (moveable and immovable) are made the Department of Archaeology, Government of Sikkim, and the Archaeological Survey of India will be informed. Will the continuation of work endanger the historical and cultural artefacts, the project work will be suspended until a solution is found for the preservation of these artefacts, or advice from the Archaeological Survey of India is obtained.
- c) Contractors, employees of the contractors and all project employees will be responsible for informing the project director immediately after discovery of the chance find, without any judgment on their own on the value of the chance find. The project director will be responsible to inform the Department of Archaeology, Government of Uttarakhand, and the Archaeological Survey of India, Gangtok office, within 48 hours of such discovery.
- d) The Project Director will request for a representative of the Department of Archaeology, Government of Sikkim, and/or the Archaeological Survey of India, Gangtok office to make a site inspection.
- e) Project Director will order cessation of work in the vicinity of the chance find until the visit of a representative (usually required within 48-72 hours of notification); and follow the advice by the Department of Archaeology, Government of Sikkim, and/or the Archaeological Survey of India on possible salvage or excavation (usually required within 48-72 hours of notification).
- f) Failure to report a chance find within the 48 hours of discovery, is a punishable offence under the relevant Indian legislation. Similarly, (intentional) damage to historical or cultural artefacts is a punishable offence.

KHC will also seek the support of the Archaeological Survey of India, Gangtok Office to periodically inspect the sites of construction, excavation and muck disposal to detect any chance finds.

### 5.9.9 Landscaping and Re-Vegetation

The contractor will prepare a Landscaping and Re-Vegetation Plan that includes measures for restoration of cleared areas, quarries which are no longer in use, spoil areas, haulage roads, construction camp areas, borrow areas, stockpile areas, working platforms and any areas temporarily occupied during construction. The measures will include landscaping, provision of adequate drainage and re-vegetation.

All areas disturbed by construction activity, including temporary access roads and tracks, will be landscaped to reflect natural contours, restore suitable drainage paths and encourage the reestablishment of vegetation.

The construction of approach roads, project colony, labour camps etc. will hamper the existing aesthetic view of the area and will also cause disturbance to the area due to increase in population and traffic movement. The landscaping and re-vegetation of the areas will be done; so that the natural surroundings and the aesthetic look of the area are restituted. Prior to initiation of quarrying activities and other constructional activities. The restoration will depend on the topography of the area, type of construction activities and their detrimental effects on the terrain and the natural habitats. A total budget of **INR 65 Lakh** is proposed for restoration and landscaping of the project area. For this the following enhancement measures are suggested:

- i) **Drainage system for diversion of run-off:** An effective drainage system will be provided for avoiding infiltration of run-off water into quarry sites and also to avoid its erosion in future.
- j) **Filling up of Depressions:** The existing quarry sites will result in formation of craters/depressions due to different construction work. These depressions will be filled up by the dumping materials comprising of rocks, boulders, gravels and soil from nearby project sites.
- k) **Development of Orchid Gardens:** A rock garden will be developed, which will have the orchids and other ornamental plants with the landscaping matching with the surroundings as an additional attraction for tourists and as well as the locals. The orchids such as *Chiloschista usneoides*, *Cymbidium irridiodes*, *Dendrobium chrysanthum*, *Cypripedium himalaicum rolfe*, *Cymbidium eburneum lindley*, *Dendrobium candidum*, *Dendrobium densiflorum* etc. will be planted.
- l) **Creation of Scenic Observatory:** Certain locations will be developed as a scenic beauty observatory spots, which will compensate the disturbance caused due to the construction of project components. Location, for example, Lethang Bridge, helipad point or any other site from where scenic view can be observed. These spot will have a slab type extension /above ground reinforced structure along with ladder and shed. This will be guarded by iron fencing and decorated with potted plants, i.e., orchids, ferns and creepers and flowering herbs.
- m) **Landscaping:** Appropriate sites along the newly developed access road, Muck dumping area, and quarry area will be stabilized by constructing a series of benches. The wall to be developed for providing the adequate slope will be embedded with local stones to integrate and enhance the aesthetic look of the area. The area will be enhanced with plantation of trees, shrubs, herbs and creepers found in surrounding.

Spoil heaps and excavated slopes will be re-profiled to stable batters and grassed to prevent erosion. Topsoil stripped from the areas occupied by the spoil heaps will be used for landscaping work. Re-establishment of vegetation will be commenced at the earliest possible opportunity. Appropriate local species of vegetation will be used.

Local depressions created by construction activities will be either backfilled or drained to prevent ponding possible. Where the local depressions cannot be reasonably drained, the contractor will minimize their number and consult with the local populations as to that population's preference for their location for reuse for fish forming or other community purposes.



All hazardous materials construction plant and waste will be removed from site and safely disposed of in an environmentally acceptable manner. Reusable construction materials will be either removed from site or, with the approval of the KHC, left in a secure manner such that they do not constitute a risk to health and safety or a source of environmental damage.

Watercourses, if any, which are temporarily diverted by the construction activities, will be restored to their former flow paths.

### **Vegetation Clearing**

During construction there will be a potential for areas to be cleared in excess of real requirements, and insufficient consideration given to retaining vegetation. KHC will minimize vegetation clearing for construction activities and control erosion and sedimentation from the disturbed areas. All such additional clearance will be subject to the approval of the State Forest Department, if the land is designated as forest land, or if the land supports forests.

All land and forest vegetation clearing activities will be carried out according to a site plan, which enforces the minimization of vegetation disturbance. Additionally, specification for control of erosion of sediments will be detailed in the Erosion and Sediment Control Plan.

The contractor will include specifications for the removal of vegetation from the construction areas and specifications for management of runoff from the disturbed areas during the construction phase. These specifications will be incorporated into the construction contracts. KHC will be responsible for ensuring the compliance of the construction contractors. KHC will also inspect the construction areas at the end of the construction phase to ensure that the areas are stabilized before the construction contractor can vacate the area.

At the end of the construction period, the disturbed areas will be inspected to ensure that the areas are re-graded to conform to the natural topography and that appropriate grasses and shrubs are planted to start the re-vegetation process. The constructor contractor will be responsible for the stabilization of construction areas before they are allowed to vacate the construction areas. Areas proposed for clearing will be submitted to and agreed by KHC, and only those proposed areas will be cleared. KHC will reasonably consider the existing usage of the project land to allow its existing usage to continue as long as is practicable, without interference with the contractor's activities.

The design of roads, including temporary and permanent access roads, will avoid crop areas where reasonable and practical. The application of chemicals for vegetation clearing will be minimized to the greatest extent reasonable and practical. Chemicals, if any, will be selected on the basis of being non-residual and with regard to human health.

Herbicides used in the project will have negligible adverse human health effects; be shown to be effective against the target vegetation species; have minimal effect on the natural environment; and be demonstrated to be safe for inhabitants and domestic animals in the treated areas, as well as, for personnel applying them. Herbicides will be appropriately packaged, labelled, handled, stored, disposed of and applied according to international standards to be proposed by the contractor for the KHC's non objection. Persons applying herbicides will be provided with appropriate training, equipment, and facilities to handle, store, and apply these products properly.

All herbicides will have labels in both English and local languages to allow those handling the herbicides to comprehend the labelling fully.

Clearing will be carried out in accordance with the following requirements, 'Logging and Removal of Waste Forestry Products' given below, which describes the contractor's responsibilities, which will be referred to in the conditions of the contract.



### **5.9.10 Logging and Removal of Waste Forestry Products**

Prior to commencement of construction, KHC will have the right, but not obligation, to remove or arrange for the removal of commercial and non-commercial timber as well as other forestry products from the designated construction areas. After commencement of construction the contractor will have the right to log and remove forestry products remaining as required to clear areas to carry out the construction of the work, as necessary. However, in either case, the ownership and any value accruing remains with the State Forest Department.

The contractor will submit plans for removal of the remaining timber and other forestry products in the areas permitted under this clause to KHC for approval at least three months in advance of any work being executed by the contractor. The plan will be in accordance with the contractor's obligations of the contract requirements, including in particular, the following items:

- a) Erosion and sedimentation control and mitigation
- a) Vegetation clearing
- b) Air quality
- c) Noise pollution.

The contractor's plan will provide detailed information regarding the proposed logging and clearing work, including the following:

- a) Clear identification and justification of the areas to be logged and cleared
- b) Name of the company or organization to do the logging and clearing work
- b) Schedule for logging and clearing to be undertaken
- c) Clear identification of disposal sites for the timber and forestry products

If KHC elects to log and clear the areas nominated in the contractor's plan as areas which KHC may log and clear, it will have the right to do so within the period specified by the contractor consistent with the obligation referred to in contract.

All work involving the logging and removal of timber and other forestry products after commencement of construction work must be carried out in accordance with the contractor's none objected Vegetation Clearance Plan.

Other than the contractor's right to use timber obtained from the areas permitted under this clause for construction or for the temporary work necessary for that construction and other than the sale rights described in contract, the contractor must not sell, use or obtain any other benefit from the commercial timber of forestry products from the construction areas.

The contractor, with explicit permission from the State Forest Department, will dispose of any timber or forestry products resulting from the clearing not used in the construction work and which are not sold, in a manner selected by the contractor including leaving the timber and forestry products at the perimeter of the cleared construction areas or areas selected by the contractor within the cleared construction areas for collection by KHC.

For timber and forestry products discarded by the contractor and left at the perimeter of the cleared construction area or at areas selected by the contractor within the cleared construction area, KHC will have the right to arrange for the removal of such discarded timber and forestry products.

### 5.9.11 Mitigation for Impacts from Construction of Roads

KHC will strive to minimize impacts during the construction and upgrading of roads. The major mitigation measure is the minimization of new road alignments in favour of upgrading existing roads and for new roads, seeking an alignment that minimizes damage to vegetation.

The contractor will be responsible for constructing and/or strengthening the access roads, the haulage roads, or any other roads within the project area in accordance with the EMP. KHC will be responsible for ensuring that contractor's environment management plan adequately covers the environmental impact mitigation measures for the road construction activities. It will also be responsible for monitoring compliance.

The approach roads will have to be constructed as a part of the access to the construction site. In a hilly environment, construction of roads sometime disturbs the scenic beauty of the area. In addition, landslides are often triggered due to road construction because of the loosening of rocks by water trickling from various streams.

Road construction is expected to generate significant quantity of wastes (muck) due to the stripping of the rocks. The stripped muck is generally cleared by dumping the material along the slopes. These dumped materials finally flow down to the valleys and ultimately find their way in to the river. In the Lethang HEP, this will be prohibited. The stripped material will be collected and dumped in the designated muck disposal areas, which will be managed and protected as described in a subsection above.

After disposal operation is complete at the dump site, dump site will be reinstated, contoured and vegetated. Various other aspects to be integrated while constructing the project roads are described below.

- a) Where erosion is likely to be a problem, clearing and grubbing operations will be so scheduled and performed that grading operations and permanent erosion control of features can follow immediately thereafter, if the project conditions permit; otherwise temporary erosion control measures will be provided between successive construction stages. Under no circumstances, however, will very large surface area of erodible earth material be exposed at any one time by clearing and grubbing.
- b) The method of balanced cut and fill formation will be adopted to avoid large difference in cut and fill quantities.
- c) Where rock blasting is involved, controlled blasting techniques adopted to avoid over shattering of hill faces.
- d) Excavated material will not be thrown haphazardly but dumped duly dressed up in a suitable form at appropriate places where it cannot get easily washed away by rain, and such spoil deposits may be duly turfed or provided with some vegetative cover.
- e) Drainage of the water from hill slopes and road surface is very important. All artificial drains will be linked with the existing natural drainage system.
- f) Surface drains will have gentle slopes. Where falls in levels are to be negotiated, check dams with silting basins will be constructed and that soil is not eroded and carried away by high velocity flows.
- g) Location and alignment of culverts will also be so chosen as to avoid severe erosion at outlets and siltation at inlets.
- h) Tree felling for road construction/work will be kept bare minimum and strict control must be exercised in consultation with the Forest Department. Equivalent amount of new trees will be planted as integral part of the project within the available land and if necessary, separate additional land may be acquired for this purpose.

- i) Depending on the availability of land and other resources, afforestation of roadside land will be carried out to a sufficient distance on either side of the road.

### **5.9.12 Mitigation for Impacts from Construction of Power Evacuation System**

The contractor will mitigate the impacts of vegetation and habitat loss, disturbance from construction, possible soil toxicity from the application of chemicals used in vegetation clearance, and possible health risks associated with electric and magnetic fields generated by transmission lines. Additional measures to mitigate against impacts includes avoidance of felling of trees as much as possible, implementation of proper logging techniques where vegetation clearing is unavoidable, avoidance of application of chemicals, and prohibition of dwellings, and businesses in the easements along the transmission lines.

The contractor will be responsible for these activities. KHC will report on the adequacy of the environment management by the contractor.

### **5.9.13 Environmental Training for Construction Workers**

During construction there will be a potential for workers to damage the forests and waterways adjacent to camps and work areas. The contractor will prepare a training plan for all construction workers. The training will need to ensure that all employees of the contractor are aware about their duties, responsibilities, liabilities and consequences of non-compliance.

All employees of the contractor will be required to comply with environmental protection procedures and they will be able to provide evidence that they have attended the training sessions detailed in the plan.

The goal of the "Environmental Training for Construction Workers" program will be to educate all construction workers on the following issue: traffic regulations, illegal logging and collection of non timber forestry products (particularly in the resettlement areas), hunting and fishing restrictions, sanitation practices, waste management, erosion control, general health issues including the information and education, specific health issues related to HIV/AIDS, safety issues and general information on the environment in which they will be working and living.

Training will also include awareness generation that (personal, not related to work) use of explosives and chemicals is not permitted; or hunting and fishing is not permitted. Contractors will establish rules and penalties for violation.

These training sessions will be organized by the contractor, and will include formal training sessions, posters, signage in construction and camp areas, and tool box meeting. These will be in addition to the training program organized by KHC. However, both training program will be coordinated.

### **5.9.14 On-Site Traffic and Access Management**

During construction there will be a potential for use of large numbers of vehicles of variable size, leading to hazardous conditions on public roads, camps, project roads and work areas. To address the potential hazardous conditions, the contractor will prepare and implement an On Site Traffic and Access Management Plan. The plan will address the following:

- a) Details regarding expected road quality, maximum permissible vehicular speed on each section of road, establishment of safe sight distance including within the construction areas and construction camp site.
- b) Detailed plans for signage around the construction area to facilitate traffic movement.
- c) Estimated maximum concentrations of traffic and effects on existing traffic patterns for different times of day, and at individual locations within the construction area.

- d) Provisions to be made by the contractor for adequate off-road parking of all construction related vehicles.
- e) Plans to be followed while moving special loads, such as hazardous material, or heavy loads.

Plans for controlling site access, including both construction areas and construction camp areas.

Monitoring and methods of enforcing the requirements of the traffic management plan.

Construction traffic, including heavy loads, must not damage public roads. Personnel authorized to the construction areas will be briefed on traffic regulations applicable to the construction area. Parking will be provided for all classes of vehicles travelling to the site. At no time will construction vehicles be parked in a manner which may restrict movement of traffic on public roads. Signage will provide directions to various components of the work, provide safety advice and warning. All signs will be in both English and local language and be constructed to Indian Standards.

## **5.10 Rehabilitation and Resettlement Plan**

### **5.10.1 Introduction**

Efficient implementation of Resettlement Action Plan (RAP) prior to handing over the site for civil construction work is a prerequisite. Implementation of RAP is designed and the entitlements for the project affected persons are estimated as per the guidelines of National Rehabilitation and Resettlement Policy, 2007. This will expedite the overall implementation of the project and will also provide adequate support to the population affected/displaced due to the proposed project.

### **5.10.2 Entitlement Framework:**

The project requires approximately 24.629 Ha (which comprises 9.269 Ha of Forest Land and 15 Ha of Revenue Land) of land to be acquired (Affected Revenue Land details see Annexure-1). There will be no structures (Household) which are going to be affected due to the project. There will be compensated for the loss of nominal land only. In the context of entitlements the following relevant definitions are adopted in the project. Resettlement and rehabilitation measures will be provided following these definitions are as follows:

- a) **“Affected Family”** means
  - i) a family whose primary place of residence or other property or source of livelihood is adversely affected by the acquisition of land for a project or involuntary displacement for any other reason; or
  - ii) any tenure holder, tenant, lessee or owner of other property, who on account of acquisition of land (including plot in the abadi or other property) in the affected area or otherwise, is involuntarily displaced from such land or other property; or
  - iii) any agricultural or non-agricultural labourer, landless person (not having homestead land, agricultural land, or either homestead or agricultural land), rural artisan, small trader or self-employed person; who is residing or engaged in any trade, business, occupation or vocation continuously for a period of not less than three years preceding the date of declaration of the affected area, and who is deprived of earning his livelihood or alienated wholly or substantially from the main source of his trade, business, occupation or vocation because of the acquisition of land in the affected area or being involuntarily displaced or any other reason;
- b) **“Affected Area”** means area of village or locality notified by the appropriate Government as part of this Policy.

- c) **“Agricultural Labourer”** means a person primarily resident in the affected area for a period of not less than three years immediately before the declaration of the affected area who does not hold any land in the affected area but who earns his livelihood principally by manual labour on agricultural land therein immediately before such declaration and who is deprived of his livelihood.
- d) **“Agricultural Land”** includes land being used for the purpose of –
- i) agriculture or horticulture;
  - ii) dairy farming, poultry farming pisci-culture, breeding of livestock or nursery growing medical herbs;
  - iii) raising of crops, grass or garden produce; and
  - iv) land used by an agriculturist for the grazing of cattle, but does not include land used for cutting of wood only;
- e) **“Appropriate Government”** means
- i) in relation to the acquisition of land for the purpose of the Union, the Central Government;
  - ii) in relation to a project which is executed by the Central Government agency or undertaking or by any other agency on the orders or directions of the Central Government, the Central Government;
  - iii) in relation to the acquisition of land for purposes other than (i) and (ii) above, the State Government; and
  - iv) in relation to the rehabilitation and resettlement of persons involuntarily displaced due to any other reason, the State Government;
- f) **“BPL Family”**: the below poverty line (BPL) families will be those as defined by the Planning Commission of India from time to time and included in a BPL list for the time being in force;
- g) **“Commissioner for Rehabilitation and Resettlement”** means the Commissioner for Rehabilitation and Resettlement appointed by the State Government not below the rank of Commissioner or of equivalent rank of that Government;
- h) **“Family”** includes a person, his or her spouse, minor sons, unmarried daughters, minor brothers, unmarried sisters, father, mother and other relatives residing with him or her and dependent on him or her for their livelihood; and includes “nuclear family” consisting of a person, his or her spouse and minor children;
- i) **“Holding”** means the total land held by a person as an occupant or tenant or as both;
- i) **“Khatedar”** means a person whose name is included in the revenue records of the parcel of land under reference;
  - ii) **“Land Acquisition” or “Acquisition of Land”** means acquisition of land under the National Highway Act, 1956.
  - iii) **“Marginal Farmer”** means a cultivator with an un-irrigated land holding up to one hectare or irrigated land holding up to half hectare;
  - iv) **“Non-Agricultural Labourer”** means a person who is not an agricultural labourer but is primarily residing in the affected area for a period of not less than three years immediately before the declaration of the affected area and who does not hold any land under the affected area but who earns his livelihood principally by manual labour or as a rural artisan immediately before such declaration and show is deprived of earning his livelihood principally by manual labour or as such artisan in the affected area;

- v) **“Occupiers”** means members of the Scheduled Tribes in possession of forest land prior to the 13<sup>th</sup> day of December 2005;
- vi) **“Small Farmer”** means a cultivator with an un-irrigated land holding up to two hectares or with an irrigated land holding up to one hectare, but more than the holding of a marginal farmer.
- vii) **“Vulnerable Group”** includes persons such as the disabled, destitute, orphans, widows, unmarried girls, abandoned women, or persons above fifty years of age; who are not provided or cannot immediately be provided with alternative livelihood, and who are not otherwise covered as part of a family;
- viii) **Community Property:** A community property is a structure or a piece of land that embodies a public utility, facility or a cultural / religious entity that belongs to a community or a group. For example a shrine, temple, mosque, church, school, well or a tube well is a community property.
- ix) **Compensation:** Compensation refers to restitution made to property under the State act for land Acquisition or Land Acquisition Act 1984. In this context it refers to payment made by the Government exercising ‘Eminent Domain’.
- x) **Right of Way (RoW):** Means the entire strip of land traversed by any highway, street, county road or roadway easement including (longitudinal drains, service roads and embankment) for the purpose of vehicle travel, and includes the entire width of the land dedicated or acquired by law for right-of-way purposes. All along the proposed corridor available RoW is not enough to contract road so additional land up to 60 meters of RoW will be acquired.
- xi) **Cut-off Date:** Cut-off date is established to identify and enumerate the Entitled Persons. For title-holders / legal owners, the cut-off date will be the notification by the PIU declaring the intention to acquire the property. The date of serving the notice u/s 3A of National Highway Act of 1956 will be established as the cut-off date.
- xii) **Encroacher:** Any person illegally occupying public property by extending their land boundary or a portion of their building onto the RoW is an encroacher.
- xiii) **Entitled Person (EP):** Entitled Person includes all PAPs who qualify for, or are entitled to, compensation / assistance since being impacted by the project. The basis for identification of Entitled Persons (EP) in the project will be the cut-off date.
- xiv) **Project Affected Household (PAH):** Any household living, cultivating land or carrying on business, trade or any other occupation within the Corridor of Impact (CoI) who are impacted by the project is a Project Affected Household. All the members of a PAH in the project will be treated as PAPs.
- xv) **Project Affected Person (PAP):** Any individual (part of the PAHs) living, cultivating land or carrying on business, trade or any other occupation within the Corridor of Impact (CoI) who are impacted by the project is a Project Affected Person (PAP).
- xvi) **Present Market Rate:** Present market rate in the project refers to the valuation of a project-affected property as per the up-dated Circle Rate or BSR Rate respectively for land and structures.
- xvii) **Titleholder / Private Property Owners:** Private property owners are persons who have legal title to structures, land or other assets. These property owners are entitled to compensation under the National Highway Act of 1956.



- xviii) **Non-titleholder:** Squatters and encroachers are non-titleholders, as they do not have any legal title of the parcel of land they occupy. However, some of the non-titleholders are found to pay certain taxes regularly to local self governments for present occupancy for their housing/commercial establishment. The Land Acquisition Act 1984 for Land Acquisition does not recognize the usufruct right so they are not eligible to any compensation or assistance as per the statutes. The R&R Policy for the project also does not specify any assistance for non-titleholders.
- xix) **Encroachment:** Private structures, which extend from private land to government land, are classified as encroachment. The portion of the structure in government land is considered illegal occupancy and is not eligible for any compensation for assistance as per the R&R Policy for the project.
- xx) **Squatter:** Any person having structures entirely within the public RoW for residential and/or commercial purposes is a squatter.

The Entitlement Framework for Project Affected Persons (PAP) in this project is presented in **Table 5.15**. PAPs are entitled for various types of rehabilitation and resettlement benefits depending upon the type of loss due to the project.

### **5.10.3 Livelihood Restoration of vulnerable groups within the project area :**

Since the project will be implemented on a commercial format, there are no inherent funds devoted to restoration of livelihoods of non-title holder occupants within the Project area/RoW, who will be evicted due to the project. However, the Consultants feel that since there will be substantial losses to livelihoods due to such eviction, it will be worthwhile on the part of the project authorities to integrate at least the vulnerable and the PAPs in various development / welfare programmes of the State and Central Governments. The Entitlement matrix for Project Affected Persons is given in **Table 5.13** below:

**Table 5.13: Entitlement Matrix for Project Affected Persons**

S. No	Category/Target Group	Details	Entitlement
<b>A Agricultural Land</b>			
1	Each displaced family owning agricultural land	Affected families owning agricultural land in the affected area and whose entire land is acquired or lost	Agricultural land or cultivable wasteland to the extent of actual land loss, subject to a maximum of 1 ha of irrigated land or 2 ha of un-irrigated land or cultivable wasteland
2	Each affected family who are reduced to the status of <i>marginal farmers</i>	-	Agricultural land or cultivable wasteland to the extent of actual land loss, subject to a maximum of 1 ha of irrigated land or 2 ha of un-irrigated land or cultivable wasteland
<b>B Land Development</b>			
1	Each <i>Khatedar</i> in the affected family	In case of allotment of wasteland or degraded land in lieu of the acquired land	One-time financial assistance of such amount as the appropriate Government may decide but not less than Rs.15000/- per hectare
<b>C Agricultural Production</b>			
1	Each <i>Khatedar</i> in the affected family	In case of allotment of agricultural land in lieu of the acquired land	One-time financial assistance of such amount as the appropriate Government may decide but not less than Rs.10000/-
<b>D Subsistence Allowance</b>			
1	Each affected family	-	25 days minimum agricultural wages per month for a period of one year from date of displacement
<b>E Ex-Gratia</b>			
1	Each <i>Khatedar</i> in the affected family	In case of linear acquisitions, in projects relating to railway lines, highways, transmission lines, laying of pipelines and other such projects wherein only narrow stretch of land is acquired for the purpose of the project or is utilized for right of way	Rs.20000 in addition to the compensation or any other benefits due under the Act or programme or scheme under which the land, house or other property is acquired
<b>F Assistance to Vulnerable Groups</b>			
1	Each scheduled tribe affected family	Additional one-time financial assistance for loss of customary rights or usages of forest produce	500 days minimum agricultural wages
2	Each scheduled tribe affected family	Those resettled out of the district	25% higher rehabilitation and resettlement benefits in monetary terms (in respect of items specified in paragraphs 7.9 to 7.12 of the Policy)
3	Affected families of scheduled tribe	-	Land free of cost for community and religious gathering

To this end, the Consultants suggest in the following a range of Government aided programmes undertaken through the District Rural Development Authority (DRDA) in the State Government in which vulnerable groups and the PAPs losing livelihoods may be integrated with:

- a) Pradhan Mantri Gram Sadak Yojana (PMGSY)
- b) Swarnjayanti Gram Swarozgar Yojana (SGSY)
- c) Sampoorna Gramin Rozgar Yojana (SGRY)
- d) Indira Ais Yojana

- e) Credit-cum-Subsidy Scheme for Rural Housing
- f) Innovative Stream for Rural Housing and Habitat Development
- g) Rural building Centres
- h) Samagra Ais Yojana
- i) National Social Assistance Programme
- j) Council for advancement of People's Action and Rural Technology
- k) Rajiv Gandhi National Drinking Water Mission
- l) Centrally sponsored Rural Sanitation Programme
- m) Drought Prone Area Programme
- n) Wastelands Development

#### **5.10.4 Implementation Procedure**

The RAP is implemented through the following five stages:

- xxi) Issue of legal notification for land acquisition and the cut-off date;
- xxii) Verification of Eligible Persons (EPs) and estimation of their types and category of losses;
- xxiii) Preparation of Photo Identity Card, issue and distribution to EPs;
- xxiv) Disbursing Compensation Money;
- xxv) Monitoring Physical and Financial Progress of Resettlement Action Plan.

#### **5.10.5 General Activities**

In order to carry out the above activities, the Authority has to carry out institutional strengthening and certain administrative responsibilities in terms of:

- a) Contracting of NGOs;
- b) Setting up of District Level Committees (DLC) and the Grievance Redressal Cell (GRC);  
Verification of Eps;
- c) Updating of the census data to include the disputed cases or left out cases to be included in the list of PAPs;
- d) Distribution of Identity Cards (see at the end of the chapter, a format for ID Card);
- e) Opening of joint accounts in the name of the EPs, representatives of the NGOs and RRO;
- f) Special emphasis on the vulnerable groups for helping enroll the PAPs from this group in Governmental welfare schemes operating in the region;
- g) Monitoring physical and financial progress; and Prepare monthly reports of the progress made.

#### **5.10.6 Specific Activities**

**Permanent Land Acquisition:** The following steps will have to be carried out for land acquisition:

- i) Appointment of the competent authority;
- ii) Identification of Villages Along the Project Corridor;

- iii) Preparing land plans for acquisition with details about the total land holdings and the area affected;
- iv) Issue of notices;
- v) Announcement of compensation awards;
- vi) Issue of cheques in public places prior to taking of possessions.

#### **5.10.7 Payment of Compensation**

- i) Ensure the amount of compensation is appropriate to PAPs;
- ii) Verification of EPs for compensation;
- iii) Ensure the receipt of cheques by owner of the affected unit;
- iv) Ensure that cheques are issued in public during meetings;
- v) Inform about acquisition or transfer of land to other authorities whose land is being taken (Forest; Defense etc).

#### **5.10.8 Grievance Redressal Mechanisms**

The objective of the mechanism is to provide a platform to the affected people to address their grievance that are sought by meaningful solutions. Thus, reflecting continued participation and justification to design, economic returns and the PAPs themselves. The grievances addressed in this manner have community approval and the redressal is appropriated through stakeholders' participation. The committee thus formed for this purpose will continue to function for the benefit of the PAPs during the entire life of the project so that the PAPs grievances are redressed at the right time. The GRC will have to be formed at every District Head Quarter consisting of the following members.

- i) The Project Director;
- ii) RRO;
- iii) District Collector;
- iv) NGO; and
- v) Monitoring Implementation of Resettlement Action Plan.

It is important to consider setting up an early system for monitoring project objectives and social accountability. Monitoring involves tracking the progress of process and implementation (as measured by indicators on inputs, outputs and outcomes) associated with the project. This is done to ensure that the desired targets are achieved.

- i) Indicators for monitoring will be designed to capture physical and financial progress of the project.
- ii) Promote Social Accountability: Monitoring and evaluation system can also be implemented to promote social accountability during the process of implementation of the project leading to sustainability. Participatory public review and perception surveys will be used for social accountability in the monitoring and evaluation process.

#### **5.10.9 The RAP Budget**

The RAP budget includes the cost of land, Rehabilitation and Resettlement Assistance in the project. The details are listed in the **Table 5.14**.

**Table 5.14: Preliminary Social Costs Details**

S. No	Details of Affected Structures	Area in Ha/ No of PAF	Unit Rate	Amount (Rs)
1	Land to be taken on Leased Bases for five years (The lease rate per year is 50,000 per Ha)	5.284 Ha	2,50,000	13,21,000
2	Proposed Affected Land for Acquisition (Sikkim Govt has fixed the Market Rates for Land @ Rs. 25,00,000 per Ha)	9.716 Ha	2,500,000	242,90,000
<b>A</b>	<b>Total (Land Acquisition Cost)</b>			<b>256,11,000</b>
3	Land Development	38 PAF	15,000	5,70,000
4	Agricultural Development	38 PAF	10,000	3,80,000
5	Subsistence Allowance	38 PAF	25,000	9,50,000
6	Ex-Gratia	36 PAF	24,000	8,64,000
7	Assistance to Vulnerable Groups (Tribal Families)	36 PAF	40,000	14,40,000
<b>B</b>	<b>Total (Rehabilitation And Resettlement Assistance)</b>			<b>42,04,000</b>
	<b>TOTAL COST (A+B)</b>			<b>29,815,000</b>

The budgeted cost of **INR 298 Lakh** is earmarked for Resettlement and Rehabilitation Assistance including the Land Acquisition cost.

A summary of the EMP is given below in **Table 5.15**: for each environmental attribute the following information is presented in the plan:

- i) Potential impacts.
- ii) Nature of impact.
- iii) Magnitude of impact.
- iv) Mitigation plan.
- v) Project phase.

**Table 5.15: Summary of Anticipated Impacts and Proposed Management Plan**

	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
<b>A. PHYSICAL RESOURCES</b>						
1.	Topography	Change in surface features and present aesthetics due to construction at various project sites	Direct irreversible impact, restricted only in the site of above ground structures.	Medium	• Plantation surrounding the submergence area to improve aesthetics.	<b>Construction</b>
2.	Climate	Change in the micro climate due to removal of trees for construction site / RoW of roads etc.	Localised but direct impact certain extent irreversible	Low	• Compensatory afforestation and plantation around the project structures, access roads and colonies.	<b>Construction and Operation</b>
3.	Hydrology	Operation of	Direct/ Local/	Medium	• Construction of	<b>Operation</b>

Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
	head work	Irreversible		trench type weir, conventional gated damage	
	Ground water	No significant impact		No specific measures is suggested.	<b>Operation</b>
	Reduction of flow due to stream diversion and ponding at diversion .	Impact is direct, localised but irreversible. More prominent during lean period.	Medium	<ul style="list-style-type: none"> <li>The studies for minimum environmental discharge are going on and the recommended discharge will be released.</li> </ul>	<b>Operation</b>
	Change in land use by submergence of land due to the construction of impoundment at diversion	0.844 ha of land, which is at present having vegetation cover will be lost permanently.	Low	<ul style="list-style-type: none"> <li>Plantation around the submergence area, colonies and side of the access roads are suggested to mitigate loss of green cover</li> </ul>	<b>Operation</b>
	Daily fluctuation in peaking water flow situation at Barrage	Variation in flow volume and quality of water	Low	<ul style="list-style-type: none"> <li>The proposed project is on run of river scheme.</li> </ul>	<b>Operation</b>
	Riverine Ecology	Reduction of flow will bring change in the existing ecosystem	Medium	<ul style="list-style-type: none"> <li>Environmental flow as observed in the environmental flow assessment, which will be decided depending upon the existing fish and other parameters, will be maintained through out the year.</li> <li>To facilitate 'to and fro' fish migration, fish pass will be constructed</li> </ul>	<b>Operation</b>
	Sedimentation	Increase in silt load during flushing period	Low	<ul style="list-style-type: none"> <li>Effective management of desilting basin during high monsoon period.</li> </ul>	<b>Operation</b>
	Infestation of pests and weeds	No significant impact is envisaged	Low	<ul style="list-style-type: none"> <li>Fish can be stocked in the reservoir to mitigate pests and weed propagation in pondage area.</li> </ul>	<b>Operation</b>



	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
<b>B. ENVIRONMENTAL RESOURCES</b>						
1.	Air quality	Project will have marginal impact on air quality during the construction period due to dust emission	Impact is direct, localized and temporary; restricted only during construction phase.	Low and reversible	<ul style="list-style-type: none"> <li>Watering at construction site, limited bare soils, covering the materials during transportation and storing, maintenance of project vehicles etc.</li> </ul>	<b>Construction</b>
		Due to crushers activities	Impact is direct, localized and temporary, restricted only during construction phase.	Low	<ul style="list-style-type: none"> <li>Install wet crusher to control the dust.</li> <li>Covering and stacking the fine aggregates till the time they are utilised</li> <li>Spray regularly the stacks with water to prevent the entrainment of fugitive emissions such as dusts.</li> </ul>	<b>Construction</b>
2.	Noise	Due to general construction activities and vehicular movements	Impact is direct, localized and temporary, restricted only and reversible also during construction phase.	Low	<ul style="list-style-type: none"> <li>Restriction on noise generating activities at night time (10 pm – 6 am) and use of personal protective equipment like ear plugs, mufflers etc.</li> <li>Avoid the noisy construction in the barrage site, which is near to forests patches.</li> <li>Implement good working practices to minimize noise.</li> </ul>	<b>Construction</b>
		Noise arising from operation of tail race tunnel, switchyard etc. at the powerhouse site	Impact is Direct, Localised and will remain Permanent	Low	<ul style="list-style-type: none"> <li>Noise from tail race tunnel will remain however to locate switchyard away from settlement area.</li> </ul>	<b>Operation</b>
		Noise arising for blasting for construction.	Impact is direct and temporary, restricted only during	Medium	<ul style="list-style-type: none"> <li>Timetable for blasting to be maintained during</li> </ul>	<b>Construction</b>

	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
			construction phase for 2 years		convenient hours. <ul style="list-style-type: none"> <li>• Proper design of blast hole to be developed.</li> <li>• Use of noiseless trunk delays to minimize the noise due to air blast.</li> <li>• Use of non-electric system of blasting for true bottom-hole initiation.</li> <li>• Use of muffling mats to arrest the dust and fly rock</li> </ul>	
3.	Surface water quality	Run off from the construction site leading to increase in COD, BOD, oil & grease etc. if mixed with any water body.	Impact is direct and Reversible	Low	<ul style="list-style-type: none"> <li>• Setting up of vehicles garages, away from slope. Construction of oil traps.</li> <li>• Turfing on the slopes along the access road, wherever possible to prevent spread of contaminated flushing.</li> </ul>	<b>Construction</b>
		Ishings from muck disposal sites may lead to increase in turbidity		<ul style="list-style-type: none"> <li>• Construction of garland drain around the bottom of the muck disposal site and settling pit.</li> </ul>		
		Domestic waste water from construction sites and during operation leading to increase in COD, BOD, oil & grease etc.		Low	<ul style="list-style-type: none"> <li>• Portable septic tanks both at the construction labour camp site and construction site will be installed.</li> <li>• Sewage Treatment Plan will be made for project colony</li> </ul>	<b>Construction and Operation</b>
		Oil spillage and oil contamination during maintenance.	Impact is indirect, localised but reversible	Low	<ul style="list-style-type: none"> <li>• Oil interceptor will be provided for vehicle parking ish down and refuelling areas.</li> <li>• Field storage will</li> </ul>	<b>Construction and Operation</b>

	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
					be in proper bounded areas • Oily wastes will be disposed off to the approved disposal sites. All spills and collected petroleum products will be disposed off in accordance with MoEF Guidelines of Sikkim Govt.	
		Oil contamination during maintenance	Impact is indirect, localised but reversible.	Low	• Oil trap installation for separation of oil from water	<b>Operation</b>
4.	Soils and Geology	Soils erosion, loss of productive top soil.	Impact is indirect, localised but reversible.	Low	• Avoiding sites which are prone to soil erosion & landslides • Levelling of construction site. Use of few access road/ power evacuation lines. • Preserving the topsoil from all the construction sites, wherever ground will be used for construction i.e roads, materials storing vehicles and construction equipment garages etc in stockpile at the edge of the site to use it to the extent possible for site restoration later.	<b>During and after the construction activities</b>
		Improper debris removal/ accumulation	Impact is indirect, localised but reversible.	Medium	• All the debris removed from tunnel, powerhouse to be stored temporarily to use it in other site preparation/levelling/for site reclamation/	<b>Pre-construction and construction</b>

	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
					concrete production. Excess material will be disposed in the muck dumping sites and will be suitably stabilized	
		Damage due to seismic activity	Impact is indirect, localised but reversible.	Low to high depending on seismic intensity	<ul style="list-style-type: none"> <li>Design and site selection for the entire project component will be made considering local geology and seismic condition. However a study is conducted by IIT roorkee to determine the seismic parameters.</li> </ul>	<b>Before the construction activity</b>
<b>C. ECOLOGICAL RESOURCES</b>						
1.	Terrestrial Ecology	Loss of vegetation	Impact is indirect, localised but reversible.	Medium	<p>Following precautionary measures will be taken to avoid any unwanted tree cutting:</p> <ul style="list-style-type: none"> <li>Selecting minimum corridor width for power evacuation line, access roads etc.</li> <li>Marking out road &amp; site boundaries.</li> <li>Identify the trees need to be cut and marking them before hand.</li> <li>Plantation of indigenous species around the constructed site, wherever possible will be made and compensatory afforestation will be implemented.</li> <li>Training will be given to all bulldozer operators and other manual labourers involved</li> </ul>	<b>Pre construction and construction phase</b>

	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
					<p>in road and site preparation to strictly confine to their work within the defined site boundaries.</p> <ul style="list-style-type: none"> <li>• Punitive measures will be enforced tree cutting and damage to natural resources.</li> </ul>	
2.	Terrestrial Fauna	Disturbance to the local fauna during construction and operation activities	Impact is indirect, localised but reversible.	Low	<ul style="list-style-type: none"> <li>• Animal movement corridors will be identified with the help of local forest officials and all work will be carried out away from the same.</li> <li>• All construction work and transportation of construction material to the site of barrage and power house, which are close to forest path will be restricted between daytime and close it before sunset preferably day time to avoid disturbance to the wild animals in the project area.</li> <li>• The project areas located close to animal movement corridor will be adequately fenced with security guard to discourage animals coming close to the project location/ workers entering into the forests.</li> <li>• Guard will be appointed to monitor the power evacuation lines</li> </ul>	<b>During pre construction and operation phase</b>

	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
					<p>especially for birds strikes during the operation.</p> <ul style="list-style-type: none"> <li>Punitive measures will be adopted in case of killing of wild animals even the small one and birds by the workers by DFO (wild life) of the district.</li> </ul>	
3.	Aquatic Ecology	Disturbance to fish during construction of barrage, tunnel as well as operation powerhouse	Impact is indirect, localised but reversible.	Medium	<ul style="list-style-type: none"> <li>Minimum flow will be maintained; in the river even during lean period, hence aquatic life will have no significant impact.</li> <li>Fish pass will be made to facilitate 'to and fro' movement of fishes.</li> <li>Proper briefing will be made to the labour force. So that unauthorised fishing does not take place. To ensure this, punitive measures will be adopted and guard will be appointed to keep vigil on such activities by workers</li> </ul>	<b>During construction/ operation phase</b>

#### D. HUMAN ENVIRONMENT

1.	Land Acquisition	Total 26.63 ha of land will be acquired for the project, in this 15 ha area is of private land and rest area is government land.	Impact is direct, local and irreversible	Low	<ul style="list-style-type: none"> <li>All the land owners will get compensation as per the protocols (NRRP 2007)</li> <li>It will be ensured that appropriate legal requirements are met with regard to land occupancy, land ownership or usage rights, notice and compensation</li> </ul>	<b>Pre - Construction</b>
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	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
					<p>prior to legal transfer.</p> <ul style="list-style-type: none"> <li>• Proper land agreement will be made with owners, users and state authorities (Forest Department). Prior to that boundaries of the property will be marked and all transactions will be clearly documented following the legal process.</li> <li>• All necessary approvals from State Authorities will be acquired prior to all transactions.</li> </ul>	
2.	Socio-Economics	Job opportunities during construction phase	Impact is positive, direct and regional	High	<ul style="list-style-type: none"> <li>• Overall industrial and economic growth of the region.</li> <li>• Undertake social welfare projects for the local communities through well thought out CSR strategy</li> </ul>	<b>During operational phase and construction</b>
					<ul style="list-style-type: none"> <li>• Keep a record of all jobs and provide monthly feedback on jobs provided to locals and others with clear reporting on each job profile.</li> <li>• All manual labor and other jobs for which local skills are available are recruited from local people</li> </ul>	<b>Construction</b>
3.	Resettlement & Rehabilitation	No family will be displaced for this project, Hence, no resettlement is	Nil	Nil	<ul style="list-style-type: none"> <li>• Compensation of the land and employment opportunities to the locals</li> </ul>	<b>Construction and Operation phase</b>

	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
		envisaged in this regard.				
<b>Other General Issues</b>						
1.	Cultural sites	No archaeological, historical or cultural important sites are affected by the construction of the project	Nil	Nil	<ul style="list-style-type: none"> <li>No mitigation measures required.</li> <li>Incase any fossils, coins, articles of value of antiquity, structure and other remains or things of geological or archaeological interests discovered on the site will be the property of the government and will be dealt with as per the provisions of the relevant legislation.</li> </ul>	<b>Operation Phase</b>
2.	Traffic and transportation	Traffic congestion due to movement of construction vehicle	Impact is direct, localised and reversible	Low	<ul style="list-style-type: none"> <li>Before taking up construction on near to any existing lanes, a traffic control plan will be devised.</li> <li>All the necessary measures for the safety of traffic during construction will be taken such as barricades, including signs, marking and flags, will be installed for the information and protection of traffic approaching or passing through the section of any existing cross roads.</li> <li>Before taking up of construction on any section of the existing lanes of highways, a traffic management plan to be devised to avoid any traffic congestion.</li> </ul>	<b>During construction phase</b>

	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
3.	Oily Waste generation	Probability of surface and ground water pollution	Impact is indirect, localised and reversible	Low	<ul style="list-style-type: none"> <li>The oil sludge will be separately stored in the containers.</li> <li>Used oil to be collected and reclaimed by contractors through the Office of Stores and Purchase.</li> <li>Separated oily waste and scrap will be collected and disposed of in compliance with the Environmental Protection Act, 1986, and applicable regulations and rules thereunder.</li> </ul>	<b>During construction and operation phase</b>
4.	Solid Wastes	Contamination of land and water	Impact is indirect, localised and reversible	Low	<ul style="list-style-type: none"> <li>A secured landfill site will be developed in a suitable location within the project acquired land following the protocol due to the absence of municipal solid waste dumping ground in yuksam or lethang or any other nearby places.</li> <li>Garbage bins will be provided in the labour camps and also in the construction site, which will be regularly emptied and disposed off in a hygienic manner.</li> <li>Degradable and non-degradable solid waste will be separated.</li> </ul>	<b>Construction</b>
5.	Labour Camp	Living conditions of workers	Impact is direct, local and reversible	Low	<ul style="list-style-type: none"> <li>Labour camps will be constructed at least 1 km away</li> </ul>	<b>Construction phase</b>

Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
				<p>from existing settlement and from any water body etc.</p> <ul style="list-style-type: none"> <li>• Necessary (temporary) living accommodation (30-40 sqm size dwelling unit to each of the labour family with all ancillary facilities, i.e, uncontaminated water supply for drinking, cooking and ishing, Latrines and urinals in an accessible places/ distance will be provided and maintained.</li> <li>• Adequate vaccination and immunization facilities will be provided for workers at construction site.</li> <li>• Public awareness programmes for increase knowledge about various diseases and actions will be taken in case of out break of any epidemic.</li> <li>• Periodic free health check up camp will be organised for the entire family of the worker.</li> </ul>	
	Diseases due to contamination of water bodies and pondage of water	Low		<ul style="list-style-type: none"> <li>• Precaution will be taken to prevent temporary pondage of water. Disinfectants like bleaching powder etc will be regularly sprinkled around the drain or garbage disposal</li> </ul>	

Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
				area and temporary toilet areas in the construction site.	
	Issue due to water supply	Impact is direct localised and reversible	Low	<ul style="list-style-type: none"> <li>• Appropriate water supply sources will be identified.</li> <li>• Appropriate infrastructure for storage and disinfections (chlorination facilities etc.) will be provided.</li> <li>• Drinking water will be regularly tested for :                             <ul style="list-style-type: none"> <li>- Orthotolodine tests for chlorine</li> <li>- Lead Acetate Paper test for bacterial infection</li> </ul> </li> </ul>	<b>Pre Construction and Construction</b>
	Sewage Treatment and Maintenance of drinking water quality	Impact is direct local and reversible	Medium	<ul style="list-style-type: none"> <li>• Sewage from toilets will be treated in septic tanks.</li> <li>• Effluent from septic tanks will be disposed off through absorption trenches.</li> <li>• Drinking water facilities and sewage disposal site will be located far away from each other to avoid contamination of water,</li> </ul>	<b>Construction</b>
	Absence of free fuel for workers	Impact is direct, localised and reversible	Low	<ul style="list-style-type: none"> <li>• A mandatory clause will be put in the contract of every contractor involved in project construction to provide supply of fuel to their labourers so that</li> </ul>	<b>Pre construction and Construction</b>

	Environmental Attribute	Potential Impacts	Nature of Impact	Magnitude of Impacts	Mitigation Plan	Project Phase
					trees are not cut for meeting their fuel demands.	
6.	Health and Safety	Exposure to Electromagnetic Fields	Impact is direct, Localized and persisting	Low	<ul style="list-style-type: none"> <li>Alignment for route power evacuation lines situated away from the settlement.</li> <li>No house will be allowed to build near power house.</li> </ul>	<b>Operation</b>
7.	Positive Impact on socio-economy of project area	Project will be beneficial for the area	Positive direct impact on the regional economy	High	<p>Implementation of the following enhancement measures:</p> <ul style="list-style-type: none"> <li>Power Supply to the surrounding areas from the power generated in the project.</li> <li>Facilities for higher education, training, skill development.</li> <li>Employment for local people</li> <li>Improvement in accessibility</li> <li>Improvement in tele-communication system</li> <li>Improved health care facilities.</li> </ul>	<b>During Construction and Operation phase.</b>



## 5.11 BUDGETS FOR ENVIRONMENT MANAGEMENT PLAN

The overall budget for implementing the EMP is **INR 1485.79 Lakh**. The detailed break- up is given in **Table 5.16** below.

**Table 5.16: Budget for EMP**

<b>Description</b>	<b>Capital Cost INR Lakh</b>	<b>Working Costs INR Lakh</b>	<b>Total Costs INR Lakh</b>
Biodiversity Conservation Plan.	53.62	70.25	123.87
Catchment Area Treatment Plan.	321.21	48.18	369.39
Fisheries Conservation and Management Plan.	50.00	80.28	130.28
Public Health / Health Delivery System.	50.50	59.77	110.27
Environment Management in Labour Camps including provisions of fuel for labour.	95.00	64.60	159.60
Stabilization of Muck Disposal Sites.	75.80	22.58	98.38
Landscaping and Restoration of Construction Area including roadside plantation.	125.00	-	125.00
Resettlement and Rehabilitation Plan	298.00	-	298.00
Compliance of Environmental Monitoring Programme during construction phase.	17.00	-	17.00
Compliance of Environmental Monitoring Programme during operation phase.	-	8.00	8.00
Purchase of Weather Station, Rain Gauges, Snow Gauges, Noise meters etc.	6.00	-	6.00
CSR activities.	-	40.00	40.00
<b>Total EMP Budget</b>	<b>1092.13</b>	<b>393.66</b>	<b>1485.79</b>

# 6

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## ENVIRONMENTAL MONITORING PLAN

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# 6

## ENVIRONMENTAL MONITORING PLAN

### 6.1 Environmental Monitoring Plan

An environmental monitoring plan provides a delivery mechanism to address the adverse environmental impacts of a project during its execution, to enhance project benefits, and to introduce standards of good practice to be adopted for all project works. An environmental monitoring program is important as it provides useful information and helps to:

- a) Assist in detecting the development of any unwanted environmental situation, and thus, provides opportunities for adopting appropriate control measures.
- b) Define the responsibilities of the project proponents, contractors and environmental monitors and provides means of effectively communicating environmental issues among them.
- c) Define monitoring mechanism and identify monitoring parameters.
- d) Evaluate the performance and effectiveness of mitigation measures proposed in the Environment Management Plan (EMP) and suggest improvements in management plan, if required.

From the monitoring point of view, the important parameters are water quality, river bank landscape, induced impacts, etc. The suggested monitoring details are outlined in the following sections.

### 6.2 Water Quality

#### Construction Phase:

It is proposed to monitor the effluent after treatment from septic tanks. The frequency of monitoring can be once per month. The parameters to be monitored include pH, Bio-chemical Oxygen Demand, Total Suspended Solids and Total Dissolved Solids. The analysis work can be done by a laboratory recognized by the State Pollution Control Board.

#### Operation Phase:

The surface water quality of Rathang Chu River needs to be monitored thrice a year. The proposed parameters to be monitored include pH, temperature, Electrical Conductivity (EC), turbidity, total dissolved solids, calcium, magnesium, total hardness, chlorides, sulphates, nitrates, DO (Dissolved Oxygen), COD (Chemical Oxygen Demand), BOD, Iron, Zinc and Manganese.

The sampling sites will be:

- a) 0.5 km upstream of the barrage site, and 1.5 km downstream of the confluence of the tail race discharge with the river
- b) The analysis will be done throughout the entire life of the project. The analysis work can be conducted by a reputed external agency recognized by State Pollution Control Board.

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 month, it is envisaged to analyse a sample each before and after treatment from the STP. The parameters to be analysed include pH, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids and Total Dissolved Solids. The analysis work can be conducted by a reputed external agency recognized by State Pollution Control Board.

### **6.3 Ambient Air Quality and Meteorology**

#### **Construction Phase:**

The ambient air quality monitoring during construction phase can be carried out by an external agency, approved by State Pollution Control Board at three where major construction sites. Every year monitoring is to be done for three seasons namely, winter, summer and post monsoon. The frequency of monitoring can 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<sub>2</sub>) and Nitrogen Oxides (NO<sub>x</sub>). Every year, ambient air quality is to be monitored for (3 stations\* twice a week\* four weeks\*three seasons) 72 days.

A meteorological laboratory will be set up at one of the ambient air quality monitoring stations. Automatic recorders for temperature, wind speed and direction, humidity, rainfall needs to be commissioned at the site. This will be a permanent monitoring station and will continue throughout operation phase of the project.

### **6.4 Noise**

#### **Construction Phase:**

Noise emissions from vehicular movement, operation of the construction equipment may be monitored during construction phase at major construction sites. The frequency of monitoring can be once every three months. For monitoring of noise generators an Integrating Noise Level Meter will be required.

### **6.5 Ecology**

#### **Construction Phase:**

A detailed ecological survey covering forestry, fisheries, wildlife is recommended during the entire construction phase. The survey can be conducted once every year for the entire construction period. The various aspects to be covered include qualitative and quantitative assessment of flora & fauna and monitoring of restoration of muck disposal area.

Moreover, animal movement corridors and man/animal conflicts will be identified with the help of local forest officials and local community.

#### **Operation Phase:**

Monitoring of aquatic ecology will be essential to achieve sustainable yield of fish. Some of the parameters to be monitored are phytoplankton, zooplanktons, benthic life and fish composition, etc. Status of greenbelt development, changes in migration patterns of the aquatic and terrestrial fauna species will be studied. The monitoring work will be conducted by an independent agency.

### **6.6 Incidence of Water-Related Diseases**

#### **Construction Phase**

Identification of water-related diseases, adequacy of local vector control and curative measures, status of public health are some of the parameters which will be closely monitored three times a year with the help of data maintained in the government dispensaries/hospitals. The monitoring can be done by Public Health Department and other infrastructure, e.g. hospitals and dispensaries constructed by the project proponents.

#### **Operation Phase**

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. The monitoring can be done by Public Health Department and other infrastructure, e.g. hospitals and dispensaries constructed by the project proponents.

### **6.7 Land Use**

#### **Operation Phase:**

During project operation phase, it is proposed to monitor land use pattern once every year using satellite data as procured by National Remote Sensing Agency, Hyderabad. A summary of the Environmental Monitoring Plan for construction and operation phase is given in **Table 6.1 and 6.2 below.**

**Table 6.1: Environmental Monitoring (Construction Phase)**

<b>Item</b>	<b>Parameters</b>	<b>Frequency</b>	<b>Location</b>
Effluent from septic tanks	PH, BOD, COD, TSS, TDS	Once every month	After treatment for each septic tank
Noise	Equivalent noise level	Once in a week	At major construction site
Air quality	SPM, RPM, SO <sub>2</sub> and NO <sub>x</sub> ,	Once every season	At major construction site (total 3 stations)

Item	Parameters	Frequency	Location
Meteorological aspects	Wind direction and velocity, temperature, humidity, rain	Once every season	At one of the ambient air quality sampling sites
Flora and Fauna	Qualitative and quantitative assessment of flora and fauna.  Animal movement corridors and man/animal conflicts will be identified	Once every year for the entire construction period	-
Aquatic Ecology	Qualitative and quantitative assessment of flora and fauna	Once every year for the entire construction period	-

**Table 6.2: Environmental Monitoring (Operation Phase)**

Items	Parameters	Frequency	Location
Water	pH, temperature, EC, turbidity, total dissolved solids, calcium, magnesium, total hardness, chlorides, sulphates, nitrates, DO, COD, BOD, Iron, Zinc and Manganese.	Thrice a year	1 km up-stream of intake site 3km downstream of the confluence of the tail race discharge, with the river
Treated Effluent from STP	pH, BOD, COD, TSS, TDS	Once every week	Before and after treatment from STP
Erosion & Siltation	Soil erosion rates, stability of bank, embankment etc.	Twice a year	-
Ecology	Status of afforestation programs of green belt development	Once in two years	-
Aquatic Ecology	Phytoplankton, zooplanktons, benthic life, fish composition	Thrice a year	1 km up-stream of intake site 3 km downstream of the confluence of the tail race discharge with the river
Land Use	Land use pattern using satellite data	Once in a year	Catchment area
Soil	pH, EC, texture, organic matter	Once in a year	Catchment area



## **6.8 Adaptive Environmental Management Requirements**

The concept of adaptive management has become a foundation of effective environmental management for initiatives characterized by high levels of ecological uncertainty. Adaptive environmental management is based upon the premise that managed ecosystems are complex and inherently unpredictable. Adaptive management accepts the uncertainty that exists in the real world rather than ignoring it. Consequently adaptive management views management actions as experiments rather than solutions. Generally, adaptive management of environmental issues involve the monitoring and evaluation of the environmental performance of a particular program or activity and responding to that evaluation with appropriate changes to the program or activity. This is an iterative process, repeated for as long as it takes for an environmental system to stabilize after an impact.

Changes may need to be made to the methods used to address and implement the impact management and monitoring objectives determined for the project. An Adaptive Management approach will therefore be adopted for environmental and social management components. Adaptive management will be applied to following project related impacts for at least five years irrespective of changes to these over five years period. If any impact does not show uncertainty within five years then that component will be assumed to be stabilized for environmental complexity point of view:

## **6.9 River Water Quality**

KHC will continuously monitor river quality for three seasons every year at three locations viz. at Lethang Hydropower Project intake structure, upstream of tailrace and downstream of tailrace. The monitored results will be utilized for adaptive management of environmental and ecological issues generated from managed flow.

## **6.10 Silt Load and Grain Size Distribution**

Siltation is common phenomenon in Rathang Chu River. Upstream project activities, floods and other natural disasters often dump large amount of silt in the river causing heavy load on power generating units downstream. For the Lethang Hydropower Project, measurement of silt load and grain size distribution every year in the river will be undertaken to evaluate the effectiveness of CAT plan and further mitigation/improvement measures required if any. State of the art tools and latest models will be used for this study.

## **6.11 Indoor Air Quality at Power House Area**

This is important parameter for measuring occupational health of the operators in the power house. Indoor air quality will be monitored twice a year for internationally established indoor air quality parameters. The results will be utilized for designing effective air quality management in the area and continuous improvement of the same.

### 6.12 Erosion and Landslide

Erosion and landslides will be monitored through photographic analysis of pre selected areas of rock and land strata at 6 monthly intervals. KHC team will undertake survey of the potential areas, mark and photograph them on visible scale of clarity. Exercise will be repeated every six month and comparative analysis will be made of photograph to identify changes, if any in the rock, vegetation, and strata locations. A record will be maintained of changes occurring in the character of the land strata and /or rock. Evaluation will be used for advance warning of possible erosion and landslide possibility.

### 6.13 Changes in Flow of the Natural Water Source

Natural water resources will be monitored every year by Kalpan Hydro physically to establish their conditions and for maintaining inventory so that compensation measures for asset loss as established during project preparation stage can be implemented effectively. This will be in addition to the system where local people have access to project information system for notifying their complaints, etc on the water resources status of the area.

### 6.14 Fish Management

Fish management as approved by state fishery department will be implemented and evaluated for progress every year. Adaptive management principles will be implemented in case the progress is not found satisfactory.

### 6.15 Budget

The monitoring and evaluation process will require additional and at times, extensive surveys and primary data collection, either to establish a base line or to measure changes. In order to respond to evolving management needs, a contingency budget may be required-especially where response may require capital works. Remaining requirement of contingency budget will be committed by KHC under performance commitment as recommended by the finance agencies.

#### Construction Phase (3.5 Years)

Attribute	Location & frequency	Parameters	Monitoring cost per year in Rs. (A)	Total cost in Rs. (A x 3.5)
Air Quality	Three locations (Yuksam, Lethang, Ramgaythrong)	So <sub>2</sub> ,NO <sub>x</sub> , SPM, RSPM	12 samples @ Rs 2500 = 30,000 / -	1,05,000
River Water	Three locations (up-stream of intake site, downstream of power house site, one in between the project stretch); bimonthly sampling	As per BIS standard	18 samples @ Rs. 4000/- = 72,000/-	2,52,000

Attribute	Location & frequency	Parameters	Monitoring cost per year in Rs. (A)	Total cost in Rs. (A x 3.5)
Septic tank effluent	Five locations; monthly sampling	pH, BOD, COD, TSS, TDS, O&G	60 samples @ Rs. 1500/- = 90,000/-	3,15,000
Erosion & Siltation	Throughout the project stretch (visual observation by experts hired – yearly)	Soil erosion, stability of bank, embankment etc.	1,00,000/-	3,50,000
Terrestrial Ecology	The project stretch and immediate surroundings including afforestation programme (visual observation by experts hired - yearly)	Status of afforestation programs & green belt development	50,000/-	1,75,000
Aquatic Ecology	Three locations along the project stretch - (sampling – Quarterly)	Phytoplankton, zooplanktons, benthic life, fish species	12 sampling @10,000/- = 1,20,000/-	4,20,000
Soil	Six locations in the project area – once in a year	Physico-chemical parameters	6 sampling @5000/- = 30,000/-	1,05,000
<b>Total Cost</b>			<b>4,92,000/-</b>	<b>17,22,000 /-</b>

### Operation Phase

Attribute	Location & frequency	Parameters	Monitoring cost per year in Rs.	Total Cost in Rs.
River Water	Two locations (up-stream of intake site, downstream of confluence of the tail race discharge with the river); Quarterly sampling	As per BIS standard	8 samples @ Rs. 4000/- = 32,000/-	Rs. 32,000/-
STP effluent	Before and after treatment from STP - monthly sampling	pH, BOD, COD, TSS, TDS, O&G	24 samples @ Rs. 1500/- = 36,000/-	Rs. 36,000/-
Erosion & Siltation	Throughout the project stretch (visual observation by experts hired – yearly)	Soil erosion, stability of bank, embankment etc.	1,00,000/-	Rs. 1,00,000 /-
Terrestrial Ecology	The project stretch and immediate surroundings including afforestation programme (visual	Status of afforestation programs & green belt	50,000/-	Rs.50,000/-

Attribute	Location & frequency	Parameters	Monitoring cost per year in Rs.	Total Cost in Rs.
	observation by experts hired - yearly)	development		
Aquatic Ecology	Three locations along the project stretch – Quarterly sampling	Phytoplankton, zooplanktons, benthic life, fish species	12 sampling @10,000/- = 1,20,000/-	Rs.1,20,000 /-
Land Use	Catchment area - yearly	Land use pattern using satellite data	4,00,000/-	Rs. 4,00,000 /-
Soil	Six locations in the project area – once in a year	Physico-chemical parameters	6 sampling @5000/- = 30,000/-	Rs. 30,000 /-
<b>Total Cost</b>				<b>Rs. 7,68,000/-</b>



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# CATCHMENT AREA TREATMENT PLAN

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# 7

## CATCHMENT AREA TREATMENT PLAN

### 7.1 Introduction

The Lethang Hydro-Electric Power Project has proposed to have a barrage across the uppermost part of Rathang Chu, a tributary of Rangit river near village Lethang at latitude 27 °23' 12" N and longitude 88 °12'43" E in the Eastern Himalayan belt in north Sikkim district. The proposed barrage site is about 4.75km downstream from the confluence of Prek Chu and Chhurong Chu. The location of the barrage site and the delineated catchment has been shown in **Fig. 7.1**

The Lethang HEP catchment form part of the 3A1A7 watershed of the Watershed Atlas of India MOA, GOI, New Delhi. It is still a large unmanageable unit for water development program, as such, the Lethang catchment has been further subdivided into 3 sub watersheds, 5 macro watersheds and 38 micro watersheds which is the lowest hydrologic unit used for soil and water conservation purpose and to project a Catchment Area Treatment (CAT) Plan with multiple objectives viz. erosion control, soil conservation, silvi-pastoral development as well as socio-economic development of the area.

The life of a barrage is directly affected by the rate of siltation and is a major threat to the utility and longevity of a barrage. In this context, the soil and Land Use Survey of India, Ministry of Agriculture and Co-Operation has developed the silt yield Index method to prioritize the micro watersheds in terms of very high, high, medium, low and very low priorities for taking up soil and water conservation works for the major river valley project in India. These thus cater the needs of selecting highly eroding area from the vast span of the large catchment and attain the following objectives.

### 7.2 Objectives

The main objectives of project are:

- a) Conservation of soil and water in the Lethang HEP and ensure the longevity of the hydel power project.
- b) Suggest neo silvi- pastoral-agrarian industrial ventures to promote the concept of Bio-Industrial watershed.
- c) Promote people's participation in project concept, execution and management to provide employment to local people and to attain economical development.
- d) Suggest ecological rehabilitation measures for physical and biological disturbances during the project execution.



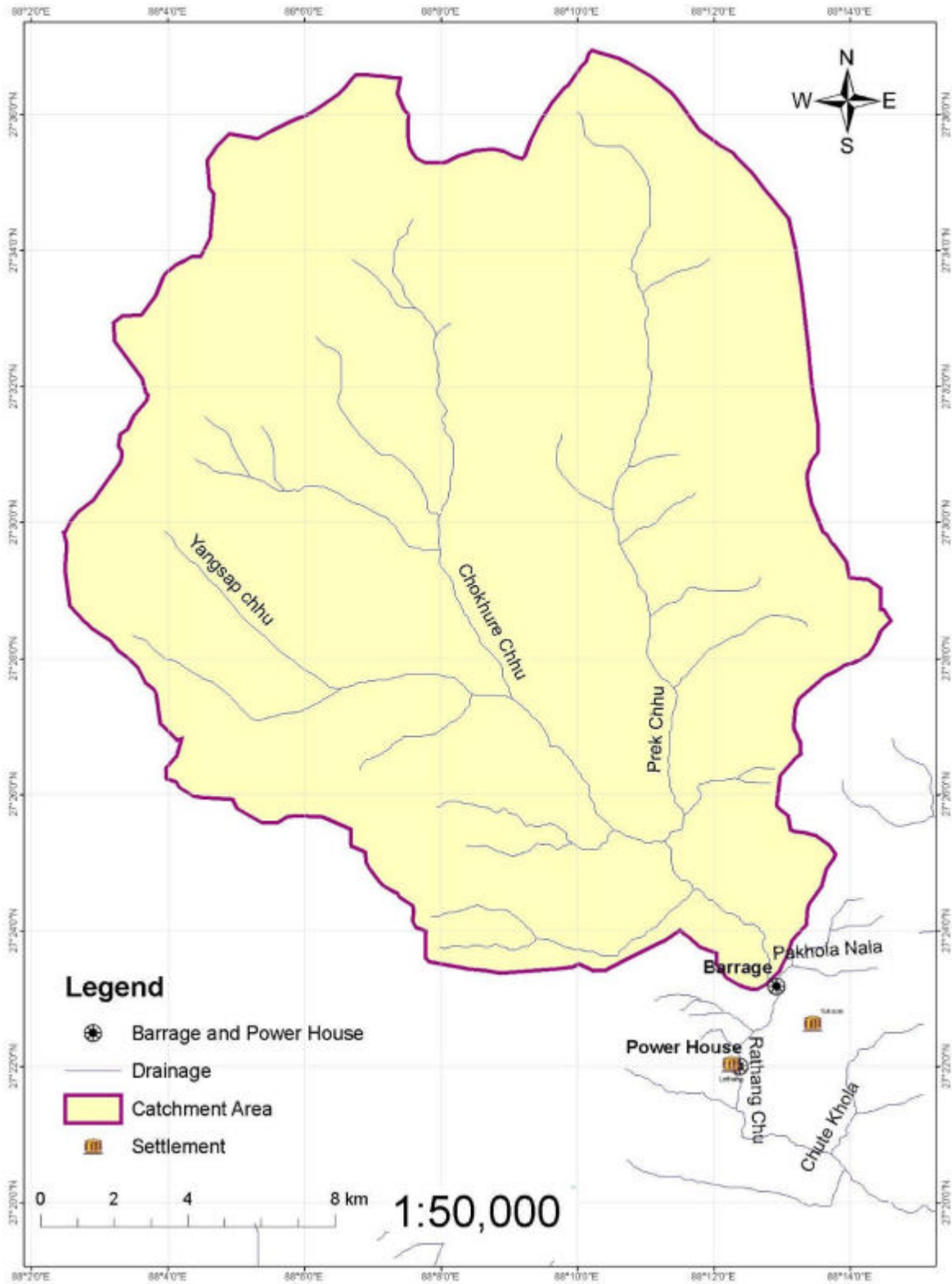


Figure 7.1: Location of Barrage Site and Delineated Catchment Area

### 7.3 Sediment Yield Index (SYI) Methodology

The Sediment Yield Index model is based on mapping Erosion Intensity Mapping Units (EIMU) which is a composite expression of physiography, land use, soil, erosion and conservation practices adopted. The EIMUs are assigned varying weightages from 1-25 or so implying the sediment detachment potential. Higher the weightage higher the detachment potential. It is further subjected to a delivery ratio and is important to convey as to how much of the detached sediment is likely to reach to the reservoir site.

Many factors like proximity to the reservoirs/ stream, texture of the eroded material, type of erosion, relief length ratio, etc. are important to fix the delivery ratio. This is further subjected to 2-3 stage system of nala or rivers, entrapments through tanks or reservoirs call for reduction of the delivery ratios. The computation of the Sediment Yield Index (SYI) is done by using the following formula:

$$SYI = \frac{\sum W * A * DR}{\sum A (MWS)}$$

$\sum$  = Summation

W = Weightage of the EIMU

A = Area

DR = Delivery Ratio

A (MWS) = Area of micro watershed

Once the micro watershed wise SYI are computed they are arranged in decreasing order of SYI i.e. highest silt yield index micro water shed will have the first priority number followed by arranging the rest of MWS in decreasing order of SYI. Prioritization into very high, high, medium, low and very low is done based on the frequency distribution of the SYI.

As per guidelines from the Central Water Commission, the very high and high priority MWS areas around the reservoir periphery and directly draining very high/ high areas in the close contributing zone are then selected for soil and water conservation planning.

#### 7.4 Catchment Characterization of Lethang HEP, West Sikkim

The Lethang catchment area is located in the extreme north east part of the West Sikkim district. It is located in between the 27°23'13.8" and 27°36'48" N and 88 ° 2'22.8" and 88 ° 14'32.4"E. It has an altitudinal variation from about 2000m above the mean sea level (msl) near the proposed barrage site to highest of 6800 msl near the mount located in the extreme north west border. In general, there is rise in elevation from south to north and from centre to east and to west also. The northern part of the catchment has ranges, steep narrow valleys and gorges with numerous kholas and chus. Of them Prek, Chhurang chus meet to form Rathang Chu on which lie the proposed Lethang Hydel Project. The extreme northern, north east and northwest parts bordering Lethang catchment is covered by snow throughout the year. The general slope of the land is toward south. Based on contours, the slope map has been generated to form 10 slope groups of which lowest is class IV from 5-10% to cover only a few patches with slightly increased coverage in class V and VI from 10-15 and 15 to 25%, respectively. By and large, there is moderate distribution of areas of slope class VII ( 25-35%) while rest of the area is shared equally between slope class VIII (35-50%), IX (50-75%) and X (> 75%). Geologically, Quartzite, Calcgneiss calgranulites and bands of biolite, schist, amphibolite and apatite veins cover this catchment. It falls within the high annual rainfall zone of 2400mm mostly during the monsoon period beginning from June to almost middle of October and experience Sub tropical to temperate climate which varies with altitude and slopes. The maximum temperature is around 15° C during July-August and subsequently fall to 3-5 ° C during December and January. Of the 10 soil groups Typic Udorthents, Typic Cryorthents and Glaciated areas are met with from south to northern parts and enjoy mesic to cryic soil temperature regime in this area. Land Use Land Cover wise major part of the area is rocky waste lands/ scrub lands, forest lands, limited agriculture, few seasonal grasslands, a few lakes and rural settlements are seen in the catchment. By and large, this area has poor network of roads, industrially backward but have great potential to generate hydropower and natural reservoirs can be well managed for socio economic development. The slope map of catchment area is shown in **Figure 7.2**.

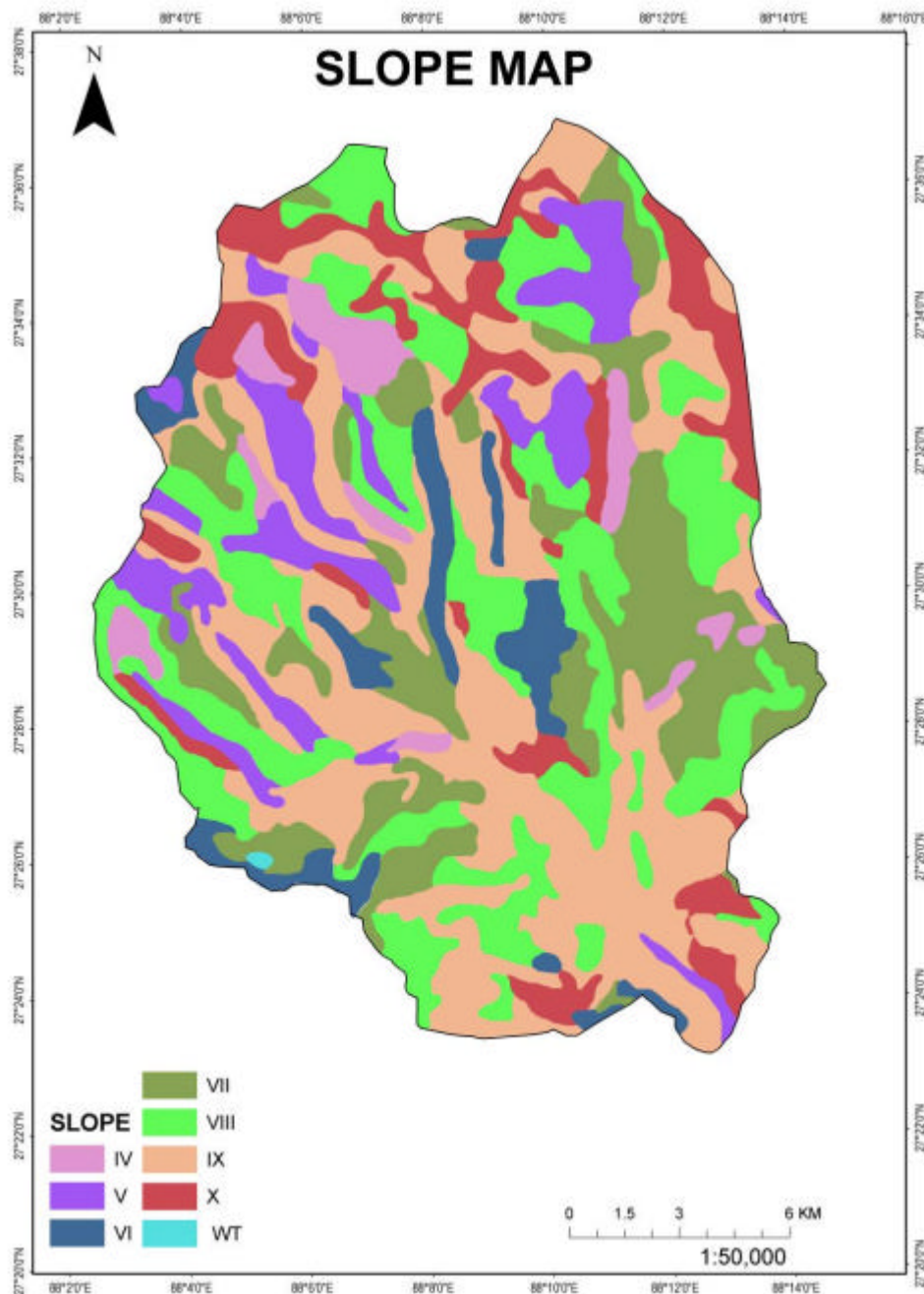


Figure 7.2: Slope Map of Catchment Area

#### 7.4.1 Erosion Intensity Mapping Units

So far general characterization on physiography, relief, slopes, drainage, geology, soils, erosion conditions, landslides/slips of the Lethang catchment has been discussed but is not enough to locate the highly eroding site specific watersheds. In order to achieve this objective and to assess the most eroding watersheds, 33 composite Erosion Intensity Mapping Units have been framed after the visual image interpretation of IR 6, P6, LISS III satellite data of October 2009 and February 2010. The Erosion Intensity Soil Mapping Units legend along with their weightages and delivery ratios is given in **Table 7.1** below.

**Table 7.1: Erosion Intensity Mapping Units**

Symbol	Description	Weightage	Delivery Ratio %
<b>Snowy Landscape</b>			
1	Permanently snow covered areas on 15-35% slopes	11:00	70
2	Permanently snow covered areas on 35-50% slopes	12:00	75
3	Ablatious snow covered areas on > 50% slopes	14:00	60
4	Ablatious snow covered areas but beyond February remains under snow cover, > 50% slopes	13:00	60
<b>Glacial Valley Landscape</b>			
5	Ablatitious upper glacial U shaped valley on 15- 35% slopes with excessively drained loamy skeletal bouldary and stony soils, severe erosion	15:00	90
6.	Ablatitious U shaped valley with shallow excessively drained loamy skeletal with stony phases over 50% slopes, severe erosion.	17	95
7	Ablatitious upper U shaped valley on 15 – 35 % slopes but beyond February remains under snow. Moraine is bouldary, moderate erosion	14	85
<b>Rocky Landscapes , Seasonally snow covered water donor areas</b>			
8.	Moderately rocky lands over 15-35% slopes but beyond February remain under thick snow cover	13	80
9	Extremely rocky lands over 50% slopes but beyond February remain under thick snow cover, moderate erosion	14	85
10	Extremely rocky lands over 50% slopes but cover thin ablatious snow cover slight to moderate erosion Very shallow to shallow loamy skeletal soils in patches, barren.	16	85
<b>Rocky Landscapes, Water Donor Areas</b>			
11	Moderately rocky areas over 15-35% slopes, very shallow to shallow loamy skeletal soils in patches, barren slight to moderate erosion.	12	80
12	Moderately rocky areas, variable slopes, shallow to moderately deep/ gravelling coarse loamy soils, waste lands, barren severe erosion.	14	80
13	Moderately rocky areas with scattered patches of shallow loamy skeletal soils over 35-50% slopes, barren, moderate erosion	13	80
14	Moderately rocky areas severely dissected shallow loamy skeletal soils in patches over 35-50 % slopes, severe erosion, slight to moderate land slides/slip hazards.	16	90
15	Moderate to occasionally severely rocky lands with a few scattered patches of shallow loamy skeletal soils over 50% slopes, barren, moderate to severe erosion	14	90
<b>Rocky Landscapes with Seasonal Vegetation</b>			
16	Slightly rocky lands over 15- 35% slopes, moderately shallow, gravely fine loamy soils, October onwards	12	75

	slight to moderate vegetation and moderate erosion		
17	Moderately rocky lands shallow loamy skeletal soils, October onwards moderate vegetation cover, moderate erosion	13	80
18	Moderately rocky lands, intercepted by fallow over 15-35% slopes, October onwards moderate vegetation cover dissected with severe erosion.	14	80
19	Moderately rocky lands, intercepted by fallow over 35-50% slopes, moderately shallow loamy skeletal soils, October onwards moderate vegetation cover dissected with moderate erosion.	15	85
20	Extremely rocky lands over 50% slopes, dissected, shallow loamy skeletal soils, moderate vegetation cover severe erosion, slight to moderate land slide/slip hazards	17	85
<b>Forest Landscapes</b>			
21	Riverine, moderately to dense forest, moderately deep to deep, gravely fine loamy soils, occasionally stony over <15% slopes moderate erosion	14	90
22	Valley bottom, moderate to dense forest, moderately deep to deep, loamy soils with slight stoniness, 5-15% slopes, dissected, severe erosion.	15	90
23	Summit/hill tops, moderate to dense forest, deep, well drained fine loamy soils, slightly stony, 15-35% slopes, moderate erosion.	13	80
24	Hillside slopes, 35-50%, moderate vegetal cover, and moderate erosion, slight to moderate landslide/slip hazards.	16	80
25	Hillside slopes, 35-50%, moderate vegetal cover, highly dissected, severe erosion and moderate landslide hazards	19	85
26	Hillside slopes >50%, moderate vegetal cover, shallow loamy skeletal soils, moderate erosion.	17	80
27	Hillside slopes >50%, moderate to dense vegetal cover, highly dissected, severe erosion and landslide hazards	21	85
28	Glacial valley moraine, 35-50% slopes, slight vegetal cover, fragmental/ skeletal soils, severe erosion	16	75
29	Glacial valley moraine, > 50 % slopes, slight vegetal cover , fragmental/ skeletal soils, moderate erosion	17	80
<b>Mixed Landuse Landscape</b>			
30	Moderate to steep slope 5-35%, gravely moderately deep, loamy soils limited agriculture, habitation and grasslands	14	80
31	Extremely steep slopes under seasonal grasslands and scrub, moderately loamy skeletal soils under snow at times, moderate erosion	12	80
<b>Riverine Stream Bank Cutting Landscapes</b>			
32	Dissected river, nala, Chu banks, gravely loamy skeletal soils, severe bank erosion and land slides/Slips	24	95
<b>Undifferentiated Landscape</b>			



33	Areas under cloud and shadows under variable slope and erosion conditions. Exact erosion could not be assessed.	12	80
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#### 7.4.2 Results of Prioritization of Micro Watersheds :

The computation of sediment yield indices of 38 Micro Watersheds within the Lethang Hydro-Electric power project catchment is presented in **Annexure – VIII**. The Sediment Yield Index ranged from 1477 to 769. Higher the Sediment Yield Index higher is the priority for implementation of soil and water conservation measures with an aim to reduce the sedimentation of the proposed reservoir site. For convenience based on SYI five classes have been proposed as indicated in **Table 7.3**. An abstract of the prioritization study in other wards number of micro watersheds falling in each priority class along with their corresponding percentage distribution is presented in **Table 7.2**. It helps to understand the areas for which soil conservation treatment are needed on priority basis. The details of micro watersheds code area in hectares, Sediment Yield Index and priority list of very high and high category are given in **Table 7.3** and computation of Sediment Yield Index **Annexure – VIII**.

**Table 7.2: Abstract of Prioritization of Micro Watershed in Lethang HEP, West Sikkim**

Category	Range of Sediment Yield Index	Area Sq. Km	Nos. of MIWS	Percentage to catchment area
Very high	> 1400	17.26	2	5.1
High	1200-1399	84.63	13	24.9
Medium	1000-1199	124.57	13	36.7
Low	800-999	102.09	9	30.1
Very low	<800	11.00	1	3.2
<b>Total</b>		<b>339.55</b>	<b>38</b>	<b>100</b>

The distribution of very high and high priority micro watersheds in Lethang catchment is seen in **Figure-7.3** and appears that most of them are concentrated along the reservoir and lower parts of Prek and Choksering Chhus. The above statistics reveals that out of 38 microwatershed nearly 30 % of the total catchment area falls under very high (5.1 %) and high (24.9 %) priority microwatershed. Two microwatersheds qualify for very high priority; while thirteen microwatersheds are classified as high priority watersheds. At a glance, these very high and high priority microwatersheds are classified as high priority water sheds. At a glance, these very high and high priority microwatersheds can be seen in **Figure-7.3**. It appears that both the very high priority microwatershed falls in lower Chokesering or Chokure and Yangsap Chus Subwatersheds. Overall all the three microwatersheds of Rathang Chu, 4 microwatersheds of Prek Chu and 6 microwatersheds of Chokhure and Yangsap Chus belong to very high and high priority category and requires soil and water conservation measures.

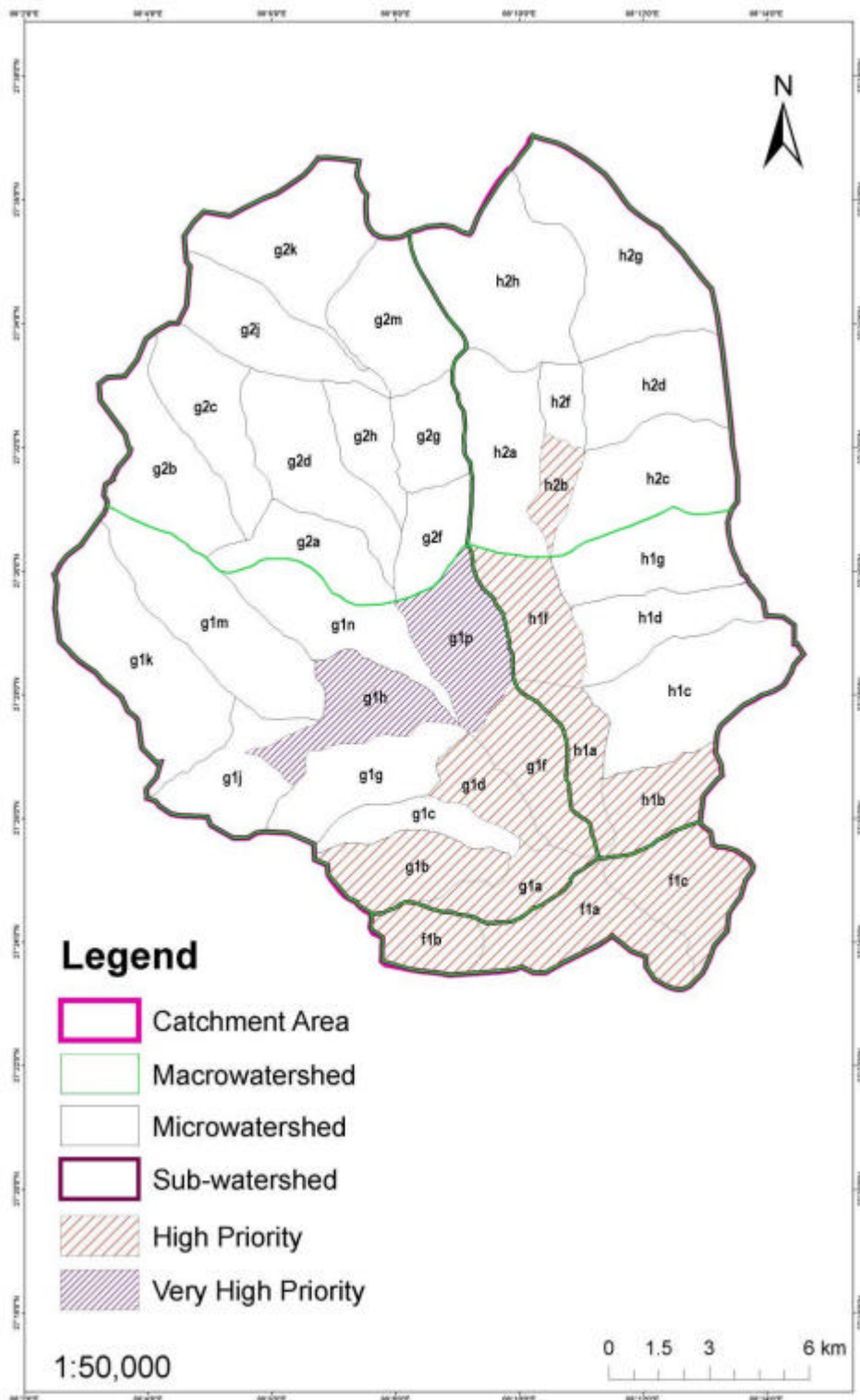


Figure 7.3: Distribution of Very High and High Priority Micro Watersheds in Lethang Catchment

### 7.4.3 Review of Soil Conservation Works:

The soil and water conservation works for arable and non arable lands under NWDPRA schemes are:  
 Arable lands: Earthen loose boulder structures with vegetative support, earthen bunds, check bunds, contour bunds, contour terrace bunds, vegetation bunds, etc.

**For Waste/Scrub Lands:** Brush wood checks, earthen loose boulder structures with vegetative support or gabions, water harvesting structures, Pasture development with over seeding. Vegetation filter strips, contour vegetation hedges, tree or shrub plantation, check bund, dug out sunken structures, percolation structures and tanks, silt retention dams, etc. Discourage deforestation and adopt 3 tier slope management technique.

**Table 7.3: List of Priority Micro Watersheds in the Lethang HEP Catchment**

S No.	Micro Watersheds Code	Area( ha)	Sediment yield Index	Priority No.
<b>Very High (&gt;1400 SYI)</b>				
1	glp	921	1477	1
2	glh	805	1429	2
<b>Total Area =</b>		<b>1726 ha</b>	<b>(5.1% of Total Catchment Area)</b>	
<b>High (1200-1399 SYI)</b>				
1	gld	432	1399	3
2	h1a	514	1373	4
3	h1f	818	1346	5
4	glf	725	1328	6
5	h1b	641	1324	7
6	f1a	1007	1320	8
7	f1b	486	1302	9
8	glc	496	1285	10
9	f1c	902	1281	11
10	h2b	267	1277	12
11	glb	773	1273	13
12	glg	927	1247	14
13	gla	475	1203	15
<b>Total Area =</b>		<b>8463 ha</b>	<b>(24.9% of Total Catchment Area)</b>	
<b>Medium (1000-1199 SYI)</b>				
1	gln	926	1179	16
2	h2f	194	1162	17
3	h2a	934	1134	18
4	glj	789	1120	19
5	h1c	1505	1104	20
6	g2d	1158	1102	21
7	glm	1490	1092	22
8	g2h	501	1068	23
9	h1g	789	1062	24
10	h1d	815	1048	25
11	g1k	1679	1046	26
12	g2a	705	1035	27
13	g2j	972	1015	28
<b>Total Area =</b>		<b>12457 ha</b>	<b>(36.70 % of Total Catchment Area)</b>	
<b>Low (800-999 SYI)</b>				
1	h2h	1677	989	29
2	h2g	1702	981	30
3	g2f	512	969	31
4	g2b	1103	926	32
5	h2c	1222	937	33
6	g2g	556	917	34
7	g2m	1054	858	35
8	g2c	971	835	36

S No.	Micro Watersheds Code	Area( ha)	Sediment yield Index	Priority No.
9	g2k	1412	832	37
<b>Total Area =</b>		<b>10209 ha</b>	<b>(30.1% of total catchment area)</b>	
<b>Very Low (&lt;800 SYI)</b>				
1	h2d	1100	769	37
<b>Total Area =</b>		<b>1100 ha</b>	<b>(3.2% of total catchment area)</b>	
<b>Total Catchment Area is 335.55 Sq.Km</b>				

#### 7.4.4 Sensitivity Analysis of Soil Conservation Measures

For impact analysis assessment of different soil conservation techniques considerable published information is available. A few references pertaining to the above study are given below. Das (1966) did critical appraisal of soil conservation measures and reported that there is hardly any measure which can control:

- i) Run off
- ii) Soil loss
- iii) Organic degradation
- iv) Maintain chemical enrichment
- v) Improve soil water storage.

There are, however, number of structural measures for reducing runoff, soil loss and improving soil water storage. Vegetation measures not only reduce organic degradation but substantially achieve the set goals. Normally soil tolerance limit (STL) ranges from 7.5 to 12 t /ha/annum.

#### 7.4.5 Efficiency of Mechanical Measures of Soil Conservation :

**Contour Bunds:** Contouring reduce soil erosion upto 50% when compared with land farming along the slope. Crop rows planted across the slope along the contour increases infiltration into the ground and reduce soil erosion. It can be spaced 10 to 20 m upto 3% slopes.

**Terraces:** Terraces are earthen embankments built across to reduce the slope and therefore the velocity of the surface flow. Design of the terrace, stability, location of the outlet and gradient of the terrace are of varied types. Terracing practices range from inward to outward slope terraces.

**Sedimentation Ponds:** These are constructed at selected locations along the channel to trap the sediment, store water and increase infiltration. They function as mini dams to stabilize and reclaim gullies and channels subjected to severe erosion.

#### 7.5 Proposed Soil Conservation Measures:

Conservation measures proposed for the Lethang Catchment requires an integrated approach of three disciplines, namely (1) Engineering (2) Agronomy and (3) Forestry, and involves a coordinated effort for a comprehensive and composite programme of development and management of watersheds. Broadly these disciplines cover:

- a) **Engineering:** Bank Protection and roadside control measures, spurs, check dams, bunding/ terracing, gully plugging, masonry or concrete water disposal system, etc.
- b) **Agronomy:** Retirement of severely eroded land to permanent protection of vegetation, Pasture development vegetative waterways, contour farming, strip cropping, crop protection etc.
- c) **Forestry:** Forest conservancy, management and protection of forest plantation etc.

The choice of any of all the above measures depends on the catchment characteristics, more important being the surface relief, as has been elaborately explained in Section 3.

In order that maximum benefits of the measures suggested in this section is to cover the most critical area of land as feasible in the shortest time span, it is essential to first identify the pockets in the catchment that contribute to the silt load and the amount of silt concentration as the unit of management. This exercise was done with visual interpretation of the recent two season's satellite data of IR6, P6, LISS III and identifying erosion intensity mapping units. The result of this prioritization study, 2 very high and 13 high priority micro watersheds for the purpose of soil and water conservation planning have been identified.

For purpose of suggesting various treatment measures the catchment area has been divided into various slope groups.

**Table 7.4: Slope Groups and Proposed Treatment Measures**

Slope Group	Potential Land Use	Treatment Proposed
0 – 35 %	Good Agricultural Land	Agronomic Practices : i. Strip Contouring ii. Contour fencing by bunding and leveling iii. Construction of small water storages iv. Pasture development v. Stone wall terracing vi. Terracing vii. Bunding viii. Graded trenching
35 – 50 %	Agricultural Agro Horticulture	i. Half (1/2) moon terracing. ii. Staggered trenching
> 50 %	Not good for agriculture	i. Agro-forestry ii. Agro-Horticulture iii. Staggered Trenching iv. Half (1/2) moon terracing
Drainage line treatment (Arable/ Non – Arable, both)		i. Gully Plugging ii. Grade control structures iii. Gabion walls

Since the catchment area has a soil depth, generally ranging between 25 cm to 100 cm no treatment involving large amount of earthwork can be recommended as the soil depth would further be reduced and the area would be rendered unsuitable for cultivation. However, there are few areas where with 25 cm cut/fill resulting final soil depth will be sufficient for shallow rooted agricultural crops and therefore, limited bench terracing and bunding has been suggested. Here again, looking to the very limited slope for earthwork and also the abundant availability of stone boulders in the vicinity, stonewall terracing has been recommended.

Similarly, in the case of drainage line treatment length, in the upper reaches of the drainage line where the runoff contributing area is small, smaller structures like earthen dykes fortified with vegetation are the recommended practices. Loose Stone Check Dams (LSCD) are suggested which would be built of locally available stone boulders, eliminating earthwork altogether.

Further, in the lower reaches of the drainage lines where the area is generally gentle (foot hill region) and can afford water storage facilities, a masonry/concrete dams can be built. But looking to the very complicated terrain, prohibitive cost of construction and above all the objective of the project, i.e., silt

control and not water harvesting, it is recommended that gabion walls be constructed in preference to solid stone/concrete dams.

### 7.5.1 Slope Group upto 35 Percent

In this group, both slope groups up to 2 - 10 % and 10–35 % are clubbed. This because the catchments have general slope ranging between 35 – 100 % and the 2 – 10 % group hardly exist except in a few patches adjoining the lake or areas levelled for cultivation/construction.

The treatments for slope groups 1-10 % and for 10 – 35 % are however described separately for purpose of clarity.

- a) **Treatment of Land under Slope Group (1-10 %):** This slope group is proposed to be treated by agronomical interventions.
- i) Pasture development and their protection.
  - ii) Construction of small water storages.
  - iii) Vegetative waterways
  - iv) Contour farming by bunding and terracing
  - v) Strip cropping
- i) **Pasture development:** It was observed during the field reconnaissance that the catchment has vast expanse of forest cover. Dense to semi dense forest of predominantly pineskesiya interspersed by carpet of herbaceous vegetation have protected steep hilly slopes of the region from erosion. The exposed land surface has suffered erosion and the run off carrying muddy water was seen flowing through series of gullies into the streams. In these areas, the gully heads are required to be treated with filter strips/vegetative barriers to check the erosion and barren patches of land underneath the trees need to be planted with grass turfing (sodding). Local people, however, reported that there is no need to plant grass sodding, as, with the onset of monsoon rains, the grass would automatically regenerate and by the time the monsoon reaches the peak stage, the entire tract would have a thick carpet of grass all over, preventing the soil erosion completely. Only mild erosion takes place when the first rain fall and that too confined to small patches. This view was confirmed as growth of grass on surface could be seen as early as in April.
- In WAPCOS report it has been suggested that jhoom cultivation be ended and that the farmer be provided with alternate livelihood be means like animal husbandry and pisciculture. In the context of promoting animal husbandry, properly managed pasture requires to be developed and therefore the barren land where ever they exist are to be planted with edible grass and forage. It has been found that abundance of high quality forage is the very foundation of any type of livestock farming.
- ii) **Construction of small water storage structures:** The steep topography of the catchment offers very little scope for water harvesting structure, but the foothill reaches, which form the lower reach of the drainage line, have few locations where sunken ponds could be built before the drains empty into another chus. These structures are inexpensive and besides storing water they will also detain silt before allowing clear water to pass through.
- iii) **Vegetative waterways:** These are waterways protected by vegetation to prevent river Rathang Chu bank slips and slides and their conversion into gullies. Natural drainage depressions, seeded or soddings planted with adoptable grass-legume mixture may be often utilized, as satisfactory water channels and meadows at the same time. These vegetated waterways are generally more than 6 m wide and the seeding is done to cover besides the entire width, a part of the banks too. These vegetative waterways are used for the safe disposal of surplus water from the terraces.



- iv) **Contour farming:** Contour farming consists in carrying out agricultural operations like planting, tillage and inter-cultivation along the contour or nearly so. Contour cultivation reduces the velocity of overland flow and retards soil erosion. In certain cases, after the inter-cultivation operation, small ridges and furrows are formed which offer more resistance to erosion and run off. It also increases the opportunity time for run off to percolate down the soil column and reduce the run off. This practice of conservation is recommended for slopes upto 2-5 % and deep permeable soils. Used in conjunction with other methods like bunding and grassed waterways. The contour farming yields better results.
- v) **Strip cropping:** Strip cropping consists of growing different crops in alternate strips across the slopes such that they serve as vegetative barriers to erosion. The alternate strip consists of close growing erosion resisting/permitting crops. For best results, like contour farming, strip cropping too is to be done in combination with other farming practices. Strips of erosion resisting and erosion permitting crops are laid out on contours. Strip cropping on contours shortens the length of slope, check the movement of run off, helps to arrest the soil loss by providing a biological barrier/filter, and increases the absorption of rain water by the soil. Strip cropping is recommended for slope group of 3 – 8.5%. Strip width varies with the degree of erosion hazard and generally ranges between 15 – 45 m. The width and spacing of strips are decided based on experience. Slope vs. strip width usually followed for soil with fairly high infiltration rates are:

Slope Group	Strip Width
2 – 5 %	15 m
6 – 9 %	25 m
10 – 14 %	20 m
15 – 20 %	15 m

- b) **Treatment of land under slope group 10 – 35 %:** The Lethang catchment has substantial areas, falling in this slope group. For treating the lands of these slope groups, mechanical measures of erosion control is suggested. These include bunding, terracing, diversion channel, grass waterways and surplussing arrangements for the safe disposal of the water, away from the bunded area.

Mechanical measures are series of mechanical barriers constructed across the slope to reduce or break the length of slope and degree of slope since the soil loss is proportionally to the square root of the length of the slope. Doubling the length increases the soil erosion by about 1.4 times. This means that besides the slope, length of slope requires to be broken at suitable interval before the run off attains erosive velocity. While contour and graded bund help in reducing the length of slope, they do not reduce slope of the land. Bench terracing on the other hand reduces both degree and length of slope. The choice of treatment is therefore governed by parameters like length/ degree of slope. The choice of treatment is therefore governed by parameters like length/degree of slope, infiltration rate of soil and the rainfall.

Based on these parameters in the Lethang Catchment, following mechanical measures have been suggested:

- (1) **Bunding**
- (2) **Graded stone wall**
- (3) **Inwards slopping bench terracing**
- (4) **Trenching continuous and staggered**



- (1) **Bunding:** Bunds are small earthen embankments/ levees built across the slope of land with the objective of reducing the length of slope to help intercept the run off, thus reducing the velocity and allow more time for water to seep through the soil mass. Bunds are of several types viz. contour bund, graded bund, side bund etc. Contour bunds and the graded bunds are more in use in the soil conservation however graded bunding are those which are given certain longitudinal grade for safe disposal or runoff. These are suitable in high rainfall areas (>800mm) with soil of low intake rates (<8mm/hr). Cross-section & spacing of bunds are designed using the standard empirical formula.
- (2) **Terracing:** Terracing is a method of modifying the land surface for erosion control and water conservation. Bench terracing is recommended in hilly areas with surface relief up to 35 % though they are in practice used up to 50 % land slopes. For hilly areas of lethang catchment where the rainfall is high (2400 mm) and slopes are steep and crops grown are mostly potato, inward and sloping bench terracing are used. These terraces ensure safe disposal of runoff through drain provided around the inner side of the terrace into grassed waterway. The limiting factor, however, is soil depth, which is in the range of 25 to 50 cm in most cases. Therefore such terracing has been restricted to areas where the soil depth is around 100 cm. In other cases stonewall terracing has been adopted. Soil depth, soil permeability, surface relief and farming practices are taken in consideration while designing the bench terraces, terrace grade and length of terrace cross-sections are the parameters which are determined using standard formula in design exercise.
- (3) **Stonewall terracing:** Due to constraints of shallow soil depth, in case of most of the catchment areas stone wall terraces rather than bench terraces have been suggested. This is further facilitated by free availability of stone boulder in the area. Stonewall terraces are small embankments constructed with stone boulders in the area. Stonewall terraces are small embankments constructed with stone boulders across the slopes, which besides intercepting the surface runoff also arrests the silt load thus helping in conserving both soil and water. There are no rigid rules governing the spacing of stonewall. However, 10 to 30 m are common spacing provided depending on the land slope. Stone terraces generally follow a straight alignment and depressions if any along the alignment are crossed at right angles, curves where ever needed are to be given smooth transitions. Wherever there is a deviation from the contour the vulnerable portion of stonewalls (crossing of depressions) are buttressed with additional stones, as the height of wall in these reaches. Stonewalls are anchored into the ground and proper interlocking is ensured in the wall masonry for imparting stability and strength. The soil recovered in the foundation excavation is placed on the upstream side of the wall in the shape of a bund, which is then fortified with vegetation.
- (4) **Contour trenching:** Contour trenching is a practice of excavating trenches along a uniform level across the slope of land. The excavated earth is then spread in the form of a bund on the down streamside. Contour trenches break the velocity of runoff and impound part of the run off and impound part of the run off which percolates into the soil mass and maintains better moisture regime. The contour trenches are either continuous or staggered, depending upon whether they are continuous or broken. In case of continuous trenches, the length varies between 10-20m, depending upon the width of the field. The trenches have a cross section of 30x30cm to 50x50cm. When the trenches are laid scattered with a maximum length of 24m with inter space between them, then these are known as staggered trenches. In staggered trenches, the trenches are dug one below the other, in alternate rows and in a staggered fashion. Each trench has a length of 2-3m and spacing between the rows varies from 3-5metres. Contour trenches have been suggested in the upper reaches of the hills for plantation of forestry/horticulture plants. For high rainfall areas and irregular slopes as in the lethang

catchment, staggered trenches are recommended. The bunds are to be fortified with fodder grass and the trees are planted on the downstream of the trenches.

### 7.5.2 Lands with Surface Slope Greater than 35 Percent but upto 50 Percent

In the areas falling in the slope group above 35% and upto 50% both agriculture and horticulture are suggested. The soil conservation practices recommended are:

1. Staggered Trenches and
2. Half Moon Terraces.

‘Staggered Trenches’ have already been discussed in previous pages and therefore only half moon terrace is discussed below:

‘Half Moon Terraces’: Individual basins are called half moon or semi circular terraces or small round benches for planting individual plants. The diameter of the basin is adjusted according to the need of the crop. They are particularly useful for establishing permanent tree crops on the steep slopes to control erosion. Half moon terraces are recommended on steep slopes and shallow soils. The diameter of the crescent bunds generally vary between 0.75 to 1.25m and have proved very effective on hilly area for plantation of fruit yielding trees and plantation and afforestation. The soil dug out for the half moon shaped pit is spread on downstream side with an inward slope. These slopes are planted with grass soddings for protection.

### 7.5.3 Lands with Slope Greater than 50 Percent

Land sloping more than 50 % are not recommended for agriculture crops. Any agriculture activities which require ploughing of land will only loosen the top soil and make it vulnerable to erosion. These areas constitute non-arable land and are sometimes called watersheds. Such lands require protection measures to save them from further degradation. Providing a good vegetation cover is the best option in this direction. But in highly degraded land establishment of vegetation cover is the best option in direction. But in highly degraded land establishment of vegetation is difficult due to high degree of soil erosion resulting in very shallow soil depth, high run off with erosive velocity which makes it difficult due to high degree of soil erosion resulting in very shallow soil depth, high run off with erosive velocity which make it difficult for the plants to establish.

Lethang catchment has large percentage of land falling in above 50 % slope group. Though agricultural crops are taken in a few cases this has been done at the risk and cost of severe erosion and loss of topsoil which happens in jhoom cultivation, as it is known in the catchment area, has further added to the problem.

The conservation measures suggested in non arable parts of the catchment are:

- a) Diversion Channels
- b) Contour and Staggered trenches
- c) Half moon terraces
- d) Agro-horticulture
- e) Agroforestry

a) **Diversion Channels:** Diversion channels are the channels constructed across the slopes for the purpose of intercepting the surface runoff and guiding it to safe outlet. Generally, the diversion channel is constructed between non-arable and arable lands. The Lethang catchment has forest area, barren and culturable waste land, in plus 50% slope group. Water bushes from high altitudes down the steep slopes, knocking down everything enroute. It is considered necessary to intercept the runoff

at regular interval to bring the velocity within safe limits (1.5-2.0m/s). Diversion channels have been proposed all along the boundary of the forest above agricultural land, which would discharge into the nearest natural drain. The design of diversion channels comprise of determining the area of the cross-section of the channel to carry peak run off discharge at safe velocity. Discharge is calculated for the maximum rate of discharge for a 10-year frequency. The cross-section of the channel to pass the discharge safely is determined using the standard formula. Wherever there is an abrupt change in the grade, a suitable drop is provided in the bed of channel. The spoil bank of the diversion channels should be planted with the suitable vegetation to protect and impart stability to the embankment.

**b) Drainage Line Treatment:** Drainage lines are the natural carriers of runoff and sediment in the watershed. Drainage lines include small channels/gullies, natural/artificial waterways, streams, rivulets or torrents. If these drainage lines are not properly controlled, they may go on extending and damaging the land. In the watershed treatment plan, a drainage line treatment is a significant component. The objectives of treating the drainage lines are:

1. To control the grade in the channel bed
2. Protect the bank/side from damage
3. Check soil erosion
4. To improve moisture regime around it
5. To recharge the ground water
6. Storage of water

For purpose of treatment of a drainage line, the course of a drainage line is marked on the contour map and cross sections along its alignment are taken and plotted. The L-section gives the bed slope while the cross-section gives the width and depth to estimate its carrying capacity. On the basis of nature of slope and the area controlling run-off to the channel, the drainage line is divided into upper (<5 ha), middle (5-20 ha) and lower (> 20 ha) reaches for purpose of deciding the treatment activity. Depending upon the size of the drainage line, gradient, catchment area, peak run-off and severity of the problem, appropriate type of check dam is selected.

For Lethang catchment loose stone check dams are proposed in the upper reaches. In the middle reach loose stone check dams (LSCD) are proposed with interspacing of gabion structures and earth fill dams or form ponds, etc. in the entire catchment, fairly good size of stone boulders is available which can be used to construct dry stone masonry wall or loose stone check dam. They have been successful in checking runoff velocity in steep and broad gullies and detaining silt while allowing water to flow down with reduced velocity.

LSCD built with stone rubbles around 23 cm size hand patched and wedged with stone chips. About 0.3 to 1.0 m deep anchoring inside the ground is provided at the bottom and sides to provide stability. Surplussing arrangement for smooth passage of surplus water should be provided at the center of the wall.

For lower middle and lower reaches where the drainage is more, gabion walls, MMS, with interspacing of LSCDs to control silt over these stations, are proposed as check dams. Here again, besides ease of construction, easily available stone boulders in catchment area, has been one of the considerations, without compromising on stability and longevity of the structure. 'Gabion check dams are made with stone boulders packed closely in wire crates made of G.I. wires of 10 gauge diameter. Gabion are preferred in soil conservation work as they are flexible, and allow water to pass through while detaining the silt load and are strong, stable and economic al. They do not need any special skill

to install. Gabion check dams encourage good vegetation growth on the upstream bed and banks as they help maintain good soil moisture regime without impounding water.

- c) **Masonry Dams for Silt Retention:** A few sites have been identified for the construction of masonry dams for water harvesting purpose. These are built of stone masonry dams for water harvesting purpose. These are built of stone masonry in cement mortar with surplussing arrangement of drop spillway. These are located in the lower reaches of the drainage line where the bed slope is comparatively flatter. The location of 3 such structures is given in **Fig 7.4**.

## 7.6 Detailed Planning

Detailed planning for the treatment of selected microwatersheds was done. For this purpose, the subwatersheds were further divided into easily manageable, smaller independent drainage units here in called as microwatersheds (MIWS).

In view to attain satisfactory situation diversion drains have been proposed in the forest areas. These channels would intercept the runoff at the entry and the exit of the forest land and carry it safely to the nearest drainage line.

Besides these drainage line which pass through the forest area, treatment in the form of grade control structures (LSCD and Gabion wall) have been proposed so that the flow velocity is brought within the critical limits before they leave forest zone.

## 7.7 Other Measures

Apart from the various engineering and biological measures suggested above, the following measures are also considered necessary, considering the status of the catchment.

### 7.7.1 Pasture Control:

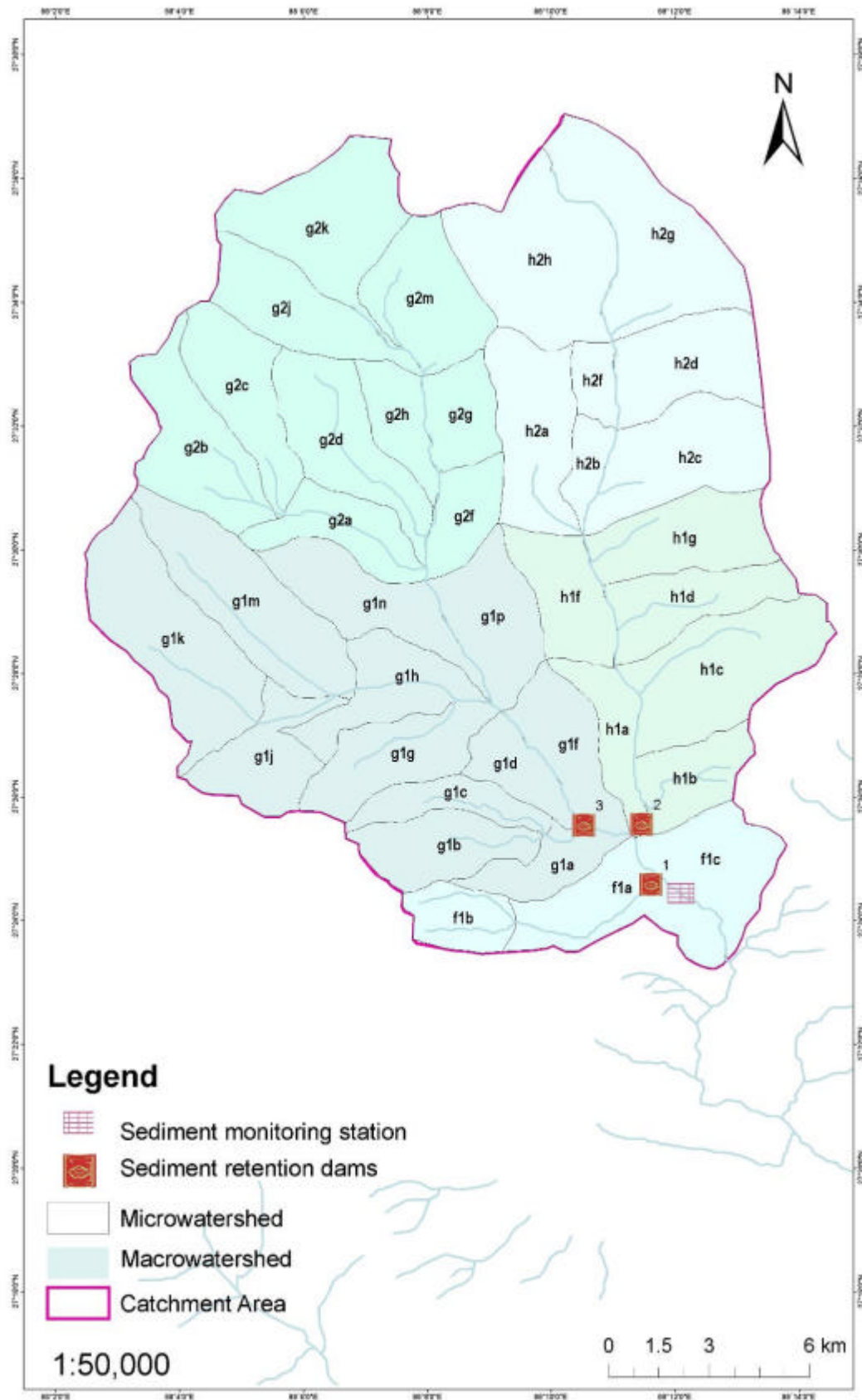
Foothills and grazing lands are severely eroded but high altitude pastures and meadows are relatively less affected by erosion. Human beings and animals exert great pressure on land and results of overgrazing cause severe erosion. The grasses control water erosion through a three tier action- i) interception of rains, reduces runoff and grass roots bind the soil mass. A systematic grass land development reduced water loss by 31% and soil loss by 95% (Hazra, 1995) as such is utilized in stabilization of terrace rivers, earthen check bunds and other structure works. Therefore, animal and soil protection is achieved by keeping some scrub and open forest lands under pasture development.

### 7.7.2 Rehabilitation of Mine Spoils/Quarry Areas:

Mining is the world's oldest industry, next only to agriculture. It provides important raw materials for the economic development of the area, but unscientific mining poses a serious threat to the environment. In the proposed Lethang diversion barrage building materials will be excavated on a large scale from the quartzite areas which will deface the landscape. During heavy rains, mass movement of such mining spoils will pollute the Lethang Rivers.

### 7.7.3 Rehabilitation of Mining Areas:

In abandoned mining/quarry areas, lands remain barren because the soil material left on the surface after mining offers poor support and plant nutrients. This fragile state causes excessive erosion



**Fig. 7.4: Location of Sediment Retention Dams in Catchment Area**



(approximately 100 times more) due to inadequate cover (U.S. Environmental Agency, 1976). In these areas, reclamation can be done for agriculture, agro-forestry, wildlife and recreation. The rehabilitation in such areas calls for steps like terraces to be made with slight land leveling and shaping merging into small lake/pond, with all precautionary measures to sustain water storage for nursery and afforestation needs. Locally mixed species could be selected or opted for development of a pasture for grazing animals.

In newer mining lease grants, many new techniques can be suggested for a well planned mining quarry for site preparation and overburden. Top soil stripping and placement separately is suggested as it is rich in plant nutrients and microbial population. Suitable site preparation consists of well planned debris stacking, compaction, leveling with final replacement of a horizon and sod seeding with proper manuring, fertilizers, and initial water management with appropriate roads, etc. all this will stabilize the erosion prone material with an improved landscape. The over head climate is favorable for re-establishment of vegetation. Reclamation options are agriculture, agro-forestry or recreation. If around the city/townships, certain engineering structures may be necessary, at times viz., stone walls, gabion structures. Geo-jute, netlon, excelsior, lives grass matting, etc. are a few useful new materials used in advanced countries.

#### 7.7.4 Landslide Scenario:

The Himalayas are geologically unstable and fall under highly seismic zone. The terrain is usually steep and high rainfall under high seismic zone. The terrain is usually steep and a high rainfall provides deeper chemical/mechanical weathering promoting rock, block, detritus/debris slides consisting of stones and boulders and unconsolidated soil slides. The causative structures are geological, hydrological, seismic, and finally the land use. The overall scenario in the study area witnessed water seeping through disturbed slopes, toe cutting by rivers and reservoir shores, quarrying, road making, etc. In land use, indiscriminate cutting of pines, over grazing, cultivation along the steep slopes, bun potato/ginger cultivation etc. are indirectly responsible for increasing the landslide proneness.

#### 7.7.5 Rehabilitation for Controlling Landslides:

The rehabilitation strategies would comprise the following mechanical and biological measures (Table 7.5).

**Table 7.5: Rehabilitation Strategies**

S.No.	Type	Mechanical Measures	Biological Measures
1	Slide face having rills and gullies	Contour wattling by breaking the slope length into shorter portions	
2	Upper reach	Drop structures, stone check dams, vertical pots, check dams, crib check dams and proper drainage facility should be created	
3	Middle reach	Series of drop structure with adequate aprons, clear spill ways with proper alignment and gabion wire	<i>Chrysopogen fulvus</i>
4	Lower reach	Gabion toe walls (60 cm deep and 60 cm top width along the concave bank of torrent) Deflecting spurs	<i>Lannea grandis, Vitex negundo, Salix tetrasperma, Cassia fistula, Ipomea cornea, &amp; Pueraria hirsuta</i>
5	Debris cone reach	Retention barrier parallel to torrent Drop structures with shallow foundation and aprons in the main torrent Protect against scouring action	<i>Pennisetum purpureum, Arundo donax</i> Slide face stabilization species

### 7.7.6 Inclusion of Aromatic Cover Crop *Java citronella*

The *Java citronella* produces essential oil that is an important ingredient of many cosmetics, soap, and pharmaceuticals and its demand is about 600 MT and expected to increase more. The climate condition of NE region of India is conducive for its growth. It grows upto 1200 m above the MSL on sandy loam to clay loam with pH varying between 5 & 6. Plantation may be done from April to August, as this crop grows luxuriantly under rainy condition of NE India. *Java citronella* can be harvested 4-6 times in a year depending upon the growth. The harvest can be taken 4 months after planting and thereafter at every 45 to 60 days interval up to 5 years. On an average, 20 tones of fresh herb can be obtained in a year from a hectare of land and yields 160-180m kg oil (Rs. 220-230 per kg and Rs. 320 kg in Bombay). By adopting this crop, a farmer can earn about Rs. 10,000 to 12,000 per year. The oil is extracted by distillation and can be done in rural areas (Saha, 1994). Some salient features about *Java citronella* are given below.

- a) Does not require terracing. Can grow on wasteland and Jhoom areas
- b) Provides good canopy over land, checks soil erosion effectively, quick returns for 5 years
- c) Maintains ecological balance and an important means for socio-economic development of the NE sector of the company
- d) It can be planted in interspaces of tree plantation under social forestry
- e) Bark is used as fuel in distillation and thus saves energy.

### 7.8 Additional Essential Provisions

The estimates of proposed soil and water conservation treatment needs selected to check soil erosion and silt load into the reservoir, very high and high priority microwatersheds are only given in the report. Considering the latest concepts, introduction of aromatic/medicinal plants can also be introduced with buy-back arrangement with the pharmaceutical companies to improve farmers' economy. Ancillary needs of a polyclinic, agriculture implement unit, Modern distillation unit for preparation of essential oils, as well as, other medicinal plants extracts to boost the farmers' economy distillation centre, at least one unit for demonstration basis considered a complementary need. Similarly, one forest product processing unit has been proposed.

Silt monitoring stations at certain priority watershed are proposed for self evaluation of the benefits of the soil conservation. Agro-forestry and agro-horticulture is already in existence in the area but its extension in this catchment is worth a trial to meet the local needs of the villagers.

#### Assessment of Treatment Needs

Adhoc treatments can be worked out from the definitions of the erosion intensity mapping units. Important needs of each EIMU have been described below.

**Table 7.6: Erosion Intensity Mapping Units -wise recommendations**

<b>EIMU</b>	<b>Snowy Landscape</b>
1,2	Avoid warming – up activities/artificial explosions etc.
3,4	Maintain ecological balance
<b>EIMU</b>	<b>Glacial Valley Landscape</b>
5,6	Create natural embankments for water storage
7	Maintain ecological balance
<b>EIMU</b>	<b>Rocky landscape, seasonally snow covered water donor areas</b>
8,9,10	Create sediment retention structures on the major chu so that relatively clean water reaches the diversion site



<b>EIMU</b>	<b>Rocky landscapes – water donor areas</b>
11, 12, 13, 14, 15	Try to seed these areas with climatically suited early colonizer plant species and grasses.
<b>EIMU</b>	<b>Rocky landscapes with seasonal vegetation</b>
16, 17, 18, 19	Plan silvi-pastoral management measures
20	In addition to above, control landslides by appropriate engineering method of strong series of gabion terraces supported by vegetative measures. Adopt three tier method: <ul style="list-style-type: none"> <li>• Natural regeneration in upper steep slope/grasses</li> <li>• Plant fruit or any economic plantation</li> <li>• Systematic terracing for agricultural production</li> </ul>
<b>EIMU</b>	<b>Forest landscapes</b>
21	Improve forest productivity by appropriate water conservation/afforestation, etc.
22	Control dissection by gully plugs, sediment retention dams, afforestation in banks
23	Avoid deforestation, control forest fires, etc. and maintain productivity
24	Adopt site specific landslide control measures, stabilize soil debris with grasses by appropriate contour terraces
25	Same as above with increased watch on fresh landslides and then stabilization
26	Like 23 above
27	Like 24 with increased frequency of landslides
28,29	Create water filter within the valley for arresting sediment/organic debris, etc.
<b>EIMU</b>	<b>Mixed Land use landscape</b>
30	Require systematic agricultural, horticultural, pasture management on scientific line as well as suitable for habitation/rural development, etc.
31	Suitable for seasonal improved temperate pasture management techniques and provide incentives for locals
32	River bank slope stabilization by grasses, create gabion spurs at appropriate places to reduce the bank cutting, rearrange bed material boulders/stones and fortify them with water loving vegetative plantation to act as sediment filters, declare at least 5 – 10 m river bank areas as reserved areas for natural regeneration avoid felling trees/shrubs and overgrazing in this zone till it attain ecological equilibrium.
<b>EIMU</b>	<b>Undifferentiated landscape</b>
33	This areas need to be visited by trained conservationist and assess their treatment needs for appropriate remedial measures.

## 7.9 Proposed Budget for Catchment Area Treatment Plan :

A small unit of establishment needs to be created to look after the following activities in the Lethang Hydro-Electric Project.

**Table 7.7 Proposed Budget for Catchment Area Treatment Plan**

<b>A. Proposed Catchment Area Treatment Plan</b>		<b>INR LAKH</b>
i)	Establishment of Environmental Management Group for 5 years Project Head, Accountant, Driver, Stationary and Maintenance office.	31.2
ii)	Research and Development for 3 Altitudinal Zones	5.00
iii)	Sediment Monitoring Station, equipments and staff	25.00
iv)	Distillation sets, Horticulture / Forest Product Processing of units	25.00
v)	Soil & Water Conservation Measures	
a)	a) Afforestation creation and maintenance 100 ha @ Rs 0.44 Lakh per ha	44.00
b)	b) Assisted Natural Regeneration Area Creation and Maintenance 200 Ha @ Rs 0.2715 Lakh per ha	54.30
c)	c) Maintenance of Replenishment in afforestation creation and maintenance 50 ha @ Rs 0.2991 Lakh per ha	14.95
d)	d) Pasture Development Creation and Maintenance 50 ha @ Rs. 0.29025 Lakh per ha	14.51
e)	e) Medicinal & Aromatic Plants Regeneration and Maintenance 55 Ha @ Rs. 0.56 Lakh per ha	30.80
f)	f) Agro - Horticultural Development for forest villages, if any	12.00
	- Terracing and other items	
	- Farm Kits including nutrient / pest management	
	- Agricultural Equipment, Harvester, Winnowers etc .	
	- Plantation of fruit trees climatically adjusted Pineapple / Orange temperate fruits etc.	
g)	Silt Retention Dams (SRDS) 3 sites @ Rs. 0.75 Lakh per site	2.25
h)	Landslides and Slips 30 sites @ Rs 0.40 Lakh per site	12.00
i)	Drainage Line Control 7.0 km @ Rs.3.0 Lakh per km.	21.00
<b>Total</b>		292.01
	Overhead expenses @ 10 % of the above cost	29.20
<b>A</b>	<b>Total Estimated Cost</b>	<b>321.21</b>
<b>B</b>	<b>Follow up Maintenance cost for another 3 years approximate 15 % of A</b>	48.18
<b>Total cost of A+B</b>		<b>369.39</b>

The total estimated cost for Catchment Area Treatment Plan is **INR 370 Lakh** approximately.

### 7.10 Activities to be Undertaken

Exhaustive presentation on soil conservation measures has been discussed in above sections. Even though suggestions have been made, specific treatment measures to be undertaken in a particular micro watershed may require further micro planning during the implementation stage. A brief outline on item-wise outlays is give below :

#### 7.10.1 Administrative Set up

The proposed environmental management group should head from the forestry as the entire Lethang catchment is dominated by forest ecosystem. Associate technical and ministerial staff should be selected to execute the program. An outlay of INR 31.20 Lakh is proposed for administrative setup.

## 7.10.2 Research and Development

This Lethang catchment has 3 altitudinal zones and has different adaptive flora and fauna. Research and development have harnessed each zone effectively. Review literature and success stories are visited to adopt in this catchment. Trial of economic species for each altitudinal zones is attempted for new species. An outlay of INR 5 Lakh has been proposed. Selection of site for this purpose is made from this theme.

## 7.10.3 Sediment Monitoring Unit

For baseline data on sediment load in different season it is essential to have the sediment monitoring must start before impounding of water at the diversion point. Further observation would present the efficacy of the soil conservation measures automatic or mechanical modes are both available. A set has been recommended the midpoint after the confluence of Prek Chu and Chhurang Chu. An outlay of INR 25 Lakh has been kept for this purpose.

## 7.10.4 Bio-Industrial Watershed

In order to provide remuneration set up, certain modern approaches of putting up a distillation plant, Juice extraction preservation and packing, collection and purification of forest product machinery promotion of wood, bamboo, etc. handcrafts need to be explored. **Fig.7.5** shows the forest product processing unit in the catchment area.

The important medicinal plants of the area are *Aconitum heterophyllum*, *A. ferox*, *A. violaceum*, *Jurinea microcephala*, *Picrorhiza kurroa*, *Gentiana kurroo*, *Podophyllum hexandrum*, *Viola banafsa*, *Valeriana hardwickii*, *Swertia chrata*, *Hyocyamus niger*, *Thymus serphyllum*, *Nardotachys jatamasi*, *Spondias mukorossi* *Terminalia chebulia*, *Embllica officinalis*, *T.belerica* and *Acorum calamus*. These non timber forest produce have been more common. Inclusion of aromatic crop of Java citronella has been successful in path of Meghalaya. An outlay of 25 Lakh for this special purpose is suggested.

## 7.10.5 Soil Conservation Measures

### 7.10.5.1 Afforestation Programme

The afforestation would be carried out in the moderate to open forest area having large chunks of silviculture blanks contour terracing staggered trenching; half moon trenches are open as per site/slope requirement. Use of 2 -3 year old seedling, be planted with the onset of monsoon in trenches of 45 cm<sup>3</sup>. These trenches be manure and booster doses of limiting plant nutrients be added for healthy plantation. Hedges like *Dodonea*, *Duranta* and *Spiracea* etc be seeded to the brims. Silt entrapment with clean run off water have been reported. Following choices for afforestation have been reported – *Acacia mollissima*, *Rhus parviflora*, *Alnus nepalensis*, *Robinia pseudoacacia*, *Silver oak*, *Darli (Toona serrata)*, *Sunnu (Fraximus floribunda)*, *Chulli (Prunus armeniaca)*, *Walnut (Junglans regia)*, *Pangar (Aesculus indica)*, *Willow (Salix spp.)*, *Ban oak*, *Dreke (Melia azedirach)*, *Angyar (Lyonia ovalifolia)*, *Burans (Rhododendron arboretum)*, *Ficus cunia*, *Ficus hooker*, *Ficus nemoralis*, *Saurania griffithi*, *Litsea polyantha*, *Morus alba*, *Bakhinia spp.*, *Duabanga indica* etc.

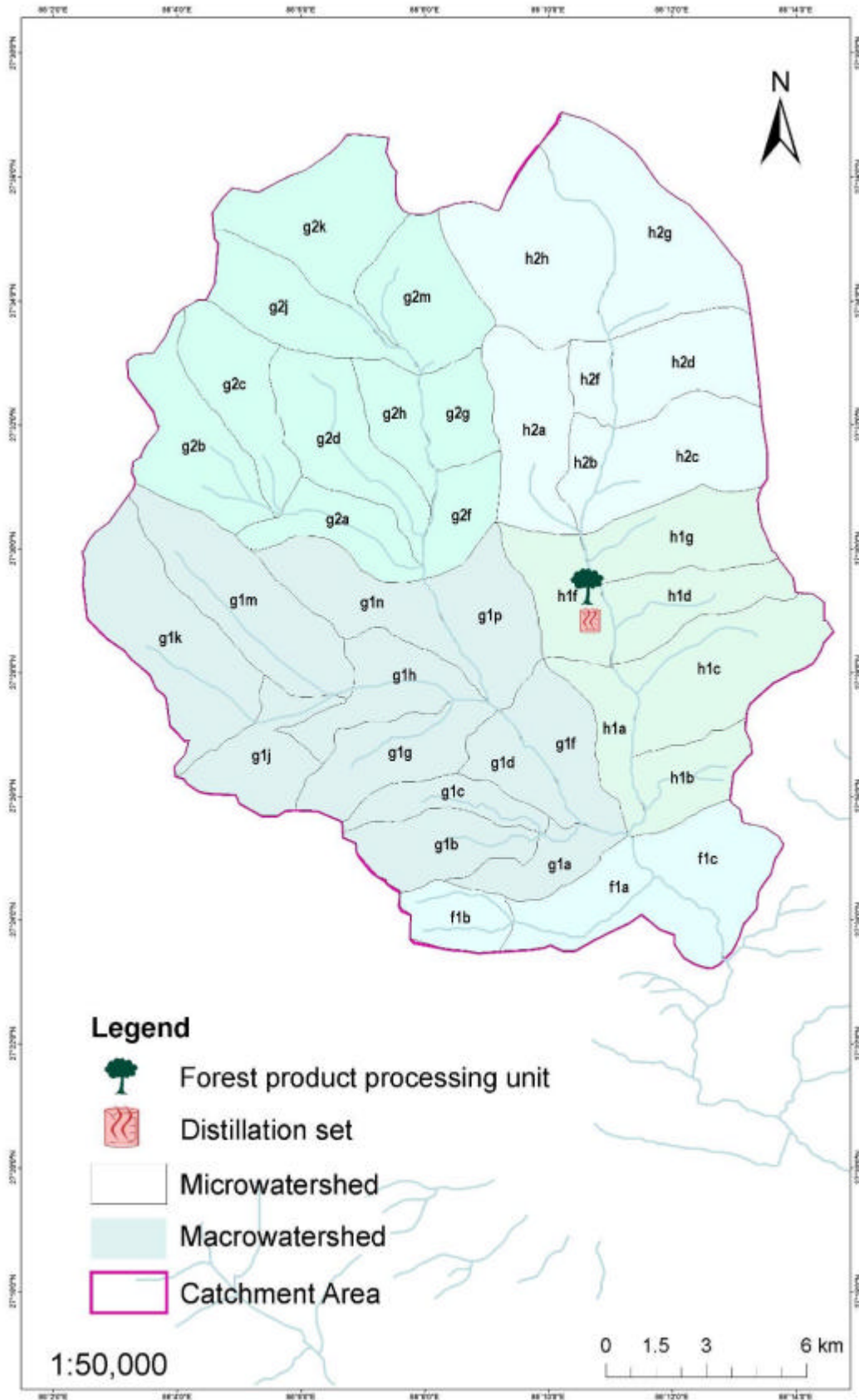


Fig. 7.5: Catchment Area Map Showing Forest Product Processing Unit

In conifer group : *Diyar (Cedrus deodara)*, *Kail (Pinus wallichiana)* *Surai ( Cupressus torulosa)*, etc are common whereas mixed plantation prefer – *Terminalia spp.*, *Grevillea robusta*, *Machelia spp*, *Toona ciliate*, *Crytomaria Japonica*, *Spondies axillaries*, *Shorea robusta*, *Chukrasia tabularis*, *Buchnaria rugulosa*, *Gmelina arborea* are suitable / upto 2000 m above mean sea level.

The Terminalia Spp, Castanopsis Spp., Betula Spp, Salix Spp, Machilus edulis, Rhododendron spp., Abies densa, Juniperous Spp., grow well in 2000 to 3500 m above mean sea level.

Road side ornamental plant species cover *Gravillea Spp*, *Prunus Spp.*, *Delonix regia*, *Cassia fistula*, *Acacia auriculiformis*, *Bogain vellia spp*, *Hibiscus Spp*, *Erythrina indica* , *Callistemom lanceolatys*, *Polyanthia spp*.

The above list is only suggested, however other species of known performance be selected.

Afforestation in erosion intensity mapping units 24 and 25 covering 100 ha @ Rs. 44 Lakh per hectare at a total outlay of INR 44 Lakh has been stipulated. Afforestation programme locations are shown in **Fig 7.6**. Tentative micro watershed wise afforestation area is given in **Table 7.8** below:

**Table 7.8: Micro-watershed wise Afforestation Area**

Micro watershed	Area (ha)
gld	10
glp	10
hla	10
fla	20
hlf	10
glf	10
flb	8
flc	15
glb	7
<b>Total</b>	<b>100</b>

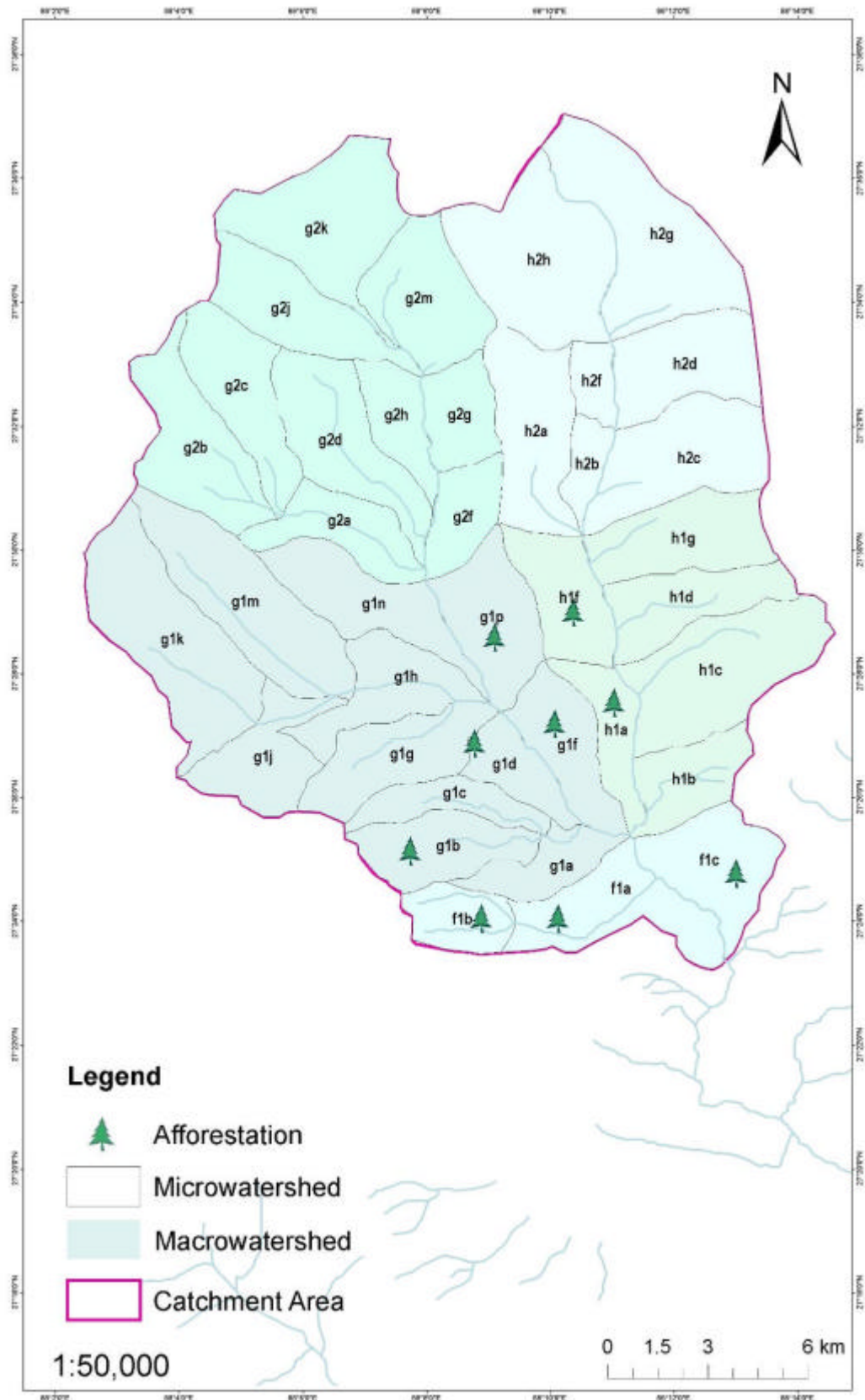
#### 7.10.5.2 Natural Regeneration:

There are other group of EIMU which needs Assistance in natural regeneration particularly in EIMU – 16,17,18,19 and 20. They have seasonal vegetal cover which needs to be conserved. The micro watersheds covering these units are listed below (**Table 7.9**) with tentative hectarage.

**Table 7.9: Group of EIMU, Which needs Natural Regeneration**

NATURAL REGENERATION	
A GROUP	B GROUP
EIMU -16, 17, 18, 19, 20	EIMU 13,14
glp – 5	h1b - 25 h1a – 20
glh – 10	g1b – 10 fla - 20
g1d – 30	g1a - 15 g1f – 20
h1f – 25	flb - 10





Fig

7.6: Location of Afforestation Programme

The B Group has potential to respond partially to seeding climatically adjusted grasses and erecting stone walls for avoiding biotic influence. The EIMU 15 covers extensive coverage over very very steep areas and need to be reserved. They are shown in **Figure 7.7** with a capsule symbol. An outlay of **Rs. 54.30 Lakh** have been kept for this purpose.

### 7.10.5.3 Replenishment Programme

This should be taken up after 3 years of activity discussed under 7.10.5.1. An outlay of **Rs. 14.95 Lakh** for stipulated area of 50 ha earmarked.

### 7.10.5.4 Pasture Development

The erosion intensity mapping unit 30 and 31 have scope to take up the pasture development activity. Microwatershed covering about 100 ha area has been marked for this activity. Tentative micro watersheds with approximate hectareage are shown below (**Table 7.10**):

**Table 7.10: Microwatersheds for pasture development activity**

Microwatershed Code	Area
g1p	5
h1f	5
g1f	15
f1b	15
g1a	10
<b>Total</b>	<b>50</b>

The proposed outlay for this purpose for 50 ha is Rs 14.51 Lakh. Selection can be made from the following grass species:

Cocks foot (*Dactylis glomerata*), Perennial Rye grass (*Lolium perenne*), Tall Fescue (*Festuca arundinacea*), Brome grass (*Bromus inermis*), Georgia selection, Timothy grass (*Phelum pretense*), Poa grass, *Ehusine coracana*, *Setaria italica*, *Panicum spp.* etc.

For Legume mixtures – White clover (*Trifolium repens*), Red clover (*T. pratense*), Lucerne (*Medicago sativa*), Vetch (*Vicia Villosa*), Sainfoin (*Onobruchis visia folia*), Caucasian clover (*T. ambiguum*). The pasture development areas are shown in **Figure 7.8** below:

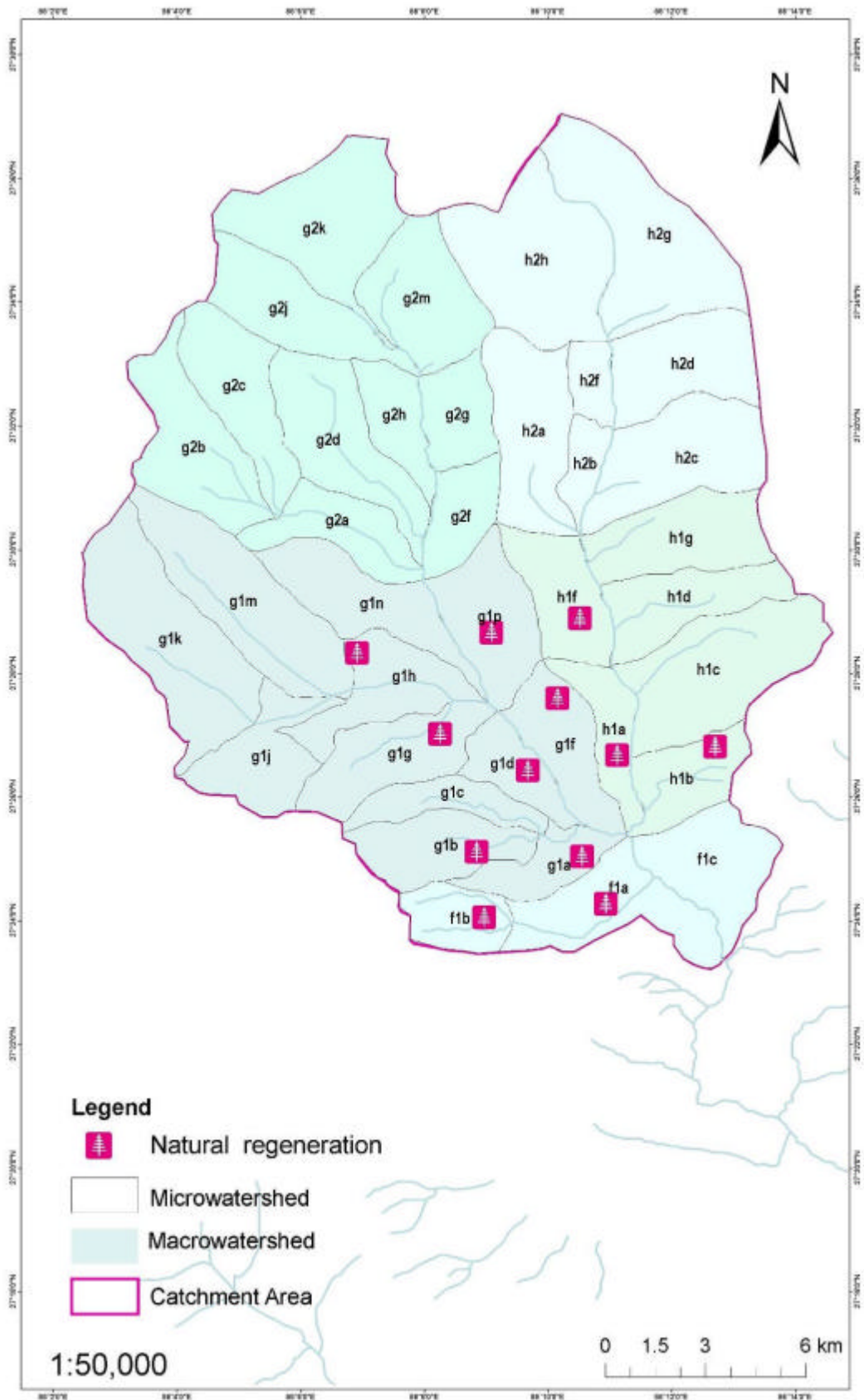
### 7.10.5.5 Medicinal and Aromatic Plants Regeneration (MAP) :

As an ambitious programme to take up high value crops – medicinal and aromatic plants are thought to be appropriate. Earlier choices of MAP species have been given. It is proposed to take up 55 ha area spread over h1f, f1c and g1h microwatershed covering 15,15,15,10 ha respectively. An outlay of INR 30.80 Lakh is proposed for this purpose.

### 7.10.5.6 Agro- horticulture Programme :

An outlay of INR 12 lakh to promote the agro horticulture activity in the selected area of 50 ha has been proposed. This activity will cover single umbrella unit to supply fertilizers implements, sprayer, dusters and plantation material like pineapple, anar, orange and other temperate fruits. **Fig 7.9.**





**Fig. 7.7: Locations of Natural Regeneration in the Catchment Area**

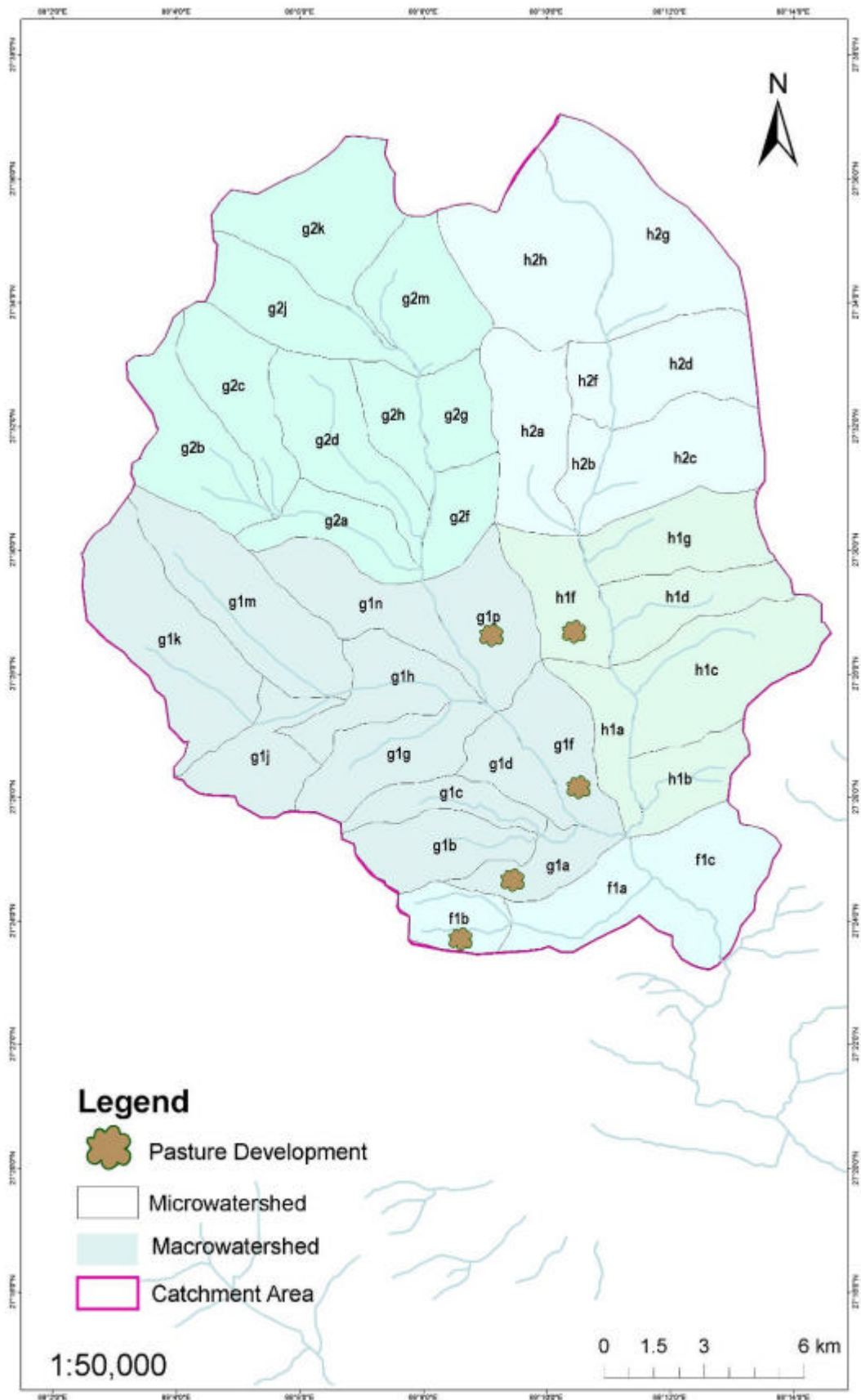


Fig. 7.8: Pasture Development Areas in Lethang Catchment

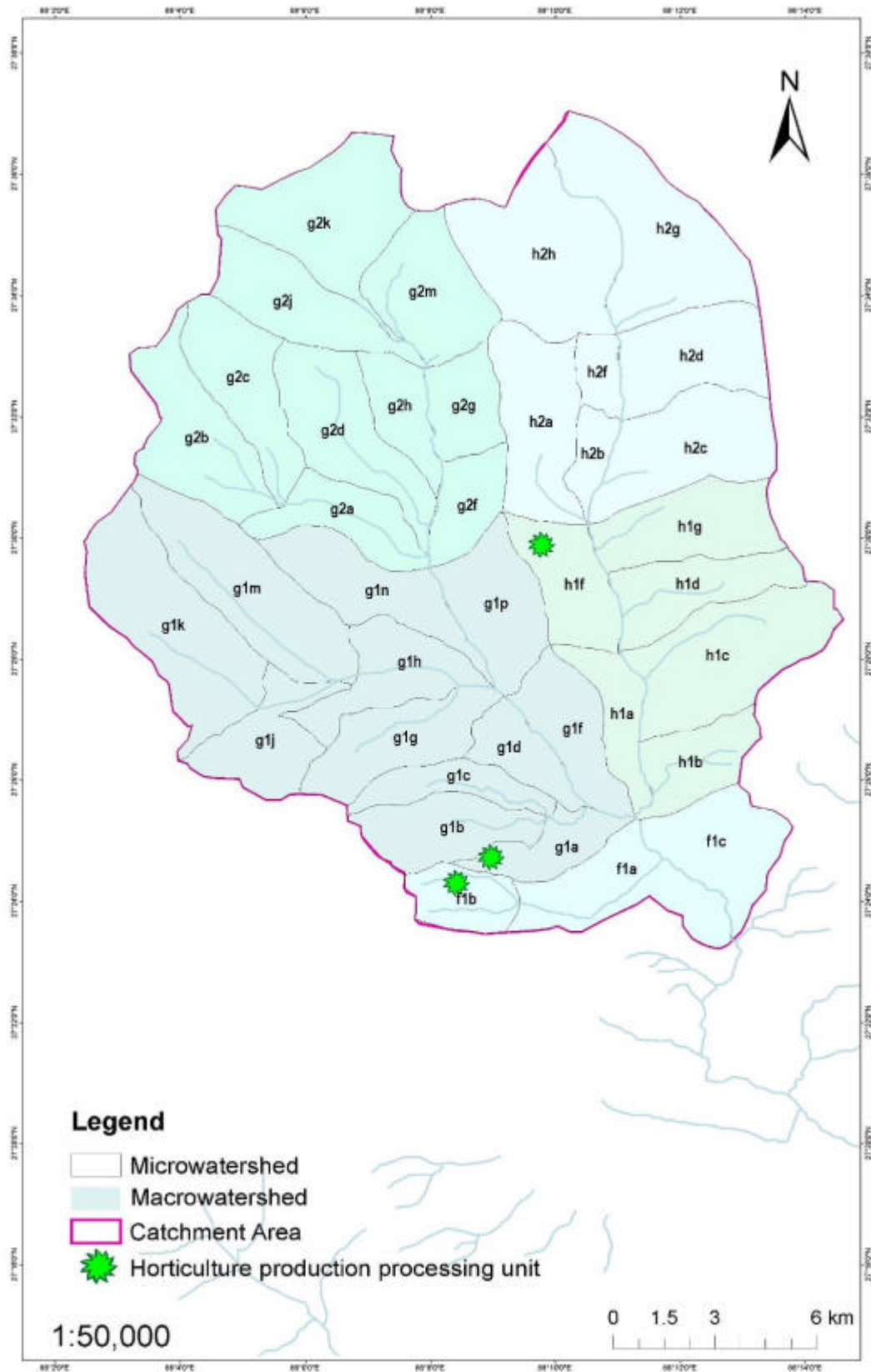


Fig.: 7.9: Site for Horticultural Programme

#### **7.10.5.7 Silt Retention Dams**

Tentative locations of 3 silt retention dams sites have been shown in Figure 7.3. Brief location is described below:

- a) fla Micro watershed tributary joining Rathang Chu.
- b) Lower Prek Chu tributary joining from h1b Microwatersheds.
- c) Lower Churang Chu above the confluence with Prek chu

Approximate budget provision for this task is **2.25 Lakh** for three sites.

#### **7.10.5.8 Landslides and Slips**

The erosion intensity mapping units 14, 24, 25 and 27 spread over glp,h1a,fla,g1f,flb needs landslides/slips control measures. Chapter 4 describes different methods of landslides control measures. About 30 sites have been proposed to be undertaken, under this treatment at a total cost of **Rs. 12.00 Lakh**. Microwatersheds listed above offer good sites for this activity and after treatment silt load are expected to be reduced. **Figure 7.10** shows sites that need landslide control measures to be taken.

#### **7.10.5.9 Drainage Line Control**

The drainage line treatment is the most effective soil conservation treatment as whatever sediment falls in river is directly carried away swiftly depending upon the gradient and hurdles like stone boulders , if any. Severely affected micro watersheds are :

glp,g1h,g1d,h1f and flc. These microwatersheds are shown by a line symbol in the **Figure 7.11**. Recent technologies offer grass mats of natural/artificial nature to quickly protect and establish on the assorted debris. These treatments are expressed in km length and the total cost is worked out to be INR 21.00 Lakh.

Besides these activities certain provisions are made to meet the deal with any environmental site specific hazards.

These works are partly subjected to stress and strain of the climate, as such, follow up maintenance is needed to sustain the results. For this purpose 15 % of the above proposed total expenditure is provided for this purpose (Rs. 48.18 Lakh)

Ultimately an expenditure of 369.69 Lakh works out to be Rs 1.1 Lakh per square km of the catchment, which is appropriate for the longevity of the proposed barrage in this hilly and mountainous Himalayan catchment.



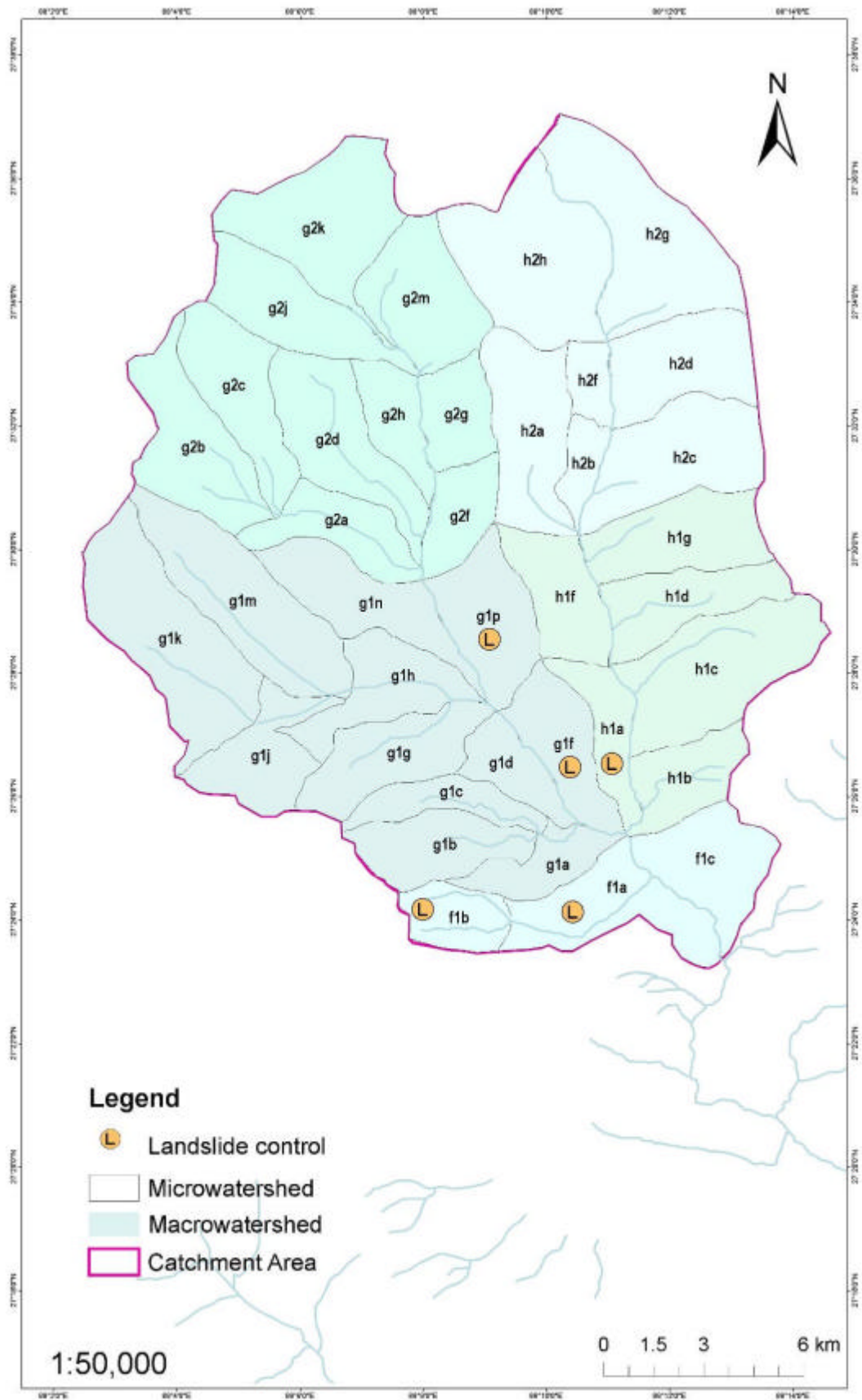


Fig: 7.10: Sites for Landslide Control Measures

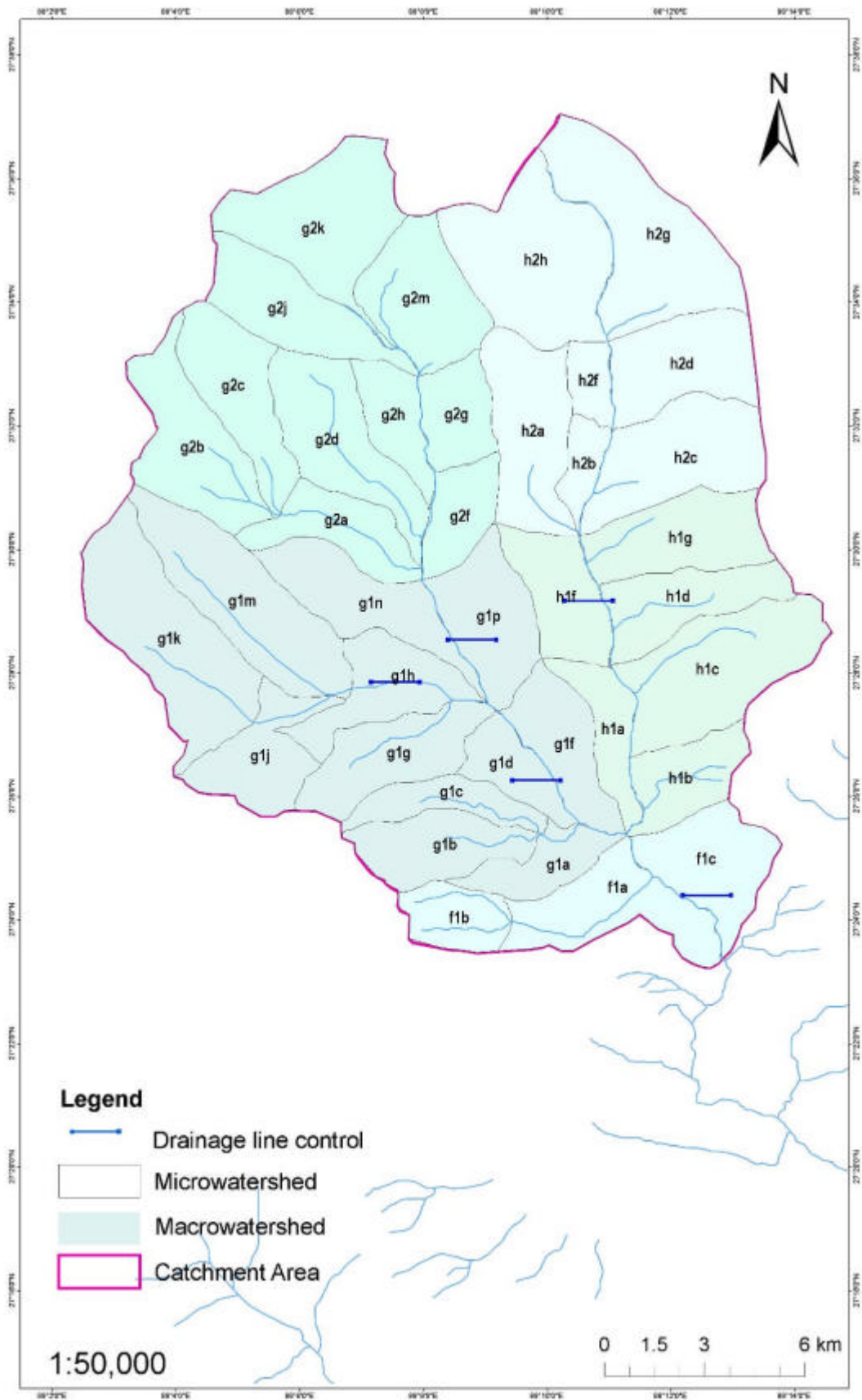


Fig. 7.11: Locations of Drainage Line Control

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# ANNEXURES

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# ANNEXURE - I

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**ANNEXURE I**

**Table 1 : Physico-Chemical Characteristics of Soil Samples in the Study Area (Monsoon Season 2009)**

S.No.	Parameters	SQ1	SQ2	SQ3	SQ4	SQ5	SQ6	SQ7
1.	pH	7.08	6.93	6.84	7.11	7.23	7.18	7.15
2.	Color	Brown	Brown	Light brown	Grayish brown	Brown	Dark brown	Grayish brown
3.	Moisture content %	0.49	0.62	0.43	0.56	0.38	0.55	0.65
4.	Organic matter %	0.59	0.55	0.52	0.37	0.86	0.62	0.81
5.	P available, mg/100gm	3.8	3.16	2.8	2.24	3.46	5.1	3.5
6.	Total Kjehldal Nitrogen %	0.0084	0.0056	0.0063	0.0042	0.0071	0.0049	0.0045
7.	Chloride mg/100gm	14.07	13.06	12.56	10.55	11.60	14.57	10.05
8.	K available mg/100gm	43.24	39.10	48.69	37.94	51.4	47.74	36.19
9.	Na available mg/100gm	28.91	26.87	28.44	25.68	36.3	27.10	23.89
10.	Ca available mg/100gm	7.01	7.21	11.83	12.02	9.62	14.43	8.02
11.	Mg available mg/100gm	0.975	1.95	8.28	4.39	4.40	4.87	0.97
12.	Bicarbonate %	0.14	0.12	0.10	0.116	0.107	0.143	0.09
13.	Organic Carbon %	0.344	0.288	0.302	0.316	0.502	0.362	0.467
14.	Na absorption ratio	6.94	8.75	4.48	5.1	7.7	4.97	6.7
15.	Texture (sand) %	38.42	42.67	43.27	44.32	43.71	42.15	45.53
16.	Texture (clay) %	36.28	31.79	31.93	33.91	34.17	32.54	39.1
17.	Texture (silt) %	25.30	25.54	24.8	21.77	22.12	25.31	15.37
18.	Gravels >2.0 mm (% by wgt.)	19.0	27.0	20.0	25.0	21.0	17.0	24.0
19.	a) Particle size 2.0-0.05 mm, % by wt.	38.42	42.67	43.27	44.32	43.71	42.15	45.53
20.	b) Particle size 0.05- 0.002 mm, % by wt.	36.28	31.79	31.93	33.91	34.17	32.54	39.1
21.	c) Particle size < 0.002 mm, % by wt.	25.30	25.54	24.8	21.77	22.12	25.31	15.37

**Table 2 : Physico-Chemical Characteristics of Soil Samples in the Study Area (Winter Season 2009-2010)**

S.No.	Parameters	SQ1	SQ2	SQ3	SQ4	SQ5	SQ6	SQ7
1.	pH	6.94	6.87	6.82	7.24	7.16	6.79	6.89
2.	Color	Grey Black	Grey Black	Black	Yellow brown	Grey Black	Grey Black	Grey
3.	Moisture content %	1.30	2.18	1.08	0.58	2.36	2.63	1.86
4.	Organic matter %	BDL	BDL	1.74	0.69	0.134	0.176	BDL
5.	P available (as P.) mg/100gm	0.38	0.34	9.20	6.80	4.78	0.54	0.512
6.	Total Kjehldal Nitrogen %	0.0021	0.0028	0.007	0.0091	0.0028	0.011	0.017
7.	Chloride mg/100gm	5.01	5.51	15.02	6.01	5.51	7.01	6.51
8.	K available mg/100gm	8.3	6.7	49.3	34.9	10.4	9.7	9.34
9.	Na available mg/100gm	4.3	3.74	21.8	17.4	3.8	4.4	2.9
10.	Ca available mg/100gm	10.42	12.42	73.35	54.51	16.03	12.83	14.43
11.	Mg available mg/100gm	4.87	5.12	39.47	23.88	10.23	7.80	9.26
12.	Bicarbonate %	0.038	0.027	0.027	0.038	0.041	0.038	0.037
13.	Organic Carbon %	BDL	BDL	1.01	0.40	0.078	0.102	BDL
14.	Na absorption ratio	0.87	0.71	1.615	1.97	0.58	0.75	0.47
15.	Texture (sand) %	89.36	87.32	48.26	47.59	86.37	77.25	86.73
16.	Texture (clay) %	6.36	8.30	32.01	33.69	8.64	20.78	18.53
17.	Texture (silt) %	4.28	4.38	19.73	18.72	4.99	19.70	5.26
18.	Gravels >2.0 mm (% by wgt.)	3.48	7.56	Nil	Nil	9.19	4.83	Nil
19.	Particle Size 2.0-0.05 mm – % by wt.	89.36	87.32	48.26	47.59	86.37	77.25	86.73
20.	Particle Size 0.05- 0.002 mm - % by wt.	6.38	8.30	32.01	33.69	8.64	20.78	18.53
21.	Particle Size < 0.002 mm - % by wt.	4.28	4.38	19.73	18.72	4.99	19.7	5.26
22.	Electrical Conductivity (uS/cm)	436.0	310.0	1040.0	356.0	512.0	349.0	289.0

**Table 3: Physico-Chemical Characteristics of Soil Samples in the Study Area (Pre Monsoon Season 2010)**

S.No.	Parameters	SQ1	SQ2	SQ3	SQ4	SQ5	SQ6	SQ7
1.	pH	6.94	6.87	6.82	7.24	7.16	6.79	6.89
2.	Color	Grey Black	Grey Black	Black	Yellow brown	Grey Black	Grey Black	Grey
3.	Moisture content %	1.30	2.18	1.08	0.58	2.36	2.63	1.86
4.	Organic matter %	BDL	BDL	1.74	0.69	0.134	0.176	BDL
5.	P available (as P.) mg/100gm	0.38	0.34	9.20	6.80	4.78	0.54	0.512
6.	Total Kjehldal Nitrogen %	0.0021	0.0028	0.007	0.0091	0.0028	0.011	0.017
7.	Chloride mg/100gm	5.01	5.51	15.02	6.01	5.51	7.01	6.51
8.	K available mg/100gm	8.3	6.7	49.3	34.9	10.4	9.7	9.34
9.	Na available mg/100gm	4.3	3.74	21.8	17.4	3.8	4.4	2.9
10.	Ca available mg/100gm	10.42	12.42	73.35	54.51	16.03	12.83	14.43
11.	Mg available mg/100gm	4.87	5.12	39.47	23.88	10.23	7.80	9.26
12.	Bicarbonate %	0.038	0.027	0.027	0.038	0.041	0.038	0.037
13.	Organic Carbon %	BDL	BDL	1.01	0.40	0.078	0.102	BDL
14.	Na absorption ratio	0.87	0.71	1.615	1.97	0.58	0.75	0.47
15.	Texture (sand) %	89.36	87.32	48.26	47.59	86.37	77.25	86.73
16.	Texture (clay) %	6.36	8.30	32.01	33.69	8.64	20.78	18.53
17.	Texture (silt) %	4.28	4.38	19.73	18.72	4.99	19.70	5.26
18.	Gravels >2.0 mm (% by wgt.)	3.48	7.56	Nil	Nil	9.19	4.83	Nil
19.	Particle Size 2.0-0.05 mm – % by wt.	89.36	87.32	48.26	47.59	86.37	77.25	86.73
20.	Particle Size 0.05- 0.002 mm - % by wt.	6.38	8.30	32.01	33.69	8.64	20.78	18.53
21.	Particle Size < 0.002 mm - % by wt.	4.28	4.38	19.73	18.72	4.99	19.7	5.26
22.	Electrical Conductivity (uS/cm)	436.0	310.0	1040.0	356.0	512.0	349.0	289.0

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# ANNEXURE - III

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**ANNEXURE III : NATIONAL AMBIENT AIR QUALITY STANDARDS, 2009**

S.No.	Pollutant	Time Weighted Average	Concentration in Ambient Air		
			Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area	Methods of Measurements
(1)	(2)	(3)	(4)	(5)	(6)
1.	Sulphur Dioxide SO <sub>2</sub> , µg/m <sup>3</sup>	Annual* 24 hours**	50 80	20 80	- Improved West and Gaeke - Ultraviolet fluorescence
2.	Nitrogen Dioxide, NO <sub>x</sub> , µg/m <sup>3</sup>	Annual* 24 hours**	40 80	30 80	- Modified Jacob & Hochheiser (Na-Arsenite) - Chemiluminescence
3.	Particulate Matter (size less than 10µm) or PM <sub>10</sub> µg/m <sup>3</sup>	Annual* 24 hours**	60 100	60 100	- Gravimetric - TOEM - Beta Attenuation
4.	Particulate Matter (size less than 2.5 µm) or PM 2.5 µg/m <sup>3</sup>	Annual* 24 hours**	40 60	40 60	- Gravimetric - TOEM - Beta Attenuation
5.	Ozone (O <sub>3</sub> )	8 hours* 1 hour**	100 180	100 180	- UV photometric - Chemiluminescence - Chemical Method
6.	Lead (Pb) µg/m <sup>3</sup>	Annual* 24 hours**	0.50 1.0	0.50 1.0	- - AAS/ ICP method after sampling on EPM 2000 or equivalent filter paper. - - ED-XRF using Teflon filter.
7.	Carbon Monoxide, mg/m <sup>3</sup>	8 hours* 1 hour**	02 04	02 04	- Non Dispersive Infra Red (NDIR) spectroscopy
8.	Ammonia (NH <sub>3</sub> ), µg/m <sup>3</sup>	Annual* 24 hours**	100	100	- Chemiluminescence - Indophenol blue method

Note :

- Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.
- 24 hourly or 08 hourly or 1 hourly monitored values, as applicable, shall be complied with 98 % of the time in a year. 2 % of the time, they may exceed the limits but not on two consecutive days of monitoring.



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# ANNEXURE - IV

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### ANNEXURE IV: Traffic Survey Results

#### LOCATION: YUKSAM BAZAR

Season Time / Categories	WINTER SEASON					PRE – MONSOON SEASON				
	HMV	LMV	Cars	2- Wheel ers	Cycles / Tricycles	HMV	LMV	Cars	2- Wheel ers	Cycles / Tricycles
10:00 am	6	10	1	6	0	0	3	1	1	0
11:00 am	3	6	-	2	0	3	2	1	-	0
12:00 pm	6	5	-	-	1	2	5	1	-	3
1:00 pm	4	6	2	3	0	6	9	14	3	2
2:00 pm	8	4	1	1	2	0	6	9	1	0
3:00 pm	5	4	-	6	0	2	15	7	3	4
4:00 pm	5	5	-	1	0	1	14	8	2	0
5:00 pm	3	4	1	-	0	2	10	1	1	0
6:00 pm	3	3	-	-	-	0	9	2	1	0
7:00 pm	2	-	-	-	-	0	5	7	1	0
8:00 pm	-	-	-	1	-	0	4	8	-	0
9:00 pm	-	-	-	1	-	0	-	-	-	-
10:00 pm	-	-	-	1	-	-	-	-	-	-
11:00 pm	-	-	-	-	-	-	-	-	-	-
12:00 am	-	-	-	-	-	-	-	-	-	-
1:00 am	-	-	-	-	-	-	-	-	-	-
2:00 am	-	-	-	-	-	-	-	-	-	-
3:00 am	-	-	-	-	-	-	-	-	-	-
4:00 am	-	-	-	-	-	-	-	-	-	-
5:00 am	-	-	-	-	-	3	5	2	-	-
6:00 am	5	10	-	6	3	0	3	3	1	4
7:00 am	5	8	2	4	1	2	8	1	3	0
8:00 am	4	6	-	5	0	3	2	1	2	5
9:00 am	5	5	1	3	0	2	5	2	1	1
<b>Total</b>	<b>64</b>	<b>76</b>	<b>8</b>	<b>40</b>	<b>7</b>	<b>26</b>	<b>105</b>	<b>68</b>	<b>20</b>	<b>19</b>

### Traffic Survey Results

#### LOCATION: LETHANG (BRIDGE)

Season	Winter					Pre - Monsoon				
	HMV	LMV	Cars	2- Wheelers	Cycles / Tricycles	HMV	LMV	Cars	2- Wheeler s	Cycles / Tricycles
10:00 am	0	0	2	-	0	0	8	13	0	0
11:00 am	1	1	-	1	0	2	15	18	0	1
12:00 pm	0	2	3	1	1	3	16	19	4	0
1:00 pm	0	0	2	2	0	2	4	08	5	2
2:00 pm	1	2	1	-	1	6	6	15	0	0
3:00 pm	1	0	4	2	0	3	18	7	0	1
4:00 pm	0	1	3	-	0	5	9	13	3	0
5:00 pm	0	0	2	1	0	2	3	7	0	0
6:00 pm	0	1	0	0	0	1	2	5	0	-
7:00 pm	0	0	0	0	0	1	5	3	1	-
8:00 pm	0	0	0	0	0	1	2	2	0	-
9:00 pm	0	0	0	0	0	0	0	0	0	-
10:00 pm	0	0	0	0	0	0	0	0	0	-
11:00 pm	0	0	0	0	0	0	0	0	0	-
12:00 am	0	0	0	0	0	0	0	0	0	-
1:00 am	0	0	0	0	0	0	0	0	0	-
2:00 am	0	0	0	0	0	0	0	0	0	-
3:00 am	0	0	0	0	0	0	0	0	0	-
4:00 am	0	0	0	0	0	0	0	0	0	-
5:00 am	0	0	0	0	0	12	4	2	0	-
6:00 am	0	2	1	1	1	5	15	18	1	-
7:00 am	0	1	2	1	0	3	19	11	2	-
8:00 am	1	2	1	0	0	6	13	23	4	2
9:00 am	0	2	3	2	1	4	25	27	3	-
<b>Total</b>	<b>4</b>	<b>14</b>	<b>24</b>	<b>11</b>	<b>4</b>	<b>46</b>	<b>164</b>	<b>191</b>	<b>22</b>	<b>6</b>

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# ANNEXURE - V

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**ANNEXURE – V: Details of Floristic Diversity (Woody Flora)**

<b>S No.</b>	<b>Species</b>	<b>Habit</b>	<b>Percentage frequency</b>	<b>Species Abundance</b>	<b>Density per ha</b>
1	<i>Acanthus carduaceous</i>	Shrub	6.66	0.18	1.66
2	<i>Acrocarpus fraxinifolius</i>	Tree	6.66	0.18	1.66
3	<i>Actinodaphne sikkimensis</i>	Tree	6.66	0.18	1.66
4	<i>Albizzia procera</i>	Tree	13.33	0.72	6.64
5	<i>Alnus nepalensis</i>	Tree	40.0	7.74	71.38
6	<i>Artocarpus lakoocha</i>	Tree	20.0	0.72	6.64
7	<i>Arundinaria hookeriana</i>	Tree	6.66	0.36	3.32
8	<i>Arundinaria sp.</i>	Tree	13.33	1.44	13.28
9	<i>Bauhinia variegata</i>	Tree	6.66	0.18	1.66
10	<i>Beilschmiedia sp.</i>	Tree	6.66	0.18	1.66
11	<i>Betula sp.</i>	Tree	13.33	0.36	3.32
12	<i>Bischofia javanica</i>	Tree	13.33	0.54	4.98
13	<i>Boehmeria sp.</i>	Shrub	6.66	0.36	3.32
14	<i>Bombax ceiba</i>	Tree	13.33	0.54	4.98
15	<i>Brassatopsis sp.</i>	Tree	33.33	2.16	19.92
16	<i>Castanopsis hystrix</i>	Tree	40.0	2.88	26.56
17	<i>Castanopsis tribuloides</i>	Tree	40.0	1.26	11.62
18	<i>Cedrela febrifuga</i>	Tree	26.66	2.16	19.92
19	<i>Cinnamomum glanduliferum</i>	Tree	13.33	0.36	3.32
20	<i>Cinnamomum impressinervum</i>	Tree	6.66	0.36	3.32
21	<i>Cinnamomum obtusifolium</i>	Tree	6.66	0.18	1.66
22	<i>Cryptolepis buchanani</i>	Tree	6.66	0.18	1.66
23	<i>Cryptomeria japonica</i>	Tree	13.33	0.36	3.32
24	<i>Daphne cannabina</i>	Shrub	6.66	0.18	1.66
25	<i>Debregeasia velutina</i>	Shrub	6.66	0.18	1.66
26	<i>Drypetes lanciefolia</i>	Tree	6.66	0.18	1.66
27	<i>Edgeworthia gardnerii</i>	Shrub	46.66	3.96	36.52
28	<i>Eleocarpus sikkimensis</i>	Tree	13.33	0.72	6.64
29	<i>Engelhardtia spicata</i>	Tree	40.0	2.70	24.9
30	<i>Erythrina stricta</i>	Tree	13.33	0.36	3.32
31	<i>Euphorbia pulcherrima</i>	Shrub	6.66	0.18	1.66
32	<i>Eurya sp.</i>	Tree	13.33	0.72	6.64
33	<i>Evodia fraxinifolia</i>	Tree	26.66	1.08	9.96
34	<i>Evodia meliaefolia</i>	Tree	6.66	0.18	1.66
35	<i>Ficus benjamina</i>	Tree	6.66	0.54	4.98
36	<i>Ficus nemoralis</i>	Tree	6.66	0.18	1.66
37	<i>Ficus roxburghii</i>	Tree	26.66	1.44	13.28
38	<i>Glochidion acuminatum</i>	Tree	20.0	0.90	8.30
39	<i>Juglans regia</i>	Tree	26.66	1.08	9.96
40	<i>Laurocerasus acuminata</i>	Tree	6.66	0.18	1.66
41	<i>Leucosceptrum canum</i>	Tree	20.0	0.90	8.30
42	<i>Litsaea citrata</i>	Tree	6.66	0.18	1.66
43	<i>Macaranga gmelinaefolia</i>	Tree	40.0	1.44	13.28
44	<i>Macaranga indica</i>	Tree	13.33	1.26	11.62
45	<i>Machilus edulis</i>	Tree	40.0	1.08	9.96
46	<i>Macropanax undulatum</i>	Shrub	13.33	0.36	3.32

47	<i>Maesa chisia</i>	Tree	40.0	2.88	26.56
48	<i>Maesa macrophylla</i>	Shrub	6.66	0.36	3.32
49	<i>Magnolia globosa</i>	Tree	13.33	0.36	3.32
50	<i>Mahonia sp.</i>	Tree	6.66	0.18	1.66
51	<i>Michelia doltsopa</i>	Tree	6.66	0.18	1.66
52	<i>Ostodes paniculatus</i>	Tree	13.33	0.36	3.32
53	<i>Pieris ovalifolia</i>	Tree	6.66	0.18	1.66
54	<i>Polygonum molle</i>	Shrub	20.0	3.96	36.52
55	<i>Populus glauca</i>	Tree	6.66	0.18	1.66
56	<i>Prunus cerasoides</i>	Tree	6.66	0.18	1.66
57	<i>Prunus nepalensis</i>	Tree	6.66	0.18	1.66
58	<i>Quercus glauca</i>	Tree	13.33	0.54	4.98
59	<i>Reevesia pubescens</i>	Tree	6.66	0.18	1.66
60	<i>Rhododendron arboreum</i>	Tree	6.66	0.18	1.66
61	<i>Rhus insignis</i>	Tree	26.66	1.62	14.94
62	<i>Rhus javanica</i>	Tree	13.33	0.36	3.32
63	<i>Rubus ellipticus</i>	Shrub	53.33	3.06	28.22
64	<i>Saurauia sp.</i>	Tree	46.66	2.52	23.24
65	<i>Schefflera elata</i>	Tree	6.66	0.54	4.98
66	<i>Schima wallichii</i>	Tree	33.33	1.26	11.62
67	<i>Solanum xanthocarpum</i>	Shrub	13.33	0.72	6.64
68	<i>Sorbus hedlundi</i>	Tree	6.66	0.18	1.66
69	<i>Spondias axillaris</i>	Tree	6.66	0.18	1.66
70	<i>Symingtonia populnea</i>	Tree	13.33	0.54	4.98
71	<i>Symplocos sp.</i>	Tree	13.33	0.90	8.30
72	<i>Terminalia myriocarpa</i>	Tree	13.33	0.36	3.32
73	<i>Trevesia palmata</i>	Shrub	6.66	0.18	1.66
74	<i>Ulmus lancifolia</i>	Tree	6.66	0.18	1.66
75	<i>Urtica parviflora</i>	Shrub	6.66	0.54	4.98
76	<i>Viburnum cordifolium</i>	Tree	46.66	3.78	34.86
77	<i>Zanthoxylum acanthopodium</i>	Tree	20.0	0.54	4.98
78	<i>Zanthoxylum alatum</i>	Tree	6.66	0.18	1.66



## 2. Details of Floristic Diversity: Non Woody Flora

S No.	Species	Habit	Percentage frequency	Species Abundance	Density per sq m
1	<i>Artemisia dubia</i>	Herb	26.66	3.06	1.13
2	<i>Asystasia macrocarpa</i>	Herb	6.66	0.36	0.13
3	<i>Cissus adnata</i>	Climber	20.0	1.26	0.46
4	<i>Cissus repanda</i>	Climber	13.33	0.36	0.13
5	<i>Dioscorea sp.</i>	Climber	20.00	0.54	0.20
6	<i>Erigeron belledioides</i>	Herb	20.00	1.26	0.46
7	<i>Eupatorium adenophorum</i>	Herb	60.00	7.20	2.67
8	<i>Hedychium spicatum</i>	Herb	6.66	0.18	0.06
9	<i>Lindenbergia grandiflora</i>	Herb	6.66	0.36	0.13
10	<i>Mucuna macrocarpa</i>	Climber	6.66	0.18	0.06
11	<i>Musa thompsonii</i>	Herb	6.66	0.18	0.06
12	<i>Nasturtium officinale</i>	Herb	6.66	6.66	2.47
13	<i>Neyrardia madagascarensis</i>	Herb	13.33	0.90	0.33
14	<i>Oxalis corniculatus</i>	Herb	13.33	1.98	0.73
15	<i>Pilea sp.</i>	Herb	6.66	0.18	0.06
16	<i>Piper longum</i>	Climber	33.33	2.34	0.86
17	<i>Pouzolzia viminea</i>	Herb	6.66	0.36	0.13
18	<i>Rumex nepalensis</i>	Herb	6.66	0.36	0.13
19	<i>Senecio scandens</i>	Climber	6.66	0.36	0.13
20	<i>Smilax sp.</i>	Climber	6.66	0.18	0.06
21	<i>Thysanolaena maxima</i>	Herb	13.33	1.44	0.53

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# ANNEXURE - VI

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**ANNEXURE-VI  
LIST OF FAUNA (MAMMALS)  
IN THE PROJECT STRETCH AREA OF LETHANG HEP**

S.No.	Common Name	Vernacular Name	Scientific Name	Status/WPA Schedule No.	Altitude
1.	Himalayan Langur	Kamba Suhu	<i>Presbytis entellus schistaceus</i>	Endangered, II (1991)	Upto 4000m
2.	Common Langur	Suhu	<i>Presbytis entellus entellus</i>	Endangered, II (1991)	At lower elevation throughout state & KNP
3.	Rhesus Monkey	Piyu	<i>Macacus mulatta mulatta</i>	Endangered, II (1991)	2400m
4.	Assamese Macaque	N.A.	<i>Macaca sp.</i>	Endangered, II (1991)	3000m
5.	Leopard	Chitta, Suchyak	<i>Panthera pardus pernigera</i>	Endangered, I (1991)	N.A.
6.	Snow Leopard	Phale	<i>Uncia uncia</i>	Endangered, I (1991)	3660-3965m
7.	Clouded Leopard	Tungmar, Zik	<i>Neofelis nebulosa</i>	Endangered, I (1991)	N.A.
8.	Leopard cat	Chita biral, Sa-ryok	<i>Felis Spp.</i>	Endangered, I (1991)	2100-2400m
9.	Marbled Cat	N.A.	<i>Felis marmorata charltoni</i>	Endangered, I (1991)	N.A.
10.	Himalayan Palm Civet	Himali Kastoori Biralo	<i>Paguma larvata</i>	Endangered, II (1991)	2000m
11.	Jungle Cat	Ban biral	<i>Felis spp.</i>	Endangered, II (1991)	
12.	Red Fox	Wamu	<i>Vulpes vulpes montana</i>	Endangered, II (1991)	Upto 5400m
13.	Indian Wild Dog	Suhutum, Buanso	<i>Cuon alpinus primavus</i>	Endangered, II (1991)	
14.	Jackal	Shial, Amu	<i>Canis aureus</i>	Endangered, II (1991)	1500-3600m
15.	Red Panda	Sankam, wakedonga	<i>Ailurus sp.</i>	Endangered, I (1991)	
16.	Himalayan Black Bear	Dom, Sanar	<i>Selenarcto thibetanus laniger</i>	Endangered, II (1991)	1200-3600m
17.	Himalayan Yellow throated Martin	Sakku, Malsampr o & Tuturala	<i>Martes flavigula flavigula</i>	Endangered, II (1991)	1200-2700m

S.No.	Common Name	Vernacular Name	Scientific Name	Status/WPA Schedule No.	Altitude
18.	Malayan Giant Squirrel	Le-hyuk	<i>Ratufa bicolor</i>	Endangered, II (1991)	N.A.
19.	Orange-bellied Himalayan Squirrel	Lokriah	<i>Dremomys spp.</i>	N.A.	1500-2700m
20.	Common House Rat	Ka Lok	<i>Rattus rattus brunneusculus</i>	Endangered, V (1991)	N.A.
21.	Common House Mouse	N.A.	<i>Mus musculus homourus</i>	Endangered, V (1991)	N.A.
22.	Crestless Porcupine	Anchotia dumsi	<i>Hystrix sp.</i>	Endangered, V (1991)	1000m
23.	Rufous-tailed Hare	Jarayo, Sueng	<i>Lepus nigricollis ruficaudatus</i>	Endangered, II (1991)	2700m
24.	Himalayan Mouse Hare	Gumchi peechi	<i>Ochotona sp.</i>	Endangered, II (1991)	2400-4000m
25.	East Himalayan Tahr	Shapi	<i>Hemitragus spp.</i>	Endangered, I (1991)	N.A.
26.	Blue Sheep or Bharal	Knao	<i>Pseudois nayaur nayaur</i>	Endangered, I (1991)	5000m
27.	Goral	Suh-ging	<i>Nemorhaedus goral hodgsonii</i>	Endangered, III (1991)	1850-3700m
28.	Serow	Gya	<i>Capricornis sumatraensis thar</i>	Endangered, I (1991)	2200-3700m
29.	Musk Deer	Kasturi mrig	<i>Moschus moschiferus</i>	Endangered, I (1991)	2800-5000m
30.	Barking Deer	Suko, Khasha	<i>Muntiacus muntjak vaginalis</i>	Endangered, III (1991)	600-2800m
31.	Bear Cat	Bhalu biral	<i>Arctictis binturong albifrons</i>	Endangered, II (1991)	N.A.
32.	Common Otter	Ote	<i>Lutralutra spp.</i>	Endangered, II (1991)	600-3600m
33.	Short Nose Fruit Bat	N.A.	<i>Cynopterus sphinx sphinx</i>	Endangered, V (1991)	Upto 2000m

WPA: Wild Life Protection Act, 1972

**LIST OF REPTILES IN THE PROJECT AREA OF LETHANG HEP**

Sl. No	Common Name	Scientific Name	Conservation Status (Wild Life Protection Act,1972 and IUCN)
1	Indian Python	<i>Python molurus</i>	Schedule I
2	Common Indian Krait	<i>Bungarus caeruleus</i>	NA
3	Bended Krai	<i>B.fasciatus</i>	NA
4	Indian Cobra	<i>Naja naja</i>	Schedule II
5	Common rat snake	<i>Ptyas mucosus</i>	Schedule II
6	King Cobra	<i>Ophiophagus hannah</i>	Schedule II
7	Russell Viper	<i>Vipera russelli</i>	Schedule II
8	Himalayan Pit Viper	<i>Agkistrodon himalayanus</i>	NA
9	Chameleon bloodsucker	<i>Galotes versicolour</i>	Schedule II
10	Common Lizard	<i>Agama tuberulata</i>	Least Concern

NA\*\* Not Available

**LIST OF AVIFAUNA IN THE PROJECT STRETCH AREA OF LETHANG HEP**

S.No.	Common Name	Scientific Name	Status/WPA Schedule No.
1	Allied fly catch Warbler	<i>Seicercus affines</i>	NA
2	Bar throated Siva	<i>Minla strigula</i>	NA
3	Black backed kalij pheasant	<i>Lophura leucomelana</i>	NA
4	Black browed tree pie	<i>Dendrocitta frontalis</i>	NA
5	Black capped Sibia	<i>Hetrophasia capistrata</i>	NA
6	Black Drongo	<i>Dicrurus adsimillis</i>	NA
7	Black Headed shrike	<i>Lanius schach tricolor</i>	NA
8	Black Spotted yellow Tit	<i>Parus spilonotus</i>	Schedule IV
9	Blyth's Pipit	<i>Anthus godlewski</i>	NA
10	Brown Shrikes	<i>Lanius cristatus</i>	NA
11	Chestnut headed Tit Babbler	<i>Alcippe castaneiceps</i>	Schedule IV
12	Common myna	<i>Acridotheres tristis</i>	NA
13	Crimson winged Laughing thrush	<i>Garrulax phoeniceus</i>	NA
14	Crow billed Drongo	<i>Dicrurus annectans</i>	Schedule IV
15	Dark Grey Bushchat	<i>Saxicola Ferra</i>	NA
16	Fine tailed Yellow backed Sunbird	<i>Aethopyga ignicauda</i>	NA
17	Golden Oriole	<i>Oriolus oriolus</i>	NA
18	Green backed Tit	<i>Parus Monticolus</i>	Schedule IV
19	Green magpie	<i>Cissa Chinensis</i>	NA
20	Green Shrike-Babbler	<i>Pteruthius xanthoclorus</i>	NA

S.No.	Common Name	Scientific Name	Status/WPA Schedule No.
21	Greyheaded Fly catch Warbler	<i>Seicercus xanthoschitos</i>	NA
22	Grey Drongo	<i>Dicrurus leucophaeus</i>	NA
23	Grey Wag tail	<i>Montacilla caspica</i>	NA
24	Hill Myna	<i>Gracula religiosa</i>	Schedule I
25	Himalayan Black Bulbul	<i>Hypsipetus midagacaranensis</i>	Schedule IV
26	Himalayan Blue Whistling Thrush	<i>Myiophorus Caeruleus</i>	NA
27	Himalayan Cuckoo	<i>Cuculus saturates</i>	Schedule IV
28	Himalayan Swift let	<i>Collocalia brevirostris</i>	NA
29	Himalayan Tree Pie	<i>Dendrocitta Formsaie</i>	NA
30	House Crow	<i>Corvus splendens</i>	Schedule V
31	House Sparrow	<i>Parus domesticus</i>	Schedule IV
32	Indian Cuckoo	<i>Cuculus micropterus</i>	Schedule IV
33	Grey Bushchat	<i>Saxicola ferrea</i>	NA
34	Indian Tree Pipit	<i>Anthus hodgsonii</i>	Schedule IV
35	Jungle Crow	<i>Corvus macrorynchos</i>	NA
36	Large Hawk Cuckoo	<i>Cuculus spaverioides</i>	NA
37	Large Niltava	<i>Niltava grandis</i>	NA
38	Large Yellow napped woodpecker	<i>Picus flavinucha</i>	NA
39	Yellow-rumped Honey guide	<i>Hirundo sp.</i>	NA
40	Mrs.Goulds sunbird	<i>Aethopygagouldiae</i>	NA
41	Nepal House swifts	<i>Apus affinis nepalensis</i>	NA
42	Nepal Yellow backed Sunbird	<i>Aethopyga nepalensis</i>	Schedule IV
43	Pale blue Flycatcher	<i>Muscicapa unicolor</i>	Schedule IV
44	Red billed Leiothrix	<i>Leiothrix lutea</i>	NA
45	Red eared Bay Woodpecker	<i>Blythipicus pyrrhotis</i>	NA
46	Great Barbet	<i>Megalaima virens</i>	NA
47	Red-tailed Minla	<i>Minla ignotincta</i>	NA
48	Red Vented Bulbul	<i>Pycnonotus cafer</i>	Schedule IV
49	Rufosbellied Niltava	<i>Muscicapa sundara</i>	NA
50	Wire-tailed Swallow	<i>Indicator xanthonotus</i>	NA
51	Sooty Flycatcher	<i>Muscicapa sibirica</i>	NA
52	Spotted Fork tail	<i>Enicurus maculates</i>	NA
53	Oriental Honey Buzzard	<i>Pernis sp.</i>	NA
54	Tibetan Shrike	<i>Lanius tephronotus</i>	NA
55	Variegated (Scaly) Laughing Thrush	<i>Garrulax variegates</i>	NA
56	Verditor Flycatcher	<i>Muscicapa thalassina</i>	Schedule IV
57	White Capped Redstart	<i>Chaimarromis lecocephalus</i>	NA
58	White Throated Fantail Flycatcher	<i>Rhipidura albicollis</i>	NA
59	Rufous-bellied Niltava	<i>Niltava sundara</i>	NA
60	Yellow billed blue Magpie	<i>Cissa flavirostris</i>	NA
61	Yellow napped Yuhina	<i>Yuhina flavicollis</i>	NA
62	Little Fork tail	<i>Enicurus Scouleri</i>	NA
63	Darjeeling Woodpecker	<i>Dendrocopos darjellensis</i>	Schedule IV
64	Red-Headed Tit	<i>Aegithalos cincinnus</i>	NA

S.No.	Common Name	Scientific Name	Status/WPA Schedule No.
65	Crested serpent Eagle	<i>Spilornis cheela</i>	NA
66	Striated Laughing Thrush	<i>Garrulax striatus</i>	NA
67	Grey Treepie	<i>Dendrocitta sp.</i>	Schedule IV
68	Slaty-backed Flycatcher	<i>Ficedula sp.</i>	Schedule IV
69	White Throated Laughing Thrush	<i>Garrulax albogularis</i>	NA
70	Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	Schedule IV
71	Indian spotted Dove	<i>Streptopelia chinensis</i>	NA
72	Snow Pigeon	<i>Columba leuconota</i>	NA
73	Red-vented Bulbul	<i>Pycnonotus cafer</i>	Schedule IV
74	Golden-spectacled Warbler	<i>Seicerus burkii</i>	Schedule IV

NA: Not Available; WPA: Wild Life Protection Act, 1972

#### LIST OF BUTTERFLIES IN THE PROJECT STRET CH OF LETHANG HEP

Sl. No	Common Name	Scientific Name	Conservation Status ( Wild Life Protection Act,1972 & IUCN)
1.	Golden Birdwing	<i>Troides aeacus</i>	NA**
2.	Common Birdwing	<i>Troides helena</i>	NA
3.	Brown Gorgon	<i>Meandrusa sp.</i>	NA
4.	Spectacle Swordtail	<i>Pazala mandarinus</i>	NA
5.	Chain Swordtail	<i>Graphium sp.</i>	NA
6.	Great Zebra	<i>Pathysa sp.</i>	NA
7.	Veined Jay	<i>Graphium chiron</i>	NA
8.	Great Mormon	<i>Papilio memnon</i>	NA
9.	Dark Blue Tiger	<i>Tirumala sp.</i>	Schedule I
10.	Chestnut Tiger	<i>Paratica sp.</i>	Schedule I
11.	Hill Jezebel	<i>Delias sp.</i>	NA
12.	Tree Yellow	<i>Gandaca harina</i>	NA
13.	ChocolateGrass Yellow	<i>Eurena sp.</i>	NA
14.	Redbase Jezebel	<i>Welias sp.</i>	NA
15.	Forest Pierrot	<i>Taraka hamada</i>	NA
16.	Metallic Green Hairstreak	<i>Chrysozephyrus khasia</i>	Schedule I
17.	Striped Punch	<i>Dodona sp.</i>	NA
18.	Tailed Red Forester	<i>Lethe sinorix</i>	Schedule I
19.	French Duke	<i>Euthalia sp.</i>	Schedule I
20.	Northern Jungle Queen	<i>Stichopthalma sp.</i>	NA
21.	Jungle Glory	<i>Thaumantis sp.</i>	NA
22.	Kohinoor	<i>Anathuxidia sp.</i>	NA

NA\*\* Not Available



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# ANNEXURE - VII

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**ANNEXURE -VII**  
**MONSOON SEASON - PLANKTONIC DENSITY AND DIVERSITY**

Sampling Location – Upstream of Barrage site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Gyrosigma sp</i>	<i>Keratelia monospina</i>	2.76	2.04	55.8	1.7
<i>Acharanthes affinis</i>	<i>Brachirous caudatus</i>				
<i>Pandorina sp</i>	<i>Ceriodaphnia reticulate</i>				
<i>Pediastrum boryanum</i>	<i>Mesocyclops hyallinus</i>				
<i>Scenedesmus bijuga</i>	<i>Coleps hirsutus</i>				
<i>Melosira gracilis</i>	<i>Arcella sp</i>				
<i>Cyclotella meneghiana</i>	<i>Actinophyros sp</i>				
<i>Microcystis sp</i>	<i>Asplancha sp</i>				
<i>Navicula gracilis</i>	<i>Mesocyclops</i>				
<i>Nitzschia gracilis</i>					
<i>Pinnularia braunii</i>					
<i>Synedra tabulate</i>					
<i>Cymbella Sp</i>					
<i>Navicula radiosa</i>					

Sampling Location – Barrage site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Acharanthes affinis</i>	<i>Mesocyclops leuckarti</i>	2.50	2.05	49.3	1.6
<i>Pinnularia braunii</i>	<i>Asplancha brighwell</i>				
<i>Chroococcus minutus</i>	<i>Colpidium colpoda</i>				
<i>Cymbella sp.</i>	<i>Ceriodaphnia reticulata</i>				
<i>Nitzschia gracilis</i>	<i>Daphnia sp.</i>				
<i>Acharanthes affinis</i>	<i>Actinophyros sp.</i>				
<i>Gyrosigma sp.</i>	<i>Brachirous caudatus</i>				

<i>Gyrosigma accuminatus</i>	<i>Coleps hirsutus</i>				
<i>Synedra tabulate</i>	<i>Arcella sp.</i>				
<i>Ankistrodesmus var tumidus</i>	<i>Keratella monospina</i>				

Sampling Location – Lethang TRT site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Gyrosigma accuminatus</i>	<i>Brachirous caudatus</i>	2.71	2.10	56.5	1.8
<i>Chroococcus minutus</i>	<i>Arcella sp.</i>				
<i>Spirulina princepes</i>	<i>Colpidium colpoda</i>				
<i>Nitzschia gracilis</i>	<i>Keratella monospina</i>				
<i>Syndera tabulata</i>	<i>Daphnia sp.</i>				
<i>Ophora sp.</i>	<i>Actinophyros sp.</i>				
<i>Cyclotella meneghiana</i>	<i>Ceriodaphnia reticulata</i>				
<i>Cymbella sp.</i>	<i>Coleps hirsutus</i>				
<i>Nitzschia gracilis</i>	<i>Asplancha brighwell</i>				
<i>Acharanthes affinis</i>					

Sampling Location – Lethang TRT downstream site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Pediastrum boryanum</i>	<i>Ceriodaphnia reticulata</i>	2.49	2.21	51.3	1.5
<i>Scenedesmus bijuga</i>	<i>Daphnia sp.</i>				
<i>Melosira gracilis</i>	<i>Coleps hirsutus</i>				
<i>Cymbella sp.</i>	<i>Arcella sp.</i>				
<i>Chroococcus minutus</i>	<i>Brachirous caudatus</i>				
<i>Gyrosigma accuminatus</i>	<i>Actinophyros sp.</i>				
<i>Pediastrum boryanum</i>	<i>Arcella sp.</i>				
<i>Spirulina princepes</i>	<i>Colpidium colpoda</i>				
<i>Ankistrodesmus falcutus</i>	<i>Keratella monospina</i>				

**MONSOON SEASON - BENTHIC DENSITY AND DIVERSITY**

Sampling Location – Lethang TRT site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Gyrosigma sp.</i>	2.60	52.7
<i>Melosira undulata</i>		
<i>Nitzschia gracilis</i>		
<i>Psephnus sp.</i>		
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		
<i>Cymbella lanceolata</i>		
<i>Diatoma vulgaris</i>		
<i>Baetis sp.</i>		
<i>Stenonema sp.</i>		
<i>Cyclotella comta</i>		
<i>Gyrosigma sp.</i>		
<i>Melosira sp.</i>		

Sampling Location – Lethang TRT downstream site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Cymbella lanceolata</i>	2.58	50.2
<i>Diatoma vulgaris</i>		
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		
<i>Gyrosigma sp.</i>		
<i>Melosira sp.</i>		
<i>Baetis sp.</i>		
<i>Stenonema sp.</i>		
<i>Cyclotella comta</i>		
<i>Melosira undulata</i>		

Sampling Location – Barrage site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Cyclotella comta</i>	2.55	47.1
<i>Gyrosigma accuminata</i>		
<i>Baetis sp.</i>		
<i>Stenonema sp.</i>		
<i>Nitzschia gracilis</i>		
<i>Psephnus sp.</i>		
<i>Cyclotella meneghiana</i>		
<i>Cymbella lanceolata</i>		
<i>Diatoma vulgaris</i>		
<i>Melosira undulata</i>		
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		
<i>Gyrosigma sp.</i>		
<i>Melosira sp.</i>		

Sampling Location – Barrage Upstream site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Melosira undulata</i>	2.49	44.2
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		
<i>Cyclotella meneghiana</i>		
<i>Cymbella lanceolata</i>		
<i>Diatoma vulgaris</i>		
<i>Melosira sp.</i>		
<i>Gyrosigma sp.</i>		
<i>Psephnus sp.</i>		
<i>Nitzschia sp.</i>		
<i>Gyrosigma accuminata</i>		
<i>Cyclotella meneghiana</i>		
<i>Baetis sp.</i>		
<i>Stenonema sp.</i>		

### PRE-MONSOON SEASON - PLANKTONIC DENSITY AND DIVERSITY

Sampling Location – Lethang TRT site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO- PLANKTON	ZOO- PLANKTON	PHYTO- PLANKTON (cell/ ml)	ZOO- PLANKTON (Individual/ litre)
<i>Pinnularia braunii</i>	<i>Colpidium colpoda</i>	3.70	3.56	69.5	18.9
<i>Acharanthes affinis</i>	<i>Actinophyros sp.</i>				
<i>Gyrosigma sp.</i>	<i>Asplancha brighwell</i>				
<i>Pandorina sp.</i>	<i>Mesocyclops leuckarti</i>				
<i>Ankistrodesmus falcutus</i>	<i>Daphnia sp.</i>				
<i>Gyrosigma accuminatus</i>	<i>Ceriodaphnia reticulata</i>				
<i>Pediastrum boryanum</i>	<i>Brachirous caudatus</i>				
<i>Scenesdesmus bijuga</i>	<i>Coleps hirsutus</i>				
<i>Melosira gracilis</i>	<i>Arcella sp.</i>				
<i>Cymbella sp.</i>	<i>Keratella monospina</i>				
<i>Chroococcus minutus</i>	<i>Asplancha sp.</i>				
<i>Spirulina princepes</i>	<i>Ceriodaphnia sp.</i>				
<i>Nitzschia gracilis</i>					
<i>Syndera tabulata</i>					
<i>Ophora sp.</i>					
<i>Cyclotella meneghiana</i>					

Sampling Location – Lethang TRT Downstream site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO- PLANKTON	ZOO- PLANKTON	PHYTO- PLANKTON (cell/ ml)	ZOO- PLANKTON (Individual/ litre)
<i>Pinnularia braunii</i>	<i>Colpidium colpoda</i>	3.12	3.03	62.5	16.8
<i>Acharanthes affinis</i>	<i>Actinophyros sp.</i>				
<i>Gyrosigma sp.</i>	<i>Asplancha brighwell</i>				
<i>Pandorina sp.</i>	<i>Mesocyclops leuckarti</i>				
<i>Ankistrodesmus falcutus</i>	<i>Daphnia sp.</i>				
<i>Gyrosigma accuminatus</i>	<i>Ceriodaphnia reticulata</i>				
<i>Pediastrum boryanum</i>	<i>Brachirous caudatus</i>				

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Scenedesmus bijuga</i>	<i>Coleps hirsutus</i>				
<i>Melosira gracilis</i>	<i>Arcella sp.</i>				
<i>Cymbella sp.</i>	<i>Keratella monospina</i>				
<i>Chroococcus minutus</i>	<i>Asplancha sp.</i>				
<i>Spirulina princepes</i>	<i>Ceriodaphnia sp.</i>				
<i>Nitzschia gracilis</i>					
<i>Syndera tabulata</i>					
<i>Ophora sp.</i>					
<i>Cyclotella meneghiana</i>					

Sampling Location – Barrage site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Acharanthes affinis</i>	<i>Mesocyclops leuckarti</i>				
<i>Pinnularia braunii</i>	<i>Asplancha brighwell</i>				
<i>Chroococcus minutus</i>	<i>Colpidium colpoda</i>				
<i>Cymbella sp.</i>	<i>Ceriodaphnia reticulata</i>				
<i>Nitzschia gracilis</i>	<i>Daphnia sp.</i>				
<i>Dictyosphaerium ehrenbergianum</i>	<i>Actinophyros sp.</i>				
<i>Gyrosigma sp.</i>	<i>Brachirous caudatus</i>	2.90	2.54	59.3	12.2
<i>Gyrosigma accuminatus</i>	<i>Coleps hirsutus</i>				
<i>Frogilaria crotonersis</i>	<i>Arcella sp.</i>				
<i>Ankistrodesmus var tumidus</i>	<i>Keratella monospina</i>				
<i>Spirulina platensis</i>	<i>Asplancha sp.</i>				
<i>Scenedesmus bijuga</i>	<i>Ceriodaphnia sp.</i>				
<i>Pinnularia sp.</i>	<i>Keratella tropica</i>				
<i>Ankistrodesmus falcutus</i>	<i>Kellicottia sp.</i>				



Sampling Location – Barrage upstream site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Gyrosigma sp.</i>	<i>Brachirous caudatus</i>	3.04	2.60	69.3	12.4
<i>Pinnularia braunii</i>	<i>Asplancha brighwell</i>				
<i>Chroococcus minutus</i>	<i>Colpidium colpoda</i>				
<i>Cymbella sp.</i>	<i>Ceriodaphnia reticulata</i>				
<i>Nitzschia gracilis</i>	<i>Daphnia sp.</i>				
<i>Dictyosphaerium ehrenbergianum</i>	<i>Actinophyros sp.</i>				
<i>Acharanthes affinis</i>	<i>Brachirous caudatus</i>				
<i>Gyrosigma accuminatus</i>	<i>Coleps hirsutus</i>				
<i>Frogilaria crotonersis</i>	<i>Arcella sp.</i>				
<i>Ankistrodesmus var tumidus</i>	<i>Keratella monospina</i>				
<i>Spirulina platensis</i>	<i>Asplancha sp.</i>				
<i>Scenedesmus bijuga</i>	<i>Ceriodaphnia sp.</i>				
<i>Pinnularia sp.</i>	<i>Keratella tropica</i>				
<i>Ankistrodesmus falcutus</i>	<i>Kellicottia sp.</i>				
<i>Navioula radiosa</i>					
<i>Coelastrum sp.</i>					

**PRE-MONSOON SEASON - BENTHIC DENSITY AND DIVERSITY**

Sampling Location – Lethang TRT site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Cymbella lanceolata</i>	3.70	56.8
<i>Diatoma vulgaris</i>		
<i>Baetis sp.</i>		
<i>Stenonema sp.</i>		
<i>Cyclotella comta</i>		
<i>Gyrosigma sp.</i>		
<i>Melosira undulata</i>		
<i>Nitzschia gracilis</i>		
<i>Psephnus sp.</i>		
<i>Acronuria sp.</i>		
<i>Cymbella proxima</i>		
<i>Navicula sp.</i>		
<i>Gomphonema sp.</i>		

<i>Achnanthes clevel</i>		
<i>Melosira gracilis</i>		

Sampling Location – Lethang TRT downstream site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Cymbella lanceolata</i>	3.60	51.9
<i>Diatoma vulgaris</i>		
<i>Baetis sp.</i>		
<i>Stenonema sp.</i>		
<i>Cyclotella comta</i>		
<i>Gyrosigma sp.</i>		
<i>Melosira undulata</i>		
<i>Nitzschia gracilis</i>		
<i>Psephnus sp.</i>		
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		

Sampling Location – Barrage site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Cymbella lanceolata</i>	2.66	51.4
<i>Diatoma vulgaris</i>		
<i>Baetis sp.</i>		
<i>Stenonema sp.</i>		
<i>Cyclotella comta</i>		
<i>Gyrosigma acuminata.</i>		
<i>Melosira undulata</i>		
<i>Nitzschia gracilis</i>		
<i>Psephnus sp.</i>		
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		
<i>Cyclotella meneghiana</i>		

Sampling Location – Barrage upstream site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Cymbella lanceolata</i>	2.60	52.3
<i>Diatoma vulgaris</i>		
<i>Baetis sp.</i>		
<i>Stenonema sp.</i>		
<i>Cyclotella comta</i>		
<i>Gyrosigma accuminatus.</i>		
<i>Melosira undulata</i>		
<i>Nitzschia gracilis</i>		
<i>Psephnus sp.</i>		
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		
<i>Cyclotella meneghiana</i>		
<i>Gyrosigma sp.</i>		
<i>Cymbella lanceolata</i>		
<i>Amphora sp.</i>		

**WINTER SEASON - PLANKTONIC DENSITY AND DIVERSITY**

Sampling Location – Lethang TRT site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Gyrosigma sp.</i>	<i>Actinophyros sp.</i>	2.78	2.59	58.3	10.3
<i>Cymbella sp</i>	<i>Daphnia sp.</i>				
<i>Nitzschia gracilis</i>	<i>Colpidium colpoda</i>				
<i>Frogilaria crotonersis</i>	<i>Ceriodaphnia reticulata</i>				
<i>Navioula radiosa</i>	<i>Asplancha sp.</i>				
<i>Coelastrum sp.</i>	<i>Asplancha brighwell</i>				
<i>Ankistrodesmus falcutus</i>	<i>Brachirous caudatus</i>				
<i>Gyrosigma accuminatus</i>	<i>Coleps hirsutus</i>				
<i>Acharanthes affinis</i>	<i>Keratella tropica</i>				
<i>Dictyosphaerium ehrenbergianum</i>	<i>Keratella monospina</i>				
<i>Chroococcus minutus</i>	<i>Arcella sp.</i>				
<i>Scenedesmus bijuga</i>	<i>Ceriodaphnia sp.</i>				
<i>Pinnularia sp.</i>					

Sampling Location – Lethang TRT downstream site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Spirulina platensis</i>	<i>Arcella sp.</i>	2.76	2.31	57.9	9.8
<i>Pinnularia braunii</i>	<i>Keratella tropica</i>				
<i>Pinnularia sp.</i>	<i>Keratella monospina</i>				
<i>Chroococcus minutus</i>	<i>Asplancha sp.</i>				
<i>Cymbella sp.</i>	<i>Mesocyclops leuckarti</i>				
<i>Acharanthes affinis</i>					
<i>Frogilaria crotonensis</i>	<i>Brachirous caudatus</i>				
<i>Gyrosigma accuminatus</i>	<i>Coleps hirsutus</i>				
<i>Scenedesmus bijuga</i>	<i>Colpidium colpoda</i>				
<i>Ankistrodesmus var tumidus</i>	<i>Ceriodaphnia reticulata</i>				
<i>Ankistrodesmus falcutus</i>	<i>Daphnia sp.</i>				
<i>Nitzschia gracilis</i>	<i>Ceriodaphnia sp.</i>				
<i>Dictyosphaerium ehrenbergianum</i>	<i>Asplancha brighwell</i>				
<i>Gyrosigma sp.</i>					

Sampling Location – Barrage site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Ankistrodesmus falcutus</i>	<i>Ceriodaphnia sp.</i>	2.78	2.38	56.9	10.1
<i>Cymbella sp.</i>	<i>Coleps hirsutus</i>				
<i>Chroococcus minutus</i>	<i>Arcella sp.</i>				
<i>Spirulina platensis</i>	<i>Ceriodaphnia reticulata</i>				
<i>Navioula radiosa</i>	<i>Daphnia sp.</i>				
<i>Coelastrum sp.</i>	<i>Actinophyros sp.</i>				
<i>Acharanthes affinis</i>	<i>Brachirous caudatus</i>				
<i>Gyrosigma accuminatus</i>	<i>Colpidium colpoda</i>				
<i>Gyrosigma sp.</i>	<i>Kellicottia sp.</i>				

<i>Pinnularia braunii</i>	<i>Keratella monospina</i>				
<i>Ankistrodesmus var tumidus</i>	<i>Asplancha sp.</i>				
<i>Scenedesmus bijuga</i>	<i>Asplancha brighwell</i>				
<i>Pinnularia sp.</i>	<i>Keratella tropica</i>				
<i>Frogilaria crotonersis</i>					
<i>Nitzschia gracilis</i>					
<i>Dictyosphaerium ehrenbergianum</i>					

Sampling Location – Barrage Upstream site

PHYTOPLANKTON	ZOOPLANKTON	DIVERSITY INDEX		DENSITY	
		PHYTO-PLANKTON	ZOO-PLANKTON	PHYTO-PLANKTON (cell/ ml)	ZOO-PLANKTON (Individual/ litre)
<i>Ankistrodesmus falcutus</i>	<i>Keratella tropica</i>	2.80	2.57	57.2	9.3
<i>Gyrosigma accuminatus</i>	<i>Asplancha brighwell</i>				
<i>Acharanthes affinis</i>	<i>Brachirous caudatus</i>				
<i>Scenedesmus bijuga</i>	<i>Colpidium colpoda</i>				
<i>Pinnularia sp.</i>	<i>Asplancha sp.</i>				
<i>Chroococcus minutus</i>	<i>Daphnia sp.</i>				
<i>Gyrosigma sp.</i>	<i>Ceriodaphnia reticulata</i>				
<i>Cymbella sp</i>	<i>Actinophyros sp.</i>				
<i>Nitzschia gracilis</i>	<i>Coleps hirsutus</i>				
<i>Dictyosphaerium ehrenbergianum</i>	<i>Keratella monospina</i>				
<i>Navioula radiosa</i>	<i>Arcella sp.</i>				
<i>Coelastrum sp.</i>					
<i>Frogilaria crotonersis</i>					

### WINTER SEASON - BENTHIC DENSITY AND DIVERSITY

Sampling Location – Lethang TRT site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Melosira gracilis</i>	3.62	51.2
<i>Gyrosigma sp.</i>		
<i>Melosira sp.</i>		
<i>Stenonema sp.</i>		
<i>Diatoma vulgaris</i>		
<i>Melosira undulata</i>		
<i>Cyclotella meneghiana</i>		
<i>Cymbella lanceolata</i>		
<i>Gyrosigma accuminata</i>		
<i>Baetis sp.</i>		
<i>Cyclotella comta</i>		
<i>Nitzschia gracilis</i>		
<i>Psephnus sp.</i>		

Sampling Location – Lethang TRT Downstream site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Cymbella lanceolata</i>	2.91	51.2
<i>Diatoma vulgaris</i>		
<i>Baetis sp.</i>		
<i>Psephnus sp.</i>		
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		
<i>Gyrosigma sp.</i>		
<i>Melosira sp.</i>		
<i>Nitzschia gracilis</i>		
<i>Gyrosigma sp.</i>		
<i>Cyclotella comta</i>		
<i>Stenonema sp.</i>		

Sampling Location – Barrage site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Psephnus sp.</i>	2.61	48.9
<i>Nitzschia sp.</i>		
<i>Stenonema sp.</i>		
<i>Gyrosigma accuminata</i>		
<i>Cyclotella meneghiana</i>		
<i>Diatoma vulgaris</i>		

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Melosira sp.</i>		
<i>Melosira undulata</i>		
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		
<i>Gyrosigma sp.</i>		
<i>Cymbella lanceolata</i>		
<i>Baetis sp.</i>		

Sampling Location – Barrage Upstream site

Name of Benthos	Diversity Index	Density(Individual/litre)
<i>Baetis sp.</i>	2.57	49.5
<i>Stenonema sp.</i>		
<i>Acronuria sp.</i>		
<i>Melosira gracilis</i>		
<i>Gyrosigma sp.</i>		
<i>Melosira sp.</i>		
<i>Gyrosigma acuminate</i>		
<i>Cymbella lanceolata</i>		
<i>Diatoma vulgaris</i>		
<i>Melosira undulata</i>		
<i>Cyclotella meneghiana</i>		
<i>Cyclotella comta</i>		



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# ANNEXURE - VIII

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ANNEXURE- VIII

Computation of Sediment Yield Index of the 38 Micro Watersheds

S. N	Micro Water shed code	EIMU	Area (ha)	Weightage	Product AxW	DR	AXWX DR 4X5X7	? Ax Wx DR/ Total Area =SYI	Priority Number
1	2	3	4	5	6	7	8	9	10
1	f1a	11	139	12	1668	80	133440		
		13	39	13	507	80	40560		
		24	46	16	736	80	58880		
		26	298	17	5066	80	405280		
		14	63	16	1008	90	90720	1328780	8
		25	116	19	2204	85	187340	1007	
		15	36	14	504	90	45360		
		15	232	17	3944	80	315520		
		26	38	17	646	80	51680		
			1007				1328780	1320	
2	f1b	14	96	16	1536	90	138240		
		15	58	14	812	90	73080		
		24	46	16	736	80	58880	6325995	9
		25	85	19	1615	85	137275	486	
		30	201	14	2814	80	225120		
			486				632595	1302	
3	f1c	12	76	14	1064	80	85120		
		.15	288	14	4032	90	362880		
		23	68	13	884	80	70720		
		24	48	16	768	80	61440		
		25	103	19	1957	85	166345	1155705	11
		.26	129	17	2193	80	175440	902	
		16	46	12	552	75	41400		
		.26	21	17	357	80	28560		
		.22	98	15	1470	90	132300		
		.15	25	14	350	90	31500	1155705	1281
4	g1a	13	129	13	1677	80	134160		
		15	320	14	4480	90	403200		
		25	8	19	152	85	12920	571400	15
		26	4	17	68	80	5440	475	
		30	14	14	196	80	15680		
			475				571400	1203	
5	g1b	12	136	14	1904	80	152320		
		13	253	13	3289	80	263120		
		15	16	14	224	90	20160	983885	13

S. N	Micro Water shed code	EIMU	Area (ha)	Weightage	Product AxW	DR	AXWX DR 4X5X7	? Ax Wx DR/ Total Area =SYI	Priority Number
		25	275	19	5225	85	444125	773	
		30	93	14	1302	80	104160		
			773				983885	<b>1273</b>	
6	g1c	15	8	14	112	90	10080		
		16	116	12	1392	75	104400		
		19	156	15	2340	85	198900		
		24	42	16	672	80	53760	<u>637185</u>	<b>10</b>
		25	131	19	2489	85	211565	496	
		26	43	17	731	80	58480		
			496				637185	<b>1285</b>	
7	g1d	15	104	14	1456	90	131040		
		20	140	17	2380	85	202300		
		24	121	16	1936	80	154880	<u>604735</u>	<b>3</b>
		25	13	19	247	85	20995	432	
		26	30	17	510	80	40800		
		32	24	24	576	95	54720		
			432				604735	<b>1399</b>	
8	g1f	14	180	16	2880	90	259200		
		20	10	17	170	85	14450		
		26	174	17	2958	80	236640		
		31	181	12	2172	80	173760	<u>963195</u>	<b>6</b>
		13	47	13	611	80	48880	725	
		27	91	21	1911	85	162435		
			725				963195	<b>1328</b>	
9	g1g	11	1	12	12	80	960		
		12	59	14	826	80	66080		
		13	93	13	1209	80	96720		
		15	62	14	868	90	78120		
		20	150	17	2550	85	216750		
		22	138	15	2070	90	186300		
		17	3	13	39	80	3120	<u>1155680</u>	<b>14</b>
		32	34	24	816	95	77520	927	
		33	72	12	864	80	69120		
		9	117	14	1638	85	139230		
30	198	14	2772	80	221760				
			927				1155680	<b>1247</b>	
10	g1h	11	45	12	540	80	43200		
		15	151	14	2114	90	190260		
		20	44	17	748	85	63580		
		22	21	15	315	90	28350		
		30	187	14	2618	80	209440	<u>1150460</u>	<b>2</b>

S. N	Micro Water shed code	EIMU	Area (ha)	Weightage	Product AxW	DR	AXWX DR 4X5X7	? Ax Wx DR/ Total Area =SYI	Priority Number
		26	66	17	1122	80	89760	805	
		32	48	24	1152	95	109440		
		27	222	21	4662	85	396270		
		31	21	12	252	80	20160		
			805				1150460	<b>1429</b>	
11	g1j	9	103	14	1442	85	122570		
		11	50	12	600	80	48000		
		15	65	14	910	90	81900		
		18	32	14	448	80	35840		
		17	155	13	2015	80	161200	<u>883780</u>	<b>19</b>
		20	134	17	2278	85	193630	789	
		30	4	14	56	80	4480		
		33	246	12	2952	80	236160		
			789				883780	<b>1120</b>	
12	g1k	11	452	12	5424	75	406800		
		14	146	16	2336	90	210240		
		18	56	14	784	75	58800		
		19	295	15	4425	85	376125		
		30	84	14	1176	75	88200	<u>1756630</u>	<b>26</b>
		33	353	12	4236	75	317700	1679	
		17	259	13	3367	75	252525		
		20	34	17	578	80	46240		
			1679				1756630	<b>1046</b>	
13	g1m	11	90	12	1080	75	81000		
		1	6	11	66	70	4620		
		15	3	14	42	90	3780		
		20	160	17	2720	85	231200	<u>1627800</u>	<b>22</b>
		26	148	17	2516	80	201280	1490	
		27	29	21	609	80	48720		
		30	636	14	8904	75	667800		
		33	358	12	4296	75	322200		
		9	60	14	840	80	67200		
			1490				1627800	<b>1092</b>	
14	g1n	11	92	12	1104	80	88320		
		15	7	14	98	90	8820		
		17	120	13	1560	80	124800		
		19	61	15	915	85	77775	<u>1092395</u>	<b>16</b>
		22	8	15	120	90	10800	926	
		30	407	14	5698	80	455840		
		31	103	12	1236	80	98880		
		32	79	24	1896	95	180120		
		33	49	12	588	80	47040		
			926				1092395	<b>1179</b>	

S. N	Micro Water shed code	EIMU	Area (ha)	Weightage	Product AxW	DR	AXWX DR 4X5X7	? Ax Wx DR/ Total Area =SYI	Priority Number
15	g1p	15	113	14	1582	90	142380		
		16	53	12	636	75	47700		
		20	19	17	323	85	27455		
		22	71	15	1065	90	95850		
		25	208	19	3952	85	335920	1360665	1
		27	230	21	4830	80	386400	921	
		30	9	14	126	80	10080		
		31	138	12	1656	80	132480		
		32	80	24	1920	95	182400		
			921				1360665	1477	
16	g2a	11	80	12	960	80	76800		
		15	20	14	280	85	23800		
		17	133	13	1729	75	129675		
		30	221	14	3094	75	232050		
		33	118	12	1416	75	106200	729375	27
		20	50	17	850	80	68000	705	
		23	30	13	390	75	29250		
		19	53	15	795	80	63600		
			705				729375	1035	
17	g2b	1	70	11	770	70	53900		
		9	21	14	294	80	23520		
		15	43	14	602	85	51170		
		16	120	12	1440	70	100800	1021465	32
		17	85	13	1105	75	82875	1103	
		31	90	12	1080	75	81000		
		33	530	12	6360	75	477000		
		30	144	14	2016	75	151200		
			1103				1021465	926	
18	g2c	16	24	12	288	75	21600		
		4	71	13	923	55	50765		
		17	35	13	455	75	34125		
		1	321	11	3531	70	247170	811175	36
		19	19	15	285	85	24225	971	
		30	59	14	826	75	61950		
		33	343	12	4116	80	329280		
		WB	62	10	620	1	620		
		9	37	14	518	80	41440		
			971				811175	835	
19	g2d	1	9	11	99	65	6435		
		15	32	14	448	85	38080		
		16	68	12	816	70	57120		
		20	301	17	5117	80	409360		
		23	23	13	299	80	23920	1276260	21

S. N	Micro Water shed code	EIMU	Area (ha)	Weightage	Product AxW	DR	AXWX DR 4X5X7	? Ax Wx DR/ Total Area =SYI	Priority Number
		26	11	17	187	75	14025	1158	
		30	328	14	4592	75	344400		
		32	22	24	528	90	47520		
		17	104	13	1352	75	101400		
		33	260	12	3120	75	234000		
			1158				1276260	<b>1102</b>	
<b>20</b>	<b>g2f</b>	11	61	12	732	75	54900		
		16	14	12	168	70	11760		
		17	48	13	624	75	46800		
		26	17	17	289	75	21675	<u>496575</u>	<b>31</b>
		30	60	14	840	75	63000	512	
		32	14	24	336	90	30240		
		33	261	12	3132	75	234900		
		31	37	12	444	75	33300		
			512				496575	<b>969</b>	
<b>21</b>	<b>g2g</b>	17	93	13	1209	75	90675	<u>509775</u>	<b>34</b>
		30	16	14	224	75	16800	556	
		33	447	12	5364	75	402300		
			556				509775	<b>917</b>	
<b>22</b>	<b>g2h</b>	19	65	15	975	80	78000		
		20	1	17	17	80	1360		
		29	32	17	544	75	40800	<u>536410</u>	<b>23</b>
		30	351	14	4914	75	368550	502	
		33	53	12	636	75	47700		
			502				536410	<b>1068</b>	
<b>23</b>	<b>g2j</b>	1	109	11	1199	65	77935		
		3	34	14	476	65	30940		
		9	1	14	14	80	1120		
		15	31	14	434	85	36890		
		18	2	14	28	75	2100	<u>987130</u>	<b>28</b>
		28	236	16	3776	70	264320	972	
		29	33	17	561	75	42075		
		30	389	14	5446	75	408450		
		31	68	12	816	75	61200		
		33	69	12	828	75	62100		
<b>24</b>	<b>g2k</b>		972				987130	<b>1015</b>	
		1	49	11	539	65	35035		
		2	457	12	5484	70	383880		
		3	116	14	1624	55	89320		
		4	278	13	3614	55	198770		
		8	28	13	364	75	27300	<u>1175105</u>	<b>37</b>
		18	20	14	280	75	21000	1412	
		28	10	16	160	70	11200		

S. N	Micro Water shed code	EIMU	Area (ha)	Weightage	Product AxW	DR	AXWX DR 4X5X7	? Ax Wx DR/ Total Area =SYI	Priority Number
		31	41	12	492	75	36900		
		33	413 1412	12	4956	75	371700 1175105	<b>832</b>	
<b>25</b>	<b>g2m</b>	3	223	14	3122	55	171710	<u>903990</u>	<b>35</b>
		2	100	12	1200	70	84000	1054	
		4	52	13	676	55	37180		
		33	679	12	8148	75	611100		
			1054				903990	<b>858</b>	
<b>26</b>	<b>h1a</b>	14	81	16	1296	90	116640		
		15	4	14	56	90	5040		
		33	60	12	720	75	54000	<u>705595</u>	<b>4</b>
		21	38	14	532	90	47880	514	
		25	125	19	2375	85	201875		
		26	206	17	3502	80	280160		
			514				705595	<b>1373</b>	
<b>27</b>	<b>h1b</b>	12	8	14	112	80	8960		
		15	374	14	5236	90	471240		
		13	49	13	637	80	50960	<u>848570</u>	<b>7</b>
		17	53	13	689	80	55120	641	
		18	27	14	378	80	30240		
		27	130	21	2730	85	232050		
			641				848570	<b>1324</b>	
<b>28</b>	<b>h1c</b>	12	80	14	1120	80	89600		
		11	101	12	1212	80	96960		
		15	77	14	1078	90	97020		
		16	314	12	3768	75	282600		
		17	284	13	3692	80	295360		
		19	38	15	570	80	45600		
		22	140	15	2100	90	189000	<u>1661475</u>	<b>20</b>
		27	23	21	483	85	41055	1505	
		31	121	12	1452	80	116160		
		32	51	24	1224	95	116280		
		33	204	12	2448	80	195840		
		18	8	14	112	80	8960		
		26	64	17	1088	80	87040		
			1505				1661475	<b>1104</b>	
<b>29</b>	<b>h1d</b>	11	141	12	1692	80	135360		
		13	13	13	169	80	13520		
		15	41	14	574	90	51660		
		17	250	13	3250	80	260000		
		26	2	17	34	80	2720	<u>854145</u>	<b>25</b>
		25	3	19	57	85	4845	815	
		31	90	12	1080	80	86400		



S. N	Micro Water shed code	EIMU	Area (ha)	Weightage	Product AxW	DR	AXWX DR 4X5X7	? Ax Wx DR/ Total Area =SYI	Priority Number
		33	248	12	2976	80	238080		
		32	27	24	648	95	61560		
			815				854145	<b>1048</b>	
<b>30</b>	<b>h1f</b>	16	164	12	1968	75	147600		
		22	301	15	4515	90	406350		
		32	18	24	432	95	41040		<b>5</b>
		25	268	19	5092	85	432820	1101090	
		30	56	14	784	80	62720	818	
		33	11	12	132	80	10560		
			818				1101090	<b>1346</b>	
<b>31</b>	<b>h1g</b>	11	22	12	264	80	21120		
		23	20	13	260	80	20800		
		10	23	16	368	85	31280	<u>838160</u>	<b>24</b>
		16	37	16	592	75	44400	789	
		32	42	24	1008	95	95760		
		30	35	14	490	80	39200		
		33	610	12	7320	80	585600		
			789				838160	<b>1062</b>	
<b>32</b>	<b>h2a</b>	5	16	15	240	90	21600		
		11	7	12	84	80	6720		
		20	219	17	3723	80	297840		
		30	329	14	4606	80	368480	<u>1058870</u>	<b>18</b>
		33	342	12	4104	80	328320	934	
		25	18	19	342	85	29070		
		32	3	24	72	95	6840		
			934				1058870	<b>1134</b>	
<b>33</b>	<b>h2b</b>	11	25	12	300	75	22500		
		16	59	12	708	70	49560		
		19	68	15	1020	80	81600	<u>340940</u>	<b>12</b>
		25	40	19	760	80	60800	267	
		32	43	24	1032	90	92880		
		30	32	14	448	75	33600		
			267				340940	<b>1277</b>	
<b>34</b>	<b>h2c</b>	2	316	12	3792	70	265440		
		11	95	12	1140	75	85500		
		16	35	12	420	70	29400		
		17	118	13	1534	75	115050		
		30	98	14	1372	80	109760	1145605	<b>33</b>
		21	88	14	1232	85	104720	1222	
		32	19	24	456	90	41040		
		3	2	14	28	55	1540		
		10	59	10	590	80	47200		
		1	37	11	407	65	26455		

S. N	Micro Water shed code	EIMU	Area (ha)	Weightage	Product AxW	DR	AXWX DR 4X5X7	? Ax Wx DR/ Total Area =SYI	Priority Number
		33	355	12	4260	75	319500		
35	h2d	1	1222				1145605	<b>937</b>	
		2	513	11	5643	65	366795	<u>845435</u>	<b>38</b>
		11	364	12	4368	70	305760	1100	
		3	9	12	108	75	8100		
			214	14	2996	55	164780		
			1100				845435	<b>769</b>	
36	h2f	30	10	14	140	75	10500		
		32	40	24	960	90	86400		
		16	19	12	228	70	15960	<u>225360</u>	<b>17</b>
		11	114	12	1368	75	102600	194	
			11	12	132	75	9900		
			194				225360	<b>1162</b>	
37	h2g	2	518	12	6216	70	435120		
		6	91	17	1547	90	139230		
		7	62	14	868	80	69440		
		8	66	13	858	75	64350		
		10	113	16	1808	80	144640		
		11	87	12	1044	75	78300	<u>1670985</u>	<b>30</b>
		15	35	14	490	85	41650	1702	
		16	109	12	1308	70	91560		
		17	85	13	1105	75	82875		
		20	77	17	1309	80	104720		
		30	40	14	560	75	42000		
			419	12	5028	75	377100		
			1702				1670985	<b>981</b>	
38	h2h	2	293	12	3516	70	246120		
		3	92	14	1288	55	70840		
		17	173	13	2249	75	168675		
		19	23	15	345	80	27600		
		20	85	17	1445	80	115600		
		30	69	14	966	75	72450	<u>1659355</u>	<b>29</b>
		33	530	12	6360	75	477000	1677	
		6	47	17	799	90	71910		
		5	56	15	840	90	75600		
		7	260	14	3640	80	291200		
		16	29	12	348	70	24360		
			20	12	240	75	18000		
			1677				1659355	<b>989</b>	