Environmental Impact Assessment (Draft)

June 2018

IND: Assam Power Sector Investment Program – Tranche 3

120 MW Lower Kopili Hydroelectric Project

Volume 1: Main Report

Prepared by Assam Power Generation Corporation Limited (APGCL), Government of Assam for the Asian Development Bank. This is an updated version of the draft available on https://www.adb.org/sites/default/files/project-documents/47101/47101-004-eia-en.pdf.

CURRENCY EQUIVALENTS
(As of 31 December 2017)

Currency unit	–	Indian rupee (₹)
₹1.00	=	$0.01566
$1.00	=	₹63.8499

ABBREVIATIONS

AAQ	-	ambient air quality
AAQM	-	ambient air quality monitoring
ADB	-	Asian Development Bank
ADC	-	Autonomous District Council
AEGCL	-	Assam Electricity Grid Corporation Limited
APDCL	-	Assam Power Distribution Company Limited
APGCL	-	Assam Power Generation Corporation Limited
APH	-	auxiliary power house
APSIP	-	Assam Power Sector Investment Program
ASEB	-	Assam State Electricity Board
ASI	-	Archaeological Survey of India
ASPCB	-	Assam State Pollution Control Board
BDL	-	below detectable limit
BIS	-	Bureau of Indian Standards
BGL	-	below ground level
BOD	-	biochemical oxygen demand
BOQ	-	bill of quantity
CA	-	compensatory afforestation
CCE	-	Chief Controller of Explosives
CEA	-	Central Electricity Authority
CGWA	-	Central Ground Water Authority
CITES	-	Convention on International Trade in Endangered Species
CO	-	carbon monoxide
COD	-	chemical oxygen demand
CPCB	-	Central Pollution Control Board
CRVA	-	Climate Risk and Vulnerability Assessment
CSC	-	Construction Supervision Consultant
CSMRS	-	Central Soil and Material Research Station
CSR	-	Corporate Social Responsibility
CWC	-	Central Water Commission
DC	-	double circuit
DFO	-	Divisional Forest Officer
DG	-	diesel generating set
DMU	-	discrete management unit
DO	-	dissolved oxygen
DPR	-	detailed project report
d/s	-	downstream
E&S	-	environment and social
EA	-	executing agency
EAC	-	Expert Appraisal Committee
EARF	-	environmental assessment and review framework

EC	-	environment clearance
e-flow	-	environmental flow
EHS	-	environment, health and safety
EIA	-	environmental impact assessment
EMoP	-	environmental monitoring plan
EMP	-	environmental management plan
EOT	-	electric overhead travelling crane
EPC	-	engineering, procurement and construction
ESCAP	-	United Nations Economic and Social Commission for Asia and Pacific
ESO	-	Environmental and Safety Officer
FFA	-	Framework Financing Agreement
FGD	-	focused group discussion
FRL	-	full reservoir level
GHG	-	greenhouse gas
GIS	-	geographical information system
GoA	-	Government of Assam
GoI	-	Government of India
GRC	-	grievance redress committee
GRM	-	grievance redress mechanism
GSI	-	Geological Survey of India
HEP	-	hydroelectric project
HFL	-	highest flood level
HRT	-	head race tunnel
HSD	-	high speed diesel
HT	-	high tension
IA	-	implementing agency
IFC	-	International Finance Corporation
IMD	-	Indian Meteorological Department
IRC	-	Indian Road Congress
IUCN	-	International Union for Conservation of Nature
IVI	-	important value index
IWPA	-	Indian Wildlife Protection Act, 1972
LHS	-	left hand side
LKHEP	-	Lower Kopili Hydroelectric Project
LPG	-	liquefied petroleum gas
LT	-	low tension
Max	-	maximum
MDDL	-	minimum draw down level
MFF	-	multitranche financing facility
Min	-	minimum
MoEF&CC	-	Ministry of Environment, Forest and Climate Change
MoP	-	Ministry of Power
MPH	-	main power house
MSL	-	mean sea level
MW	-	megawatt
NAAQS	-	National Ambient Air Quality Standards
N, S, E, W, NE, SW, NW	-	wind directions (north, south, east, west or combination of two directions like south west, north west)
NE	-	north eastern
NEEPCO	-	North Eastern Electric Power Corporation Limited

NGO	-	non-governmental organization
NGT	-	India's National Green Tribunal
NH	-	national highway
NOC	-	No Objection Certificate
NO_x	-	oxides of nitrogen
NP	-	national park
NPK	-	nitrogen, phosphates, and potassium
NPL	-	National Physical Laboratory, U.K.
NBWL	-	National Board for Wildlife of India
OSHA	-	Occupational Safety and Health Administration
PAH	-	project-affected household
PAP	-	project affected persons
PAF	-	project affected family
PAS	-	protected areas
PCC	-	Portland Cement Concrete
PD	-	Project Director
PFR	-	periodic financing request
PM	-	particulate matter
PIA	-	project influence area
PIU	-	Project Implementation Unit
PMSC	-	Project Management and Supervision Consultant
PMU	-	Project Management Unit
PPA	-	Power Purchase Agreement
PPE	-	personal protective equipment
PPT	-	parts per trillion
PPTA	-	Project Preparatory Technical Assistance
PUC	-	Pollution Under Control
PWD	-	Public Works Department
RCC	-	reinforced cement concrete
REA	-	Rapid Environmental Assessment
RFA	-	recorded forest area
RHS	-	right hand side
RoW	-	right of way
R&R	-	Rehabilitation and Resettlement
RSPM	-	respiratory suspended particulate matter
RTDP	-	Resettlement and Tribal Development Plan
SAARC	-	South Asian Association for Regional Cooperation
SC	-	Scheduled Cast (name of a community in India)
SEIA	-	Supplemental Environmental Impact Assessment
SEIAA	-	State Environmental Impact Assessment Authority
SESC	-	Social and Environmental Safeguards Cell
SH	-	state highway
SIA	-	Social Impact Assessment
SEMP	-	site-specific environmental management plan
SO_2	-	sulphur dioxide
SoI	-	Survey of India
SPCB	-	State Pollution Control Board
SPL	-	sound pressure level
SPM	-	suspended particulate matter
SPS	-	ADB Safeguard Policy Statement, 2009
S/S	-	substation

ST	-	scheduled tribes
STP	-	sewage treatment plant
TA	-	technical assistance
T&D	-	transmission and distribution
TDS	-	total dissolved solids
TL	-	transmission line
ToR	-	terms of reference
TRC	-	tail race channel
TSS	-	total suspended solids
UA	-	urban agglomeration
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
u/s	-	upstream
USEPA	-	United States Environmental Protection Agency
UT	-	union territories
WHC	-	water holding capacity
WLS	-	Wildlife Sanctuary
WWF	-	World Wildlife Fund
ZSI	-	Zoological Survey of India

WEIGHTS AND MEASURES

dB(A)	–	A-weighted decibel
ha	–	hectare
km	–	kilometre
km^2	–	square kilometer
kV	-	kilovolt (1000 volt)
kW	-	kilowatt (1000 watt)
kWh	-	kilowatt-hour
KWA	–	kilowatt ampere
Leq	–	equivalent continuous noise level
µg	–	microgram
M	–	meter
MW (megawatt)	–	megawatt
$PM_{2.5}$ or PM_{10}	–	particulate matter of 2.5 micron or 10 micron size

NOTES

(i) The fiscal year (FY) of the Government of India and its agencies begins on 1 April and ends on March 31. “FY” before a calendar year denotes the year in which the fiscal year ends, e.g., FY2017 begins on 1 April 2016 and ends on 31 March 2017.

(ii) In this report, "$" refers to United States dollars.

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EXECUTIVE SUMMARY

A. Introduction

1. This report presents the findings and results of the Environmental Impact Assessment (EIA) for Lower Kopili Hydroelectric Project (LKHEP or the Project). WAPCOS Limited, a public sector enterprise under the aegis of the Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India (GoI) has been engaged by the Assam Power Generation Corporation Limited (APGCL) for preparation of the EIA for the proposed Project to meet GoI requirements. The draft EIA was prepared by WAPCOS in September 2015 and finalized in March 2017 incorporating public hearing findings.

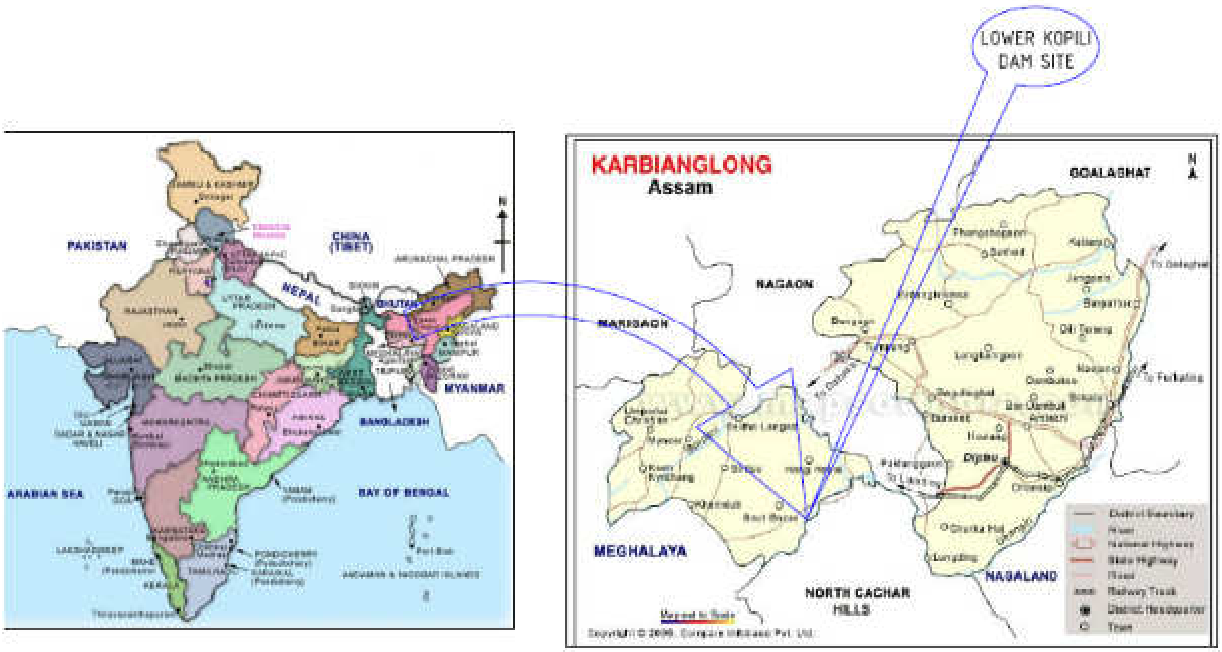
2. Since this Project is proposed for financing under Tranche 3 of Asian Development Bank (ADB) funded Assam Power Sector Investment Program (APSIP or Investment Program) in India, this EIA document utilizes the primary and secondary data, findings and results from the WAPCOS EIA that meets the requirements of GoI as well as this EIA ensures compliance with the requirements of ADB's Safeguard Policy Statement 2009 (SPS 2009) and the International Finance Corporation (IFC) Environmental, Health, and Safety (EHS) Guidelines.

3. The proposed project is designed as a run-of-river scheme with diurnal storage on the Kopili river at Longku and will generate 120 MW power comprising the Main Power house (MPH) with 2 units of 55 MW each and an Auxiliary Power house (APH) with 10 MW capacity (with 10% continuous overload) to be located at the dam toe. The dam will be designed as a concrete gravity dam, of height 70.13 m and width 345.05 m. The scheme has been planned to run at full potential in the monsoon season and operate as a peaking station in the non-monsoon season (December-March), for at least 3 hours a day (with reservoir storage occurring for 21 hours/day, with no tailrace discharge). The proposed project will be the final stage of development of the Kopili river valley and along with the existing upstream hydropower plants, it is expected to fully harness the hydropower potential of the Kopili river.

B. Description of the Project

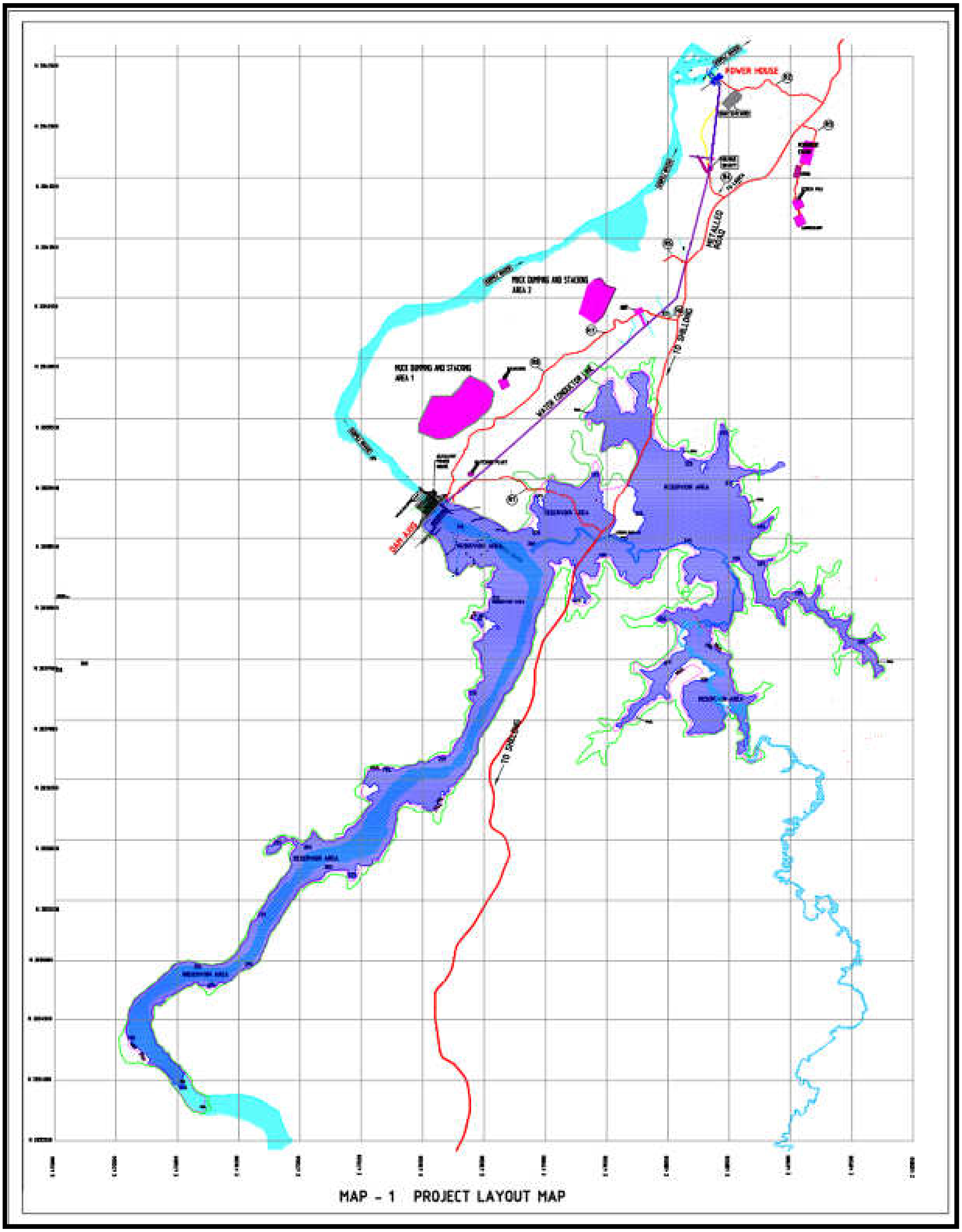
4. The proposed project is situated in east of Karbi Anglong and west of Dima Hasao (also known as North Cachar Hills), the Autonomous District Council (ADC) areas in Central part of Assam State in India (Figure E-1). The dam structure is located on Kopili river (a major tributary of the Brahmaputra river) and the Power House structures are located on right bank of Kopili river. The project diversion site is located at village Longku.

Figure E-1: Project Location Map



5. The project envisages construction of a 70m concrete gravity dam across the Kopili river at Longku, about 20 km downstream of Kopili HEP Stage-I Power house. A water conductor system comprising of an Intake Structure, Head Race Tunnel along with Surge Shaft and Penstock, and a Surface Main Power house with installed capacity of 110 MW, for utilizing the inflow from a catchments area of 2,076.62 sq. km with a gross head of 122.63 m is proposed. An APH with installed capacity of 10 MW is also proposed at the dam toe for generation of power. The proposed layout of the project is enclosed as Figure E-2.

Figure E-2: Project Layout Map



6. ***Land Requirement***: The total land requirement of the project is 1,577 ha. The forest land to be acquired is 523 ha. and remaining 1,054 ha land to be acquired is private land. The component wise land area required is listed in Table E-1 and the details of land category of land is listed in Table E-2.

Table E-1: Component-wise Land Area Required

S. No.	Name of the Components	Area (ha)
1.	Project Component & Project Infrastructure	355.00
2.	Submergence	552.00
3.	Other Infrastructure[1]	72.00
4.	Rehabilitation and Resettlement (R&R)	75.00
	Sub-Total	**1,054.00**
5.	Land for other purposes (Recreational facilities, helipad for helicopters and light aircraft, etc.)	523.00
	Total	**1,577.00**

Table E-2: Land requirement for LKHEP

S. No.	Name of the District	Forest Land (ha)	Private Land (ha)	Total (ha)
1.	Dima Hasao	478.00	909.00	1387.00
2.	Karbi Anglong	45.00	145.00	190.00
	Total	**523.00**	**1,054.00**	**1,577.00**

7. ***Access Roads:*** The project site can be reached by road from Guwahati on the National Highway (NH-52) up to Lanka (distance of approximately 180 km). From Lanka up to dam site area, the State Highway exists (distance of approximately 33 km) and further up becomes the Public Works Department (PWD) road (Longku-Garampani) that shall be the main access road to the project. Total distance from Lanka to project site is 48 km. Several smaller access roads are proposed from the PWD road to various project components e.g. dam complex and Power House, etc. (length of approximately 13.10 km). The Lanka-Garampani access road (48 km) will also be improved as part of the project.

8. ***Power Evacuation System***: The power generated in LKHEP will be evacuated through 50 km long 220 KV D/C Transmission line from LKHEP project site to the existing 132/33 KV Lanka (Sankardev Nagar) Substation. The 220kV transmission line and associated system will also be constructed as part of the project.

9. ***Construction Schedule:*** The construction schedule of the project is expected to be four years from the commencement of work on physical infrastructure (that is required to facilitate construction of the dam and the reservoir). The physical infrastructure work will be completed within 9 months while the main works of the project will be completed within 3 years 3 months' time. Once completed, the project will operate to serve the State grid of Assam.

10. ***Coverage of EIA:*** The study area considered for the EIA study included the submergence area, area within 10 km of the periphery of the submergence area, area to be acquired for locating the various project appurtenances, area within 10 km of various project appurtenances, catchment area intercepted at the dam site extending up to diversion structure of LKHEP[2].

[1] This infrastructure includes offices, health centre, colony, schools, parking area, club, guest house, hostel, water pumping stations, sewage treatment plant, stores, patching plant, garden, petro pump, service station, community centre, etc.

[2] WAPCOS LTD EIA, October 2016.

Alignments and impacts areas of the access road (from Longku-Garampani) and power evacuation system (50 km long 220 KV D/C Transmission line from LKHEP project site to the existing 132/33 kV Sankardev Nagar Substation) have also been assessed as part of this EIA study.

C. Policies and Regulatory Framework

11. The legal framework of India consists of several Acts, Notifications, Rules and Regulations to protect the environment and wildlife. The national legislations are broadly divided under three categories as i) environmental protection, ii) forests conservation, and iii) wildlife protection. The EIA requirement in India is based on the Environment (Protection) Act, 1986, the EIA Notification, 2006 (amended 2009), and all its related circulars.

12. A comprehensive review of the relevant parts of the environmental policies, rules and regulation of GoI that may be applicable to the project implementation activities have been undertaken. This included a description of environmental policy framework, relevant legislation and standards, etc., that will assist the Executing Agency (EA) in compliance with the various Acts, Rules, and Standards. The project will also be guided by ADB SPS 2009 and World Bank Group IFC EHS Guidelines.

13. **Categorization:** The proposed project has been evaluated considering the outcome of the ADB Rapid Environmental Assessment (REA) checklist (Annex 1). As per the ADB SPS 2009, the project was classified as environment Category A. This categorization was based on the magnitude and extent of likely impacts from typical hydropower projects. As a precaution, and subject to verification of issues through field work and consultations, the safeguards process and documents were designed to meet all national requirements as well as the requirements of the ADB SPS 2009, without precluding the possibility that environmental issues might be less severe than other hydropower projects in the region, given that LKHEP will be at the lower end of a cascade system, and the Kopili River is already severely degraded due to acid runoff from coal mining further upstream from the proposed project site (in other words, a less weighty Category A project).

14. As per EIA Notification, dated 14th September 2006 (and amendments thereafter), under Activity 1(c) - River Valley projects; if, the capacity of power generation for any HEP will be more than 50 MW, the project falls under Category A. Such projects mandatorily require a Comprehensive EIA study to be undertaken and environmental clearance (EC) to be obtained from the MoEF&CC before the start of any construction activity. Therefore, the 120 MW project falls under Category "A" listed for EC by the MoEF&CC, and a comprehensive EIA including EMP has been prepared. The EIA study along with public hearing report have been submitted to the Expert Appraisal Committee (EAC) of the MoEF&CC for EC. The EAC has recommended grant of the EC to the project in its 10th meeting held on 5th December 2017.

15. The EIA for the proposed project has been carried out as part of project preparation and in compliance with ADB SPS 2009 and GoI requirements.

D. Description of the Baseline Environment

16. The baseline data on physical, biological and social-economic aspects have been collected, analyzed and compiled to obtain the true picture of the existing environment in the project influence area (PIA). The field studies for physio-chemical parameters have been

conducted for three seasons:[3] monsoon (August 2014), post monsoon, i.e. winter (December 2014–January 2015) and pre-monsoon, i.e. summer (April 2015).

1. Physio-Chemical Aspects

17. **Physiography:** The project area represents hill topography with dense vegetation with low mounds and valleys with a general slope towards north-east. The highest elevation is 356m just beyond the southern limit of the reservoir (near origin of Saini Langso nala). In general, the drainage system is dendritic; however the near right angle swing of the SW-NE flowing Kopili river just after its meeting with Lonku nala indicates that at places it is structurally controlled. Trend of major ridges in the area is N-S to NW-SE. At dam site, the bed level of Kopili River is ±170m above mean sea level.

18. Kopili river has perennial drainage in the area, which follows a SE to NW course at dam site with moderate to steep valley slopes (with local slope breaks) towards both abutments. The flatter portions of hills are comprised of weathered rock mass while valley slopes are comprised of slope wash material with intermittent rock exposure.

19. **Soils:** The pH of soil at various sites in the project area lies within neutral range of 7.0 to 7.24. The levels of Nitrogen, Phosphates, and Potassium (NPK) indicate moderate to high soil productivity. The sodium levels do not indicate any potential for soil salinization or adverse impacts on soil productivity.

20. In a hydroelectric project, no significant impact on soil quality is expected barring soil pollution at local level due to disposal of construction waste. For amelioration of such impacts, appropriate management measures are recommended.

21. **Hydrology Dynamics:** The drainage system in Assam is governed by two major river systems: the River Brahmaputra and the River Baraak. River Kopili is a south (left) bank tributary of Brahmaputra. It originates in State of Meghalaya in the Borail hill range and drains a total area of about 16,421 km^2. Its basin is bound by the Jaintia hills in the West and the South Cachar and Mikir hills in the East. The catchment of the River Kopili lies on the leeward side of the Borail, Khasi and Jaintia hills range of Meghalaya. The river basin receives a good amount of rain fall and, as a result, is a perennial river. The total catchment area of the Kopili basin is 2,076.62 km^2 while the Lower Kopili (uncontrolled) catchment area is 788 km^2.

22. The River Kopili has two operational hydroelectric power projects upstream of the proposed project (LKHEP): The 75 MW Khandong HEP served by the Khandong reservoir and the 200 MW Kopili HEP served by the Umrong reservoir (on River Umrong). The water sources for the proposed project are (a) tailrace releases from the Kopili HEP at Umrong, (b) inflow from intermediate catchment between Khangdon and Longku dam sites (that also includes Umrang reservoir catchment); and (c) the spill from the Khangdon and Umrong Reservoirs.

23. **Sediment:** The Sediment load of the upper stage Kopili reservoir analyzed by the Central Water Commission (CWC) was estimated to be 281 m^3/km^2/year (0.59 acre feet/square mile/year) at Garampani. Silt composition was considered to be 50% fine, 25% medium, and 25% coarse. Given the proximity and similar nature of catchment of the proposed project on the same river (situated about 20 km downstream of the upper stage Kopili HEP), the same sediment load is assumed for the project reservoir (it may in fact be lower, given the sediment trap that is created by the upper Kopili dam and reservoir).

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[3] As per MoEF&CC issued ToR and guidelines three season monitoring of physio-chemical parameters (pre-monsoon, monsoon, and post monsoon) have been carried out.

24. **Water Quality:** The surface water pH level in the project area ranged from 3.2 to 5.2 at various sampling sites covered in the study area. The pH levels indicate acidic nature of the water, mainly due to acid drainage from illegal mining of coal in upstream areas of the river, rendering the water unfit for consumption and construction activities. However samples collected during visit of Sub-committee of MoEF&CC indicated that the pH is in the range of 4.56 – 6.86. This could be mainly due to NGT ban on rat hole coal mining. The Total Dissolved Solids (TDS) level ranged from 40 to 47 mg/l in the monsoon season, 59 to 66 mg/l in the winter season, and 61 to 66 mg/l in the summer season. The TDS level were below the permissible limit of 500 mg/l specified for drinking water.

25. The hardness level was below the permissible limit of 200 mg/l specified for drinking water, indicating the soft nature of the water (due to the acidic conditions) and also low levels of cations like calcium, magnesium, strontium and ferrous iron. The chlorides and sulphates levels were below the permissible limit of 200 mg/l for drinking water. Iron level (0.4-0.8mg/l) was below the permissible limit of 1 mg/l specified for drinking water standards. However, the acidic nature of the water has led to deposition of iron (the red color on the river bed).

26. The concentration of various heavy metals was below the Central Pollution Control Board (CPCB) permissible limits. Concentrations of phenolic compounds, oil and grease, were low and this is expected for a region with no major sources of water pollution from domestic or industrial sources.

27. The Total Coliforms ranged from 3 to 9 MPN/ 100 ml across three seasons which is well below the permissible limit of 50 MPN/100 ml for drinking water. The BOD values were within the permissible limits; this indicates the absence of organic pollution loading in the basin. This is mainly due to the low population density, low cropping intensity, and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters the Kopili River gets diluted.

28. **Alternative Sources of Water in the Project Area:** Four independent water sources- independent tributaries of Lower Kopili river, have been identified in and around the project area for utilization in construction works. These are: Dong Ekpi Nala; Longku Nala, Kala Nala, and Longsomipi Nala. As per the recommendations of Central Soil and Materials Research Station (CSMRS), the water from these sources shall undergo chemical analysis from a reputed laboratory in light of its implications on the longevity of the structure and various components. Dong Ekpi Nala and Longsomipi are not perennial with low discharge, therefore the project is not expected to use water from these streams. The analysis of water samples collected from this Longku Nala and Kala Nala reveal a pH range between 6.7 and 7.4 that is an acceptable limit (pH range between 6.5 and 8.5) for utilization of these waters in construction works.

29. **Ambient Air Quality**: The maximum PM_{10} level during all three seasons ranged between 28.1–31.2 $\mu g/m^3$. This is well below the permissible limit 60 $\mu g/m^3$ specified for industrial, residential, rural and other areas. The SO_2 level was below 5.0 $\mu g/m^3$ across all the sampling locations which was much lower than the permissible limit of 50 $\mu g/m^3$. The highest NO_2 value was observed in the summer season at 14.2 $\mu g/m^3$. The NOx level observed at various sampling stations was also much lower than the permissible limit of 40 $\mu g/m^3$ for industrial, residential, rural and other areas. The ambient air quality in and around the project area is good. The values of these parameters were well below the permissible limits specified for industrial, residential, rural and other areas.

30. **Noise Environment**: The day time equivalent noise level in monsoon and winter seasons at various sampling stations ranged from 37.3 to 38.1 dB(A) and 36.9 to 40.0 dB(A). The day time

equivalent noise level in summer season ranged from 37.5 to 40.2 dB(A). Overall, the day time equivalent noise level in various seasons across sampling locations were well within the permissible limit specified for residential area. Night time monitoring has not been done because of the rural area and very limited movement of vehicles in the night time. However, night time monitoring will be done as part of pre-construction baseline monitoring.

31. **Land use pattern**: The major land use categories in the study area are Dense Vegetation and scrubs, accounting for 67.07% and 12.07% of the total study area, respectively. The open vegetation is 11.22% while settlements account for about 0.16% of the study area. The area under agricultural land is 7.97% of the study area. The land use pattern of the study area is given in Table E-3.

Table E-3: Land use pattern of the study area of LKHEP

S.No	Category	Area(ha)	Area (%)
1	River	7,486	1.50
2	Dense Vegetation	334,972	67.08
3	Open Vegetation	56,048	11.22
4	Agricultural Land	39,795	7.97
5	Scrubs	60,287	12.07
6	Settlements	814	0.16
	Total	**499,402**	**100.00**

2. Ecological Aspects

32. **Forests and Vegetation**: The total recorded forest area (RFA) of Assam is 2,676,300 ha (as per State forest record as on Dec. 2005) constituting 35% of the total geographical area of the State. Out of 2,676,300 ha of recorded forest area, there are 312 Reserved Forests (1,387,000 ha, 52% of the RFA), 145 Proposed Reserved Forests (310,300 ha, 11% of the RFA), as well as Protected Areas (392,500 ha, 15% of the RFA) and Un-classed State Forests (586,500 ha, 22% of the RFA). The forests in the State may be divided into six major forest types as i) Tropical Wet Evergreen, ii) Tropical Semi-Evergreen, iii) Tropical Moist Deciduous, iv) Sub-tropical Broad-leaved Hill, v) Sub-tropical Pine, and vi) Littoral swamp Forests.

33. The proposed project falls in two forest divisions namely the Haflong Forest Division covering Dima Hasao (right bank of river Kopili) and the Diphu Forest Division covering Karbi Anglong (left bank of river Kopili). The catchment area of proposed project covers almost all 6 major forest types. However, the forest types in the lower valley of the project area comprises of Assam valley tropical semi-evergreen forest, East Himalayan moist mixed deciduous forest, and tropical riparian fringing forest, whereas Cachar tropical evergreen forest, and Cachar tropical semi-evergreen forest occurs in the lower hills and adjoining Cachar around the Surma valley. The major five forest types found in the Study Area are given below:

- 1B/ C3 *Cachar tropical evergreen forest*
- 2B/ C1 *Assam Valley Tropical semi-evergreen forest*
- 2B/C2 *Cachar tropical semi-evergreen forest*
- 3C/C3b *East Himalayan moist mixed deciduous forest*
- 4E/ RS1 *Tropical Riparian fringing forest*

34. About 172 species of angiosperms including trees, shrubs, climbers and herbs are recorded in the study area. The ground vegetation comprised of ephemeral, annual, and perennial species of grass, hedges, legumes and non-legume forbs. The upstream area of

Longku from the bank of river Kopili is moderately sloped with fairly dense Mixed Semi Evergreen forest. The impenetrable growth of large trees and evergreen shrubs (in the upper rich of dam-outside reservoir area) provide rich habitat for wild elephants and other mammals. In regions of Cachar, Khasia, and Jaintia Hills, rich habitats of rare, endemic and threatened species are gradually depleting due to natural and anthropogenic causes.

35. **Fauna:** Assam's mammalian diversity is represented by 193 species that are widely distributed in the region with the exception of the One-horned Rhinoceros, Water Buffalo, Pigmy Hog, Swamp Deer, Golden Langur, and Hoolock Gibbon that have their distribution limited to isolated pockets and protected areas in the State. Out of 15 primate species in India, 9 are found in Assam. A total of 21 mammalian species grouped under 13 families were confirmed in the study area. The primate fauna is represented by Macaca mulatta. Viverridae comprises of 2 species, common and widely distributed in India. They inhabit the dense and inner parts of forests, and are not a common presence in the close surroundings of project area. Herpestidae comprises of 2 species: Herpestes urva and Herpestes edwardsii, common and widely distributed in India as well and in the surroundings of the project area. Cervidae comprised of 1 species (Sambor), common and widely distributed in India as well as reported from the project area (inhabiting dense and inner parts of forests). Bovidae is represented by *Bos gaurus* and occupies open forests in the lower reaches especially flood plains. Manidae includes *Manis pentadactyla*, highly restricted in distribution and inhabiting the lower hills (mainly teak forests). Rodents include 1 species of mouse, 2 species of rats, and 3 species of squirrels with possibility of many more species of rodents; these species are common in the settlement area, agricultural fields and bamboo forests. Chiroptera (Bats) comprises of 3 species.

36. Stakeholder consultations held in June 2015 confirmed the presence of Asian Elephants in and around the project area surrounding Longku (note: there are no known demarcated elephant corridors in the area) as well as of the Chinese Pangolin. Under IUCN conservation status, elephants are considered as endangered (EN) while Chinese Pangolins are considered as Critical (CR); both are on Schedule I of the Indian Wildlife Protection Act (1972) which is the highest protection accorded to species in India. A critical habitat assessment has been carried out and suitable mitigation measures have been included in the biodiversity conservation and management plan with a focus on additional camera trap surveys in the undisturbed southern forest area between the upper and lower Kopili HEPs, and creating river crossing locations for elephants.

37. While the avifauna information for North Cachar Hills (Dima Hasao) and Jaintia Hills is plentiful, it is inadequate for the direct area of concern (i.e. proposed LKHEP site and surrounding areas). The climatic conditions, topographic and forest covers in the proposed project and surrounding areas suggests rich diversity of avifauna. During the primary survey a total of 59 species grouped under 24 families were confirmed in the study area. Except for a few species like *Spelaeornis longicaudatus* (Tawny-breasted Wren Babbler) that is endemic to the left bank of the river Brahmaputra, all other species are widely distributed especially in northeast region and adjacent countries like Myanmar and Bhutan. Widespread resident species are predominant, accounting for nearly 52% of total species in the study area and these are followed by the local resident species, accounting for nearly 32% of total species. Most common species observed during the primary survey were *Merops leschenaultia* (Chestnut Bee-eater), *Motacilla alboides* (White Wagtail), *Columba livia* (Rock Pigeon), *Streptopelia chinensis* (Spotted Dove), *Treron phoenocoptera* (Bengal green Pigeon), *Acridotheres tristis* (Indian Myna), *Corvus splendens* (Common Crow), *Dicrurus adsimillis* (North Indian Black Drongo), *Pycnonotus atriceps* (Black headed Bulbul), *Pellorneum albiventre* (Assam Brown Babbler) and *Passer domesticus* (House Sparrow).

38. *Dicrurus adsimillis* (North Indian Black Drongo) is only local migrant species in the study area. There are only three species namely *Tringa glareola* (Spotted Sandpiper), *Ficedula parva* (Red-throated Flycatcher) and *Acrocephalus dumetorum* (Reed Warbler), which are considered as widespread winter visitor in the study area. All observed / recorded species are considered as Low Risk / Least Concerned in IUCN RED List and covered under Schedule IV of the IWPA (1972) with the exception of two species (*Aviceda leuphotes and Pavo cristatus*) that are covered under Schedule I of the IWPA (1972).

39. A total of 32 species of reptiles grouped under 11 families and 19 species grouped in 6 families were reported from the study area. Most observed / recorded species are considered as Low Risk / Least Concerned in IUCN RED List; only one species *Python molurus* is covered under Schedule I of the IWPA (1972).

40. About 60 butterfly species were recorded from the study area of which a total of 56 species grouped under 5 families were identified during field survey. All recorded species are common in occurrence and widely distributed. None of the recorded species have restricted distribution or are endemic to the region.

41. **Aquatic Ecology**: The aquatic ecology in and around the proposed project and surrounding areas (river Kopili) has been affected grievously by acid drainage due to illegal and uncontrolled rat hole mining upstream in State of Meghalaya. India's National Green Tribunal (NGT) passed a directive in April 2014 to ban rat hole mining in Meghalaya leading to some improvement to the downstream aquatic ecology. However, some illegal mining activities still happening.

42. The health of aquatic ecosystem of river Kopili was assessed by recording different biotic communities namely zooplankton, phytoplankton, and phytobenthos under micro flora and fauna; macro-invertebrates and macrophytes under macro flora and fauna; and vertebrate group represented by fish fauna.

43. Overall, the species density of different biotic communities of river Kopili is at the lower end. A total of 22 fish species belonging to 12 families were reported in the Panimur stretch. 4 fish species namely *Garragotylagotyla, Daniorerio, Puntius sophore* and *Barilius bendelisis* were caught in side streams along the downstream influence zone (near PH site and 4 km downstream of PH site), while no fish were present or caught in the immediate vicinity of the proposed dam site. Consultations with local communities confirmed the absence of fish in the river Kopili. Additionally, there are no migratory fish species observed in Kopili River or its tributaries.

44. **Protected and Ecologically Sensitive Areas**: Assam has 5 National Parks (NPs) and 18 Wildlife Sanctuaries (WLSs). In total, these parks and sanctuaries cover 392,500 ha or 5% of the total geographical area of the State. As per the information retrieved from the State Forest Department, the forest working plan of the districts, and due diligence conducted for the proposed project, Tranche 3 project (including 220kV transmission line and access road) does not affect any of the protected areas (or ecological sensitive areas). Kaziranga National Park is the nearest protected area situated about 172 km away from the proposed site of the LKHEP.

45. **Ecosystem Services**: The ecosystem services such as fisheries, livestock, forests etc. in the project influence area are very limited. This is mainly due to acidic nature of water.

3. Socio-Economic Aspects

46. The project will directly affect 1,842 households of which 18 will be physically displaced. 6 households will lose structures other than dwellings. Only 18 households from the Dima Lanku village in the Dima Hasao autonomous district will be physically displaced. 70 percent of affected households will lose only cultivated land. 15 households will lose their houses, cultivated land and homesteads. Another 22 percent of households will lose land partially where they have grown perennial trees. The male-female ratio is 53:47. The average household size is 4.7 members. About 30 percent of the population of the affected households are below 14 years. Two-thirds of the population is in productive employment age (15-60 years). The population in the project is a youth population with more than 50 percent of productive employment age are young people between 15 and 40 years. About 65 percent of men and 70 percent of women are in the productive employment category. More than three-fourths of the surveyed households are nuclear households. About 13 percent of households are joint-families and 10 percent of households are extended families. The dominant religious group in the project area is the Hindu community. About one-third of the affected households are Christians. Except at two households, all households are occupied by married couples with their children and dependents. About 20 percent of households have lived in their current village communities for less than 15 years. One third of households have lived in their current locations between 15 to 30 years. Others have lived more than 30 years in their current village communities. 56 percent of household heads are illiterate, and about 43 percent of household heads have studied up to the grade 10 in school. Only about one percent of household heads reached the grade 12 in school and 4 household heads are graduates. 25 percent males and 30 percent females are illiterate in the project area. Farming on leaseholds is the main occupation of the households and 78 percent of the households are farming households. Only five percent of households fall below poverty line (BPL) category.

E. Analysis of Alternatives

47. Since the project is a new project development, alternatives sources of energy (such as Biomass and/or waste-to-energy, Solar, Wind, Thermal, Hydro – annual storage), tandem operation with Kopili HEP, multiple smaller hydro projects, longer tunnel with smaller dam, etc. have been considered and analysed for its likely impacts on various environmental parameters. Additionally, an evaluation of 'with' and 'without' project scenario has been assessed in terms of the potential environmental impacts for the justification of this project. On the basis of analysis of alternatives, it was concluded that the project imparts positive/beneficial impacts "with" project scenario and will most likely improve the social and economic development of the State as compared to "without" project scenario. Alternative sites for project facilities as well as technological alternatives have also been considered while locating the project facilities.

F. Consultation, Participation, and Information Disclosure

48. In accordance with the requirements of ADB SPS 2009 and EIA Notification of GoI (2006), public consultations were held as part of the EIA study. The consultations were undertaken with project beneficiaries, local/government officials, autonomous district council representatives, non-government organizations (NGO's), and other stakeholders in the PIA likely to be affected due to the project. APGCL and ADB staff have also participated in some of the public consultations. Discussions pertained to various environmental and social issues affecting them and likely methods to resolve the same. The process of public participation/ consultations started in 2014

and continued till now and it formed an integral part of the project in accordance with ADB SPS 2009.

49. Consultations were carried out using standard structured questionnaires as well as unstructured questionnaires. In addition, focused ground discussions (FGDs) were also conducted. Key issues highlighted during the public consultations were: (i) the affected communities showed a public acceptance of the project, mainly due to anticipated provision of basic infrastructure (roads, bridges, water and electricity connection and supply, education and health services) as well as access to employment opportunities (contract, civil works, etc.); (ii) compensation payments for resettlement and development of alternative livelihood options; (iii) the affected communities anticipate deriving monetary benefit from the EA's Corporate Social Responsibility (CSR) - Community Development Scheme as per the GoI Circular dated 19 May 2012 and the MoEF&CC ToR memo dated 30 January, 2014; and (iv) consultations with local communities confirmed the presence of Asian Elephants in and around the project area as well as of the Chinese Pangolin; (v) the affected communities confirmed the importance of access to areas affected by the proposed project for livelihood such as hunting, collecting firewood, obtaining water from local streams (not the Kopili) to maintain their tribal cultural practices. Local communities were also informed that the project will have an emergency response mechanism in place (in the event of pending dam failure or significant water releases) and the same will be communicated to them prior to commencement of civil works.

50. The above key points have been recurrent topics that have come up at various consultative meetings and negotiations. The consent of the affected communities / persons to handover their tribal land and other property for the proposed project are contingent upon the satisfactory implementation of the above key points and potential project sustainability.

51. In order to fulfill GoI EIA requirements for Category A projects, an official public hearing has been conducted by the Assam State Pollution Control Board (ASPCB) on 10 January 2017 at the project site. The public hearing meeting was coordinated by the EA (APGCL) with the active support from ASPCB and the local district administrations. Representatives from affected districts of Karbi Anglong and Dima Hasao (such as Autonomous District Council (ADC) members, project affected persons, NGO, and other stakeholders) attended the public hearing. The ASPCB has forwarded public hearing report to EAC of the MoEF&CC and the same has also been disclosed on the website of ASPCB. The EAC considered recommendations made in the report while issuing the EC to the project (those points are reflected in this EIA).

52. The EA holds responsibility for the disclosure of the EIA in compliance with ADB's Communication Policy 2011 and ADB SPS 2009. The EIA will be disclosed in the English language (and a summary of the EIA in Asamese-local language) in the office of the EA, which will be made known to local communities. The EIA will also be made available to interested parties on request from the office of the EA. Since this is Category A project, the EIA will be disclosed to the public through the ADB website, 120 days before the approval of Tranche 3 for ADB financing. The EIA will also be made available to all stakeholders as part of the consultation process required under ADB SPS 2009. After incorporation of comments and updating upon design changes, if any, the final EIA document will be disclosed on the ADB website.

G. Grievance Redress Mechanism

53. A Grievance Redress Mechanism (GRM) has been proposed to address grievances related to the implementation of the project, particularly regarding the environmental management plan (EMP), issues related to biodiversity conservation and management. The GRM will

acknowledge, evaluate, and respond to complainants with a proposed corrective action(s) using understandable and transparent processes that are gender responsive, culturally appropriate, and readily accessible to all project affected people and other affected stakeholders. Records of grievances received, corrective actions taken, and outputs and outcomes will be maintained and form part of the quarterly environmental monitoring report to the ADB.

H. Anticipated Environmental Impacts and Mitigation Measures

54. The main impacts associated with planning and design of the proposed LKHEP include loss of land due to acquisition of 1,577 ha of land for various project components, among which submergence of 552 ha of land under reservoir, change in land use, loss of biodiversity and habitats due to diversion of 523 ha of forest land, and disruption of hydrological balance by disrupting river flow for creation of reservoir.

55. The loss of land and livelihood will be compensated as per the provisions made in the Resettlement and Tribal Development Plan (RTDP) document. Loss of forest land will be compensated by implementation of compensatory afforestation plan. Whereas loss of biodiversity and likely impacts on flora and fauna in the project areas will be addressed by implementing the measures proposed in the biodiversity conservation and management plan. To minimize downstream impacts a minimum e-flow recommended by MoEF&CC will be maintained.

56. The impacts and mitigation measures associated with construction and operation of LKHEP are briefly discussed in following sections.

1. Impacts on Water Environment

1.1 Water Quality

57. **Sewage from labor camps/colonies**: The construction phase is likely to last for a period of 4 years. The peak labor strength during project construction phase is estimated at 1,000 with about 800 workers and 200 technical staff. Considering per capita water supply as 135 lpcd, the domestic water requirement has been estimated as 0.38 mld which will be sourced from underground (by tube wells). Considering sewage generation as 80% of the total water supplied, quantum of sewage generation is expected to be 0.30 mld. A sewage treatment plant will be commissioned for treatment of sewage generated from labor camps, prior to final disposal. The treated effluent may be used for irrigation requirements in areas marked for afforestation.

58. **Effluent from crushers**: A total quantity of 50 m^3/hr of effluent is expected to be generated from various crushers. The effluent from the crusher would contain high levels of suspended solids. The effluent, if disposed without treatment, can lead to marginal increase in the turbidity levels in the receiving water bodies. Therefore, the effluent from crushers will be treated in settling tank(s) before disposal.

59. **Pollution due to muck disposal**: The major impact on water quality arises when the muck is disposed along the river bank. Suitable muck disposal sites located away from the river have been identified. The muck will be generated via activities such as road-building, tunnelling, and other excavation works. The unsorted waste if going into the river channel will lead to the turbidity of water continuously for long time periods. The high turbidity is known to reduce the photosynthetic efficiency of primary producers in the river, low biological productivity and negative impact on aquatic life. Therefore, muck disposal will be conducted in line with the Muck Disposal Plan (Annex 13).

60. **Effluent form tunneling sites**: During tunneling works, the ground water will flow into the tunnel along with construction water (used for various works like drilling, shotcreting, etc.). The effluent thus generated during tunneling works contains high levels of suspended solids. Normally, water is collected in the side drains and drained into nearby water bodies without treatment. However, a settling tank of adequate size will be constructed nearby to collect effluent before discharge.

61. **Effluent from batching plants:** During the construction phase, batching plants will be commissioned for production of concrete. The operation and cleaning of batching plants will result in the generation of a small volume of effluent containing high levels of suspended solids. No major adverse impacts are anticipated due to small volume of effluent discharged to river Kopili. However, the effluent will be treated prior to disposal to ameliorate the marginal impacts likely to accrue on this account. This will involve a settling pond prior to discharge.

62. **Effluent from fabrication Units and workshops**: The fabrication units and workshops will generate effluents containing high levels of suspended solids, as well as oil and grease. The effluent will be treated prior to disposal.

63. **Ground water pollution**: The effluent generated from the project construction activities (and camps) will be collected and treated. Therefore the impacts on ground water quality are not anticipated from the project construction work.

1.1.2 Impacts on Hydrologic Regime

64. **Impact due to Peaking Power Operation:** The proposed project is likely to fill the reservoir up to its live storage capacity, which would then be used for peaking power. This may lead to reduction in flow of the river downstream of dam site, which could reduce the wetted area of the river until there is enough discharge accumulation from downstream tributaries. The effect due to reduction of flow will be most pronounced in the non-monsoon seasons and lean seasons. To mitigate this adverse impact, the e-flow (5.345 m^3/s) shall be released as recommended by MoEF&CC while approving the project. This e-flow was derived based on the following three assumptions as recommended by EAC of MoEF&CC and further analyzed as part of the supplemental Integrated Water Resources Management (IWRM) study (Detailed derivation of e-flow is presented in Annex 34). The proposed e-flow is “generous” compared to previous projects and will ensure a wetted cross-section of the lower Kopili, assuming that fish may come back to river at some point in the future (they are currently not present in the lower Kopili river due to the acid drainage from upstream coal mining areas).

- Monsoon Season (May to September): 30% of the average flows during 90% dependable year
- Non-monsoon Non-lean Season (October and April): 25% of the average flows during 90% dependable year
- Lean Season (November to March): 20% of the average flows during 90% dependable year.

1.1.3 Impacts of Sedimentation

65. The Sediment load of the upper stage Kopili reservoir analyzed by the Central Water Commission (CWC) was estimated to be 281 m^3/km^2/year (0.59 acre feet/square mile/year) at Garampani. Silt composition was considered to be 50% fine, 25% medium, and 25% coarse.

Given the proximity and similar nature of catchment of the proposed project on the same river (situated about 20 km downstream of the upper stage Kopili HEP), the same sediment load is assumed for the project reservoir (it may in fact be lower, given the sediment trap that is created by the upper Kopili dam and reservoir). Necessary design arrangements have been included for flushing of sediment deposited in the vicinity of power intake by providing low level sluice spillways near the intake.

66. Sediments in the river are mostly rich in quartz content (71-86%) followed by muscovite and biotile. Organic content (wood and grass roots) content only a small part (1.5 to 4.5%). Considering the presence of low organic content in the sediments the issue of sedimentation contamination with heavy metals is not anticipated. However, monitoring of heavy metal components in the sediment will be conducted during pre-construction stage, if needed, the sediment management plan will be prepared.

1.1.4 Impacts on Water Resources and Downstream Users

67. Construction of the dam will lead to the formation of a reservoir. The passage of flow through a reservoir will lead to the reduction in peak flow. The lean season flow in the river too will be regulated. The 5.65 km long river stretch downstream of the dam site up to the confluence point of tail race discharge and about 8.26 km stretch further downstream (from tail race discharge to confluence point of river Mynriang river) will have reduced flow. The reduction in flow of the river in the intervening stretch is not likely to have any adverse impact on the downstream users. This is mainly because of the fact that no settlement exists near this stretch (no downstream users up to 15 km stretch downstream from the powerhouse); thus there is no dependency on the water of the Kopili in this specific stretch. However, less flow in this river stretch may impact the riverine ecology, in as much as it has some ecological value despite the acidic nature and lack of fish. Apart from the above, a water reservoir will be formed due to construction of the dam, which can be used for tourism, fisheries development (assuming the low pH can be addressed further upstream), and possible creation of new aquatic biodiversity.

2. Impacts on Air Environment

68. **Emissions due to fuel combustion in various construction equipments:** The operation of various construction equipments requires combustion of fuel (such as diesel). The major pollutant due to diesel combustion is SO_2 and Suspended Particulate Matter (SPM) emissions. The short-term increase in SO_2, even when assuming that all construction equipments are operating at the same time, are expected to be less than 1 $\mu g/m^3$ and transient, as well as sporadic. Also low ash content of diesel fuel is recommended to use by contractors for vehicles. Hence, no major lasting impact is anticipated on air quality.

69. **Emissions from construction of access roads:** Strengthening of 48 km Lanka-Garampani access road and construction of about 13.10 km of new access road will lead to emissions and fugitive dust from operation and movement of construction vehicles, earthwork (excavation) and handling construction material. Suitable mitigation measures (Annex 35 EMP and EMoP for road component) are included in the EMP to control emissions from the vehicles and construction activities.

70. **Emissions from quarrying and crushers**: During the construction phase, at least one crusher will be commissioned at the quarry site by the contractor involved in construction activities. The operation of quarries and crushers is likely to generated SPM. One crusher each is likely to be commissioned near the proposed quarries for the dam and the power house, where

there will be no major settlements. Hence, no major human health adverse impacts are anticipated. However, during the layout design of crushers, it will be ensured that the labor camps, colonies, etc. are located on the leeward side and outside the impact zone (generally about 2 km upwind, in the prevailing wind direction) of the crushers. Forest cover between worksites and the crusher plants will also mitigate dispersal of particulates from crusher plants.

71. **Emissions from blasting operations**: Blasting will result in vibration through rock layers and may cause loosening of rocks/boulders. The overall impact due to blasting operations will be restricted well below the surface and no major impacts are envisaged at the ground level. For tunneling works, generation of dust is anticipated during blasting and this will be captured via a ventilation system with a dust handling system. In the predominant downwind direction, dust may settle on vegetation. Appropriate control measures to monitor vibrations have been included in the EMP, even though there are no residential areas near the project work sites.

72. **Fugitive emissions due to increased vehicular movement**: During the construction phase, there will be increased vehicular movement for transportation of various construction materials and equipment to the project site, and transportation of muck / construction waste from the project site to designated dump sites. The maximum number of vehicles are estimated as 20 vehicles per hour, causing air pollution due to dust (SPM) as well as Hydrocarbons, SO_2 and NOx.

73. **Fugitive emissions from other sources:** fugitive emissions are also expected from storage areas for construction materials like sand, fine aggregate etc. The impacts due to fugitive emissions are insignificant in nature; however, appropriate dust suppression measures will be employed (see the EMP for details).

74. **Dust emission from muck disposal:** The loading and unloading of muck in the form of crushed rock pieces, stone, etc., will result in some dust emissions. However, this is not expected to be significant, since muck from tunnels tends to be damp and cohesive. Nevertheless, muck piles will be water-sprinkled as needed and trucks will be covered when muck spoil is dry. Workers will also wear face masks. There are no local communities in the vicinity of project work sites. Thus, adverse impacts due to dust generation during muck disposal will be insignificant and can be managed by implementing the suitable mitigation measures.

75. **Mitigation Measures:** All project work sites will be located between the national highway (to the east) and the Kopili River (to the west), where there are no towns, villages, or even single residences or farming areas (it is a reserve forest area, with just a few field sheds). This is one of the main mitigation measures in limiting air quality impacts and other such construction disturbances (assuming that all workers will be wearing face masks). In any case, three principles will apply to air quality management, as follows: prevention, suppression and containment, to control dust and other emissions. The impact on air quality will be temporary and controllable, and with little or no human impacts. The contractor(s) will implement air pollution control measures that include methods for dust suppression due to crushers, batching plants, blasting operations, loading and unloading of muck for disposal as well as from other construction activities such as construction of access roads, work camps, etc. The following measures will be used:

- As noted above, there are no local communities or buildings in close proximity to the project work sites; construction equipment, machinery and dust causing activities will be located away from sensitive receptors.
- Location for stockpiles will be selected, taking prevailing wind direction into consideration, to avoid long exposure of workers to dust (they will have face masks, in any case).

- There will be no blasting activities close to villages or work camps. Blasting will be carried out during the day time only.
- All vehicles will be required to switch off engines when at a halt, with no vehicle idling.
- All vehicles will be washed or cleaned before leaving the project sites, to remove dust.
- Loads entering and leaving the project sites will be covered by tarps if they are expected to contribute to dust emissions.
- Construction equipment utilizing fuel for combustion will be inspected on a regular basis and adjusted as required to minimize pollution levels.
- In an event construction equipments are used underground, suitable ventilation systems will be provided to avoid air pollution and capture of toxic gases released from excavated rock during underground works.
- Sprinkling of water on unpaved roads will be administered to reduce incidence of dust, especially at work sites closest to the National Highway. This will be done at least 2 times per day during the dry season, and frequency will be increased depending on observations / monitoring.
- Sprinkling of water as needed for dust suppression, to avoid mobilization by wind.
- Cutting equipment will use water as a suppressant, or employ other practical ventilation systems.
- Securely cover skips and minimize drop heights.

3. Impacts on Noise Environment

76. The main sources of noise during construction activities are from earth moving machinery, quarrying, blasting, and vehicular movement. The noise impacts are highly dependent on the sound source, the topography, land use, ground cover of the surrounding site, and climatic conditions. Topographic barriers or vegetated areas can shield or absorb noise. The operation of construction equipment on local communities is likely to have insignificant impact on the ambient noise level since settlements are at least 1.5 km away from the main work areas in the Reserve Forest (communities are located along the National Highway). However, the effect of high noise levels on the operating personnel has to be considered as this may be particularly harmful. It is known that continuous exposure (more than 8 hr/day) to high noise levels (above 85 dB(A)) affects the hearing acuity of the workers/operators and hence, should be avoided; all workers will be provided with ear protection. The impact on laborers/workers/operating personnel that are subjected to continuous exposure of high noise levels (above 85 dB(A)) will be addressed by following recommendations of the IFC EHS Guidelines.

77. **Mitigation Measures**: There are no habitations /residential houses/ communities in the immediate vicinity of the project site. Therefore the primary noise impact would be on the laborers/workers/operating personnel, on some communities that have been proposed to be resettled by the river side, and wildlife in the larger vicinity of the project area. Recommended mitigation measures for noise impacts are as follows:

- Appropriate and sufficient Personal Protective Equipment (PPE) shall be provided to all laborers/workers/operating personnel.
- All noise generating construction equipments / machinery shall have sound control devices (e.g., exhaust mufflers).
- Mufflers shall be used for all fuel driven construction equipment's / machinery, and these shall be maintained and serviced as per the manufacturer's maintenance schedule.
- Construction works that result in high noise generation will be limited to day time (7 AM – 6 PM) in order to minimize community disturbance.

- Vehicular movement will be restricted to day time (7 AM – 6 PM) in order to minimize community disturbance. Noise monitoring shall be conducted as per environmental monitoring plan.
- Noise barriers will be installed at the construction camp and near villages along access roads if noise levels are found to exceed standards during noise monitoring.
- Site Specific EMP (SEMP) shall be implemented to reduce noise impact. The SEMP shall provide the project map layout, indicating transportation/expected vehicular movement, blasting sites, worker camps, nearby habitations/villages, and approximate wildlife (elephant) corridors (still to be determined, through field observations pre-project), and noise monitoring stations.
- A schedule for blasting operations with details of time of blast (specific hour in a given day), period of blast (in seconds), and procedures will be made available to nearby communities. Warning signs will be posted, and trespassing to the blasting area shall be strictly prohibited.

78. To control vibrations due to blasting activities, EPC contractors shall be required to retain a qualified blasting specialist to develop a site-specific blasting program that will assess, control, and monitor air blasts and ground vibrations from blasting operations.

4. Impacts on Land Environment

79. **Quarrying operations**: The construction of the proposed project will involve handling of large quantities of different materials. The estimated total quantities of principal construction materials are 95,000 m^3 of fine aggregates and 1,558,037 m^3 of coarse aggregates. To prevent soil erosion and landslides across quarrying sites, appropriate slope stabilization measures will be implemented. Quarry slopes will be maintained at a slope ratio 1:1, covered with topsoil of at least 30 cm and turfed with grass, herbs, shrubs, and local trees of high ecological and economic value. If required, retaining walls will be constructed for ensuring slope stabilization. At the end of the construction phase, all quarry sites will be restored through engineering and biological measures.

80. **Operation of construction equipment**: During construction phase, various construction equipments will be brought to the project site. These will include crushers, batching plant, drillers, earthmovers, rock bolters, etc. The siting/storage of these construction equipments will require significant amount of space. Additionally, land will be acquired on temporary basis (i.e. for the duration of project construction) for storage of quarried material prior to crushing, crushed material, cement, rubble, etc. Siting/storage of construction equipments, materials etc. will follow the specified Site Layout Plan. The site layout plan will ensure appropriate siting /location of construction equipments and materials such that any adverse impacts on the environment are minimal.

81. **Muck disposal**: The total quantity of muck generation has been estimated to 1.005 million m^3. Considering, 40% swelling, the total muck that will be handled is 1.407 million m^3. About 30% muck shall be used as construction material. Thus, only 0.985 million m^3 of muck is planned for disposal at the pre-designated disposal sites. The holding capacity of pre-designated disposal sites is estimated as 1.032 million m^3. The muck disposal sites will be suitably stabilized on completion of the muck disposal.

82. **Changes in land use:** There will be a significant land use change due to the project which involves construction of dam, reservoir, land acquisition of both reserve forests and private land

holdings. The total land area required for project components like dam structure, power house and other appurtenances is 1,577 ha. The project reservoir area is 552 ha, which in pre-project scenario is the river, river bed, reserve forest, and private land. Similarly, quarry sites and muck disposal sites will result in land use change of the area. Measures to control land use change include reclamation of quarry and muck disposal sites at the end of construction phase.

83. **Impacts due to road construction:** Several smaller access roads are proposed from the Lanka-Garampani PWD road to various project components e.g. dam complex and Power House, etc. (length of approximately 13.10 km). Also Lanka-Garampani road will be improved (mainly repairing) up to Umrangsu (48 km) as part of the project. Since most of the new access roads will be aligned on the hill slopes, it will lead to generation of debris/muck from hill cutting and removal of vegetation and trees from hill slopes. Suitable slope stabilization measures such as bioengineering measures (planting of soil binding tree species) will be implemented. Soil erosion from road/bridge construction activities will also lead to increase in turbidity in river water, which could reduce the photosynthetic activity to some extent. Measures such as i) provisions of adequate signages and speed limit on road sections within forest areas to avoid accidental roadkills, and ii) monitoring of poaching activities in workers areas and as well as community areas are proposed. Adequate measures are included in the EMP to ameliorate these adverse impacts. The new roads will also provide better connectivity to the villagers of the region.

5. Impacts on Biological Environment

5.1 Impacts on Terrestrial Flora

84. **Increased human interferences**: The direct impact of construction activities of LKHEP is limited in the vicinity of the construction sites only. It is estimated that during construction phase a population (1,000) including technical staff and workers are likely to congregate in the project area. Although the contractor will provide adequate sources of fuel to the workers, some workers and population groups may use fuel wood for cooking purpose. To minimize loss of trees, it is proposed that contractor will provide community kitchens to workers. These community kitchens will use liquefied petroleum gas (LPG) or diesel as a fuel. Besides fuel wood, workers may also cut trees to construct their houses and other needs. However, it is proposed that contractors will provide sufficient accommodation in labor camps with requisite facilities. In addition, there will awareness-raising sessions with workers and a ban on tree cutting, with a harsh penalty for breaking it.

85. **Diversion of forest land:** The project will require diversion of about 523 ha of forest land. The tree density in the submergence, dam and power house sites ranged from 270 to 330 per ha, which represents a low to moderate tree density forest. To compensate for the loss of trees and vegetative cover, a compensatory afforestation plan has been prepared. It is proposed that a total of 1,046 ha (523 ha x 2) of degraded forest land will be afforested with slightly higher density than the current forest, as recommended by forest department. The afforestation work is to be done by the Forest Department. No diversion of forest land is required for the transmission line and access road.

5.2 Impacts on Terrestrial Fauna

86. **Disturbance to wildlife**: The total land required for the project is 1,577 ha, of which about 552 ha comes under submergence (including the river bed). As most of the submergence lies within the gorge portion of the river, it is expected that there will not be any significant adverse impacts on wildlife movement due to creation of reservoir. The project work areas and

surroundings are not reported to serve as critical habitat for wildlife (although Chinese pangolins are reported in this part of Assam, actual presence in the forest area at the project work sites is not documented). Asian elephants have been reported in the project area, but further north and south of the project work sites. The project area is a forest patch between the river and the National Highway that does not have contiguity to the north and south (therefore isolated). Thus, no significant impacts on wildlife are anticipated with the project.

87. During construction period, large number of machinery and construction workers shall be mobilized, which may create disturbance to wildlife population in the project area. The operation of various equipments will generate significant noise, especially during blasting which may have adverse impact on faunal species. The noise may scare the fauna and force them to migrate to other areas. Likewise siting of construction plants, workshops, stores, labor camps etc. could also lead to adverse impact on fauna of the area. During the construction phase, accessibility to area will lead to influx of workers and inflow of the people associated with the allied activities. Increase in human interference could have an adverse impact on terrestrial ecosystem. The other major impact could be the blasting to be carried out during construction phase.

88. To minimize any harm due to poaching activities from immigrant labor population, strict anti-poaching surveillance measures are proposed. Other measures such as rescue and release of wildlife species encountered during construction works: the contractor will be required to contact the forest office in case any wildlife /avifauna are encountered or injured by accident during construction works.

89. **Impacts on migratory routes**: The faunal species observed in the project area are not migratory in nature. Also there are no reported migratory route of wild animals in the project area.

90. **Impacts on avifauna**: The project area and its surroundings are rich in avifauna. However, water birds are not very common in the area. The main reason for this phenomenon is that water birds generally require quiescent or slow-moving water environment. However, in the proposed project area and its surroundings due to terrain conditions, water flow is swift, which does not provide suitable habitat for water birds. With the damming of the river, a reservoir of an area of about 552 ha will be created, with quiescent/tranquil conditions. The reservoir banks will also have wet environment (although fluctuating diurnally, with peaking power water storage and draw-down) which can lead to proliferation of vegetation e.g. grass, etc. along the reservoir banks. Such conditions are generally ideal for various kinds of birds, especially, water birds. This is expected to increase the avifaunal population of the area (as occurred at the upper Kopili dam site).

91. The critical wildlife habitat tests using the biodiversity decision framework tool of IFC, World Bank indicates that there will be no major or severe impacts on the critical habitat and its endangered/ threatened species as listed above. The main predicted impact is the loss of habitat due to inundation and acquisition of forest area. Conservation actions as proposed by IUCN (during construction and during the initial project operation) such as conducting a comprehensive survey and monitoring in and around the project area to establish range, distribution and population status of vulnerable and critical habitats in the project area for assessing its habitat requirements and identifying threats will be undertaken.

5.3 Aquatic Flora

92. Wastewater generated (0.30 mld) from domestic sources (workers camps), if discharged in the river, could cause adverse impacts on aquatic flora. It is proposed to construct an appropriate sewage treatment plant to avoid adverse impacts on riverine ecology.

5.4 Impacts on Aquatic Fauna

93. **Impacts due to extraction of construction material:** The extraction of construction material from the river bed (existing quarries so no separate permit required) will affect the river water quality due to increase in the turbidity levels. This is mainly because the dredged material gets released during dredging operations. The dredging and deposition of dredged material may affect the survival and propagation of benthic organisms. There is less concern for fish and spawning areas, since the acidic nature of the river precludes fish in the main section of the Kopili at this point. In any case, appropriate measures, including fish management measures, if the pH of the river improves, are included in the biodiversity conservation plan (Annex 9) prepared for the project.

94. **Impacts due to discharge of sewage from labor camps/colony:** The proposed LKHEP envisages construction of a project colony at village Hawai and labor camps. If untreated wastewater generated from colony/labor camps is discharged in the river it will affect the river water quality. It is proposed to commission appropriate units for treatment of domestic sewage before its disposal into the river. Due to perennial nature of river Kopili, it maintains sufficient flow throughout the year which is sufficient to dilute the treated sewage from residential colonies during the construction period, and there will be significant e-flow (more than 5 m^3/s) from the dam site during project operation, for adequate dilution. It is also proposed to use treated water for agricultural/green belt development purpose.

6. Health and Quality of Life

95. An estimated 1,000 laborers and technical staff will aggregate in the project area during construction phase. Most of the laborers will be accommodated in the dormitories at labor camps. Laborers coming from outside project are potential carriers of certain diseases. It is proposed to undertake complete screening of workers health at the beginning of the construction work. Also contractor will ensure that proper sanitary facilities are provided at labor camps. Besides, adequate training and awareness programs for the workers are included in the EMP.

96. **Excavations:** Accumulation of rain water in excavated borrow pits and water in the reservoir may act as a breeding ground for various vectors and mosquitoes. However, since the requirement for borrow areas in this project is limited, little additional habitat for mosquito breeding will be created due to excavated pits. Reservoir filling and draining will present more of a challenge and it is proposed to fumigate ponding areas (pest control measure) as needed as suggested in the EMP.

97. **Inadequate facilities in labor camps:** Labor camps without adequate facilities for potable water supply and sewage treatment could lead to outbreak of epidemics of water-borne diseases. Adequate measures for the supply of potable water and treatment of effluent/waste from labor camps are recommended as a part of EMP.

7. Impacts Due to Construction Power

98. To meet the construction power requirements it is proposed to construct a 33 kV overhead distribution line from Umrangso to project site. Total length of the line is 20 km. The 33 kV voltage level will be stepped down to 11 kV/415 V via distribution transformer. Necessary sub-stations will also be installed at all strategic locations. Besides the project will also mobilize DG sets for all key locations for smooth functioning of construction activities. The DG sets will only work in case of non-availability of grid power. Appropriate mitigation measures are included in the EMP to control and mitigate impacts associated with the construction of 33 kV distribution line from Umrangso to project site and emissions from operation of DG sets.

8. Protection of Concrete and Steel from Acidic Water

99. The pH level in Kopili river ranges from 3.2 to 5.2 rendering it unfit for use in construction works and highly corrosive for concrete structures. Latest samples collected during visit of Sub-committee of MoEF&CC (in October 2017) indicated that the pH is in the range of 4.56 – 6.86. The acidic water shall also have a serious impact on the durability of the project components (equipments) and thus following preventive measures (listed below) have been proposed to reduce the impact of acidic water. These measures are currently being implemented by North Eastern Electric Power Corporation Limited (NEEPCO) (in existing Umrangso HEP) to protected plant equipments from acidic water.

- All reinforcement near the water front shall be of stainless steel with corrosion resistant properties.
- Use of epoxy coated reinforcement or corrosion resistant reinforcement.
- Corrosion resistant painting shall be applied to the reinforcement bar.
- Metallic trash rack with its embedment shall be of stainless steel.
- Steel liner in pressure shaft shall be painted with corrosion resistant paint.
- All pipes in power house or elsewhere shall be of stainless steel.
- Use of high density concrete (HPC) on water exposed surfaces will be used in dam structure.
- All concrete in contact with direct water shall consist of 5 to 6% Silica fumes (micro silica).
- Concrete mix with suitable admixtures such as metakaolin along with fly ash (about 30-35%) shall be used to resist the acid attack.
- Use of polyurethane spray on water exposed concrete surface.

9. Downstream Impacts

100. The Project is planned as a run of river scheme. The diversion of water for hydropower generation will result in change in the hydrological regime of the area, such as drying or reduced flow in the river stretch downstream. During the lean season, hydroelectric generation will result in drying of river stretch due to storage of water for minimum draw down level (MDDL) to full reservoir level (FRL) for peaking power generation. There are no users of water in the intervening stretch of 5.6 km, as the river stretch flows through a gorge, and there are no villages or residences along this whole stretch. Also, the water of river Kopili is highly acidic in the project area. Thus, riverine fisheries are not found in the area. As a result, there are no uses of water of river Kopili in the project area. Thus, no major adverse impacts are anticipated on downstream water users as it is proposed to release minimum e-flow throughout the year.

10. Impacts on Socio-Economic Environment

101. **Employment opportunities:** The construction phase will last for 4 years. The peak labor force and technical staff required is estimated at about 1,000. The total number of persons inhabiting the area including the service population will be about 2,800. The following impacts are envisaged: i) Improved business opportunities, and ii) improved access facilities in the project area.

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

103. **Impacts due to acquisition of land and homesteads:** During operation, one of the most important and negative impact due to the commissioning of the project would be that a number of families could be displaced from their lands, and economic activity. As per the assessment, a total of 1,854 landholders/ land titleholders would be losing land in varying proportions. About 18 project affected families (PAFs) would be losing homesteads, in the reservoir area.

11. Associated Facilities, Cumulative and Induced Impacts

104. The proposed Investment Program will expand power supplies and improve efficiency in the Assam State Electricity Grid, with significant reduction in greenhouse gas (GHG) emissions intensity due to the proposed project. As gas supplies to the Lakhwa plant are currently limited to the allotment for the existing power generation units, air pollutant loads will not be increased; rather, emissions intensity will be reduced by use of gas and hydropower instead of coal. Other environmental objectives such as GHG emission reduction, afforestation, and waste management are expected to be met after the planned power plants (including LKHEP) become operational. Corresponding to the project, a power evacuation system will be used to evacuate power it generates into the State Electricity Grid.

105. The power evacuation system and access road are included as project components. The existing 132/33 kV substation at Sankardev Nagar (to terminate 220 kV transmission line) and 33/11kV substation at Umrangsu (to terminate 33 kV construction power line) are the only associated facilities of the project, along with upgrades to the existing highway and the transmission lines mostly running along the edges of the road. These facilities already have a footprint; therefore no incremental impacts on biodiversity are anticipated with these associated facilities. An environmental and social audits of existing associated facilities (132/33 kV Sankardev Nagar and 33/11kV Umrangso substations) have been undertaken and provided in Annex 32.

106. Cumulative and induced impacts are expected to result from domestic, commercial, agricultural, and industrial sector growth. In the case of agriculture, groundwater pumping could be increased theoretically by at least 100%, which could stress available groundwater resources. Additive impacts from industrial development will be mitigated by rational land use planning and enforcement of existing environmental regulations by State/Central authorities. LKHEP staff can continue to be involved in future planning functions in this part of Assam.

107. The ADB funded investments will have cumulative and induced impacts that can be mitigated effectively under the GoI and Government of Assam (GoA) regulatory regime and ADB SPS 2009. The detailed findings of the cumulative impacts are discussed in the Cumulative

Impact Assessment (CIA) Report conducted by APGCL and financed under Tranche 2 of this MFF.

12. Climate Change Risk Assessment

108. Hydropower projects are likely to be affected by climate change, A climate risk screening and climate risk and vulnerability assessment studies have been carried out for LKHEP. The geo-environmental setting of Assam makes the State highly susceptible to multiple hazards caused by geological, climatic and hydrological factors. The main hazards include: 1) earthquake; 2) flood; 3) landslide; 4) lightning; and, 5) cyclones. Soil erosion may impose a serious problem to the sediment flushing schedules due to increased precipitation and storms. As part of LKHEP, a sedimentation study has been conducted to set a reservoir sediment management scheme. Acid coal mine discharge is a detrimental problem within the watershed. Sustainable watershed management, including the restoration of ecosystems within the watershed by eliminating illegal coal mining in upstream areas, needs to be implemented by the State (LKEHP can continue to provide technical inputs). A water quality restoration plan has been developed as part of EIA study and budgetary provisions are made in the EMP for piloting the proposed measures. Cyclones may bring gusty winds to the project area therefore transmission lines must be able to withstand strong winds. Based on the results of the climate change risk assessment, the project is High Risk for Climate Impacts.

I. Environmental Management Plan

109. A fully budgeted EMP has been prepared for mitigation/management/avoidance of the potential adverse impacts and enhancement of various environmental components of the proposed project. For each mitigation measures to be carried out, its location, timeframe, implementation and overseeing/ supervising responsibilities have been identified. Monitoring plan for construction and operation phases have been framed to ensure effective implementation of EMP.

110. The monitoring program included performance indicators for biodiversity values, water, air, and noise level monitoring, frequency of monitoring, and institutional arrangements of the project in the construction and operation stages, along with the estimated costs. The reporting system included roles and responsibilities of each party involved in the project implementation, i.e. Project Management Unit (PMU), Project Implementation Unit (PIU), Supervision Consultant, External Monitor, Contractors, and reporting mechanisms during implementation and operation phases.

111. An environmental management budget of Rs. 826.038m (US$ 12.90m) has been estimated for implementation of the EMP. This also includes cost of environmental monitoring (including transportation) and associated trainings. The EMP cost represents about 4.42% of the total project cost.

J. Conclusions

112. As per the ADB SPS 2009 EIA categorization process, the project (hydropower development) falls under Environment Category A. However, there are no environmentally sensitive areas (protected areas) within the PIA. The presence (and movement) of Asian elephants has been noted by local communities north and south of the project area, and Chinese Pangolins have been reported (but not seen during surveys). A critical habitat assessment (Annex 5) has been carried out and suitable mitigation measures have been included in the biodiversity

conservation and management plan (Annex 9) with a focus on additional camera trap surveys in the undisturbed southern forest area between the upper and lower Kopili HEPs, and creating river crossing locations for elephants.

113. The diversion of water for hydropower generation will result in change in the hydrological regime of the area, however minimum e-flow 5.345 m^3/s (20% of average lean season flow at the dam, and increasing continuously downstream) will be maintained for maintaining ecological habitat in the downstream river sections. Overall, there are no significant negative environmental and socio-economic impacts associated with the proposed project that cannot be mitigated to negligible or acceptable levels. All significant issues have been screened during consideration of alternative locations.

114. The project footprint in 523 ha of Reserve forest land does not contain discrete management unit (DMU)[4] for unique or critically vulnerable flora and fauna. Experience with similar projects in North East region indicates that the temporary negative impacts due to pre-construction preparation and construction works can be managed with "Best Practices" and measures to address issues such as: minimize sediment mobilization, reduce noise and air quality issues, and manage waste (management and disposal). Diversion of 523 ha of Reserve forest land will be compensated via Compensatory Afforestation (CA) scheme in coordination with the Assam State Forest Department. The impacts on wildlife and critical habitats will be managed via Biodiversity Conservation and Management Plan. Aquatic ecology in the river is negligible due to acidic nature of water. Nevertheless, minimum e-flow will be maintained. These are the main measures in mitigating environmental impacts at an acceptable and manageable levels.

115. There is full local community acceptance of the project. Affected persons/ households will be compensated as per provisions of the Resettlement and Tribal Development Plan developed for the project. The project will bring in significant power service reliability to the State and lead to local and national economic benefits while resulting in GHG emission reductions.

116. All required mitigation measures and monitoring are documented in the EMP, which also includes a Biodiversity Conservation and Management Plan. The EMP will become the *modus operandi* for the project, ensuring that predicted impacts are well-managed and monitored, and that accountability for mitigation performance is in place.

117. Given the observations and conclusions from the EIA, the project appears to be acceptable for implementation, as designed according to GoI and ADB SPS 2009 requirements.

[4] A DMU is an area with a clearly demarcated boundary within which the biological communities and/or management issues have more in common with each other than they do with those in adjacent areas.

I. INTRODUCTION

A. Background and Rational

1. A Framework Financing Agreement (FFA) for the Assam Power Sector Investment Program (APSIP or the Investment Program) was signed between ADB and GoI on 13 May 2014. On 3 July 2014, ADB's Board of Directors approved the provision of a Multitranche Financing Facility (MFF) to Government of Assam (GoA) through the GoI for the APSIP, with the aggregate facility amount of $300 million. The APSIP aimed to finance a portion of the power sector investment plan for generation and distribution of the GoA. The APSIP objectives are to increase capacity and efficiency of power generation and distribution systems in the State of Assam and to reduce load shedding while meeting growing demand for power in the region. The investment program's impact will be to increase availability of electricity in Assam. The outcome will be increased capacity and efficiency of energy generation and distribution systems in Assam. The MFF comprise three tranches. Tranche 1 includes replacement of an aging, inefficient gas plant, and project implementation support and capacity development support to Assam Power Generation Corporation Limited (APGCL). Tranche 2 includes expansion and upgrading of power distribution system in the state of Assam, and strengthening institutional capacity of Assam Power Distribution Company Limited (APDCL).

2. Two loans have been approved under the MFF. Tranche 1 for US$ 50 million (Loan 3140-IND) was approved on 11 July 2014 and it became effective on 12 May 2015, whereas Tranche 2 for US$ 48 million (Loan 3327-IND) was approved on 23 November 2015 and became effective on 7 November 2016. The Government is planning to submit Periodic Financing Request (PFR) 3 (Tranche 3), which includes financing for the proposed LKHEP. Tranche 3 of the MFF of amount $200 million will finance the construction of LKHEP (Tranche 3 project of APSIP MFF). APGCL will be the executing agency (EA) for the proposed LKHEP. The detailed project report (DPR) for LKHEP has been prepared by APGCL.

3. The proposed project is downstream of the existing Kopili HEP. The project envisages utilization of the regulated discharge from the existing Kopili HEP (spills of Khandong and Umrong dams upstream of the LHHEP) and the discharge from the intermediate catchment by creation of a reservoir and utilizing a gross head of about 114 m.

4. The proposed project is a run-of-river cum storage scheme (for peaking power) on the Kopili river at Longku. The live storage in the reservoir will last for a few days only if the power generation is continued at full installed capacity in the powerhouse. The scheme has been contemplated to run at full potential in monsoon season and operate as a peaking station in non-monsoon season. The installed capacity of project has been kept as 110 MW comprising of 2 units of 55 MW each. An Auxiliary Power House having a capacity of 10 MW (2x2.5 MW+1x5 MW) has also been planned at the toe of the dam for utilizing the mandatory releases for ecological purposes.

5. This Environmental Impact Assessment (EIA) covers the proposed project (LKHEP) including associated power evacuation facilities, in the State of Assam. All discussions thereafter focus only on this project. Note: WAPCOS Limited, a public sector enterprise under the aegis of the Ministry of Water Resources, River Development & Ganga Rejuvenation, GoI was engaged by APGCL for preparation of the EIA for the proposed project as per GoI requirements. The GoI EIA was prepared in September 2015 and finalized in March 2017. Since this project is proposed for financing under Tranche 3 of ADB's APSIP in India, this EIA document utilizes the primary and secondary data, findings and results from the WAPCOS EIA that meets the requirements of GoI as well as this EIA ensures compliance with the

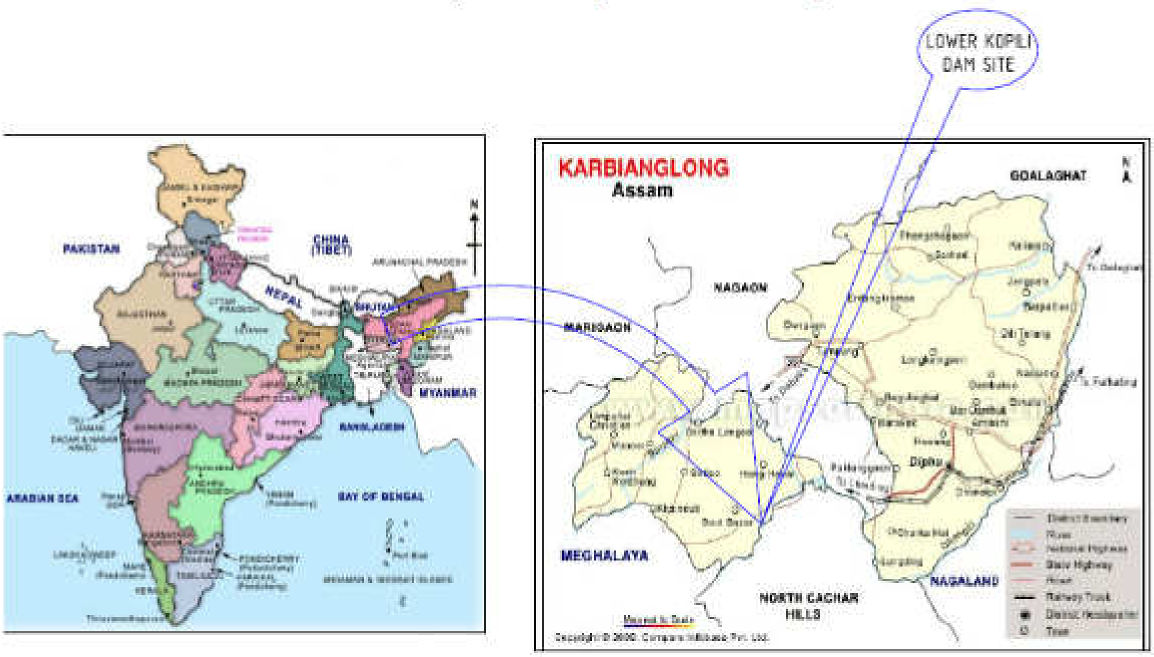
requirements of ADB's Safeguard Policy Statement 2009 (SPS 2009) and the International Finance Corporation (IFC) EHS Guidelines.

B. Project Location and Key Features

6. The proposed project is located in Karbi Anglong and Dima Hasao districts of Assam. The project location (dam site) is defined by 25°39'57.39"N latitude and 92°46'53.62"E longitude. Along with the Kopili HEP currently under operation by North Eastern Electric Power Corporation Limited (NEEPCO), the project is expected to fully harness the hydropower potential of the Kopili river. Kopili river is a major tributary of Brahmaputra river, which along with the Baraak river is the principal river basin of North-East region consisting of 7 States. Both Brahmaputra and Baraak rivers have large mountainous catchment with abundant rainfall and have significant identified hydropower potential.

7. The project site can be reached by road from Guwahati on the National Highway (NH-52) up to Lanka (distance of approximately 180 km). From Lanka up to dam site area, the State Highway exists (for a distance of approximately 33 km) and further up becomes the Public Works Department (PWD) road (Longku-Garampani) that shall be the main access road to the project. Total length from Lanka to the project site is 48 km. Several smaller access roads are proposed from the PWD road to various project components e.g. dam complex and Power House.(length of approximately 13.10 km). The Lokpriya Gopinath Bordoloi International Airport at Guwahati connects Guwahati to all important destination of India and abroad by air, whereas nearest railhead will be at Lanka which is proposed to be used as transit point for various construction materials like cement, steel, etc. The project location map is shown in Figure 1.

Figure 1: Project Location Map



C. Objective and Scope of the Study

8. WAPCOS has prepared an EIA for the proposed project (following the ToR issued of MoEF&CC) in September 2015 and later finalized in March 2017. Primary and secondary data

from EIA prepared by WAPCOS has been utilized in preparation of this EIA with an objective to identify potential environmental impacts of the proposed project and formulate strategies to avoid/mitigate the same. A comprehensive EIA report including an Environmental Management Plan (EMP) will be prepared in compliance with ADB's SPS 2009 requirements as well as fulfill policy and regulatory requirements of the GoI. The scope of work to accomplish the above objective, comprises of the following,

- understanding the baseline environmental conditions (hydrology, water quality, soil, sediment, land use, ecosystem, climate change risks, socio-economic, health and cultural resources) of the project area,
- identifying the potential environmental impacts of the proposed project on various environmental components due to activities envisaged during pre-construction, construction, and operational phases,
- prediction of significant impacts on the major environmental components using appropriate mathematical/simulation models wherever necessary,
- recommending appropriate mitigation measures to avoid/minimise the environmental impacts, and
- preparing an EMP for implementation. The EMP will outline preventive and curative strategies for minimizing adverse impacts during pre-construction, construction and operational phases of the proposed project along with the cost estimates and time schedule for implementation of EMP.

9. The study area considered for the EIA study included the submergence area, area within 10 km of the periphery of the submergence area, area to be acquired for locating the various project appurtenances, area within 10 km of various project appurtenances, catchment area intercepted at the dam site extending up to diversion structure of LKHEP, alignments and impacts zones of access road and power evacuation (transmission) lines.

D. Stages and Methodology Adopted for EIA Study

10. The EIA study has been carried out, in accordance with the requirements of the ADB SPS 2009 and EARF prepared for the APSIP (MFF). The EIA also follows the Terms of Reference (ToR) issued by the MoEF&CC of India for the LKHEP during 169th Meeting of the Expert Appraisal Committee (EAC) held on 11th -12th November 2013 (Annex 33); EIA Notification 2006 of MoEF&CC, and hydropower sector EIA guidance manual 2010.

11. The EIA methodology ensures that environmental concerns are given adequate weightage in the selection of locations and design of the proposed LKHEP. The methodology employs an iterative approach in which potential environmental issues were examined at successive levels in detail and specificity, at each step of the process.

12. The environmental assessment is based on the information collected from primary as well as secondary sources on various environmental attributes. As per requirements of the MoEF&CC, three seasons' data of air, water, noise and soil quality has been collected and various issues have been examined during field surveys to determine the magnitude of environmental impacts.

13. The major steps in the EIA process for the project were as follows:

1. Scoping

14. A scoping exercise has been conducted. This included preparation of an exhaustive list of likely impacts drawing information from various sources. The next step included the selection of manageable number of attributes which were likely to be impacted/affected as a result of the proposed project. The criteria applied for selection of the impacts were i) magnitude, ii) extent, and iii) significance. Based on this scoping exercise, a draft ToR for EIA was prepared and submitted to the MoEF&CC for approval. Subsequently, the MoEF&CC issued an approved ToR (with slight modifications) during its 169th Meeting of the EAC held on 11th -12th November 2013.

2. Collection and Analysis of Data

15. Data was collected for various environmental attributes such as soil, meteorology, geology, hydrology, water quality, aquatic and terrestrial flora and fauna, habitats, demography, land use, cultural properties etc. This data was used for establishing the baseline environmental conditions. Primary data collection was completed with the help of field surveyors and enumerators/investigators. The surveyors and enumerators/investigators were trained in taking samples and filling up of Questionnaires on-site. To ensure the accuracy of the data, collection was performed under the supervision of a consultant. Secondary data was collected both from published and other relevant sources e.g., the Water Resources Department, Central Water Commission, State Department of Forest, Meteorological Department, Assam State Pollution Control Board, and State Statistical Department, etc.

3. Environmental Monitoring and Analysis

16. During the screening exercise and site visits of the PIA, different locations were identified for monitoring and analysis of environmental parameters such as noise level, ambient air and water quality. The monitoring and analysis have been done by National Accreditation Board for Education and Training (NABET), accredited laboratory. As per the ToR, three seasons' data (pre-monsoon, monsoon and post-monsoon) for environmental parameters were collected during years 2013 - 2015. Air quality monitoring has been carried out as per MoEF&CC notification November 2009 the revised National Air Quality standards. Table 1 shows the summary of data collected during preparation of EIA study and the on-site monitoring results are presented in Chapter - IV of this EIA report

Table 1: Summary of data collected for the Comprehensive EIA study

Aspect	Mode of Data collection	Parameters monitored	Frequency	Source
Meteorology	Secondary	Temperature, humidity, rainfall	-	India Meteorological Department (IMD)
Water Resources	Secondary	Flow, Design hydrograph and design flood hydrograph	-	Detailed Project Report (DPR)
Water Quality	Primary	Physic- chemical and biological parameters	Three seasons	Field studies for summer, monsoon and winter seasons
Ambient air quality	Primary	PM_{10}, $PM_{2.5}$, SO_2, NO_x	Three seasons	Field studies for monsoon, winter and summer seasons
Noise	Primary	Hourly noise and equivalent noise level	Three seasons	Field studies for summer, monsoon and winter seasons

Aspect	Mode of Data collection	Parameters monitored	Frequency	Source
Land use	Primary and secondary	Land use pattern	–	NRSA and Ground Truth Studies
Geology	Secondary	Geological characteristics of the study area	–	DPR
Soils	Primary	Physic- chemical parameters	Three seasons	Field studies for summer, monsoon and winter seasons
Terrestrial Ecology	Primary and secondary	Floral and faunal diversity	Three seasons	Field studies for summer, monsoon and winter seasons
Aquatic Ecology	Primary and Secondary	Presence and abundance of various species	Three seasons	Field studies for summer, monsoon and winter seasons
Socio-economic aspects	Primary and secondary	Demographic and socio-economic, Public health cultural aspects	-	Field studies for PAFs, secondary data collection from Revenue Department and literature review.

4. Vegetation and Wildlife Surveys

17. In order to assess presence of flora and fauna in the PIA, field surveys were carried out for three seasons (summer, monsoon and winter seasons). As recommended by the EAC of MoEF&CC, the biodiversity study for the LKHEP was conducted by a reputed institute in India (Centre for Inter-Disciplinary Studies for Mountain and Hill Environment – CISMHE, Delhi University, One of the top institutes recommended by MoEF&CC). Findings are presented in Chapter - IV of this EIA report.

5. Analysis of Alternative

18. Analysis of Alternates for the project has been made on the basis of “with” and “without” project scenario as well as alternate alignment and design options. The parameters considered for the analysis are the environmental and social features and their likely impact on the natural ecosystem. Analysis are presented in Chapter - VIII of this EIA report.

6. Assessment of Potential Impacts

19. Potential impacts were identified on the basis of: analytical review of baseline data; review of environmental conditions at site; analytical review of the underlying socio-economic conditions within the PIA. An attempt was made to forecast future environmental conditions quantitatively to an extent possible. But for parameters that could not quantified, an approach was utilized to discuss intangible impacts in quantitative terms such that planners and decision-makers were aware of their existence as well as their possible implications. Findings are presented in Chapter - V of this EIA report.

7. Preparation of the Environment Management Plan

20. An EMP for the project has been prepared, specifying necessary measures for management and monitoring of potential impacts during pre-construction, construction, and

operation phases of the project. The EMP also includes details of the resources budgeted and the implementation arrangements.

8. Additional Studies

21. Additional studies required to fulfill ADB SPS 2009 as well as MoEF&CC requirements have been undertaken as part of this comprehensive EIA. This included Cumulative Impact Assessment (CIA), Integrated Water Resources Management Plan (IWRMP), and Water Quality Restoration Plan (WQRP). These reports are presented as supplemental EIA (SEIA) to the EIA report.

E. Structure of the Report

22. In line with ADB SPS 2009, this EIA report has been organised into twelve chapters as described below:

- Chapter I - Introduction: This section describes the background information about the project and EIA study.
- Chapter II - Policy, Legal, and Administrative Frameworks: This section summarizes the National and State legislation and administrative framework including ADB SPS 2009 and International conventions and treaties that guided the EIA assessment.
- Chapter III - Project Description: This section presents the key features and components of the proposed project.
- Chapter IV - Description of the Environment: This section discusses the relevant physical, biological, and socioeconomic features that may be affected by the proposed project.
- Chapter V - Anticipated Environmental Impacts and Mitigation Measures: This section presents the environmental assessment of likely potential and adverse impacts attributed to the proposed project and concomitant mitigation measures.
- Chapter VI – Cumulative and Induced Impacts: This section provides an analysis of cumulative and induced impacts due to the implementation of proposed project.
- Chapter VII - Climate Change Risk Assessment: This section provides an analysis of climate change impacts and risks due to the implementation of proposed project.
- Chapter VIII - Analysis of Alternatives: This section covers analysis of alternatives considered to minimise the overall impacts of the proposed project and suggest most appropriate alternatives based of the detailed analysis of impacts and risks associated with each alternative.
- Chapter IX - Information Disclosure, Consultation, and Participation: This section describes the consultation process undertaken during the environmental assessment and its results, their consideration in the project design, and manner of compliance to the GoI, National laws, and ADB’s Public Communication Policy 2011.
- Chapter X - Grievance Redress Mechanism: This section describes the formal and informal redress procedures for registering, resolving, and reporting complaints by an affected party/person.
- Chapter XI - Environmental Management Plan: This section discusses the action plans to avoid, reduce, mitigate or compensate potential and adverse impacts and reinforces beneficial impacts. EMP has been divided into three sub-sections; mitigation, monitoring, and implementation arrangements
- Chapter XII - Conclusion and Recommendation: This section discusses the potential for further detailed environmental studies / assessments and highlights key findings and recommendations to be implemented by the borrower (EA).

23. An Executive Summary has also been prepared and presented in the beginning of the report as well as series of 37 annexes (as Volume 2). Specific studies conducted as part of supplemental environmental assessment, i.e. CIA, IWRMP, and WQRP, are provided as SEIA to this EIA report as independent volumes.

II. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

24. India has a well-defined institutional and legislative framework that covers all components of the environment viz. air, water, soil, terrestrial, aquatic flora and fauna, natural resources, and sensitive habitats. India is also signatory to various international treaties, conventions, and protocols. The ADB has also defined its Environmental and Social Safeguard policy requirements viz. ADB's SPS 2009. This assessment is about the applicability of National laws and regulations, conventions, protocols, to the proposed project. The project will also be guided by ADB's SPS 2009 and IFC EHS Guidelines. This chapter summaries the following while details are included in Annex 2:

- National (India) Environmental Legislation and Administrative Framework,
- Social Safeguards Regulatory Requirements of India and State of Assam,
- ADB safeguard policies and Categorization of the project,
- IFC EHS Guidelines (General), and
- International Treaties, Conventions, Protocols and applicability to the project.

A. National (India) Environmental Legislation and Administrative Framework

25. The National legal framework consists of several acts, notifications, rules and regulations to protect the environment and wildlife. In 1976, the 42nd Constitutional Amendment created Article 48A and 51A, placing an obligation on every citizen of the country to attempt to conserve the environment. The national legislations are broadly divided under the following categories:

- **The Environment (Protection) Act 1986** was enacted with the objective of providing for the protection and improvement of the environment. It empowers the Central Government to establish authorities charged with the mandate of preventing environmental pollution in all its forms and to tackle specific environmental problems that are peculiar to different parts of the country. Various rules are framed under this Act for grant of environmental clearance for any developmental project, resources conservation and waste management.

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

- **The Wildlife (Protection) Act 1972** was enacted with the objective of effectively protecting the wildlife of the country and to control poaching, smuggling and illegal trade of wildlife and its derivatives. It defines rules for the protection of wildlife and ecologically important protected areas.

26. The implementation of the LKHEP project will be governed by GoI and GoA environmental policies, statutes and legislation as well as International Best Practices related to environment. The State Pollution Control Board of Assam (SPCB, Assam) is tasked to ensure that environmental clearances and environmental standards are complied with by the EA (project proponent/operator) during project implementation. These regulations impose restrictions on project activities to minimize and/or mitigate likely impacts on the environment. It is the responsibility of the EA to ensure that the project is consistent with the policy, legal and administrative framework across all hierarchy - National, State, Municipal and local. The details

of governance structures that will be involved both at local and state level for the LKHEP project are described in Annex 2.

27. **Environmental Impact Assessment in India:** The EIA requirement in India is based on the Environment (Protection) Act, 1986, the Environmental Impact Assessment Notification, 2006 (amended 2016), and all its related circulars. In addition to the hydroelectric power project development project, additional activities include establishment of workshops, construction camps, hot mix plants, and opening of quarries for construction material and are required to comply with the provisions of the Forest (Conservation) Act 1980 and Rules (and amendments); Wildlife (Protection) Act, 1972 (and amendments); the Water (Prevention and Control of Pollution) Act 1972 and Rules (and amendments); the Air (Prevention and Control of Pollution) Act, 1981 and Rules (and amendments); the Noise Pollution (Regulation and Control) Rules, 2000 (and amendments 2002); and Hazardous Waste (Management, Handling and Trans-boundary Movement) Rules 2008 (and amendments).

28. The Summary of National policies, guidelines, acts and regulations are summarised in Table 2 along with its applicability to the proposed project. Detailed review of policies, guidelines, acts, and regulations are presented in Annex 2.

Table 2: Summary of Applicable National and State Policies and Regulations

S. No.	Name of Policy / Guideline / Act / Regulations	Applicability	Duration of Compliance
A	**Policies (India)**		
1	National Forest Policy 1988; Draft National Forest Policy 2016[5]	Yes	
2	Policy statement for Abatement of Pollution, 1992	Yes	
3	National Conservation Strategy and Policy Statement on Environment and Development, 1992	Yes	
4	National Environmental Policy, 2006	Yes	
5	Water Policy of India, 2002	Yes	
6	Wildlife Conservation Strategy 2002	No (as project does not affect any legally protected area)	
7	National Policy on Hydropower Development, 1998	Yes	
8	Policy for Development of Small Hydropower (SHP) 2007 Assam	No (LKHEP is a major HEP)	
B.	Guidelines		
9	National Board for Wildlife (NBWL)	No (No protected areas involved)	
10	Central Electricity Authority (CEA)	Yes	
B.	**Statutes and Legislation (India)**		
1	The Environmental Impact Assessment (EIA) Notification, 2006 and Amendments (up to 2016)	Yes	Pre-Construction, Construction and Operation
2	The National Environmental Appellate Authority Act, 1997	Yes	Pre-construction and Construction
3	National Environment Tribunal Act, 1995	Yes	Pre-construction,

[5] http://www.moef.nic.in/sites/default/files/Draft%20National%20Forest%20Policy,%202016.pdf.

S. No.	Name of Policy / Guideline / Act / Regulations	Applicability	Duration of Compliance
			Construction and Operation
4	National Green Tribunal Act, 2010	Yes	Pre-construction, Construction and Operation
5	The Biodiversity Act, 2002 and Rules, 2004	Yes	Pre-construction, Construction and Operation
6	Wetlands (Conservation & Management) Rules, 2010	No (no wetlands in project area)	
7	The Wildlife (Protection) Act, 1972 and Amendments (2006); The Wildlife Protection Rules 1995 Wildlife (Protection) Amendment Bill 2013 National Board of Wildlife Rules 2007	No (as project does not affect any legally protected area)	
8	The Indian Forest Act, 1927	Yes	Pre-construction
9	Forest (Conservation) Act, 1980, and Amendments (1988) • Forest (Conservation) Rules, 1981, Amendments 1992 and 2003 • Guidelines for diversion of forest lands for non-forest purpose under the Forest (Conservation) Act, 1980	Yes	Pre-Construction, Construction and Operation
10	The Environment Protection Act, 1986; The Environment Protection Rules 1986 and Amendments (2009)	Yes	Pre-construction, Construction and Operation
11	The Air (Prevention and Control of Pollution) Act, 1981; The Air (Prevention and Control) Rules 1982 and Amendments (1988)	Yes	Construction and Operation
12	Water (Prevention & Control of Pollution) Act, 1974; and Amendments (1988) Water (Prevention & Control of Pollution) Rules, 1975, and Amendments (2011)	Yes	Construction and Operation
13	Water (Prevention & Control of Pollution) Cess Act, 1977; and Amendment (2003) Water (Prevention & Control of Pollution) Cess Rules, 1978	Yes	Operation
14	Noise Pollution (Regulation and Control) Rules, 2000 and Amendments (2010)	Yes	Pre construction, Construction and Operation
15	Ozone Depleting Substances (ODS) Regulation and Rules, 2000	Yes	Operation
16	The Hazardous Waste (Management, Handling and Trans-boundary Movement) Rules, 2008 (and Amendments 2009)	Yes	Construction and Operation
17	The Manufacture, Storage and Import of Hazardous Chemical Rules, 1989	Yes	Construction and Operation

S. No.	Name of Policy / Guideline / Act / Regulations	Applicability	Duration of Compliance
18	Biomedical Waste (Management and Handling) Rules, 1998 (and Amendments 2003)	No (no generation of medical waste)	
19	Batteries (Management and Handling) Rules, 2001 and amendments (2010)	Yes	Construction and Operation
20	Notification on Special Areas/ Restricted Activities	No	
21	The Electricity Act, 2003;(and Amendments 2014)	Yes	Construction and Operation
22	No Development Zone around refinery at Numaligarh, East of Kaziranga, 1996 (Notification)	No (away from PIA)	
23	E-Waste (Management and Handling) Rules, 2011	Yes	
24	Construction and Demolition waste Management Rules, 2016	Yes	
25	Plastic Waste Management Rules, 2011	Yes	
C.	**Statutes and Legislation (Assam)**		
1	Assam Ancient Monuments and Records Act, 1959	No (no ancient monuments in PIA)	
2	Forest related Acts and Rules • Karbi Anglong (Mikir) Hills District Forest Act, 1957 including Karbi Anglong District (Forest) (Amendment) Act, 1965 • Assam Forest Protection Force Act, 1986 • Assam Compensatory Afforestation Fund Rules, 1994; and GoA Guidelines for Compensatory Afforestation, 2000 • Assam Forest Regulation, 1891 including Assam Forest Regulation (Amendment) Act, 1995 • The Assam Forest (Removal And Storage of Forest Produce) Regulation Act, 2000 • Assam Revolving Fund (Forest Department) Rules, 2000 • The Assam Forest (Forum of Appeal) Rules 2001 • Assam Forest (Rewards) Rules, 2002 • Assam (Control of Felling and Removal of Trees from Non-Forest Lands) Rules, 2002 • Assam Forest Policy 2004 • The Assam Joint Forest Management Rules, 2004 • The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act ,2006 (FRA 2006)	Yes	

S. No.	Name of Policy / Guideline / Act / Regulations	Applicability	Duration of Compliance
	• Forest Rights Act, 2006		
3	Assam Biodiversity Rules, 2010	Yes	
4	Assam National Park Act, 1968	No (not near national parks)	
5	Assam Land and Revenue Regulation, 1886	Yes	
6	Assam Irrigation Act, 1983	Yes	
7	Assam Fishery Rules, 1953	No (no fisheries activities taking place in the river)	
8	Wildlife Protection Rules, 1980	Yes	
9.	Assam Minor Minerals commencement Concession Rules, 2013	Yes	
D.	**Occupational, Health and Safety Regulations**		
1	Public Liability Insurance Act (PLIA), 1991, and Amendments (1992) and Rules, 1991	Yes	Pre-construction, Construction and Operation
2	Explosives Rules, 2008 (under Act of 1884)	Yes	Pre-construction and Construction
3	Factories Act, 1948 and Amendments (1987)	Yes	Pre-construction, Construction and Operation
4	Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Yes	Pre-construction and Construction
5	The Building and other Construction Workers' Welfare Cess Act, 1996	Yes	Pre-construction and Construction
6	Central Motor Vehicle Act 1988 & Rules, 1989 and Amendments (2001)	Yes	Pre-construction, Construction and Operation
7	National Building Code, 2005 – Part IV: Fire and Life Safety	Yes	Construction
8	Petroleum Act, 1934 and Rules 2002	Yes	Pre-construction, Construction and Operation
9	Gas Cylinder Rules and Static and Mobile Pressure Vessels (Unfired) Rules, 1981	No	Pre-construction, Construction and Operation
10	CEA (Safety Requirements for Operation, Construction and Maintenance of Electric Plants and Electric Lines) Regulations 2008 and Amendments (2010)	Yes	Construction and Operation
11	Indian Electricity Rules, 1957 and Amendments (2000)	Yes	Construction and Operation

B. Social Safeguards Regulatory Requirements of India and State

29. There are many rules and regulations framed by the GoI for the protection of workers. Most of these legislations will be applicable to contractors and laborer’s in charge of

construction works. The EA will ensure compliance to these social safeguards through contractual obligation, regular checks and penalties. Regulatory requirements include The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996; Child Labor (prohibition and Regulation) Act, 1986; Minimum Wages Act, 1948; Workmen Compensation Act, 1923; Payment of Gratuity Act, 1972; Employee State Insurance Act; Employees P.F. and Miscellaneous Provision Act, 1952; Maternity Benefit Act, 1951; Payment of Wages Act, 1936; Equal Remuneration Act, 1979; Inter-State Migrant Workmen's (Regulation of Employment & Conditions of Service) Act, 1979; Equal Remuneration Act, 1979 etc. The social related policies, key legal instruments and international best practices applicable to tribal rights and their involuntary displacement are included in RTDP document. Table 3 provides the summary of social safeguard policies and regulatory requirements of India and Assam. Detailed review is provided in Annex 2.

Table 3: National and State Social Regulatory Requirements

S. No.	Name of Social Policy / Guideline / Act / Regulations	Applicability	Duration of Compliance
1	The Land Acquisition Act, 1894 and Amendments	Yes.	Pre-Construction
2	Draft National Tribal Policy 2006	Yes	Pre-Construction and Construction
3	Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013	Yes	Pre-Construction and Construction
4	The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act 2006 and Rules 2007	Yes	Pre-Construction and Construction
5	The Provision of the Panchayat (Extension to the Scheduled Areas) Act, 1996	No	
6	Indian Treasure Trove Act, 1878 (as modified up to September 1949)	No	
7	The Antiquities and Art Treasures Act, 1972	No	
8	Minimum Wages Act, 1948	Yes	Pre-construction, Construction and Operation
9	Payment of Wages Act, 1936 and Amendments	Yes	Pre-construction, Construction and Operation
10	Workmen's Compensation Act, 1923 (Amended 2009)	Yes	Pre-construction, Construction and Operation
11	The Contract Labor (Regulation & Abolition) Act, 1970 and Rules	Yes	Pre-construction, Construction and Operation
12	The Employees Provident Fund. and Miscellaneous Provisions act, 1952	Yes	Pre-construction, Construction and Operation
13	Employers' Liability Act No. 24 of 1938	Yes	Pre-construction, Construction and Operation
14	Payment of Bonus Act, 1965 and Amendment Act No.43 of 1977 and No.48 of 1978 and amendments	Yes	Pre-construction, Construction and Operation
15	The Personal Injuries (Compensation Insurance) Act, 1963 (as amended)	Yes	Pre-construction, Construction and Operation

S. No.	Name of Social Policy / Guideline / Act / Regulations	Applicability	Duration of Compliance
16	The Child Labor (Prohibition and Regulation) Act, 1986	Yes	Pre-construction, Construction and Operation
17	The Bonded Labor (Abolition) Act 1976	Yes	Pre-construction, Construction and Operation
18	The Trade Union Act, 1926	No	
19	Interstate Migrant Workers Act 1979	Yes	Pre-construction, Construction and Operation

C. Applicable Environmental Standards

30. The project will follow environmental standards as prescribed by GoI as well as International agencies such as the IFC EHS Guidelines.

31. **National Standards:** To ascertain and categorize the existing water quality and its designated best use in and around the project area, the results of the analysis of water quality will be compared with the water quality standards as prescribed by Central Pollution Control Board (Annex 2, Table 2.2). The revised National Ambient Air Quality Standards (NAAQS) for major pollutants were notified by the Central Pollution Control Board (CPCB) in November 2009. The NAAQS prescribe specific standards for industrial, residential, rural and other ecologically sensitive areas (Annex 2, Table 2.3). Ambient noise level standards have been notified by the MoEF&CC under Noise (Regulation & Control) Rules 2000 and also in the Schedule III of the Environmental (Protection) Rules 1986. IFC EHS Guidelines for noise will also be referred to for comparing the standards. Noise levels are measured in dB (A) Leq which denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing (Annex 2, Table 2.4) Noise standards in the work environment are specified by IFC EHS Guidelines will be also be used. (Annex 2, Table 2.5).

32. **IFC EHS (General) Guidelines:** The IFC EHS Guidelines and Good Practice Note on EHS Approaches for Hydropower Projects are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). These General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines which provide guidance to users on EHS issues in specific industry sectors. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them. The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account.

33. The project proponent/operator shall follow all the EHS Guidelines of IFC for this project and should also ensure that all appointed contractors/subcontractors follow the IFC EHS Guidelines.

D. International Treaties and Relevance to the Project

34. The GoI has signed many international treaties, and have framed guidelines and laws to meet the country’s obligations under these treaties. The project of this magnitude may

contribute in meeting country's obligation to international treaties either directly or indirectly. A screening process was carried out regarding applicability of the international treaties to the project. Table 4 provide summary of international treaties while detailed reviews are provided in Annex 2.

Table 4: International Treaties and Agreement Signed and Ratified by India

S. No.	International Agreements and Commitments	Applicability	Date of Signing / Ratifying
	Nature Conservation		
1	Convention on Wetlands of International Importance (Ramsar Convention)	No (no wetland involved)	Signed by India in 1981 and ratified in February 1982
2	Convention on International Trade in Endangered Species of Fauna and Flora (CITES)	Yes	Signed by India in 1976
3	The Wildlife Trade Monitoring Network (TRAFFIC)	Yes	-
4	Convention on Migratory Species (CMS)	Yes	-
5	Coalition Against Wildlife Trafficking (CAWT)	Yes	-
6	Convention on Biological Diversity (CBD)		Ratified February 1994 and September 2003 by Protocol.
7	International Tropical Timber Organization (ITTO)	Yes	-
8	United Nations Forum on Forests (UNFF)	Yes	-
9	International conventions such as the International Union for Conservation of Nature and Natural Resources (IUCN)	Yes	-
10	Global Tiger Forum (GTF)	No (no tigers involved)	-
	Hazardous Material		
11	Cartagena Protocol on Bio safety	No (no issues of biosafety)	Signed the Protocol in 2000 and it came into force in 2003
12	Strategic Approach to International Chemicals Management (SAICM)	Yes	-
13	Stockholm Convention on Persistent Organic Pollutants (POPs)	No (No POPs will be used in project)	-
14	Basel Convention on the Control of Trans-boundary Movement of Hazardous Waste and Their Disposal	Yes	Adopted on 22 March 1989
15	Rotterdam Convention on Prior Informed Consent (PIC) for certain Hazardous Chemicals and Pesticides in International Trade	Yes	Adopted in 1998
	Atmospheric Emissions		
16	United Nations Framework Convention on Climate Change (UNFCCC)	Yes	

S. No.	International Agreements and Commitments	Applicability	Date of Signing / Ratifying
17	Kyoto Protocol	Yes	Signed by India in August 2002 and ratified in February 2005.
18	Paris Agreement	Yes	Ratified by India on 2 October 2016. The agreement entered into force on 4 November 2016.
19	United Nations Convention to Combat Desertification (UNCCD)	No (no desertification involved)	-
20	Montreal Protocol (on Ozone Depleting Substances)	Yes	India signed on 17-9-1992 and also ratified on 3rd March, 2003
	Marine Environment		
21	International Whaling Commission (IWC)	No (no whaling involved)	Not applicable

Source: MoEF&CC, India.

35. India has also ratified many of the International Labor Organization conventions that are relevant to the project including:

- C1 Hours of Work (Industry) Convention, 1919 (14:07:1921, ratified);
- C5 Minimum Age (Industry) Convention, 1919 (09:09:1955, ratified):
- C11 Right of Association (Agriculture) Convention, 1921 (11:05:1923, ratified):
- C14 Weekly Rest (Industry) Convention, 1921 (11:05:1923, ratified);
- C29 Forced Labor Convention, 1930 (30:11:1954, ratified) & C105 Abolition of Forced Labor Convention, 1957 (18:05:2000, ratified);
- C100 Equal Remuneration Convention, 1951 (25:09:1958, ratified);
- C107 Indigenous and Tribal Populations Convention, 1957, and
- C111 discrimination (Employment and Occupation) Convention, 1958 (03:06:1960,ratified).

E. ADB's Safeguard Policy Statement Requirements

36. ADB requires consideration of environmental issues in all aspects of its operations and the requirements for mainstreaming environmental safeguard are embodied in ADB's SPS 2009, which applies to all projects that require financing from ADB. Detailed review of ADB's SPS 2009 are provided in Annex 2.

37. ADB has defined its Safeguard requirements under its SPS 2009. The prime objectives of safeguard policy are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; and (ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible. This policy requires assessment, mitigation and commitment towards environmental protection. The

policies apply to all ADB-financed projects, including private sector operations, and to all project components.

38. A key concern of ADB is that the Project does not result in degradation of sensitive ecosystems including critical and natural habitat. The SPS 2009, Appendix 1, paragraph 27, states that “the project mitigation measures should be designed to achieve at least no net loss of biodiversity,” which could be achieved by post-project restoration of habitats or “through the creation or effective conservation of ecologically comparable areas,” i.e. an ecological “offset.” SPS 2009 provides the working definition of critical habitat, including: habitat required for the survival of (i) globally endangered and/or critically endangered species, (ii) nationally endangered or critically endangered species, (iii) endemic/restricted range species, and (iv) migratory/congregatory species. Any Important Bird Areas (IBA) should be considered as critical habitat until further notified.

39. The extent of assessment depends on the category of the project. ADB’s SPS 2009 classify a project depending on following three categories.

- **Category A:** A proposed project is classified as category A if it is likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works. An environmental impact assessment is required.
- **Category B:** A proposed project is classified as category B if its potential adverse environmental impacts are less adverse than those of category A projects. These impacts are site-specific, none or very few of them are irreversible, and in most cases mitigation measures can be designed more readily than for category A projects. An initial environmental examination is required.
- **Category C:** A proposed project is classified as category C if it is likely to have minimal or no adverse environmental impacts. No environmental assessment is required although environmental implications need to be reviewed.

F. Category of the Project

40. **ADB Screening and Categorization:** The proposed project has been evaluated considering the outcome of the ADB Rapid Environmental Assessment (REA) checklist (Annex 1). All environmentally sensitive areas within the PIA have been critically analyzed to assess the magnitude and extent of likely impacts. Although there are no environmentally sensitive areas (protected areas) within the PIA, the project (hydropower development) falls under Environment Category A. Given this, safeguard documents shall meet all the requirements of ADB’s SPS 2009 as well as National requirements. Hence, an EIA including EMP has been carried out.

41. **GoI Categorization:** As per EIA Notification, dated 14th September 2006 (and amendments thereafter), under Activity 1(c) - River Valley projects; if, the capacity of power generation for any HEP will more than 50 MW, the project falls under Category A. Such projects mandatorily require a Comprehensive EIA study to be undertaken and EC to be obtained from the MoEF&CC before the start of any construction activity. Therefore, the 120 MW project falls under Category “A” listed for EC by the MoEF&CC, and a comprehensive EIA including EMP has been prepared. The EIA study along with public hearing report have been submitted to EAC of the MoEF&CC for EC. The EAC has recommended grant of EC to the project in its 10th meeting held on 5 December 2017.

G. Clearances and Approvals for the Project

42. Table 5 list out the key applicable permits and clearances required for the project and its status as on May 2018.

Table 5: Environmental Permit / Clearances for the Proposed Project

S. No	Environmental Permit / Clearance	Stage	Status (as on May 2018)
Planning Stage: Before start of Civil Works Construction (Responsibility: Executing Agency)			
1.	Site clearances from various State departments	Prior to Construction	In progress. (Expected by July 2018).
2.	Prior Environmental Clearance (approved ToR) from the MoEF&CC, GoI as per EIA Notification 2006 under the Environment (Protection) Act, 1986	Planning	Obtained.
3.	Forest clearance from MoEF&CC, GoI	Prior to Construction	In progress (with regional office of MOEF&CC). 1st stage clearance expected to be granted by November 2018.
4.	Proceedings of Public Hearing as per EIA notification 2006 (and addendum thereafter) by Assam SPCB	Prior to Construction	Completed on 10 January 2017.
5.	Environmental Clearance from MoEF&CC, as per EIA notification, 2006 under the Environment (Protection) Act, 1986	Prior to Construction	Obtained on 5 December 2017.
Construction Stage (Responsibility: EPC Contractor)			
6.	No Objection Certificate (Consent to Establish) from Assam SPCB for establishment of contractor's facilities under Water Act of 1974, Air Act of 1981, Noise Rules of 2000 and the Environment Protection Act of 1986 (and amendments)	Construction	To be initiated
7.	No Objection Certificate (Consent to Operate) from Assam SPCB for operation of contractor's facilities under Water Act of 1974, Air Act of 1981, Noise Rules of 2000 and the Environment Protection Act of 1986 (and amendments)	Construction	To be initiated
8.	Explosive license from Chief Controller of Explosives for use and storage of explosive for quarry blasting work	Construction	To be initiated
9.	Permission from Assam SPCB or Local Authority (DM/DC) for storage of hazardous chemical	Construction	To be initiated
10.	Quarry Lease Deed and Quarry License from State Department of Mines and Geology for establishment and operation of Quarry operation	Construction	To be initiated
11.	Permission from State Ground Water Board for extraction of ground water for use in project construction activities	Construction	To be initiated
12.	Permission from Water Resources Department for	Construction	To be initiated

S. No	Environmental Permit / Clearance	Stage	Status (as on May 2018)
	use of water for construction purpose		
13.	Labor license from Labor Commissioner for Engagement of labor	Construction	To be initiated
14.	Obtaining Environmental clearance for minor minerals	Construction	To be initiated
15.	Blasting permission from concerned District Administration and Explosive Department	Construction	To be initiated

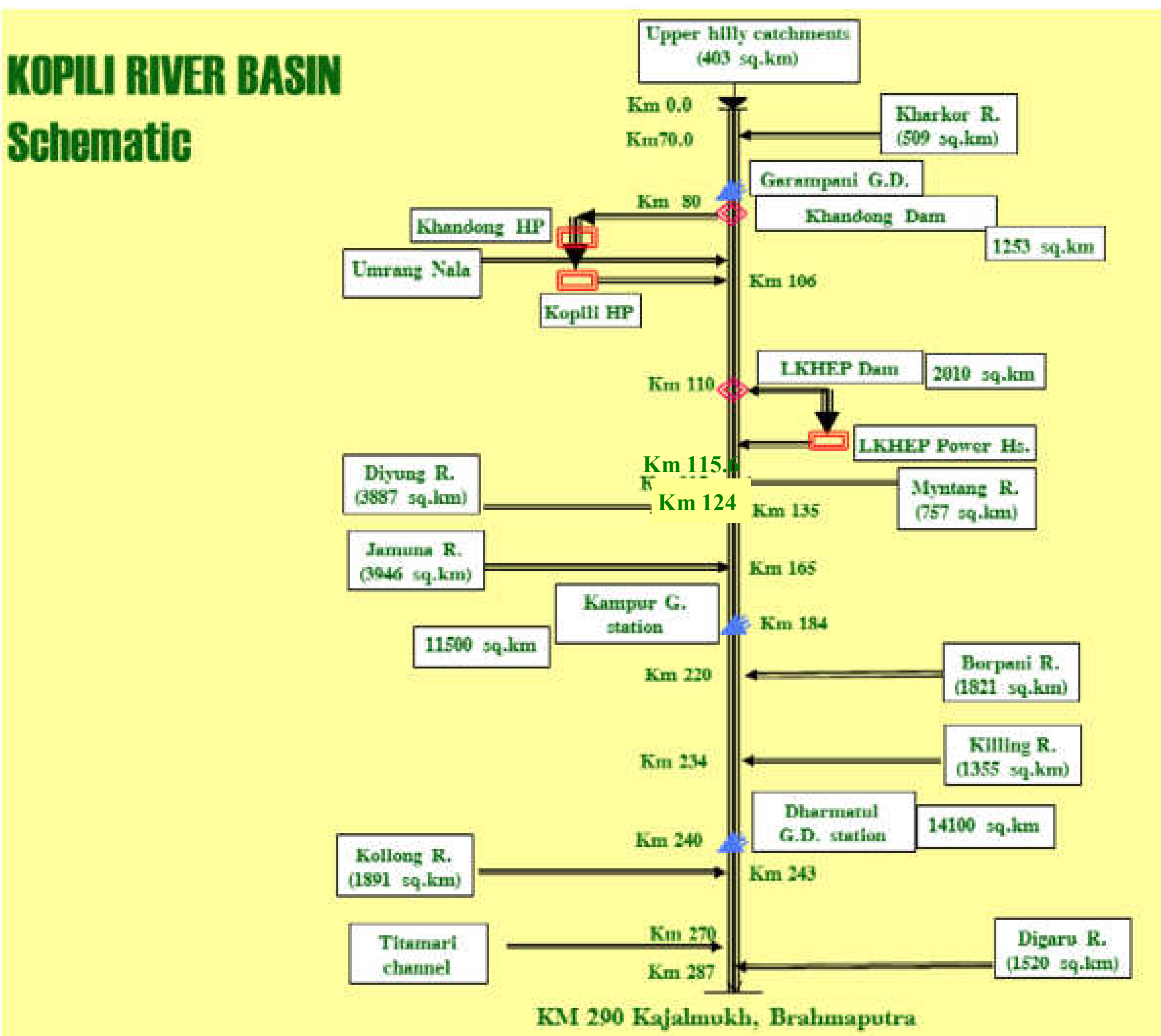
43. Before the start of civil works for the any facility of the project, the EA (project proponent) must obtain necessary clearances/permits from the statutory authorities. The EA will comply with the conditions of the EC and FC given to the project by concern authorities. The conditions of EC and FC will form integral part of the EIA and EMP.

III. PROJECT DESCRIPTION

A. Type of Project

44. To meet the ever-increasing demand of reliable and sustainable power in Assam and North-Eastern (NE) region, the EA has proposed the LKHEP (project) which consists of building a dam across Kopili river at Longku. The proposed project is situated in the Karbi Anglong and Dima Hasao (also known as North Cachar Hills) Autonomous District Council (ADC) areas of Central Assam. The Kopili river has two hydroelectric power plants already operational, both upstream of the proposed project: Khandong HEP (75 MW, served from Khandong reservoir on Kopili river) and Kopili HEP (200 MW, served from Umrong reservoir on the Umrong river). Umrong river is tributary of Kopili river, and receives water from the Umrong river as well as the tail water from the Khandong power plant. Both the existing power plants upstream of the proposed project are owned and operated by North Eastern Electric Power Corporation Limited (NEEPCO). Figure 2 show the schematic of Kopili River Basin.

Figure 2: Schematic of Kopili River Basin



45. The proposed project will receive water from (i) tail race water release from the existing Kopili power plant, (ii) incremental flow from the river catchment area between Khandong dam and the proposed LKHEP dam, and (iii) any reservoir spill from Khandong and Umrong reservoirs. The proposed project is designed to operate as a run-of-river power plant, and proposed to have a total capacity of 120 MW, in two power plants: the main power house (MPH) will be rated at 110 MW and the auxiliary power house (APH) will be rated at 10 MW. The MPH would receive water diverted at the dam in Longku on Kopili river, while the APH is located at the bottom of the dam at Longku, using water released at the bottom of the dam to maintain the minimum river flow downstream of Longku. The MPH is expected to operate on base load during rainy season, but operate at the diurnal peak time during the dry season. The APH would operate throughout the day, when water is released from the bottom of the dam to maintain the e-flow. Table 6 shows the basic information about the project.

Table 6: Details of the LKHEP Project

Name of the Project	Subproject No.	Total Project Capacity (MW)	Districts	State
Lower Kopili Hydroelectric Project in the State of Assam	Tranche 3 of APSIP MFF (Non-sample subproject)	120 MW	Karbi Anglong and Dima Hasao	Assam

B. Need for the Project

46. **Socio-economic Context in Assam**: There are about 700 tea gardens in Assam. Taking an average requirement of 300 kW per tea garden, the total power requirement for tea gardens works out to 210 MW while only 60 MW is currently supplied by Assam State Electricity Board (ASEB) and rest on diesel generating (DG) sets. Many tea processing factories burn coal for steam generation utilized for dying of tea leaves. Furthermore, the per capita electricity supply of 228 kWhr/person/year in Assam is only a quarter of the National per capita generation of 720 kW hr. This suggests that Assam has one of the lowest per capita electricity consumption in India; affecting both the quality of life and level of economic activity in the State.

47. Currently, APGCL's total installed capacity is 375 MW and with the State share of 710 MW in central generating stations of North-East region, the total capacity is 1,085 MW. This compares well with the peak demand of 1,250 MW but problems such as high pilferage, poor liquidity, solvency and escrow ability, poor quality of transmission and distribution (T&D) systems (loss of the order of 50%), inadequate transformation capacity, insufficient capacitor banks and high density of low tension (LT) lines vis-à-vis high tension (HT) lines, implies that the State has a perpetual power shortage condition.

48. Assam also faces a huge hide-thermal imbalance as almost all of the State's power generation comes from thermal sources although these are not in good shape, e.g. the 60 MW Chandrapur Thermal Power Station has been closed down due to high price of fuels; the 240 MW Bongaigaon Thermal Power Station hardly generates power due to poor coal linkage and structural problems in turbo-generators. Out of the APGCL's total installed capacity of 375 MW, 276 MW is derived from Gas Based Thermal Power Stations, but natural gas resources are depleting, and gas providers such as Oil and Natural Gas Corporation Limited of India and GAIL India Limited are unable to meet existing commitments to APGCL such as towards Lakhwa thermal power station. As a result, Assam's peaking shortage is about 12.5% while the energy shortage is about 4.5% and the gap between the average cost of supply and the average tariff is about Rs. 4.00 per unit.

49. The commissioning of the 100 MW Karbi Langpi Hydroelectric Power Project (not in the Kopili river basin) has been a major step forward in improving the power scenario in the State. In addition, the 120 MW LKHEP (project) will harness the hydropower potential of the State and help alleviate power shortage, provide peaking capacity and correct the hydro-thermal imbalance. The project will contribute in meeting the future power demand in the State, thereby improving livelihoods and inducing economic activity.

50. **Power Potential, Supply–Demand in India and at Regional Level:** As per the latest assessment (2015) carried out by the Central Electricity Authority (CEA), exploitable hydro potential in India has been estimated at about 84000 MW at 60% load factor, yielding an annual power generation of over 440 TWh of electricity and with additional seasonal energy, the total energy potential is about 600 TWh per year. Only 20.43% of this potential is under operation and 5.07% of the potential is under execution while the 74.5% of this potential is yet to be developed (Table 7). About 75% of the hydro potential in India comes from the Himalayan river systems (the Indus, Ganga and the Brahmaputra), of which 37.9% is located in the North-Eastern (NE) region[6] and 35.9% in the Northern region.

Table 7: Status of Hydro-electric Potential Development

(In terms of installed capacity – Above 25 MW) (Status as on 31.03.2015)

Region/State	Identified Capacity		Capacity Under Operation		Capacity Under Construction		Capacity Under Operation + Under Construction	
	Total (MW)	Above 25 MW	(MW)	%	(MW)	(%)	(MW)	(%)
NORTHERN	53,395	52,263	17,852.3	34.16	5,362.0	10.26	23,214.3	44.42
WESTERN	8,928	8,131	5,552.0	68.28	400.0	4.92	5,952.0	73.20
SOUTHERN	16,458	15,890	9,426.9	59.33	510.0	3.21	9,936.9	62.54
EASTERN	10,949	10,680	3,138.7	29.39	2,902.0	27.17	6,040.7	56.56
NORTH-EASTERN	58,971	58,356	1,242.0	2.13	2,954.0	5.06	4,196.0	7.19
Meghalaya	2,394	2,298	282.0	12.27	40.0	1.74	322.0	14.01
Tripura	15	0	0.0	0.00	0.0	0.00	0.0	0.00
Manipur	1,784	1,761	105.0	5.96	0.0	0.00	105.0	5.96
Assam	680	650	375.0	57.69	0.0	0.00	375.0	57.69
Nagaland	1,574	1,452	75.0	5.17	0.0	0.00	75.0	5.17
Other State	50,328	50,064	405.0	0.81	2,854.0	5.70	3,259.0	6.51
Mizoram	2,196	2,131	0.0	0.00	60.0	2.82	60.0	2.82
ALLINDIA	148,701	145,320	37,211.8	25.61	12,128.0	8.35	49,339.8	33.95

Source: CEA website

51. **Power in North-Eastern (NE) Region:** Over the last 50 years of planning and development, only a fraction of hydroelectric potential in the NE region has been developed and the region remains economically the most backward and under developed part of the nation. The region has only 60 kWh per capita consumption of electric energy against national average of 280 kWh. There is a wide variation in demand, availability and installed capacity in the region, and a steep rise in the shortfall from 1990-91 onwards. Therefore, the NE region suffered from serious load shedding rendering the region unsustainable for developmental activities.

52. **Power Potential in Assam:** Investigations carried out so far reveal that the proven power potential through hydroelectric projects in Assam is of the order 495 MW installed

[6] The hydro potential of the NE region is approx. 32,000MW at 60% load factor, which is almost 95% of the Brahmaputra basin potential.

capacity with annual generation of the order 2,482 Million Units (MU) as shown in Table 8. Except 100 MW Karbi Langpi (Lower stage) HEP (which is operations) all other projects are planned. None of these projects are related to LKHEP (they are not in the same basin).

Table 8: Total Hydro Potential in the State of Assam

Sl. No.	Name of Project	Installed Capacity (MW)
1	Lower Kopili HEP	(2 x 55)+(2 x 2.5+1 x 5)=120
2	Karbi Langpi (Lower stage) HEP	2 x 50=100
3	Karbi Langpi (Upper stage) HEP	2 x 30=60
4	Karbi Langpi (Intermediate Stage) HEP	
	Stage-I	21
	Stage-II	24
5	Karbi Langpi Dam Toe Project	19
6.	Amring HEP	2x10 = 20
7.	Dhansiri HEP	20
8.	Small, Mini & Micro Hydel Projects	111
	Total	**495 MW**

Source: Detailed Project Report

53. **Load Survey Status:** There is a rapidly increasing demand of power in the State on account of huge number of tea factories, development of forest-based agro industries, cement production units, and various small scale industries. The ASEB has projected demand up to 2019-20 as 2,222 MW. To offset increasing demand, APGCL is implementing energy efficiency measures (such as refurbishment of turbines and equipments, improvement in transmission and distribution systems, etc.). Table 9 presents yearly expected demand position from 2014-15 to 2019-20.

Table 9: Yearly Expected Demand Position till 2019-20

Sl. No.	Financial Year	Demand	Availability	Shortfall		Rise in Demand
		MW	MW	MW	%	%
1	2014-2015	1618	1608	10	1	1
1	2015-2016	1715	1644	71	41	41
2	2016-2017	1817	1644	173	10	10
3	2017-2018	1946	1706	240	12	12
4	2018-2019	2080	1706	374	18	18
5	2019-2020	2222	1706	516	23	23

Source: Detailed Project Report

54. In summary, the current power scenario in the State suggests a severe power crisis, and the requirement for the proposed project cannot be overemphasized due to the following:

- Currently, out of 375 MW installed capacity in the State, about 275 MW comes from gas-based thermal plants.
- There are no known gas reserves in the State to support existing or new gas based power projects.
- Gas producing agencies like ONGC and GAIL are finding it difficult to meet existing power requirements.
- There are inefficient coal linkages as the Coal India Limited (CIL) is not able to meet its existing commitments and not providing new linkages.

C. Location and Features of the Project

55. The Kopili river originates in the Meghalaya state at an altitude of about 1,600 meter above sea level, and flows over a distance of about 300 km through the states of Meghalaya and Assam, and then joins the Brahmaputra river. The EA proposes to build the project (a dam) across Kopili river at Longku. The proposed project is situated in the Karbi Anglong and Dima Hasao (also known as North Cachar Hills) ADC areas of Central Assam. Project location maps are shown in Figure 3 (on map of India) and Figure 4 (on Google-earth map).

Figure 3: Location of Project on Map of India

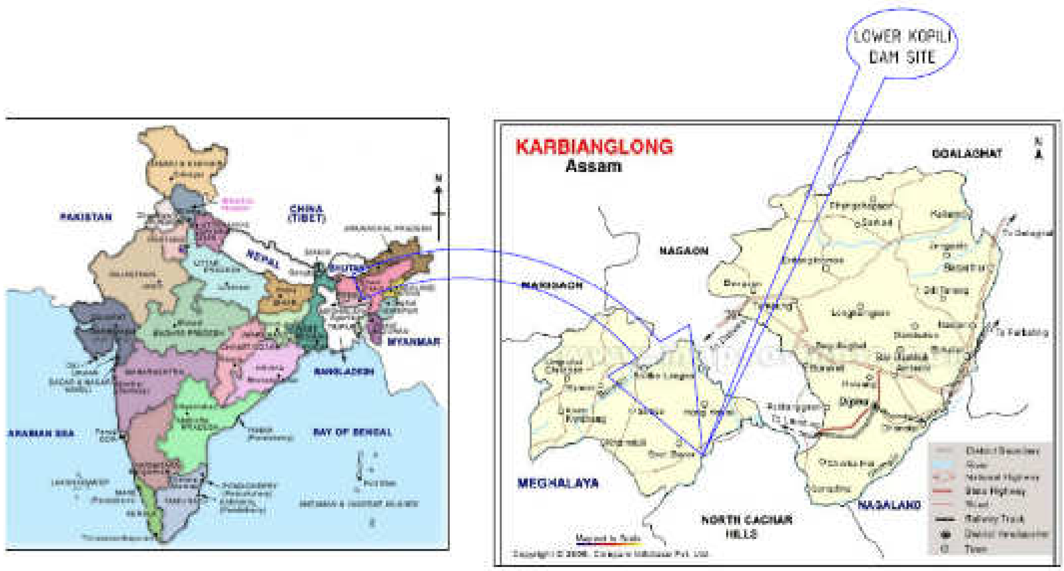
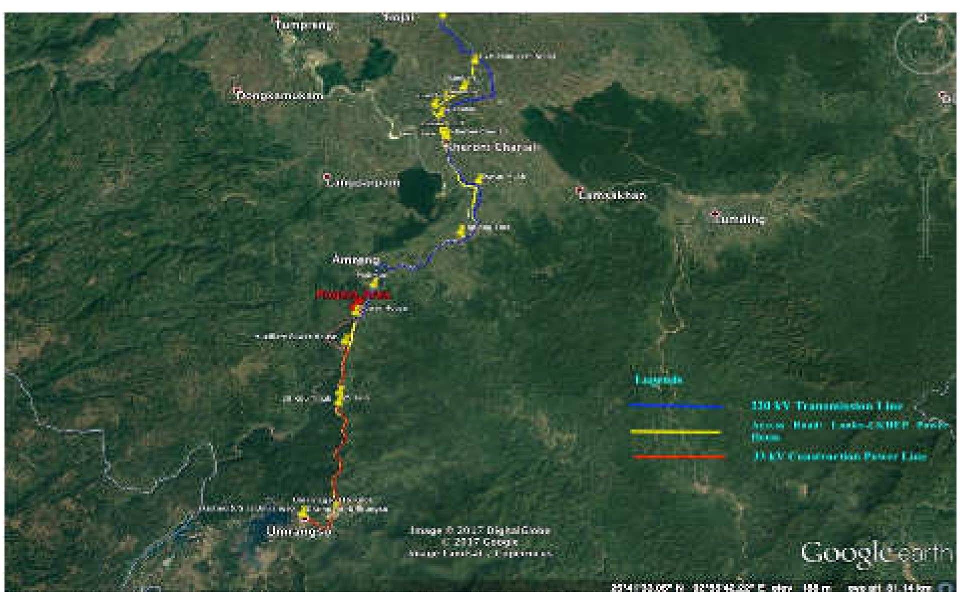


Figure 4: Location of Project (Project Facilities) on Google Earth Map



56. The Project location (dam site) is defined by 25°39'57.39"N latitude and 92°46'53.62"E longitude. The Kopili river has two HEPs already operational, both upstream of the proposed project: Khandong HEP (75 MW, served from Khandong reservoir on Kopili river) and Kopili

HEP (200 MW, served from Umrong reservoir on the Umrong river). Umrong river is tributary of Kopili river, and receives water from the Umrong river as well as the tail water from the Khandong power plant. Both the existing power plants upstream of the proposed project are owned and operated by NEEPCO.

57. The MPH of 110 MW is designed to have an average net head of 108 m. It is estimated to produce 456 GWh of electricity per year under average hydrological conditions. The APH is estimated to have a net head of 47 m, to produce 55 GWh of electricity per year. Accordingly, the two power houses of LKHEP are expected to jointly produce 511 GWh per year, reflecting an annual capacity factor of 48.6%.

58. The dam proposed to be built at Longku will be a concrete gravity dam, of height 70.13 m and width 345.05 m. The crest of the dam will be 232.5 m above mean sea level (MSL). The dam will create a reservoir at Longku with a spread of 620 ha, with a live storage of 77 million cubic meter. The maximum operating level will be 226 m above Mean Sea Level (MSL), while the maximum water level expected will be 229.6 m above MSL. Water stored in the reservoir will be taken out for power generation through two separate intake structures, one for the MPH and the other for the APH. The MPH intake is on the right bank of the reservoir, and would be controlled with 2 vertical gates. The APH intake too has 2 vertical gates.

59. A tunnel will be excavated to deliver the water from the reservoir to the MPH. Water from the intake to the MPH enters the tunnel of diameter 6.65 m on the right bank of the Kopili river. The designed discharge capacity is 112.7 cum per second, at a flow velocity of 3.13 m/s. This tunnel will be 3.6 km long at a gradient in the range 1:88 to 1:110. At the end of this low pressure tunnel, water will enter the pressure shaft. The pressure shaft will be circular of 5.2 m diameter, steel lined, with a length of 704 m. The pressure shaft will deliver water to two steel penstocks each of length of about 60 m, which in turn would convey water to the turbines. Water to the APH will be taken directly along a steel-lined circular pressure shaft of diameter 2.7 m and of length 70 m, and delivered to the turbine through three steel penstocks, each about 30 m long.

60. The MPH and APH will be surface-type power houses. The MPH will have two generating units each rated at 55 MW. Turbines will be of Francis type. Each turbine will be mounted on a vertical shaft, with the respective power generator mounted above the turbine. The APH too will have two Francis turbines, but they will be mounted on a horizontal shaft. The rated speed of the MPH will be 230.8 revolutions per minute (rpm), while the APH will have a rated speed of 750 rpm. Power generated at the MPH will be stepped up from its generating voltage of 11 kV to 220 kV. This transformation will be done using six single phase transformers, and there will be one spare transformer. Power generated at the APH will be stepped up to 33 kV from its generating voltage of 6.6 kV, using two 3-phase transformers.

61. Water released from turbines at the MPH will be taken along a 3.2 km long tail race channel to be built under the project, and discharged to the Kopili river at an elevation of 102 m above MSL at about 5.6 km downstream from dam section. The tail race channel of the APH will release water to the river at an elevation of 168.5 m above MSL. Figure 5 shows the layout plan of the project.

62. There will be temporary structures built to facilitate construction of the dam at Longku and the tunnel. The Kopili river will be diverted using a coffer dam and a diversion channel, both upstream and downstream. The upstream coffer dam will be 18 m tall, and 160 m wide. Its crest will be at 186 m above MSL. There will also be a downstream coffer dam, 13 m tall and 126.3 m

wide. The diversion channel will be of cross section 11m x 11m, and 98.2 m long at upstream, and 59.2 m long at downstream as shown in Figure 6.

63. **Power Evacuation System:** Power generated at the 110 MW MPH would be transferred to the Lanka substation (S/S) located at Shankerdev Nagar, through a new 220 kV double circuit (DC) transmission line. This transmission line is estimated to be about 50 km long and would use a new right of way (RoW) from LKHEP to Lanka. The existing S/S at Lanka is presently rated at 132/33 kV, and this S/S will be upgraded and expanded to 220/132kV to receive power from the project. Power received at Lanka from the project will be partly used to serve customers and regions presently served by the Lanka S/S. The balance power from the project will be transferred to the upstream network through the Lanka-Misa transmission lines. Figure 8 shows the alignment of the transmission line.

64. Power generated at the 10 MW APH will be transferred to Umrangso, along a new double circuit 33 kV line, 20 km long, to be built under the project. There is an existing 33/11 kV S/S at Umrangso, where two new bays would have to be built to receive the new line from the project. There will be a 33 kV connection from the APH to the MPH, to provide auxiliary power and back-up power, to ensure the ability to start the MPH, in case the Lanka S/S is de-energized during a transmission network outage in the Lanka-Misa area.

65. **Timeline and Schedule of Project:** The construction schedule of LKHEP is expected to be four years from the commencement of work on physical infrastructure required to facilitate construction of the dam and the reservoir. Once completed, the LKHEP will operate to serve the State grid in Assam.

66. **Access to Project Site:** The project site can be reached by road from Guwahati on the National Highway (NH-52) up to Lanka (distance of approximately 180 km). From Lanka up to the dam site area, the State Highway exists (for 33 km) and further up becomes the PWD road (Longku-Garampani). This will be the main access road to the project. Total length from Lanka to the project site is 48 km. Several smaller access roads are proposed from the PWD road to various project components e.g. dam complex and Power House, etc. (length of approximately 13.10 km). The Lokpriya Gopinath Bordoloi International Airport at Guwahati connects Guwahati to all important destinations of India and abroad by air, whereas nearest railhead will be at Lanka which is proposed to be used as transit point for various construction materials like cement, steel, etc.

D. Project Components and Key Parameters

1. Project Components

67. The key components of the project are:

- Dam: A concrete gravity dam with 8 sluice spillways, 345.05 m long, 70.13 m high across river Kopili at Longku.
- Intake Structure: An independent intake structure with trash racks located at 35 m upstream of Lower Kopili Dam to carry a discharge of 112.71 m^3/sec.
- Head Race Tunnel: 6.65 m diameter, 3,619.62 m long, modified horse shoe section, with one adit 334 m long, 6.0 m diameter. D-shaped at CH. 2,216.44 m.
- Surge Shaft: 25.0 m diameter, 82.9 m total height with restricted orifice of 3.6 m diameter provided as a riser shaft of 32.21 m height (one adit is also proposed for approach to bottom of surge shaft).

- Pressure Tunnel: 5.20 m diameter, 703.8 m long up to bifurcation at 75 m upstream of D-line in the power house. The pressure tunnel is steel lined for its full length.
- Penstock: 2 nos. penstocks of 3.70 m diameter fully steel lined with lengths varying from 75 to 80 meters from bifurcation point to the power house.
- Power House: Surface main power house (MPH) to accommodate 2 units of 55 MW each. Main power house building of size 77.55 m (L) x 21.50 m (W) at the elevation of service bay with a common Electric Overhead Travelling (EOT) crane 230/40 t capacity over units and service bay.
- Draft Tube Gates: 2 Nos. of draft tube gates at EL. 92.00 m is proposed.
- Tail Race Tunnel: 1 No., 26.3 m wide and 52.0 m long rectangular channel with reverse slope of 1 in 5, designed for carrying a discharge of 112.71 m^3/sec.
- Auxiliary Power House: Surface auxiliary power house (APH) to accommodate 2 units of 2.5 MW each and 1 unit of 5 MW with a total of 10 MW. The power house building to be located just downstream of dam on the right bank side (e-flow goes through this).
- Tail Race channel of APH is an open channel.
- Improvement of 48 km long access road from Lanka to LKHEP.
- 13.10 km new small access roads to various project components.
- 20 km 33 kV construction power line from LKHEP to Umrangso.
- 50 km 220 kV transmission line from LKHEP power house to Sankardev Nagar.

68. The proposed layout of the project is presented in Figure 5. The project layout superimposed over toposheet is presented in Figure 6 and Figure 7. Figure 9 to 21 show the plans and sections of the main components of the LKHEP.

Figure 5: Project Layout Map

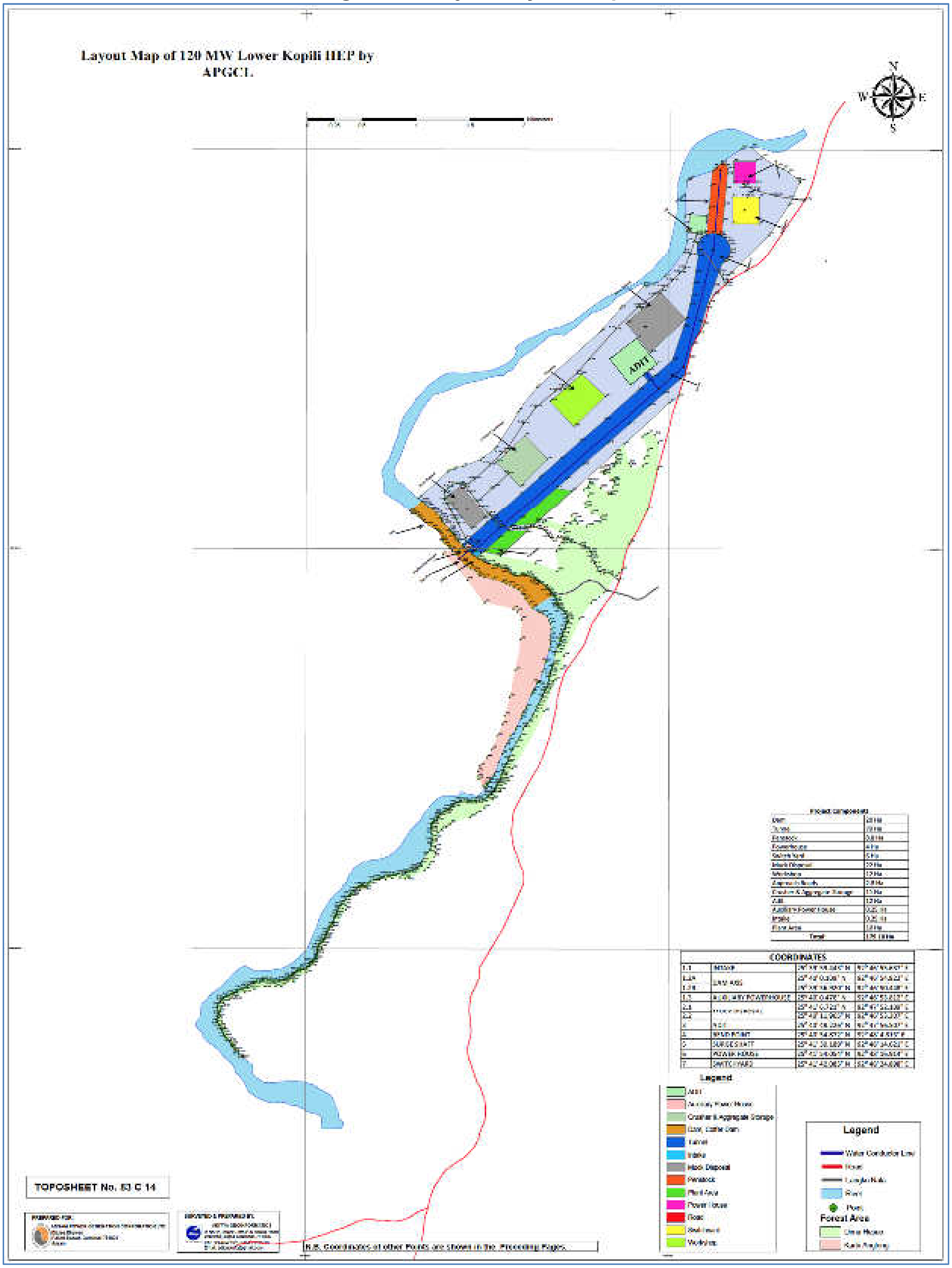


Figure 6: Project Layout superimposed over toposheet

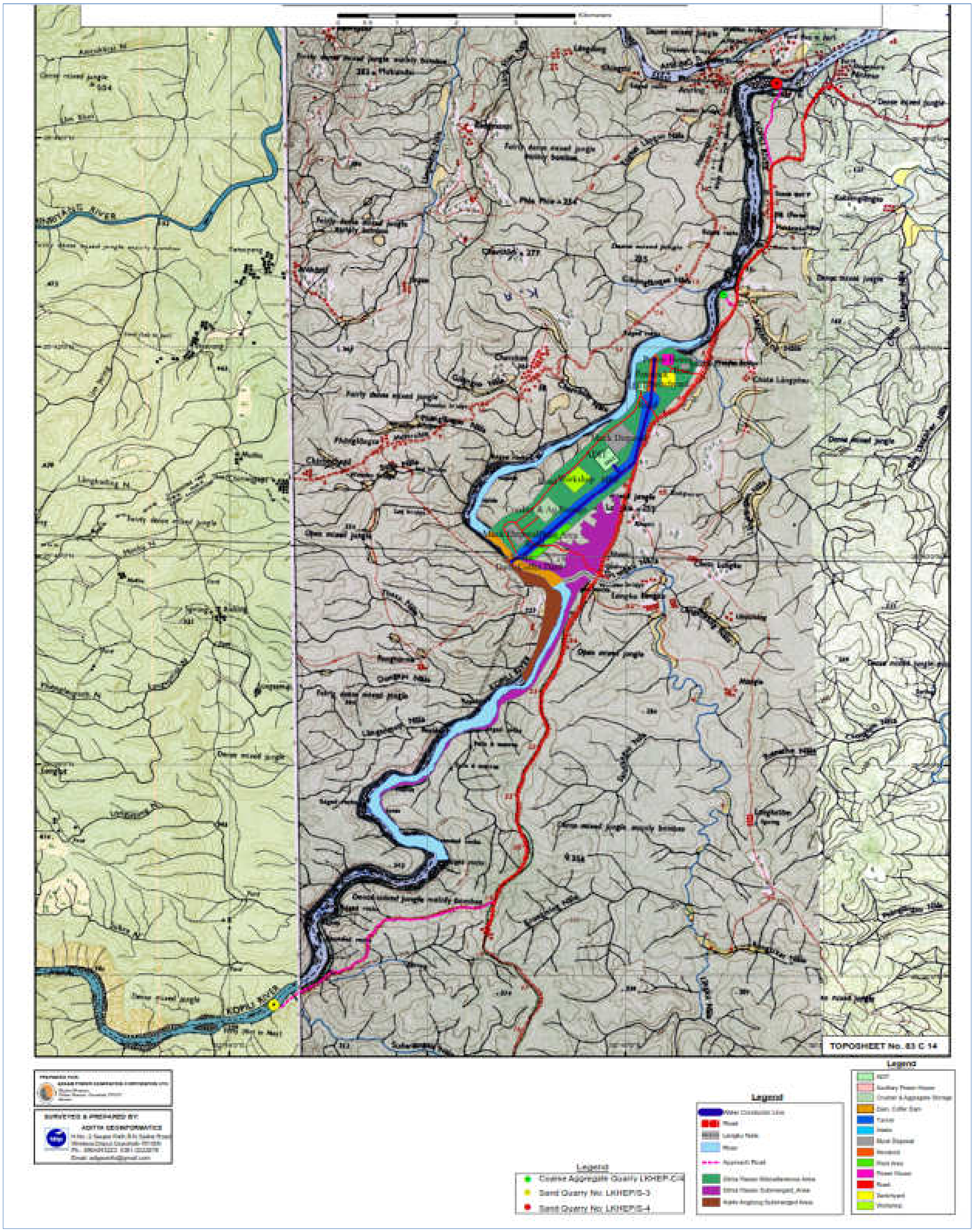


Figure 7: Project Layout on Topo map

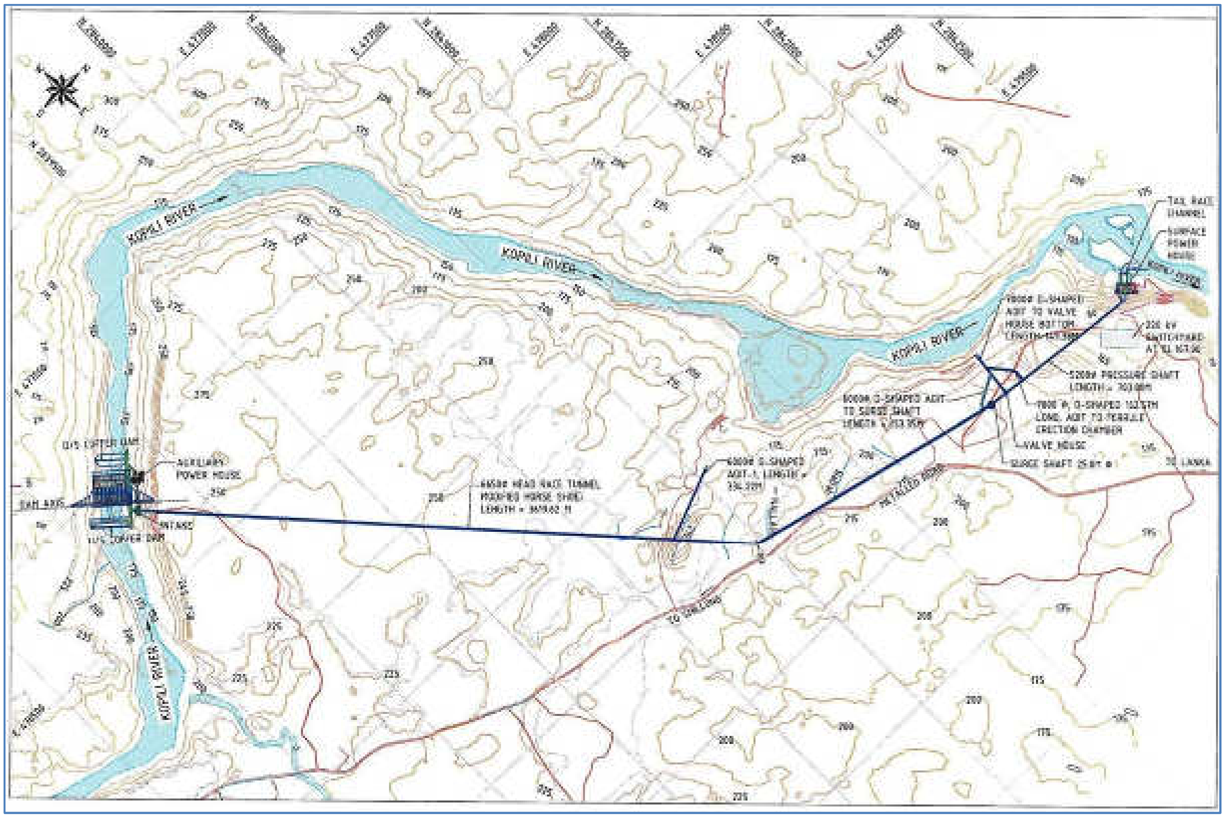


Figure 8: Proposed route map on Topographical sheet for the 220 kV TL

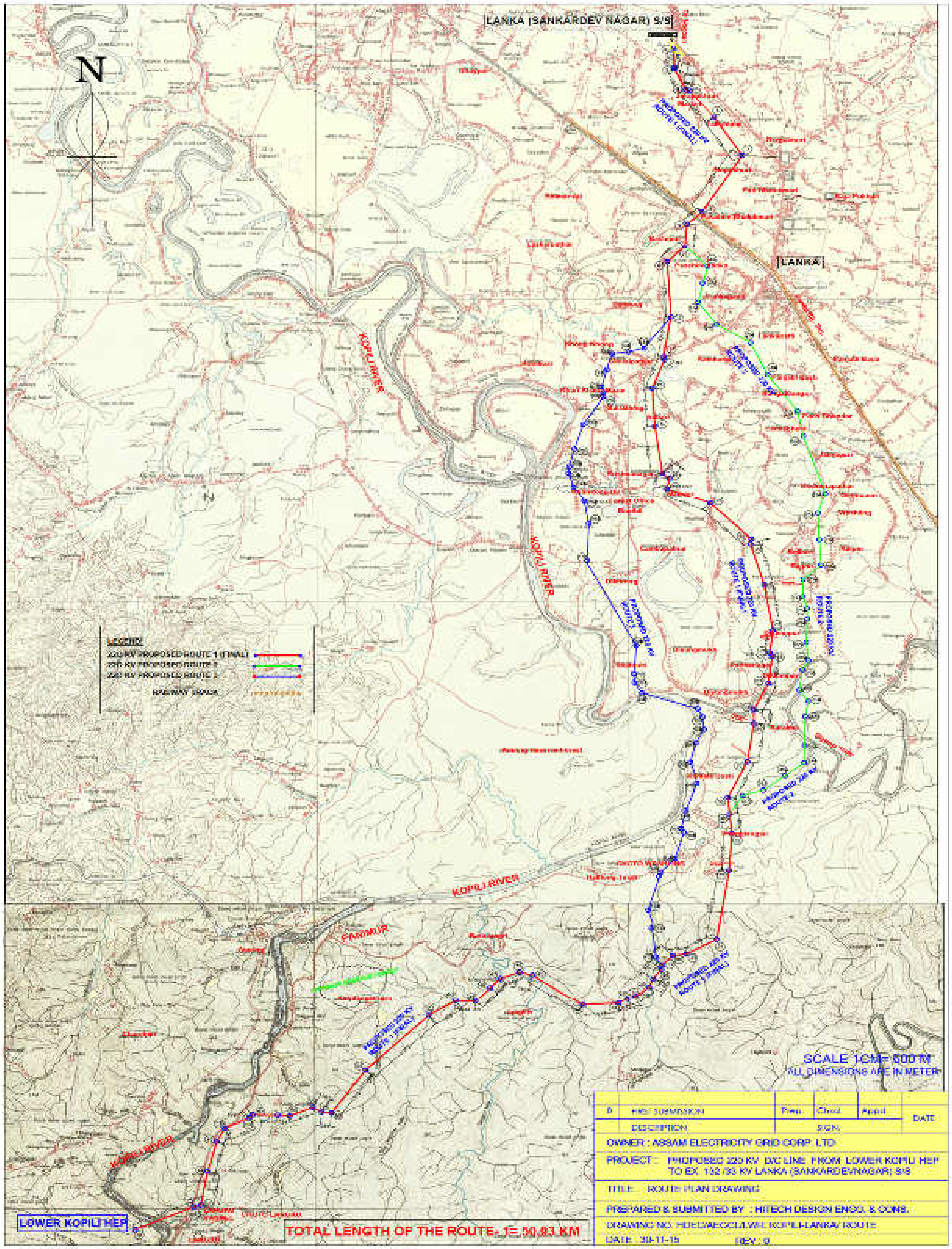


Figure 9: Layout Plan of the Coffer Dams, Diversion Channel & Construction Sluice

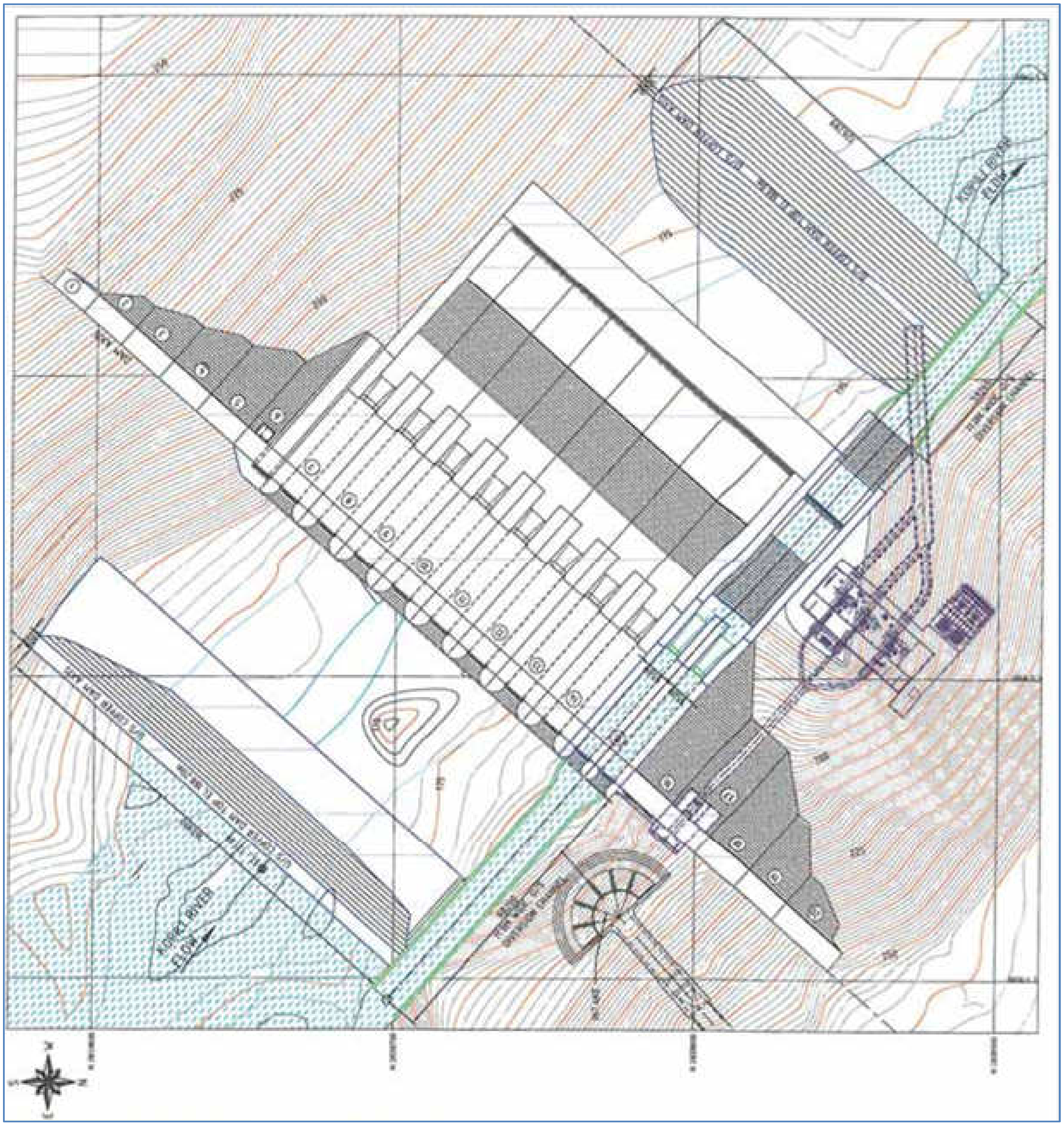


Figure 10: Geological Section at Dam Axis

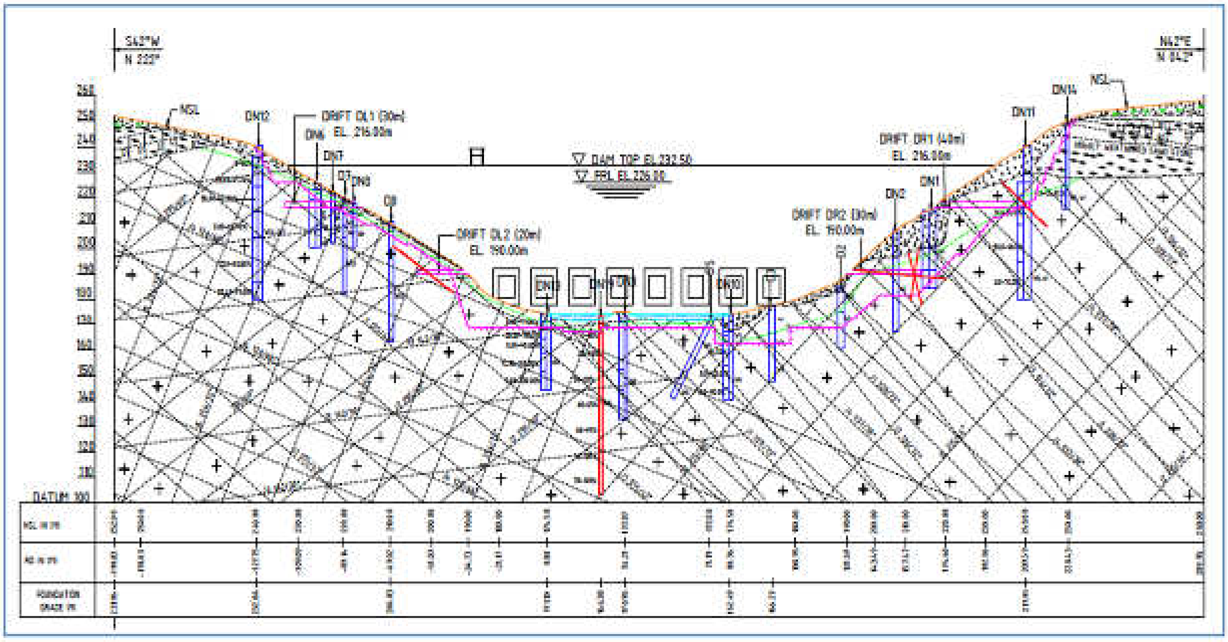


Figure 11: Dam Layout Plan

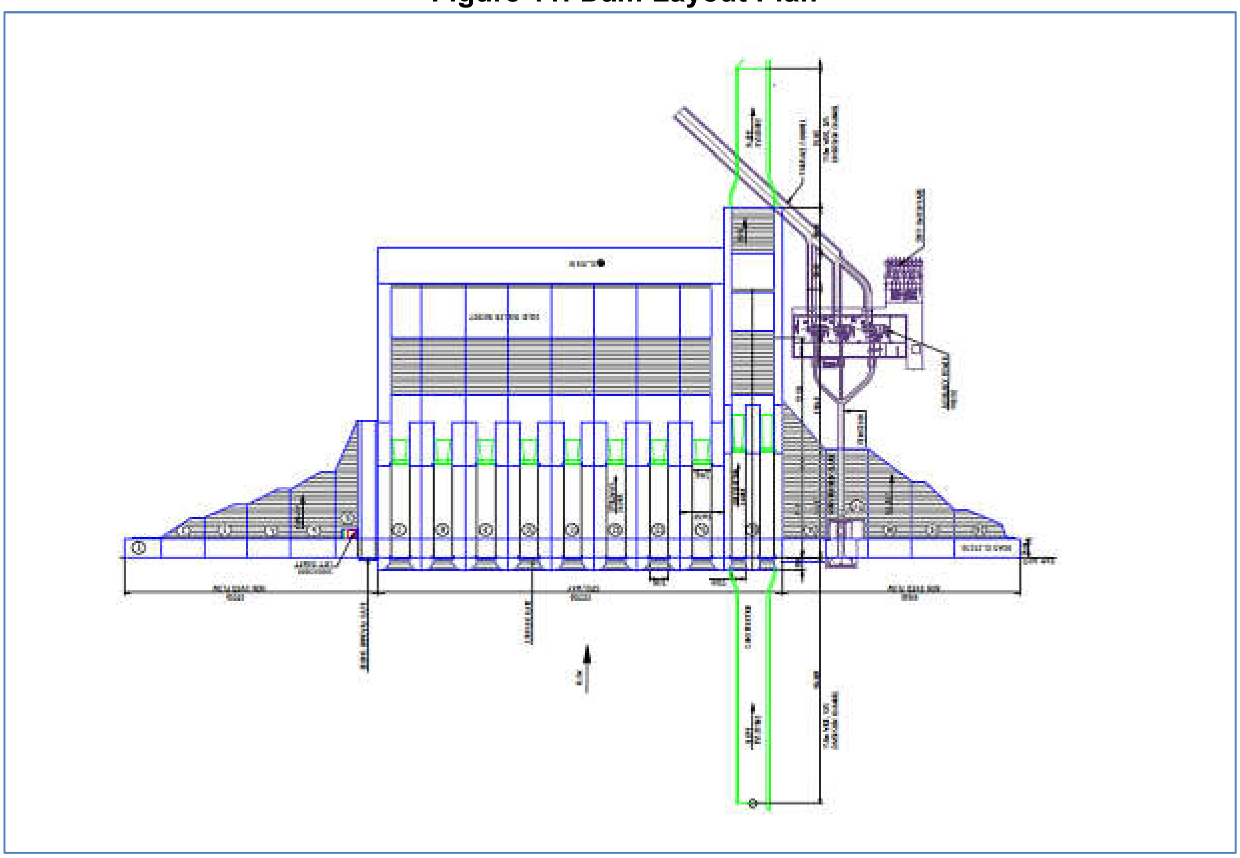


Figure 12: Dam Upstream Elevation

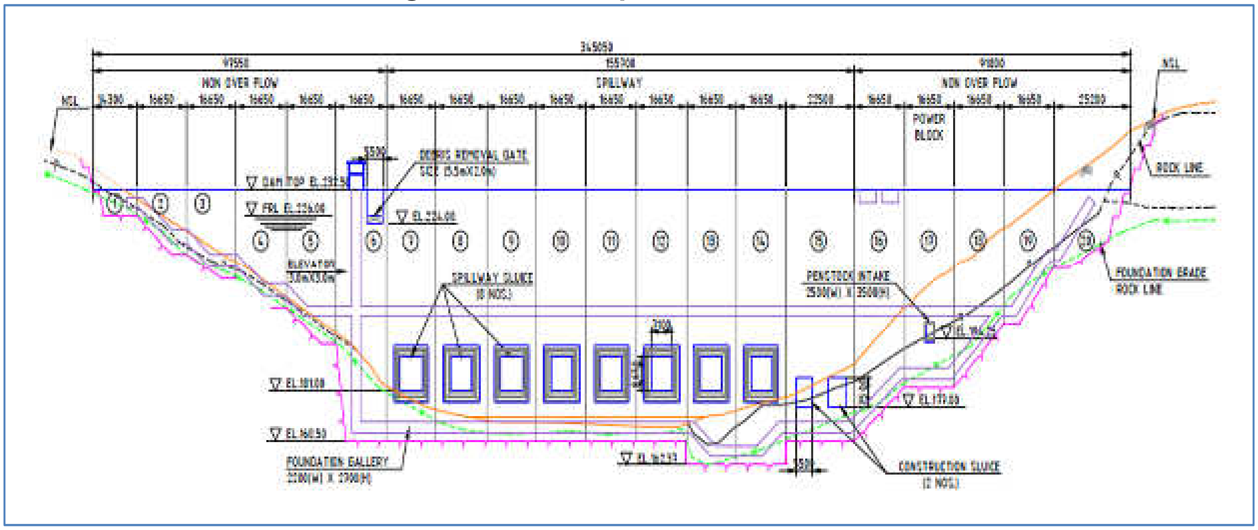


Figure 13: Upstream Inlet Section of the Diversion Channel

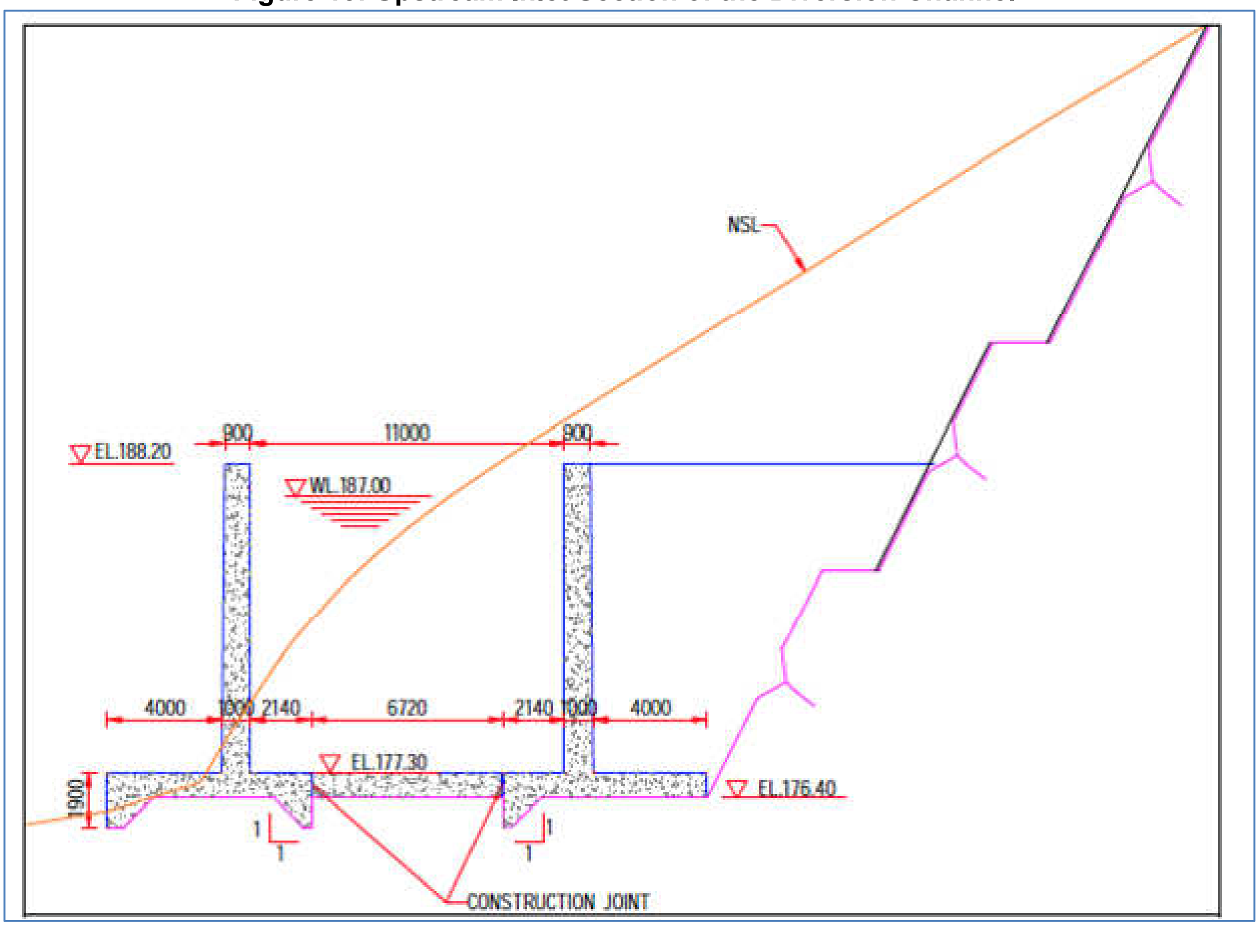


Figure 14: Dam Section through Spillway Sluice

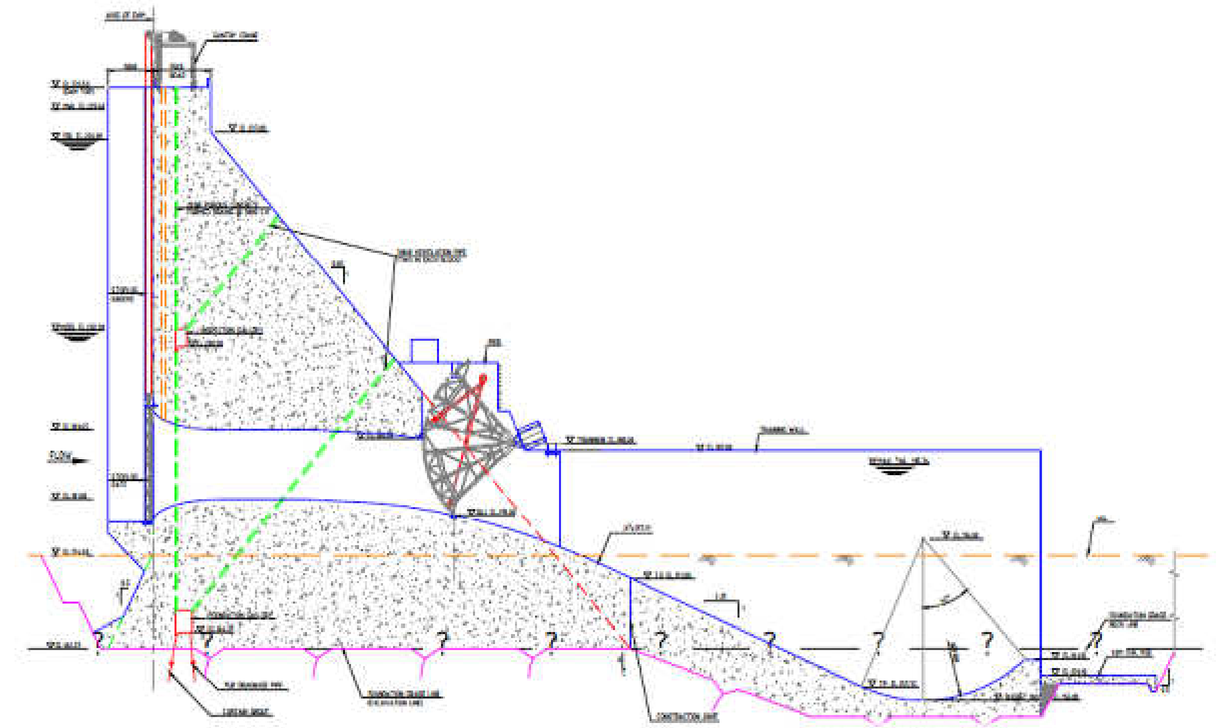


Figure DN 2.5: Dam Section through Spillway Sluice

Figure 15: Typical Section of the Upstream Coffer Dam

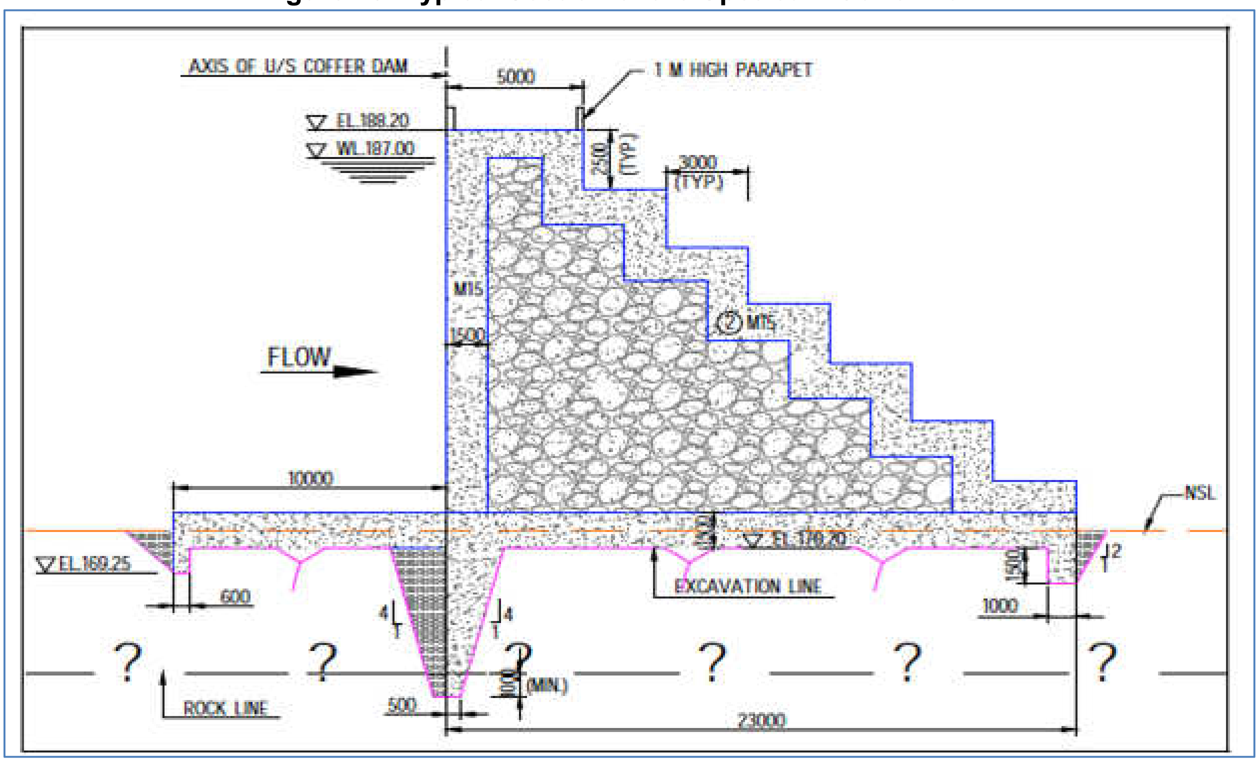


Figure 16: Typical Section of the Downstream Coffer Dam

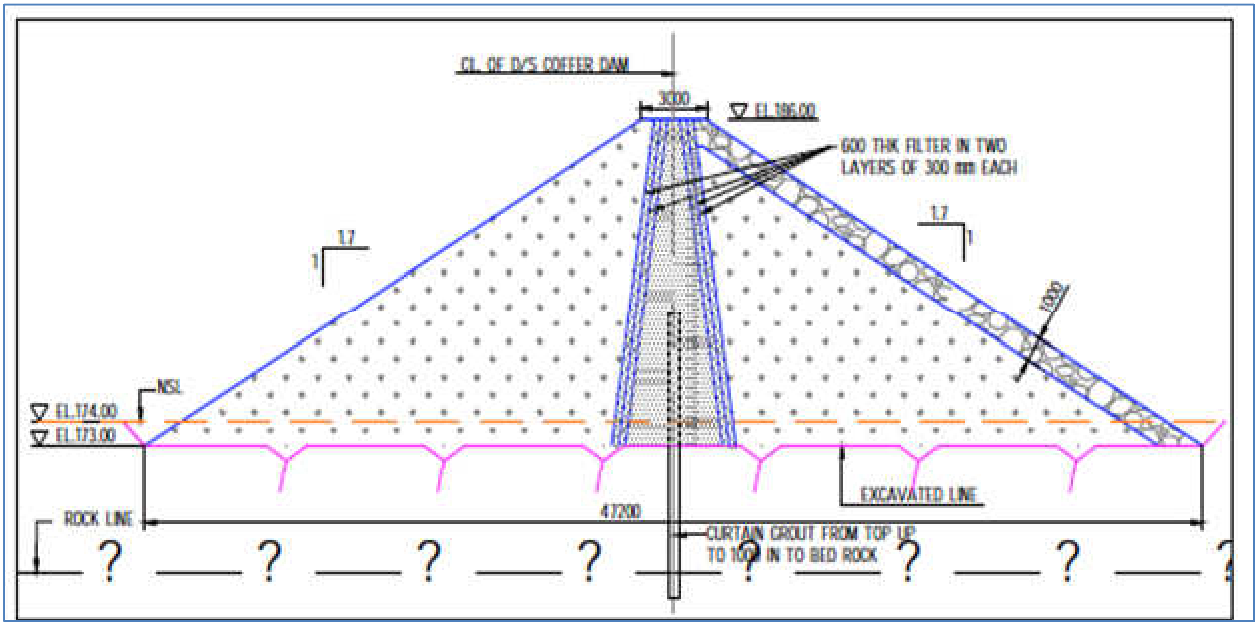


Figure 17: Typical L-Section of the Channel & Construction under sluice

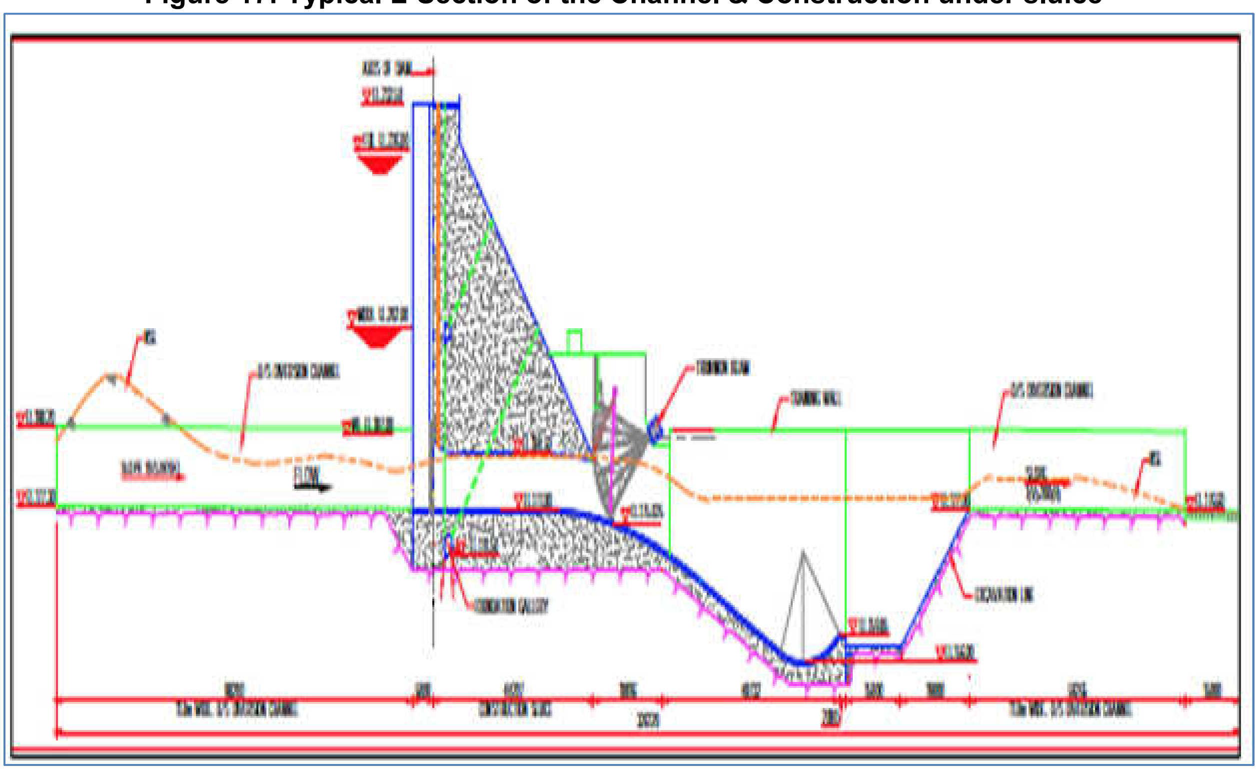


Figure 18: Power Intake – Plan

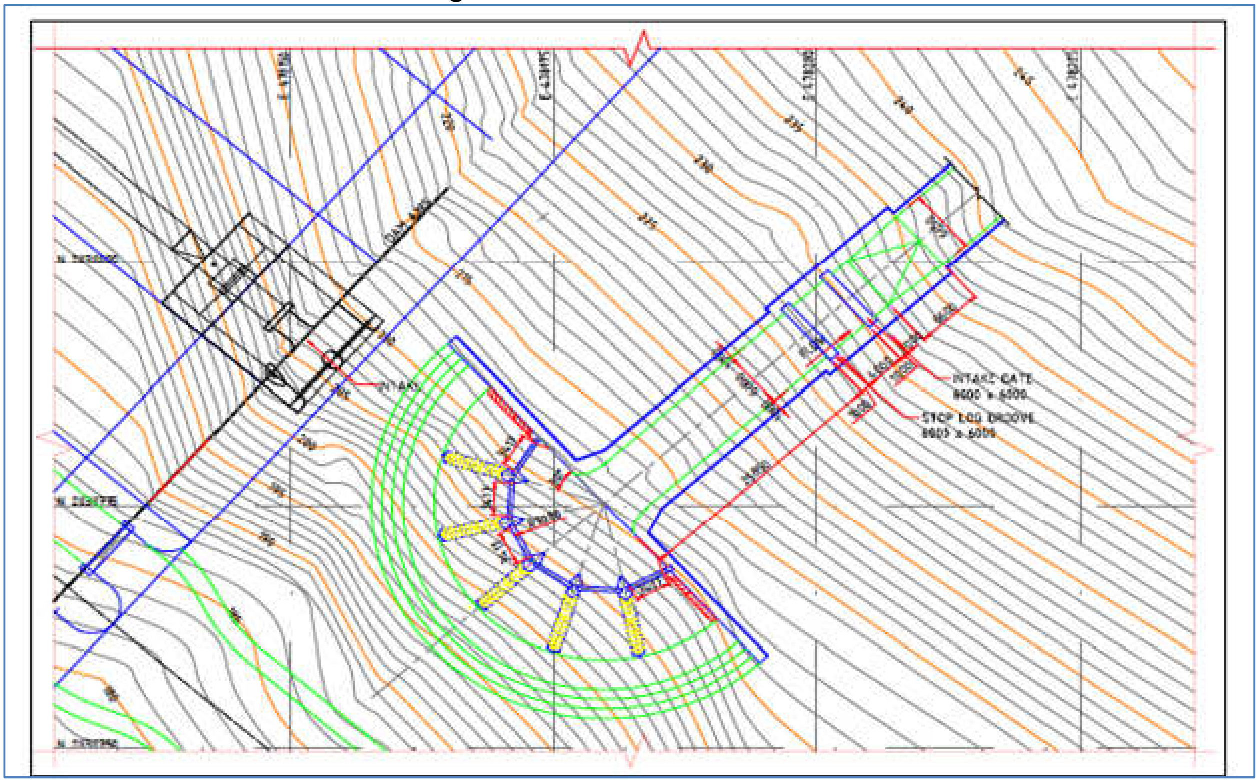


Figure 19: Typical Excavation & Support Details of HRT in Class III

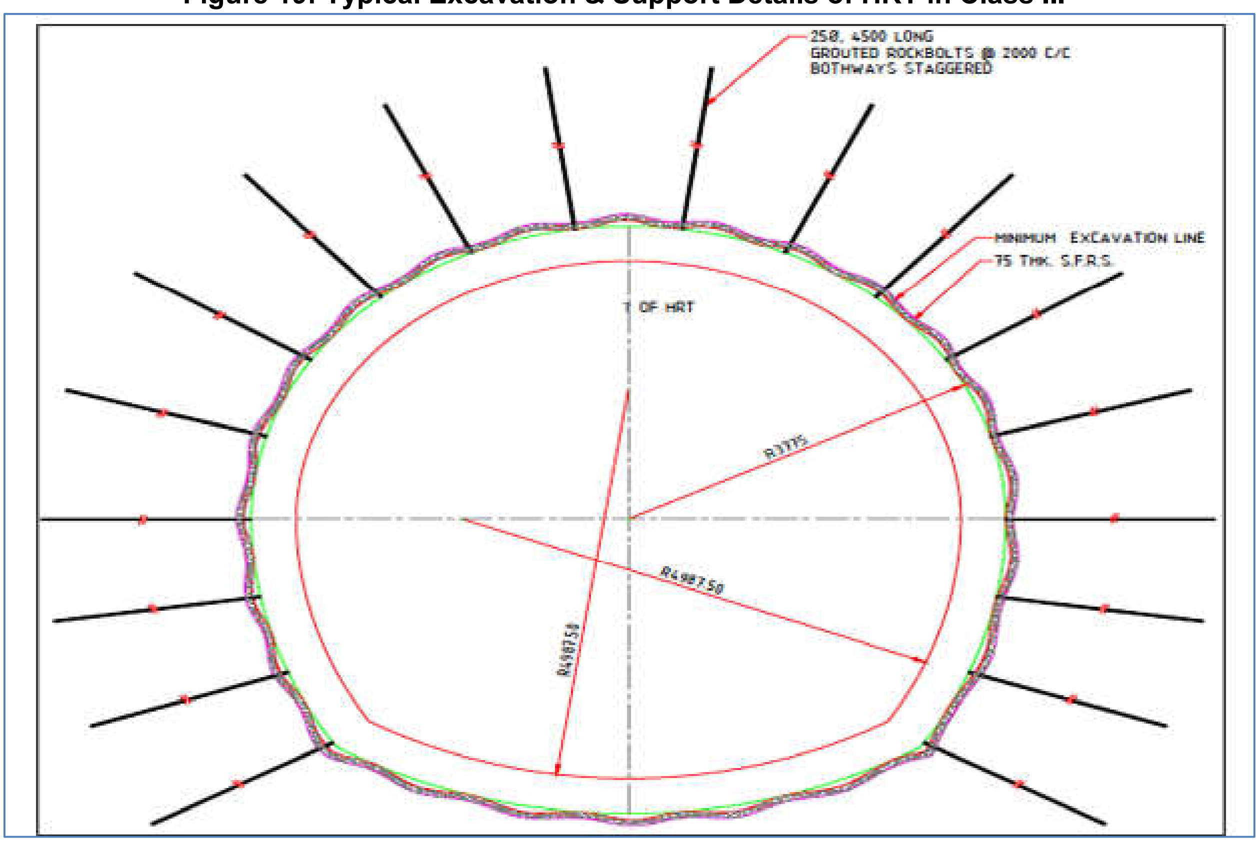


Figure 20: Surge Shaft Section

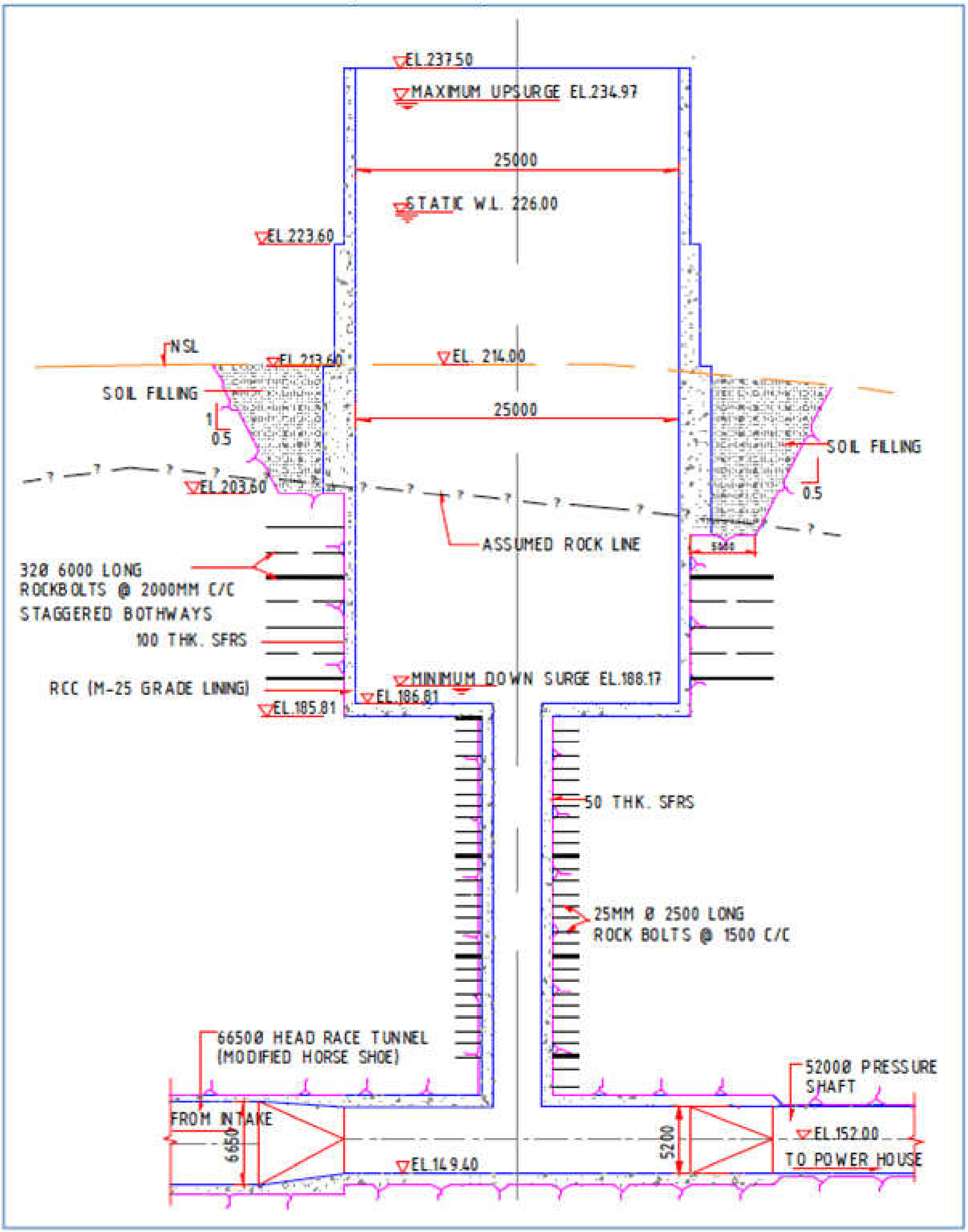
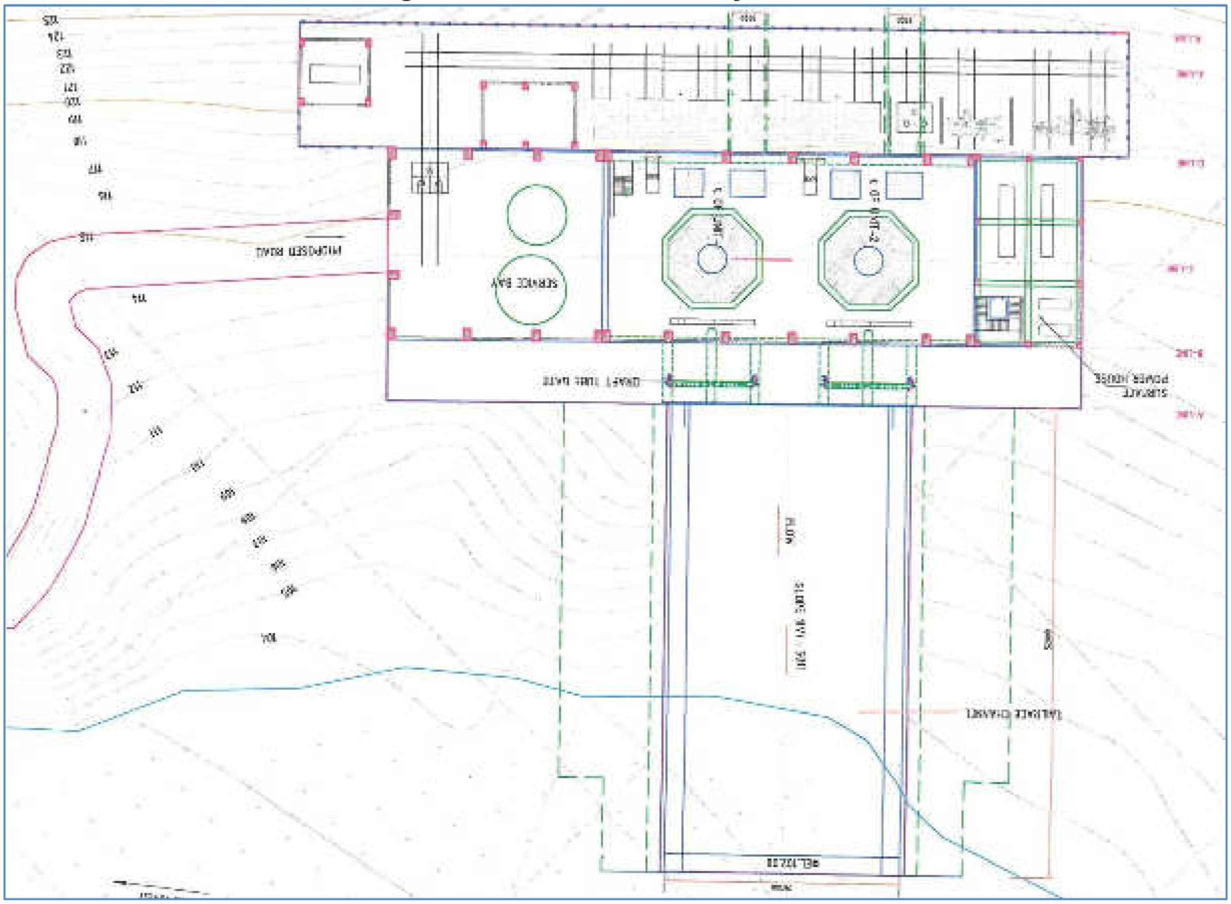


Figure 21: Power House Layout Plan



2. Salient Features

69. The salient features of the project are given in Table 10.

Table 10: Salient features of LKHEP

PROJECT LOCATION	
State	Assam
District	East of Karbi Anglong and West of Dima Hasao (North Cachar) Hills District
River	Kopili
Latitude	Diversion Site Powerhouse Site 25º39’57.39”N 25°41’54.02”N
Longitude	92º46’53.62”E 92°48’15.98”E
Nearest railway station	Lanka (BG), 48 km away
Nearest road	Lanka – Garampani road
Nearest township	Lanka 40 km away
CATEGORY OF PROJECT	Hydro Electric Power Project
HYDROLOGY	

Catchment area[7]	2,076.62 sq. km
Snowed catchment area	0
Lower Kopili (uncontrolled) catchment area	788 sq.km.
Average annual rainfall	1,557 mm
Annual evaporation rate	638.81 mm
Temperature	Summer – 23°C to 32°C Winter – 6°C to 14°C
90% dependable yield	2,184.4 MCM
50% dependable yield	2,483.6 MCM
Flood discharge for river diversion (25 years) Non monsoon flow (Nov. to May)	720 m^3/s
Standard Project Flood (SPF)	7,510 m^3/s
Probable Maximum Flood (PMF)	11,030 m^3/s
Sedimentation rate	0.1 Ha-m / km^2 /year
Environmental flow (e-flow)	Minimum 5.345 m^3/s
RESERVOIR	
Reservoir spread (at FRL)	620 ha
Maximum water level (MWL)	EL 229.60 m
Full reservoir level (FRL)	EL 226.00 m
Minimum draw down level (MDDL)	EL 202.00 m
Capacity at FRL	106.29 Mm^3
Capacity at minimum draw down level	29.00 Mm^3
Live storage	77.29 Mm^3
DAM	
Type	Concrete Gravity Dam
Average river bed level at dam axis	EL 174.00 m
Deepest river bed level	EL 172.00 m
Deepest foundation level	EL 162.37 m
Top of the dam (Bridge deck level)	EL 232.50 m
Maximum height of dam	70.13 m
Overflow spillway for debris removal size (W x H)	5.5 m x 2.0 m
Sluice spillway No. & size (W x H)	8 No.s, 7.1 m x 8.65 m
Construction Sluice spillway No. & size (W x H)	2 No.s, 5.5 m x 7.5 m
Non overflow length	Left - 97.55 m, Right - 91.80 m
Total width of dam structure including overflow & non overflow blocks	345.05 m
Crest level of overflow spillway for debris removal	EL 224.00 m
Crest level of sluice spillway	EL 181.00 m

[7] Out of a total catchment area of 2,076.62 km^2, 1,288.62 km^2 lies above the upstream reservoirs Umrong and Khandong. The remaining intermediate catchment between the upper reservoirs and the project dam is only about 788 km^2.

Crest level of construction sluice spillway	EL 177.00 m	
Energy dissipation arrangement	Solid roller bucket type	
Sluice spillway capacity	11,030 m^3/s	
Gate type & Number	Radial gate & 8 No. with hydraulic hoist	
Gate Size of Sluice Spillway (W x H)	7.1 m x 9.54 m	
Gate Size of Construction Sluice Spillway (W x H)	5.5 m x 8.475 m	
Spillway stoplog gate No. & Size	1 Set, 7.1 m x 14.33 m	
RIVER DIVERSION		
Diversion type	Coffer dams, Channel with construction sluices	
Upstream Coffer dam		
Type	Plum Concrete	
Height	18.00 m	
Top Length	160.10 m	
Top Level	EL. 188.20 m	
Downstream Coffer dam		
Type	Earth & Rockfill	
Height	13.00 m	
Top Length	126.30 m	
Top Level	EL.186.00 m	
Diversion Channel		
Diversion channel size (W x H)	11 m x 11 m	
Channel length	U/S-98.2 m, D/S 59.265 m	
INTAKE	**MAIN POWERHOUSE**	**AUXILIARY POWERHOUSE**
Number of openings	1	1
Invert sill level	EL 186 m	EL 194.25 m
Intake top level	EL 232.50 m	EL 232.50 m
Nominal discharge	112.71 m^3/s	24.94 m^3/s (e-flow of 5.345 m^3/s within this)
Intake gate - Number - Hoist type - Gate sill level - Gate operating platform level	2 vertical fixed wheel gates, one emergency - and other service gate Independent rope drum hoists EL 186.0 m EL 232.50 m	2 vertical fixed wheel gates, one emergency - and other service gate Independent rope drum hoists for emergency gate and hydraulic hoist for service gate EL 194.25 m EL 232.50 m
HEAD RACE TUNNEL		
Location	Right bank of Kopili river	
Excavated shape	Modified Horseshoe	
Finished shape	Modified Horseshoe	
Length	3,619.62 m	
Finished diameter	6.65 m	
Nominal discharge	112.71 m^3/s	
Flow velocity	3.13 m/s	
Slope	Chainage 62.58 to 2,241.48 m Slope 1 in 88.76, From Chainage 2,241.48 m to 3,682.20 m Slope 1 in 110.17	

ADIT-1 TO HRT		
Shape & Size	D-Shape, 6.0 m	
Length	334.22 m	
Type & Number of Gate	Hinge type, One	
Gate Size (W x H)	2.5 m x 2.5 m	
ADIT-2 TO HRT AND SURGE SHAFT		
Shape & Size	D-Shape, 6.0 m	
Length	153.35 m	
ADIT-3 TO VALVE HOUSE		
Shape & Size	D-Shape, 7.0 m	
Length	149.38 m	
ADIT TO FERRULE (Ring) ERECTION CHAMBER		
Shape & Size	D-Shape, 7.0 m	
Length	162.57 m	
SURGE SHAFT		
Vertical shaft	32.21m	
Type	Restricted orifice type	
Top elevation	EL. 237.50 m	
Bottom elevation	EL. 149.40 m	
Total height	82.90 m	
Riser Size, height	3.6mφ , 32.21 m	
Max. upsurge level	EL. 235.33 m	
Min. down surge level	El. 188.81m	
Diameter	25 m	
VALVE HOUSE		
Type & Number	Underground, 1	
Size (L x W x H)	19.9 m x 11.5 m x 17.25 m	
Butterfly valves - Number - Diameter	 1.0 5.0 m	
PRESSURE SHAFT	**Main Power House**	**Auxiliary Power House**
Type	Circular steel lined	Circular steel lined
Nominal discharge	112.71 m^3/s	24.94 m^3/s
Internal diameter of pressure shaft liner	5.2 m	2.7 m
Flow velocity	5.31 m/s	4.36 m/s
Length of pressure shaft	703.80 m	70 m
Number of pressure shaft	1	1
Specification of steel plates	ASTM A537 Class II (YS-415 MPa)	E410 (Fe 540)
Unit Penstock - Number - Internal diameter - Length	 2 3.70 m 57.06 m/ 65.52 m	 3 2 Nos.1.2 m & 1 No.1.7 m 30.79m/27.16 m/31.62 m
POWER HOUSE	**MAIN POWERHOUSE**	**AUXILIARY POWERHOUSE**
Installed capacity	2x55 MW=110 MW	2x2.5 MW+1x5 MW=10 MW
Location	Right side of river Kopili	Right side of river Kopili
Type	Surface powerhouse	Surface powerhouse
Powerhouse dimensions (L x W x H)	77.55 m x 21.5 m x 42.9 m	44.2 m x 11.5 m x 36.0 m
Average gross head	114 m	48.30 m

Type of turbines	Francis, vertical	Francis, horizontal
Number of units	2	3
Turbine setting (elevation)	EL 98.80 m	EL 169.50 m/170.5 m
Rated discharge per unit	56.35 m^3/s	6.23 m^3/s/ 12.47 m^3/s
Installed capacity per unit	55 MW	2.5 MW / 5 MW
Continuous overloading	10%	10%
Spacing of Units	17.5 m	10 m /12 m
Rated Net Head	108.00 m	47.30 m
Normal T.W.L. (2 machines for Main PH & 3 machines for Auxiliary PH in operation)	EL 104 m	EL 169.70 m
Minimum T.W.L. (1 machine in operation)	EL 102.8 m	EL 169.00 m
Maximum T.W.L (during flood)	EL 111.66.00 m	EL 185.34 m
Turbine efficiency (Considered)	94.5 %	90 %
Generator efficiency (Considered)	98.5 %	96 %
Draft Tube Gates - Type & Number - Size (W x H)	 Fixed Wheel , 4 3.9 m x 4.4 m	 Fixed Wheel , 3 1 Nos. 3.x1.8 m, 2 Nos. 2 x 1.8 m
Main Inlet Valve - Type - Axis elevation - Diameter	 Butterfly type EL 98.80 m 3.0 m	 Butterfly type EL 168.00 m 1.2 m/ 1.86m
Generator - Type & Number - Rated capacity - Synchronous speed - Voltage/Frequency - Power factor - Excitation	 Vertical synchronous (2 nos) 55MW 230.77 rpm 11kV/ 50 Hz 0.9 (lagging) Static excitation	 Horizontal synchronous (3 nos) 2.5MW/5MW 750 rpm 6.6kV/ 50 Hz 0.85 (lagging) Brushless excitation
TRANSFORMER YARD		
Type	1 phase, OFWF cooled Generator Transformer	3 phase, ONAN/ ONAF cooled Generator Transformer
Location	Upstream of powerhouse	Downstream of powerhouse
Number	7 (6+1 spare) nos.	2 nos.
Rated capacity	22.5 MVA	6.5 MVA
Voltage ratio	11/220/√3 kV	6.6/33 kV
TAIL RACE CHANNEL		
Type	Rectangular	Rectangular
Numbers	1	1
Size (L x W)	52 m x 26.3 m	72.18 m x 5 m after junction
Slope	5H:1V	5H:1V
Nominal discharge	112.71 m^3/s	24.94 m^3/s
Outlet sill elevation	102.0 m	168.50 m
SWITCH YARD		
Type & Size	Outdoor-152 m x 71 m	Outdoor-19.3 m x 16 m

Voltage level	220 kV	33 kV
Scheme	Double bus with bus coupler	Single bus
No. of outgoing feeders	4 (Four) nos.	2 (Two) nos.
POWER BENEFITS		
90% dependable energy with 95% plant availability	415.78 MU	53.80 MU
90% dependable energy with 95% plant availability (Total)	469.58 MU	
CONSTRUCTION PERIOD		
Mobilisation and infrastructure development	9 Months	
Main construction period	3 Years 3 Months	
Total construction period (Mobilisation and Infrastructure Development)	4 Years	
ESTIMATED COST OF PROJECT		
Civil Works (Including HM Works)	Rs. 89,948.69 Lakhs	
Electro-mechanical (E&M) Works	Rs. 19,539.55 Lakhs	
Total Hard Cost	Rs.109,488.24 Lakhs	
Interest during construction	Rs. 2,025 Lakhs	
Financing charges	Rs. 78 Lakhs	
Total cost (including IDC and FC)	Rs.111,591.24 Lakhs	
FINANCIAL ASPECTS		
TARIFF		
First Year Tariff (in Rs./Unit)	Rs.3.32	
Levelized Tariff (in Rs./Unit)	Rs.3.37	

3. Land Requirements

70. The total land requirement of the project is 1,577 ha. The component wise land details are presented in Table 11. The reserve forest land to be acquired for the project is 523 ha while the private land to be acquired is 1,054 ha (see Table 12).

Table 11: Component-wise Land Area Required for Project

S. No.	Name of the Components	Area (ha)
1.	Project Component & Project Infrastructures	355.00
2.	Submergence	552.00
3.	Other Infrastructures[8]	72.00
4.	Rehabilitation and Resettlement (R&R)	75.00
	Sub-Total	**1,054.00**
5.	Land for other purposes (Recreational facilities, helipad for helicopters and light aircraft, etc.)	523.00
	Total	**1,577.00**

[8] This infrastructure relates to offices, health centre, colony, schools, parking area, club, guest house, hostel, water pumping stations, sewage treatment plant, stores, patching plant, garden, petro pump, service station, community centre, etc.

Table 12: Land Requirement for the Project

S. No.	Name of the District	Reserve Forest Land (ha)	Private Land (ha)	Total (ha)
1.	Dima Hasao	478.00	909.00	1,387.00
2.	Karbi Anglong	45.00	145.00	190.00
	Total	**523.00**	**1,054.00**	**1,577.00**

4. Construction Material

71. The total requirement for coarse and fine aggregates is above 1.242 million m^3. The estimated requirements of coarse and fine aggregates are presented in Tables 13 and Table 14, respectively.

Table 13: Estimated Requirement of Coarse & Fine Aggregate (cum = m^3)

S. No.	Description	Quantity	Remarks
1	**Combined Concrete and shotcrete Quantity**	**660,000 cum**	
	Assumption: 90 cum of Coarse aggregate is required to produce 100 cum of concrete. Moreover a wastage of 38% is considered as per CWC guideline		
i)	Requirement of Coarse aggregate (CA) for producing 6,60,000 cum of concrete	594,000 cum Say 600,000 cum	660,000.00 x 0.90 = 594,000 cum
ii)	Requirement of CA for producing 6,60,000 cum of concrete considering wastage	828,000 cum	600,000 x 1.38 (wastage of 38%)
iii)	Requirement of fine aggregate (FA) for producing 6,60,000 cum of concrete	414,000 cum	(Normally 50% of coarse aggregate)
	Total requirement of coarse and fine aggregate	**1,242,000 cum**	
2	**Concreting in Wearing surface**	**58,000 cum**	
i)	Requirement of CA for producing 58,000 cum of wearing concrete surface, without wastage	52,200 cum	58,000 x 0.90 = 52,200 cum
ii)	Requirement of CA for producing 58,000 cum of wearing concrete surface, including wastage	=52,200 X 1.38 =72,036 cum	38% wastage as per CWC guideline
iii)	Requirement of FA for producing 58,000 cum of wearing concrete surface including wastage	36,000 cum	(Normally 50% of coarse aggregate)
	Therefore Total requirement of coarse and fine aggregate for wearing concrete surface	108,000 cum	CA for Wearing coat only
3	**Concreting in Non-Wearing surface**	**602,000 cum**	
i)	Requirement of CA for producing 602,000 cum of non-wearing concrete surface, without wastage	541,800 cum Say 550,000 cum	602,000 x 0.90 = 541,800 cum
ii)	Requirement of CA for producing 6,02,000 cum of non-wearing concrete surface, including wastage	= 541,800cum x1.38 = 759,000 cum	38% wastage as per CWC guideline
iii)	Requirement of FA for producing 6,02,000 cum of non-wearing concrete surface including wastage	375,000 cum	(Normally 50% of coarse aggregate)
iv)	Therefore Total requirement of coarse and fine aggregate for non-wearing concrete surface	1,134,000 cum	CA for Non-wearing coat only

S. No.	Description	Quantity	Remarks
	Total requirement of coarse and fine aggregate for Wearing Surface & Non Wearing Concrete Surface	**1,134,000 cum + 108,000 cum = 1,242,000 cum or 1.242 million m^3)**	

Source: DPR

Table 14: Requirements of Coarse and Fine Aggregates
(in Wearing and Non-Wearing Surfaces)

S.No.	Type	Wearing surface (m^3)	Non-Wearing surface (m^3)	Total (m^3)
1.	Coarse Aggregate	72,000	759,000	831,000
2.	Fine Aggregate	36,000	375,000	411,000
	Total	**108,000**	**1,134,000**	**1,242,000**

Source: DPR

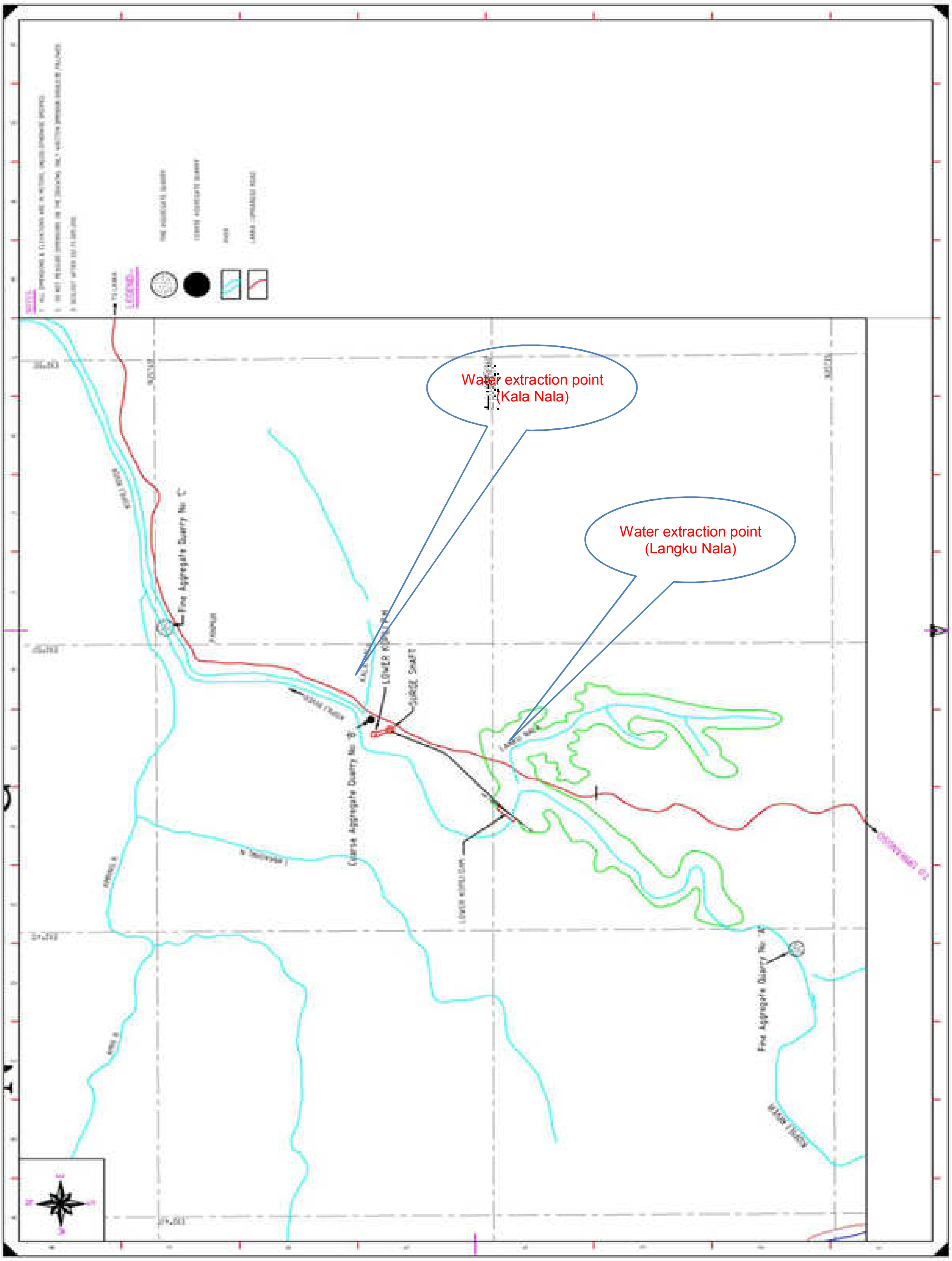
72. As a part of investigation for preparation of the DPR, coarse and fine aggregate material, identification and testing for suitability, silt analysis of river water has been completed. The available quantities of construction material from various selected quarries are presented in Table 15.

Table 15: Details of selected Quarries

Quarry No.	Location	Haulage Distance	Type of Aggregate	Estimated Quantity
'A '	Near Sudariang Nala Lat: $25^0$35'30" N Long: $92^0$44'30" E'	10 km u/s of dam axis	Fine Aggregate	40,500 m^3/year
'B'.	Near Kala Nala Lanka Umrangshu Lat: $25^0$41'53.56" N Long: $92^0$48'47.50 E	3 km d/s of proposed Power house	Coarse Aggregate	1,558,037 m^3
'C'.	Near Langpher Nala, Panimur Lat: $25^0$42'49" N Long: $92^0$50'21" E	7 km d/s of proposed Power house	Fine Aggregate	55,000 m^3/year

73. The proposed locations of selected fine aggregate quarries are presented in Figure 22.

Figure 22: Selected Quarry Locations for Construction Materials



74. ***Steel:*** The estimated quantity of reinforcement steel required shall be about 9,171 metric ton (MT) which includes 7,947 MT of Tor steel and 1,224 MT of stainless steel. The estimated quantity of boiler steel required shall be 2,325 MT. The steel grade for reinforcement shall be Fe-500 and that for boiler grade steel shall be: Dillimax-500/Sumiten-780/ASTM and 517/IS-2062 E550 BO. The All type of steel requirement shall be made available from Guwahati (the State capital) located at a distance of 210 km from the project site.

75. ***Cement:*** The cement requirement for concrete shall be made available from the Guwahati (the State capital) located at a distance of 210 km from the project site.

76. ***Availability of Explos*ives:** The explosives required for blasting operation at the project site shall be made available from Guwahati located at a distance of approximately 250 km from the project site. The availability and use of explosives shall be under the scope of the hired contractor.

77. **Availability of High Speed Diesel (HSD):**The requirement of HSD for construction works shall be made available from Lanka located at a distance of 48 km from the project site.

78. ***Other Construction Material:*** All other construction materials such as dowels, anchors, penstock lining, etc. shall be procured in sufficient quantities from outside the project area.

5. Requirement of Construction Water

79. The peak water requirement has been estimated as 0.5 million litres per day. The distribution of 0.5 million litres of construction water has been presented in Table 16. Although, the construction water requirement could be met from the two tributaries i.e. Longku and Kala nala (shown in Figure 22), a provision for treatment of acidic water of river Kopili with adequate capacity will be made during the construction stage if required. This will be identified during the construction phase (the facility would be located near the dam site).

Table 16: Construction Water Quantity Requirement and Sources

S. No.	Location to be Utilized at	Estimated Daily Construction Water Quantity (litres)	Sources of Water for Construction Works
1	Dam Site	300,000	Shall be met from Longku Nala (initial estimate shows available flow >20 million litre/day)
2	Power House (P/H) Site	150,000	Shall be met from Kala Nala (initial estimate shows available flow >10 million litre/day)
3	Intermediate Location	50,000	May be sourced from Longku or Kala nala.

6. Protection of Concrete and Steel from Acidic Water

80. The pH level in Kopili river ranges from 3.2 to 5.2 rendering it unfit for use in construction works and highly corrosive for concrete structures. The acidic nature of Kopili river is attributed to acid drainage due to illegal and uncontrolled rat hole mining upstream in State of Meghalaya.[9] The acidic water shall have a serious impact on the durability of the project components and thus various preventive measures have been mooted to reduce the impact of acidic water such as:

[9] India's National Green Tribunal (NGT) passed a directive in April 2014 to ban rat hole mining in Meghalaya leading to some improvement to the downstream aquatic ecology. However, the issue continues to need attention.

- All reinforcement near the water front shall be of stainless steel with corrosion resistant properties.
- Use of epoxy coated reinforcement or corrosion resistant reinforcement.
- Corrosion resistant painting shall be applied to the reinforcement bar.
- Metallic trash rack with its embedment shall be of stainless steel.
- Steel liner in pressure shaft shall be painted with corrosion resistant paint.
- All pipes in power house or elsewhere shall be of stainless steel.
- Use of high density concrete (HPC) on water exposed surfaces will be used in dam structure.
- All concrete in contact with direct water shall consist of 5 to 6% Silica fumes (micro silica).
- Concrete mix with suitable admixtures such as metakaolin along with fly ash (about 30-35%) shall be used to resist the acid attack.
- Use of polyurethane spray on water exposed concrete surface.

81. All suggested provisions have been agreed and shall be implemented during the detail engineering stage. However the costing of such provision shall be incorporated in the DPR.

7. Access Roads

82. ***Roads to the Projects*:** From Lanka up to dam site area, State Highway exists (for a distance of approximately 33 km) and further up becomes the PWD road (Longku-Garampani) that shall be the main access road to the project. Total distance from Lanka to project site is 48 km. This 48 km road will be main access road and it will be improved under the project. The scope of improvement will be limited to existing carriageway width and there will not be any widening involved.

83. ***Roads in the Project Area:*** The PWD road (Longku-Garampani) shall be main access road to the project and from this several smaller access roads will be constructed to the various components of the project e.g. dam complex and Power House, as presented in Table 17. The layouts of the proposed roads are presented in Figure 23.

Table 17: Proposed Roads in the Project Area

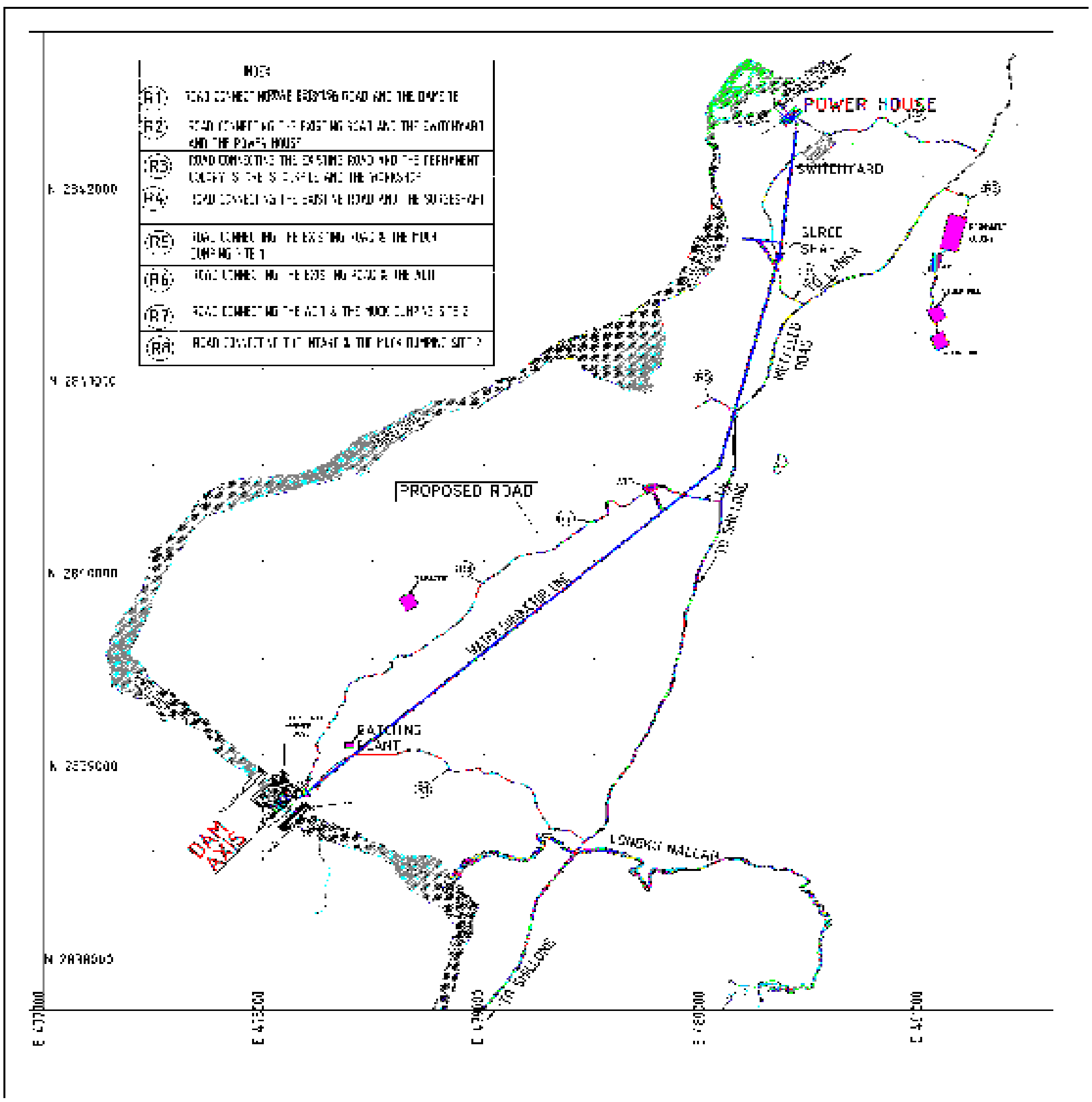
S. No.	Description	Unit	Quantity
I)	**Roads**		
1	Lanka Garampani road to dam site & Rehabilitation area, dyke & intake shaft top including existing road diverted	km	5.52
2	Explosive magazine road	km	0.84
3	Lanka Garampani road to powerhouse	km	1.21
4	Approach road to colonies	km	0.37
5	Road to rock Quarry area	km	1.19
6	Road to Dumping area	km	0.61
7	Road to Adit portal	km	1.22
8	Road to Hydro mechanical workshop	km	0.1
9	Road to Electro mechanical workshop	km	0.03
10	Road to Surge Shaft	km	1.85
11	Road to proposed bridge		0.16
	Total	**km**	**13.10**
II)	**Improvement of Lanka Garampani road up to Umrangsu**	km	48

S. No.	Description	Unit	Quantity
III)	**Bridges and culverts:**		
1	No. of bridges	No.	3
2	No. of culverts	No.	10

84. One bridge (BRG 3) of span 60 m will be constructed on the PWD road over Longku nala. One bridge (BRG 1) of span 48 m will be constructed on an existing road at Longku nala crossing. One bridge (BRG 2) of span 11 m will be constructed across the diversion channel to pass over upstream coffer dam.

85. ***Railhead:*** The broad gauge railhead at Lanka is about 48 km from the proposed project site and approximately 180 km from Guwahati. This railhead will be utilized for transportation of the equipment and construction materials to Lanka and subsequently transported via existing and to be constructed access roads to the project site.

Figure 23: Details of Proposed Roads for the Project



86. Lanka railhead includes provisions for unloading and covered and uncovered storage of heavy machinery, construction materials, electrical, and other equipment and space for parking (of heavy machinery). No additional works are required here.

87. ***Port Facilities***: The nearest port to the project site is located at Kolkata. However, port facilities for the project are not required since there are no imported machineries required for construction works.

8. *Power required for Construction Works*

88. The power requirement is based on the number of proposed power driven equipments for construction works throughout all locations of the project site including site facilities. The location wise breakup of power load is presented in Table 18.

Table 18: Location Wise Breakup of Construction Power Load

S. No.	Location	Power Requirement (kW)	Power Requirement (kVA)
1	Dam Complex (Diversion, Dam and Intake)	460.00	575.00
2	Adit-1	430.00	537.50
3	Adit-2	610.00	762.50
4	Pressure shaft & Surge Shaft	300.00	375.00
5	Power House complex	260.00	325.00
6	Central Work shop & laboratory	240.00	300.00
7	Crusher Plant	350.00	437.50
8	Colony, laboratory and Office	55.00	68.75
	Total	**2,705.00**	**3,381.25**

89. ***Construction Power Arrangement:*** The nearest available grid is the 33/11 kV Umrangso substation (S/S) located at a distance of 20 km from the project. Power at 33 kV voltage level from the 33/11 kV Umrangso S/S will be drawn to the project site for use in construction works. 33 kV overhead lines to the dam site will be drawn and 11 kV distribution lines will be laid to various load centres. 33 kV voltage level will be suitably stepped down to 11 kV/415V with the help of a step down transformer. Substations will be constructed at the following locations, and will be the responsibility of the EA, undertaken as a deposit work. Details are provided in Table 19. Detailed plan will be prepared during detailed design by EPC contractor.

- Dam site,
- In between the Surge shaft and Power House, and
- Project Colony, Intermediate Adit to HRT and various facilities.

Table 19: Main Scope of Works for Construction Power Arrangement

S. No.	Description
1	Construction of 33/11 kV S/S near Dam complex with 2 Nos. Transformers each of capacity 2 × 2.5 MVA with provision for incoming 33 kV lines from Umrangso)
2	Construction of 11kV/0.415kV S/S at Dam site with 2 Nos. Transformers each of capacity 1.7 MVA
3	Construction of 11 kV double circuit line from 33/11 kV S/S near Dam site to middle of surge shaft and power house (about 4.4 km)
4	Construction of 11 kV double circuit line from 33/11kV S/S near Dam site to Colony, Intermediate Adit to HRT and various facilities (about 2.2km).
5	Construction of 11 kV/0.415 kV S/S at middle of surge shaft and power house with 2 Nos. Transformers each of capacity 2x 1.0 MVA.

S. No.	Description
6	Construction of 11 kV/0.415 kV S/S at colony with 2 Nos. Transformers each of 750 kVA capacity.
7	HT/LT switchgears.
8	Associated civil works.

90. Construction of 20km 33 kV line from Umrangso S/S is not considered in the cost of construction power arrangement since the same 33 kV line would be used for power evacuation from the 10MW APH after commissioning of the project. Construction and cost of these 33kV lines is proposed at the State transmission utility's account.

91. For supply of reliable construction power as described above, it is proposed to install two transformers (11/0.415 kV) each of 1.7 MVA capacity at dam site for catering to requirement of dam site, crusher plant & Adit -1, two transformers each of 1.0 MVA at middle of surge shaft for catering to requirements of construction power supply for pressure shaft and surge shaft, power house complex and central workshop and laboratory. In order to ensure reliable power supply at the 3rd location to project colony, intermediate adit to HRT (Adit II) & other facilities it is proposed to install two transformers (11/0.415kV) each of 750 kVA capacity in the Sub Station. Breakers/ Switchgears, LT panels and cabling will be provided for further distribution of power supply to the construction equipments. Same arrangement will be kept for back-up supply project operation after commissioning of the project.

92. ***Construction Power with Diesel Generating (DG) Sets:*** Total number of 12 DG sets will be installed at 8 locations across the project site for smooth functioning of various construction works, and supply to work colonies, residential facilities, etc. and will function only as a back-up supply in case of power outage. The total requirement of DG sets and location wise distribution are presented in Tables 20 and 21, respectively. New DG sets will be procured to follow international standards and norms for noise and emissions.

Table 20: Number of DG Sets Required for Back-up Power Supply

S. No.	DG Set requirement	Number
1	500 KVA	1
2	320 KVA	7
3	125 KVA	3
4	25 KVA	1
	Total Number	**12**

Table 21: DG Sets Requirement for Different Component of the Project

S. No.	Location	DG Set capacity (KVA)	No. of DG Set	Power requirement as per DG Set (KVA)
1	Dam Complex (Diversion, Dam and Intake)	320 & 320	1 each	640
2	Adit-1	500	1	500
3	Adit-2	320 & 125	1 each	445
4	Pressure shaft & Surge Shaft	320	1	320
5	Power House complex	320	1	320
6	Central Work shop & laboratory	320	1	320
7	Crusher Plant	320 & 125	1 each	445
8	Residential Colony and Office	125 & 25	1 each	150

S. No.	Location	DG Set capacity (KVA)	No. of DG Set	Power requirement as per DG Set (KVA)
	Buildings			
	Total Power Availability (as per DG set)			**3,140**

9. Telecommunication Facilities

93. Telecommunication facilities will be set up at different work sites of the project site to ensure efficient execution of works. Very Small Aperture Terminal (VSAT) and Very High Frequency (VHF) wireless link have been proposed for the project site while video / teleconferencing facilities at the EA Corporate office will monitor the site progress.

10. Project Colonies, Buildings, Workshops

94. The buildings (both residential and non-residential) will be constructed and shall be further divided into permanent and semi-permanent or temporary structures. Permanent buildings may be considered only required for post construction period. For example: residential buildings will be required to house staff employed for construction works and these will subsequently be used for housing the operational staff. Non-Residential buildings include project administrative building and other facilities and will be located close to the power house on the right bank of Kopili river. Temporary buildings and facilities such as contractor and labor colonies will be constructed as required such as close to the dam complex area on the right bank of Kopili river, at adit portal location, and the power house location. The details of temporary and permanent residential buildings are presented in Tables 22 and 23, respectively while details of temporary and permanent non-residential buildings are presented in Tables 24 and 25, respectively. Locations of temporary/permanent buildings are shown in Figure 24. Detailed layout will be prepared by EPC contractor.

Table 22: Details of Residential Buildings –Temporary

S.No	Designation	Type of Quarters			
		I	II	III	IV
1	GM (Project Head)	1			
2	DGM		4		
3	AGM		8		
4	DM		20		
5	Engineer			20	
6	Assistant Engineer			26	
7	Medical Officer		1		
8	Nurses & Compounders				4
9	Security Officer		1		
10	Assistant Security Officer		1		
11	Security Assistants				20
12	Accounts Assistants			10	
13	Engineering Consultant Representative		1		
14	Laboratory Incharge			1	
15	Lab Assistants				3
16	Geologist		1		
17	Assistant Geologists			4	
18	CAD Operators			3	
19	Work Charge/Maintenance Staff				20

Table 23: Details of Residential Buildings – Permanent

S.No	Designation	Type of Quarters			
		I	II	III	IV
1	GM (Project Head)	1			
2	DGM		2		
3	AGM		6		
4	DM		11		
5	Engineer			11	
6	Assistant Engineer			11	
7	Medical Officer		2		
8	Nurses & Compounders				4
9	Security Officer		1		
10	Assistant Security Officer			2	
11	Security Assistants				10
12	Accounts Officer		2		
13	Accounts Assistants			8	
14	Electrician				5
15	Foreman/Mistry			3	
16	Car Drivers				3
17	Administrative Assistants			9	
18	Peons & Messengers				10
19	CAD Operators			2	
20	Work Charge/Maintenance Staff				20
21	Store Incharge		1		
22	Store Keeper			3	
23	Store Helpers				6

Note: Type I Quarters consist of plinth area 176 m^2
Type II Quarters consist of plinth area 84 m^2
Type III Quarters consist of plinth area 54 m^2
Type IV Quarters consist of plinth area 36 m^2

Table 24: Details of Non Residential Buildings – Temporary

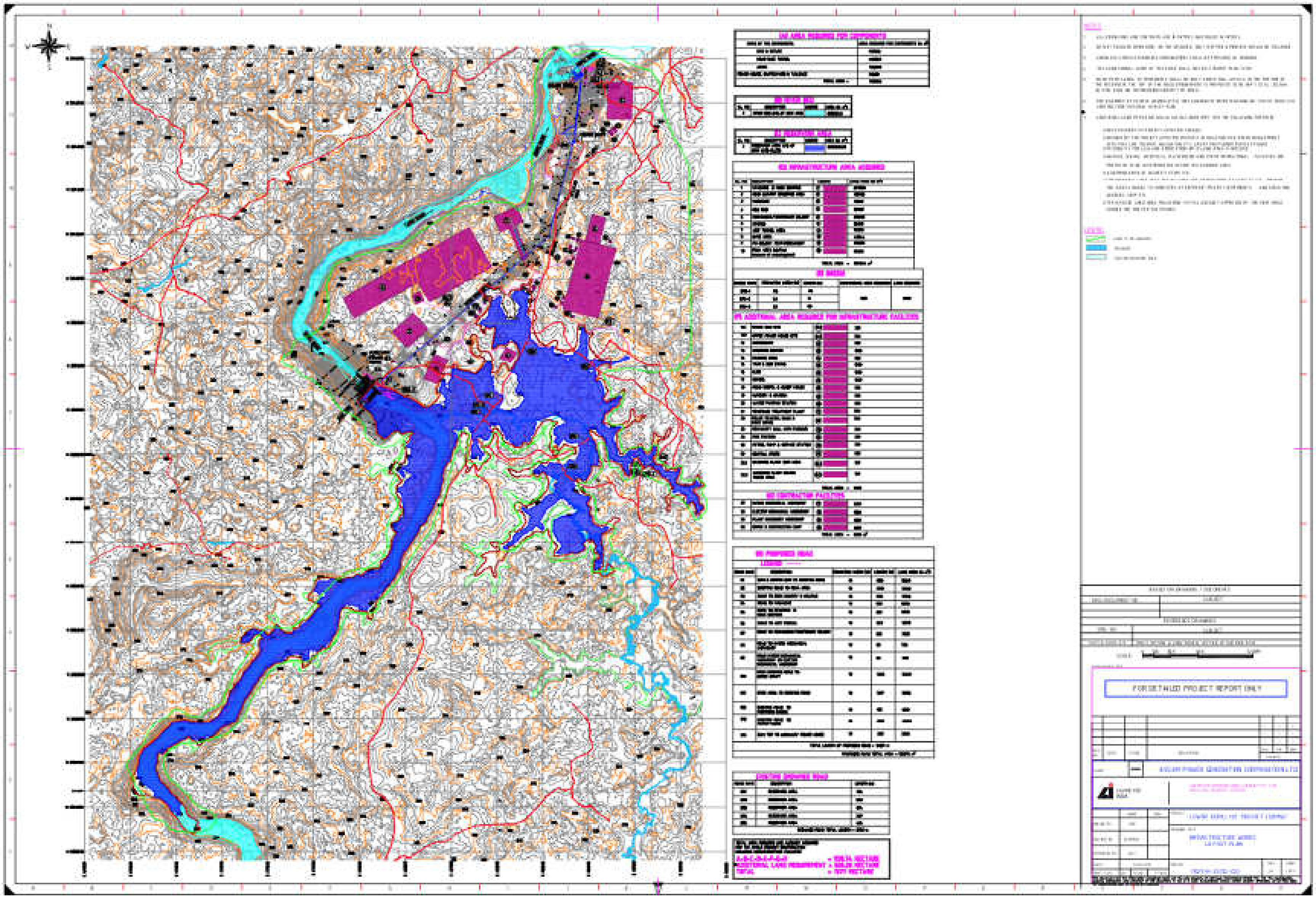
S. No.	Description	Plinth Area (m^2)
1	Administration block & site office	1,500
2	Batching plant area	100
3	Shopping centre	1,000
4	Workshop building	500
5	Petrol pump with service station	300
6	Explosive magazine 2 nos. 20 T capacity	200
7	Sewerage treatment plant	500
8	Water pumping station	100
9	Stores	1,000
	Total	**5,200**

Table 25: Details of Non Residential Buildings – Permanent

S. No.	Description	Plinth Area (m^2)
1	Administration block & site office	1,500
2	Field hostel / Guest House	500
3	Parking Area	500
4	Store	500
5	Primary school	1,000
6	Post office, Police Station & Bank	300
7	Dispensary	500

S. No.	Description	Plinth Area (m^2)
8	Club/recreation	1,000
9	Community hall with parking	500
10	Fire Station	300
11	Taxi & Bus stand	1,000
	Total	**7,600**

Figure 24: Layout Plan showing locations of temporary/permanent buildings



95. The permanent/temporary colonies at suitable topographic location such as between the dam site and power house shall consist of the following facilities:

- Potable Water Supply facility (pumped from underground sources)
- Sanitation and waste disposal facilities
- Drainage arrangements
- Internal roads and cross-drainage works
- Electrical supply
- Dispensary
- Club
- Community Hall
- Field Hostel
- School
- Nursery
- Water Treatment Plant (treated water will be used for gardening/green belt)
- Sewage Treatment Plant (treated sewage will be used as fertilizer)

96. Two office complexes at suitable topographic location such as near the power house site and close to the dam site will also be constructed. Additionally, Hydro Mechanical, Electro Mechanical, and Plant Machinery workshops and workshop for repair of heavy earth moving equipment and transport vehicles will be constructed. A separate workshop will be constructed for fabrication purposes and will be located near the surge shaft area.

11. Muck Disposal Areas

97. Muck will be produced due to excavation of the river bed for dam foundation, adits/HRT, surge shaft, value house, pressure shaft, power house complex, and other construction activities. The total quantity of muck generation due to excavation works is estimated as 0.963 million cum. Some quantity of muck will be utilized for generation of concrete aggregates, widening of access roads (laying the muck on the side of the road for widening up to 15 m), and balance quantity will be dumped at designated muck dump sites on the right bank of the Kopili River. The quantity of muck generation and dumping sites are presented in Table 26.

Table 26: Estimates of Muck Generation Quantities from Various Components

Project Component	Quantity of Muck/Debris generated (m^3)	Quantity of muck with 40% swell factor (m^3)	Total Quantity of muck/debris including swell factor (m^3)	Estimated quantity of muck/debris proposed to be utilized 930% of total muck considered) (m^3)	Estimated quantity of muck/ debris proposed to be dumped (m^3)	Name of the dumping site as shown in the plan (Figure 24)
u/s Coffer Dam	10,894	4,357	15,251	4,575	10,676	AREA 1
D/S Coffer dam	5,199	2,080	7,279	2,183	5,096	
Diversion Channel	51,473	20,589	72,062	21,618	50,443	
Dam	434,542	173,817	608,359	182,507	425,851	
Power House	28,141	11,256	39,397	11,819	27,577	AREA 2
Surge Shaft	21,561	8,624	30,185	9,055	21,129	
Valve house	54,667	21,867	76,534	22,960	53,573	

Project Component	Quantity of Muck/Debris generated (m^3)	Quantity of muck with 40% swell factor (m^3)	Total Quantity of muck/debris including swell factor (m^3)	Estimated quantity of muck/debris proposed to be utilized 930% of total muck considered) (m^3)	Estimated quantity of muck/ debris proposed to be dumped (m^3)	Name of the dumping site as shown in the plan (Figure 24)
Tail Race	71,830	28,732	100,562	30,167	70,393	
Auxiliary Power House Tailrace	76,615	30,646	107,261	32,178	75,082	AREA 1
HRT & Adits	221,716	88,686	310,402	93,120	217,281	AREA1 & AREA 2
Pressure Shaft	27,458	10,983	38,441	11,532	26,909	AREA 2
Auxiliary Pressure Shaft	980	392	1,372	412	960	AREA 2
Total	**1,005,076**	**402,029**	**1,407,105**	**422,126**	**984,971**	

98. The muck disposal area will consist of a retaining wall of maximum height of 7 m while disposal height will be maximum of 10-12 m with 36º slope. Total area of much disposal sites is 112,000 m^2.

12. Drinking Water Facilities

99. The water requirement for drinking and construction works will be met from Longku Nala and Kala Nala. A water treatment plant of adequate capacity will be constructed, and water for drinking purposes across the project site will be treated as per Bureau of Indian Standards (IS) specifications.

E. Project Cost and Project Benefits

100. **Project Cost:** The project is estimated to cost $282.0 million The cost of civil works including Hydro Mechanical and Electro Mechanical works amounts to USD 136.39 million. Table 27 show the componentwise break-up of project cost.

Table 27: Summary of Project Costs ($ million)

	Item	Total Cost
A.	**Investment Costs**	
1	Turnkey contract for civil and hydromechanical	104.48
2	Turnkey contract for electromechanical	31.91
3	Turnkey contract for access roads and buildings	9.53
4	Turnkey contract for transmission line	24.43
5	Consulting service	
	a. Project management and supervision for hydropower	9.01
	b. Community Interventions on Kopili	1.45
	c. External monitoring	1.38
6	Tools and Equipment	

	a. Community Interventions on Kopili	1.35
	b. Vehicles etc.	0.47
7	Capacity development	1.22
8	Establishment Cost	12.02
9	Environmental and Social mitigation cost	10.84
10	Land acquisition and Resettlement cost	32.67
	Subtotal (A)	**240.76**
B.	**Recurrent Costs**	
1	Incremental administration cost	2.50
	Subtotal (B)	**2.50**
	Total Base Cost (A+B)	**243.25**
C.	**Contingencies**	
1	Physical	7.30
2	Price	24.11
	Subtotal (C)	**31.41**
D.	**Financing Charges During Implementation**	
1	Interest during construction	6.36
2	Commitment charges	0.98
	Subtotal (D)	**7.34**
Total Project Cost (A+B+C+D)		**282.00**

Source: PAM

101. **Energy Benefits:** As per the DPR, the gross energy benefits from the project have been estimated as 469.58 Gwh per annum corresponding to 120 MW in a 90% dependable year after ecological release (the latter required as per the ToR requirements of the MoEF&CC). As per the ToR of the MoEF&CC, 20% of the average of four consecutive leanest months in 90% dependable year has been considered as the e-flow during the lean season. During the 4 monsoon period (June to September), 30% of inflow calculated on the basis of 90% dependable year will have to be released. For the non-lean, non-monsoon period, environmental release has to be 25% of the inflow, calculated on the basis of 90% dependable year. The estimated design energy of the project is taken as energy generated in 90% dependable year.

Socioeconomic and Other Benefits: The project will harness the hydropower potential of the river Kopili in the State and alleviate chronic power shortage, provide peaking capacity and correct the hydro thermal imbalance. This in turn will improve the power scenario in the State, generate livelihood, and induce economic activity in the region.

F. Construction Programme and Planning

1. Implementation Schedule

102. For implementation of the project, the construction time has been estimated for each of the proposed project components to be carried out as several contract packages such as civil works (for dam), power house, mechanical component, electrical components, etc. The project contracts will be floated through International Competitive Bidding (ICB). Currently there is project mobilization of the Project Management Consultant (PMC). The main considerations in the implementation schedule are as follows:

- Project Period — 4 years (Including Infrastructure Development & Mobilisation)
- Infrastructure and Mobilisation Period — 9 Months

- Construction Period 3 years 3 Months (Excluding Mobilisation)

2. Infrastructure Facilities and Mobilization Period

103. All infrastructure activities (locations show on layout map Figure 24) will be carried out over a period of 9 months (M-1 to M-09); with mobilisation carried out within 6 months from the award of work; these shall include the following:

- Project roads, Infrastructure facilities including Construction Camps, Office, Residential Quarters / Colonies, Stores, Workshops, QC Labs and other related facilities required for construction of the project.
- Setting up of Explosive Magazine. Mobilisation of available equipments as well as procurement of unavailable but required equipment.
- Completion of all Infrastructures facilities and installation of all required temporary services.
- Erection & Commissioning of Stationary Plants such as Aggregate crushing plant / Batching plant / DG Power location / Recreation clubs,
- Note: Residential Quarters: Quarters will be constructed as per requirement for different category of staff; land will be acquired from the local residents on lease basis.

3. River Diversion & Coffer Dam Construction

104. **Dam Works:** This activities will be completed in 13 Months (M-13 to M-25): The diversion arrangement comprises of upstream coffer dam, a diversion channel along with two construction sluices and a downstream coffer dam. The diversion has been designed to pass the 25 year flood of 720 m/s (if higher discharges are anticipated, the work sites will be evacuated). The project is envisaged as right bank development scheme; hence river diversion has been planned on the right bank of river Kopili through the diversion channel and sluices with the upstream and downstream coffer dams. Diversion channel alignment is fixed to pass the construction flood through the sluices at right bank block. Based on the topography, inlet and outlet of the diversion channel are planned for a length of 104 m at upstream and 155 m at downstream along with 50.12 m of construction sluice at the right block. The longitudinal slope of the diversion channel up to the inlet of sluice is 1 in 297, in sluice 1 in 297 and in downstream channel 1 in 200. From the channel outlet, the water is discharged into the river where the bed level is EL.174 m. The wall of the diversion channel has been designed as cantilever RCC wall of about 11 m height and 11 m clear floor width to pass the 720 cum of discharge.

105. The upstream (u/s) cofferdam has been designed as Plum concrete/ concrete with 1:2:4 PCC with a top width of 5.0 m and downstream slope with a horizontal tread of 1.5 m with 1.5 m rise of concrete for 17.95 m height. The downstream (d/s) coffer dam has been designed as muck, impervious material and dumped rock, with an upstream slope of 1.7H:1V along with 1000 mm thick stones/boulders pitching. The slope of the downstream face of the downstream coffer dam is also kept as 1.7H:1V and is built of excavated muck for 12.50 m height. The salient features of cofferdam are presented in Table 28.

Table 28: Salient Features of Coffer dam

Details	Upstream	Downstream
Type	Plum concrete/ concrete	Earth & Rockfill
Height	18.0 m	13.0 m
Length	160.1 m	126.3 m

Top EL	188.20 m	186.0 m
Base Width	20 m	47.20 m

106. The diversion arrangement is planned to be carried out in two phases. The first phase of the river diversion work will involve construction of the pre-coffer dam and the Construction sluice block. The first phase activities will be carried out in the lean season. The second phase of river diversion works will involve the construction of d/s coffer dam, and dam works.

i. First Phase

107. **Diversion Channel:** The Pre coffer dam will be constructed before the open excavation along with the preparation of berms and hill slope stabilisation/protection with drainage holes etc. as per engineering drawings (DPR). The Pre coffer dam will allow for the construction of the diversion channel along with the sluice block with 2 Nos. construction under sluices of openings 5.5 m (w) x 7.5 (h) at right bank and u/s coffer dam.

108. Second Phase: The river diversion work in the second phase will involve construction of 1 Nos. rectangular shaped diversion Channel of 11m (w) x 11m (h) x 274 m (l) along with 2 Nos. construction under sluices of openings 5.5 m (w) x 7.5 (h) in right dam block of 50.12 m (l). The diversion channel will be 900 mm thick concrete lining and will have a provision of gate at the diversion sluice inlet.

109. The inlet and outlet of diversion channel will be constructed, and the diversion channel excavation will be advanced from both ends using conventional processes (suitable for an open channel). Mucking may be carried out by Loader/Excavator and 16-Ton tippers. Service lines (e.g. power supply, water supply, air supply and dewatering needs) will be provided as required.

110. **Muck Disposal:** Most of the surface excavated materials will be transported from the excavation location to designated dump locations; some surface excavated materials (those suitable) will be directly dumped in the d/s coffer dam or used in backfilling. Surface excavated materials, if approved by project authorities for its incorporation in construction works, will be stacked separately in stock piles near the aggregate crushing plant until further use. The balance muck shall be disposed in the designated dumping areas, followed by levelling as presented in infrastructure works drawing (DPR). The diversion channel work quantity are presented in Table 29.

Table 29: Diversion Channel Works Quantity

Work Items	**Quantity (m^3)**
Earthwork	74,261.00
Providing and laying M20 concrete channel	11,037.25

111. **Upstream (u/s) Coffer dam:** The construction of u/s coffer dam will have top EL.188.20 m for 17.95 m top height and will be designed of Plum concrete/ concrete with 1:2:4 PCC with a top width of 5.0 m. For d/s slope, a horizontal tread of 1.5 m with 1.5m rise will be designed. The u/s coffer dam work quantity are presented in Table 30.

Table 30: Coffer Dams (Upstream) Works Quantity

Work Items	**Quantity (m^3)**
Earthwork	10,894
Concrete work	45,920

112. **Concreting:** The concreting will be executed with transit mixers from both ends as well as at the sluice block. While pouring, care will be taken for compaction of concrete through the needle vibrator.

113. **Gate Erection:** A Gate will be erected at the sluice-inlet. The embedded parts in the construction sluice for the gate will be carried out during the concreting activity of the diversion tunnel/channel. The complete activity is planned to be completed in a time frame of 20 days.

ii. Second Phase

114. **Downstream (d/s) Coffer dam:** In the second phase of river diversion works, d/s coffer dam, sluice spillways up to the top of Sluice blocks shall be constructed in the lean season. The d/s coffer dam works quantity are presented in Table 31.

Table 31: Coffer Dams (Downstream) Works Quantity

Work Items	Quantity (m^3)
Earthwork	42,795
Rockfill placing	3,470.50

4. Dam Works

115. Dam works will be completed in 33.23 months (M-13 to M-46.23). The proposed concrete gravity dam with sluice spillways is 345.05 m long, 70.13 m high across the river Kopili at Longku and will consist of 20 Nos. blocks: 8 Nos. blocks are for under sluices, 1 No. is for construction sluices and overflow spillway for floating debris, and 11 Nos. are for non-overflow blocks. The ground levels are at EL. 172.0 m at dam site; the foundation rock are at 11.63 m below the ground level. The crest level of the spillway under sluices are at EL181.0 m i.e. 7.0 m above the river bed. The opening size of each spillway under sluice is 7.1m (w) x 8.65m (h). Eight radial gates are planned on the downstream side of the sluices and these will be resting over piers extending by 17.7 m outside the dam face on the downstream side. Seven intermediate piers of 9.55 m width each, with contraction joint at downstream of the dam are provided to accommodate the gate control room, trunnion beam and anchorage for the radial gates. The size of the end pier shall be of 4.775 m (w). These piers along with the end pier at downstream side are proposed with the top elevation at EL. 198.0 m. The trunnion is at EL. 187 and with a free board of 1.66 m i.e. above the calculated maximum tail water level of EL185.34 m. The salient features of dam are presented in Table 32. The works quantities of dam and sluice spillway are presented in Table 33.

Table 32: Salient Features of Dam

Parameter	Details
Type	Concrete gravity
Top of dam level (Bridge deck), m	232.5
River bed level, m	174
Deepest Foundation. Grade Line, m	162.37
Top width, m	7.5
Top Length, m	345.05
Maximum Bottom base width at foundation bed, m	133.42
Design flood discharge, m^3/s (15x the 1/25-year flood)	11030
Full reservoir level (FRL), m	226.00
Maximum Water Level (MWL), m	229.60
Minimum draw down level (MDDL), m	202
Sluice Spillway	8

Parameter	Details
Design Discharge	11,030
Crest Level	181
Sluice size	7.1m(w)x8.65m(h).
Energy dissipation arrangement	Solid Roller Bucket

Table 33: Dam and Sluice Spillway Works Quantity

S.No.	Concrete Gravity Dam	Quantity
1	Earthwork, m^3	276,882
2	Excavation in hard rock, m^3	157,661
3	Concrete in Structures	
	All type concrete , m^3	421,419
4	Drilling for both consolidation and curtain grouting, Rm	52,113

116. The dam construction is planned to be carried out as follows: the construction of diversion channel, u/s coffer dam and right construction sluices will take place over one lean season; the construction of d/s coffer dam will take place over the next lean season, and later the water will be diverted through the diversion channel and the construction of sluice followed by excavation in the sluice spillway blocks foundation area. After this, the consolidation grouting will be carried out and the entire sluice spillway blocks will be raised up to the top of sluice level (all carried out over the lean season), construction of non-overflow dam blocks will take place during monsoon season as well from the beginning of the construction activities.

117. **Excavation:** The excavation of dam site will be planned to correspond with the excavation of abutments on each side of dam. To start the stripping works, an access road reaching the top of the abutments on each side of the dam will be constructed, with gradient not steeper than 1 in 12. The top-over burden will be removed with the help of excavators/dumpers while rock excavation will be conducted by controlled drilling – crawler mounted drill machine, jack hammer and open cut blasting method. Rock excavation will be carried out in multiple benches of 3 – 4 m (h) and accordingly suitable ramps will be provided for removal of the blasted muck. The excavated materials will be disposed at the designated muck disposal sites using excavators/dumpers. The disposal will be in the required lines and levels, in steps from the top bench to the low bench in a downward direction as shown in the engineering drawings (DPR). Initially, after creating sufficient space for operation of excavators/dumpers at a particular bench, mucking (excavation) will be carried out simultaneously as the lowering of bench progresses. The work will be carried out in stages adopting a bench height of about 3 m in each stage so that the rock stabilization can be done without any difficulty. The excavation of abutments will be up to a level just above the normal flow level of the river. After the complete enclosure of the u/s and d/s coffer dams and initial dewatering, the river bed material will be excavated and removed in required lines and levels. Trenches and pits will be dug near the coffer dams to collect water from the working area. Additionally, submersible pumps with high head capacity will be deployed for deep dewatering of slush and grit at certain intervals throughout the working area (at the cofferdams; with water pumped to settling ponds prior to discharge to the river). As the excavation proceeds downwards the position and depth of the submersible pumps will be modified accordingly. If required double stage pumping may also be planned.

118. **Consolidation Grouting Works:** Consolidation grouting will be carried out over the entire dam area after the excavation of the foundation grade rock of the dam with 58 mm diameter primary holes @ 6m c/c,10m deep and secondary holes in between them.

119. **Concrete Works:** For the purpose of concreting works at the dam site, and area will be earmarked for 2 Nos. of batching plant of 30 and 60 Cum/hr. Tower cranes with 3.5 ton at 70 m lifting capacity and concrete pumps for placing concrete in the dam body will be utilized. After excavation of the river bed up to the foundation level, the rock foundation of the dam will be prepared. The rock foundation surface will be cleaned with air and water jet pump, inspected for seams of soft materials and will be treated as per the directions of the Geologist/Engineer-in-Charge. Concreting will start from the lowest level and block using tower crane and transportation of concrete through transit mixers from the batching plant. The placement temperature of concrete will be maintained as per technical specifications. Vibration and compaction of concrete will be done with the help of 150 mm dia and 62 mm dia immersion type needle vibrators operated with frequency changers. After the hardening of the concrete surface (6 to 8 hours after pouring concrete), the foundation surface will be green cut with air and water jet pump to remove the laitance from the surface and expose the coarse aggregates. This will be necessary in order to have a proper bond between two lifts. In case the concrete has hardened to such an extent that green cutting is not possible, then the laitance will be removed by high pressure water jets, sand blasting, or mechanical chipping. The surface will be thoroughly cleaned with air and water jet pumps before placing the next layer of concrete. After initial layering of concrete, consolidation and contact grouting operations will be carried out in parallel with concreting in adjacent blocks. Drilling for grouting operations will be done using wagon drills through the embedded pipes left in concrete.

120. **Curtain Grouting Works:** Curtain grouting will be carried out after the construction of foundation gallery. Primary grout curtain holes will be carried out @ 6m c/c, 75% of hydraulic head and secondary holes (in between the primary holes) with a minimum depth of 10 m unless the water absorption exceeds 1 lugeon.

121. **Hydro Mechanical Works:** The gates will be erected along with the civil works and are planned to be completed in 15 months.

122. **Dyke Works:** There is a saddle formation (with its lowest elevation at EL 222.50m) on the eastern periphery of the proposed reservoir. As the maximum water level of the reservoir has been fixed at EL 229.60 m, an earthen dyke will be constructed over the saddle to contain the water. The length of the proposed earthen dyke will be 225.0 m and the maximum height from the deepest foundation level will be 13.0 m including a provision of 2.9 m free board. The dyke construction works will be during the lean season from the start of the construction activities. The list of equipment to be utilized for construction of dam complex are presented in Table 34.

Table 34: List of Equipment to be used for construction of Dam Complex

Details of Equipment	Number
Dam Complex (Diversion, Dam, Intake)	
Excavator (1.2-1.5 cum bucket capacity	2
Tippers (28-T)	12
Rig-On-Crawler	2
Jack hammers with pusher legs	6
Dozer	1
Soil compactor	2

Hydra crane-2OT	1
Transit Mixer (6 cum capacity)	6
Batching Plant (60 cum/hr)	2
Tower crane (3.5T @ 70 meter)	1
Concrete Pump (38 cum/hr)	2
Shotcrete machine (6 cum/hr)	1
Compressor (1000 cfm)	1
Dewatering Pumps (65 HP-2; 40HP-2; 20HP-2)	6
Welding machine	4
Bar cutting machine	2
Bar bending machine	2
Group Pump	2

5. Intake

123. This activity will take 25.70 months (M 16 to M-41.70).

124. **Excavation:** Intake will be at a distance of 30 m upstream of the dam axis on the right bank of river Kopili. Since the location of intake is close to the dam structure, open excavation for intake will take place simultaneously by utilizing the same equipments as used for the dam structure works. The loose excavation will be carried out from top to bottom.

125. **Concrete Structure:** The concreting works for intake structure will take place simultaneously with the dam structure works utilizing the same equipments. The lining for the bell mouth of the power intake will be required installation of form-work and concreting thereafter. The tunnels will be concrete lined by use of shutter as per requirement. Pouring of concrete will be carried through concrete pumps installed near the batching plant and concrete pipeline while needle vibrators will be used for compaction of concrete works. While pouring of invert concrete, care will be taken for compaction of concrete through needle vibrators. The intake gates for service and stop-log will be erected at the end. Air vent pipes will be provided downstream of the intake gates. First stage concreting will be done with steel embedment's for providing the steel channel for stop-log groove and the intake service gate groove. After installation of the stop-log gates and service gate, second stage concreting will be carried out. Hoist platform with steel frame will be erected on the top slab of power intake for operations of the gates. Trash racks and cleaning machine will be erected later on.

6. Head Race Tunnel (HRT)

126. This activity will take about 29.70 months (M-17.20 to M-46.90). Salient features regarding HRT are presented in Table 35.

Table 35: Salient Features of HRT

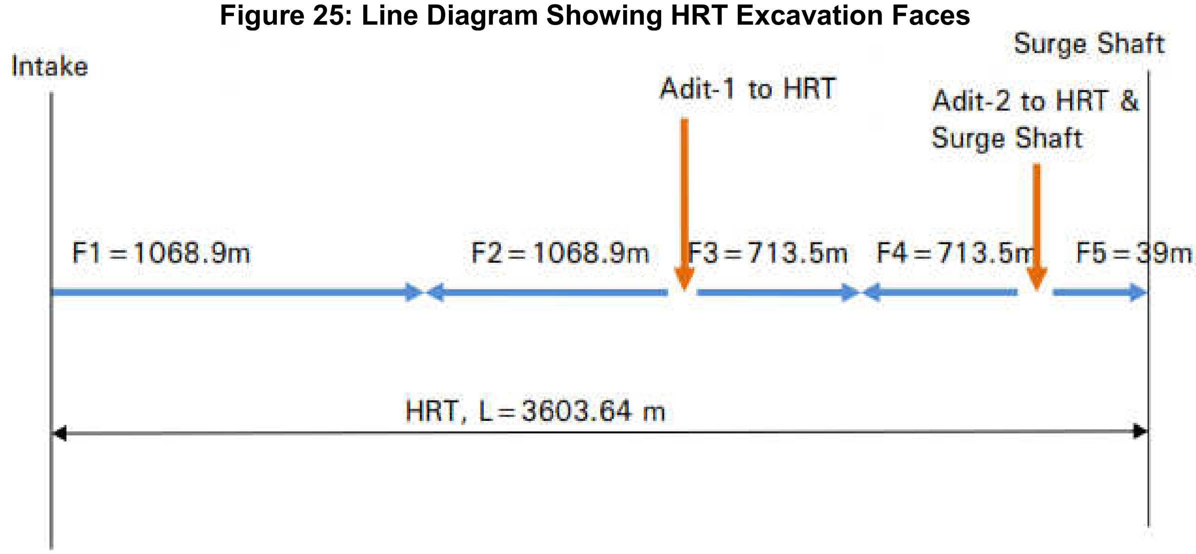
Parameter	**Description/Value**
Location	Right bank of Kopili river
Excavated shape	Modified Horse Shoe
Finished Shape	Modified Horse Shoe
Number of HRT's	1.0
Finished Diameter	6.65 m
Length of HRT	3619.62 m
Construction Adits	
Number of Adits to HRT	2.0

Parameter	Description/Value
Excavated shape	D-Shape
Finished shape	D-Shape
Finished Diameter	6.0 m
Length of Adit-1 to HRT	334.22 m
Length of Adit-2 to HRT & Surge Shaft	153.35 m

127. **Adits Excavation:** Construction of adits 1 & 2 will be undertaken simultaneously after the initial construction of access roads. Adit 1 & 2 portals will be constructed first, followed by adoption of full face method of excavation using conventional controlled drilling and blasting method for excavation of adit tunnels.

128. **HRT Excavation:** Once the construction of adit 1 & 2 has been completed, the full face method of excavation will be adopted using conventional controlled drilling and blasting method for excavation of HRT. In case of weaker strata encountered in HRT, heading and benching process of excavation will be carried out. The HRT will be excavated from five faces i.e. adit-2 two faces from surge shaft end, intake end, two faces from an intermediate adit, and adit-1. A line diagram showing the excavation faces planned for construction of HRT is presented in Figure 25.

Figure 25: Line Diagram Showing HRT Excavation Faces



129. Once the excavation of adits has been completed the same equipment will be utilized for the construction of HRT.

7. Surge Shaft

130. This activity will take about 24.6 months (M-14.5 to M-39.10). The salient features of surge shaft are presented in Table 36.

Table 36: Salient Features of Surge Shaft

Parameter	Description/Value
Shape	Circular
Number of Surge shafts	One
Finished diameter	25 m
Height of Shaft	82.90 m (23.5 m above NSL +27.19 m having

Parameter	Description/Value
	finished dia.25 m + 32.21 m orifice having excavated size 8.2 m (L) x 3.95 m (W)
Average Lining Thickness	1,600 mm
Top Elevation	EL. 237.5 m
Bottom Elevation	EL. 149.4 m

131. **Excavation:** Excavation of surge shaft will be performed with a pilot hole at first, and later further enlargement till the required dimension. The surge shaft bottom will be accessed through adit-2 via valve house. Whereas the top of the surge shaft will be open to the sky and may be accessed by road on the top. The excavation of surge shaft and orifice will be carried out by the conventional controlled drill and blast process. 10 T capacity Gantry crane along with the bucket (4 m^3 capacity) will be installed at the surge shaft top. For drilling, conventional jack hammers and pusher legs along with crawler drill machine will be used. Initially a pilot hole of about 2.50 – 3.0 m diameter will be excavated. The mucking operation will be carried out with the help of an Electric Overhead Travelling (EOT) crane attached with a bucket and installed at the top of the surge shaft. After excavation of the pilot hole, the widening and benching of the surge shaft to its required dimension will be carried out. Through adit-2, a small excavator will be lowered and removed time to time from the top of surge shaft with the help of an EOT crane to complete the muck removal operation of the surge shaft.

132. The type of equipment required for excavation of surge shaft are presented in Table 37.

Table 37: Equipment planned for Surge Shaft Excavation

S.No.	Items	Number
1	Electric Overhead Travelling (EOT) 10-T capacity with bucket	1
2	Excavator 0.75 cum bucket capacity	1
3	Rig-On-Crawler	2
4	Jack hammers with pusher legs	6
5	Concrete pumps (30 cum/hr)	1
6	Wet shotcrete machine	1
7	Air compressor (600 cfm)	1
8	Tippers (16-T)	3
9	Slip form shutter	1 set
10	Grout Pump	1
11	Tower Crane	1

133. **Surge Shaft Lining:** The concrete lining in the surge shaft will start from the bottom and progress upwards, in 2 stages: Stage-1: Concrete lining for Orifice (EL. 149.40 m to EL.186.81 m) will be carried out from bottom to top; the pouring of concrete will be carried out from the bottom of the surge shaft by a concrete pump through Adit-2. Stage-2: Concrete lining for Main Surge shaft – Underground and Above Surface (EL.186.81 m to EL.237.50 m) will be carried out from bottom El186.81 to top El- 213.60;the pouring of concrete will be carried out utilizing EOT crane installed at the top of surge and concrete buckets. Later, the concrete works from El-213.60 to El-237.50 will be executed.

8. Valve House

134. This activity will take over 19 Months (M-19.5 to M-38.5).

135. **Excavation:** Valve house shall be accessed through Adit-3 at bottom and via a proposed access road at top. The top loose over burden will be removed at the top. The methodology employed for excavation of the valve house shall be same as that of the surge shaft. A pilot hole will be excavated. Mucking will be carried out by an EOT crane installed at the top of valve house. Enlargement of the valve chamber to its required dimension will be carried out by slashing down. The blasted muck will be pushed down and thereafter removed through Adit-3. A separate EOT crane with bucket arrangement and a small excavator of 0.40 cum bucket capacity at the bench will be provided. The same equipment will be shared from Adit-2 at the bottom of the valve house.

136. **Concreting:** The concreting of valve house will be carried out from bottom proceeding upwards. Shuttering of 1.50 m height will be used for concreting of the valve house. The valve house RCC and structural part will be erected forming the Valve house along with concreting of crane beam with embedment parts of EOT. The EOT crane will be erected and commissioned thereafter. The roof of the valve house will be fabricated and erected in place. All the hydro-mechanical components of the valve house will be placed in position along with its concrete and electro-mechanical components will be commissioned. The ferrules at the upstream and the downstream of the two Butterfly valves will be placed in line and level of the penstock and will be surrounded with concrete.

9. Pressure Shaft

137. This activity will take over 18.60 Months (M-26.20 to M-44.88). Salient features of pressure shaft are presented in Table 38. The top portion of the pressure shaft tunnel will be accessed through Adit-3 which passes through the valve house, whereas the bottom horizontal portion will be accessed through the power house side.

Table 38: Salient Features of Pressure Shaft

Parameters	Description/Value
Excavated shape	D-Shape (Horizontal portion) Circular (vertical portion)
Finished shape	Circular
Number of pressure shafts	One
Internal diameter of pressure shaft	5.2 m
Length of pressure shaft	703.80 m (630 m horizontal portion + 73.714 m vertical portion)
No. of unit pressure shafts	Two
Internal diameter of unit pressure shafts	3.70 m
Length of unit pressure shafts PS1/PS2	57.06 m/65.52 m
Average Lining Thickness	1600 mm
Top Elevation	EL 237.50 m
Bottom Elevation	EL 149.40 m

138. **Excavation (Horizontal Excavation):** Pressure shaft excavation shall be carried out by conventional drill and blast process in D shape tunnel. Adit-3 will be facilitated for excavation of the top horizontal portion whereas the bottom horizontal portion will be excavated from the Power House end. The excavation and the concrete activity for the tunnel is proposed to be carried out with the same equipments as deployed for the Head Race Tunnel (HRT) for the top horizontal pressure shaft.

139. **Vertical Pressure Shaft:** Vertical portion of the pressure shaft will require excavation for about 73.714 m height, and will be done by either of the two methodologies described above

with details finalized at the later stage of engineering. Procedure-1: After completion of the horizontal pressure shaft, a pilot hole of about 2.20 m diameter will be excavated. Allimack Raise Climber will be used for excavation of the vertical pressure shaft proceeding from bottom to the top. After completion of 73.714 m of 2.20 m diameter pilot hole, widening and slashing down of the shaft for 5.80 m diameter will be carried out. The removal of muck will be carried out from bottom of the horizontal pressure shaft. Procedure-2: The excavation of vertical pressure shaft will be carried out by a 10-T EOT crane equipped with 4 cum bucket installed at the top for carrying out the excavated muck (from the top). Loading of buckets will be done manually. The vertical pressure shaft excavation will be carried out for full face shaft excavation.

10. Main Power House (MPH)

140. This activity will take over 39 Months (M-8.5 to M-47.5). Salient features of the Powerhouse are presented in Table 39.

Table 39: Salient Features of Power House

Parameter	Value/Description
Main Power House	
Type	Surface Power House
Number of Units	2 (2x55 MW)
Dimensions of Powerhouse (LxWxH)	77.55 m x 21.5 m x 42.9 m
Turbine Setting Elevation	EL. 98.8 m

141. **Excavation:** The excavation for the power house sites will be carried out in stages and by developing routing of construction ramps, zones, and levels. Excavation that requires no blasting operation will be executed in accordance with the theoretical cut line as defined by the cross section on the construction drawing; this will take into account the nature of ground. Surfaces will be evenly leveled to ensure final shape as required. Excavations that require blasting such as in rock surface, shall be carried out in accordance with blasting specifications, in layers while prescribing to the thickness requirements to meet the specified excavation face. A controlled perimeter blasting technique shall be used only and if required., to obtain the specified excavation faces on permanent works. Any excavated material (soil/blasted rock) to be used later in backfilling will be kept in a well-covered temporary storage area to maintain the material properly. The temporary storage area shall be safe with slopes in accordance with angle of internal friction of materials and with necessary drainage to prevent water accumulation/ flooding during periods of heavy rainfall. Hydraulic excavators will be used to load the excavated material (soil/blasted rock) into the dumpers and taken to the muck disposal yard. All necessary slope protection measures such as rock anchors, shotcreting will be practiced during the excavation process.

142. **Power House Concreting and Electro-mechanical Works:** Stage-1: After completion of final excavation, raft concreting below the draft tube will be carried out in lifts of 1.5 m. Concreting will be carried till the completion of each 1.5 m lift. Mobilization of column formwork for lifts of 2.4 m will be carried out simultaneously: All beams forming a frame/grid with the columns will be simultaneously concreted and completed.

143. Stage-2: After the achievement of required strength for the columns and EOT beams, EOT gantry will be erected to facilitate erection of mechanical equipment / items. Before starting Stage 2 concreting, a portion of raft (unit wise) will be taken up for mechanical installation, laying of conduits, Penstock erection and alignment, draft tube and knee liner erection.

144. Stage-3: After the erection, positioning and aligning of turbine will be completed for one unit, Concreting will be carried out up to turbine floor level in lifts of 1.5 m. After the erection of other turbine units sequentially, concreting will be carried out for the respective units and completed. Concreting will be carried out by tower crane and 3.0 cum bucket arrangement or concrete pump and pipeline or a combination of both. Shutter handling will be done by tower crane.

145. Stage-4: After the erection, positioning and aligning of generator will be completed for one unit, Concreting will be carried out up to machine floor level in lifts of 1.5 m. After the erection of other generator units sequentially, concreting will be carried out for the respective units and completed. Mobilization of slab formwork for different floors and concreting will be carried out simultaneously. Concreting will be carried out by tower crane and bucket arrangement or concrete pump and pipeline or a combination of both. Shutter handling will be done by tower crane. After completion of erection works and concreting works, backfilling will be carried out as required. Table 40 presents the main equipment envisaged for construction of the power house.

Table 40: Equipment Envisaged for Construction of Power House

S.No.	Item	No.
1	Jack Hammers with pusher legs	5
2	Emco loader with rail line	1
3	Excavator (1.2-1.5 cum bucket capacity)	2
4	Tippers (16 – T)	5
5	Concrete pump (30 cum/hr)	1
6	Grout Pump	1
7	Shotcrete machine (wet)	1
8	Compressor (600 cfm)	1
9	Batching Plant (30 cum/hr)	1
10	Welding machine	3
11	Bar cutting machine	1
12	Dewater pumps (20 HP)	3
13	Transit Mixers (6 cum/hr)	4
14	DG Set (515 Kva)	1

11. Tail Race Channel

146. Tail Race Channel (TRC) will be 26.3 m (w) by 52 m (l) approximately. The TRC will involve an open excavation on the d/s end of project near the river Kopili. Open excavation will take place simultaneously with the excavation of the power house. The side slopes for TRC will be given an even finish by concrete. The concrete works will utilize the same equipments as employed in the construction of the power house works.

12. Auxiliary Power House (APH)

147. This activity will take over 21.50 months (M-17.8 to M-39.30). The salient features of Auxiliary power house are presented in Table 41.

Table 41: Salient Features of Auxiliary Powerhouse

Parameter	Description/Value
Number of penstocks	1
Diameter of penstock	2.7 m
Length of penstock	70 m

Number of unit penstocks	3
Diameter of unit penstocks	2 Nos.-1.2 m & 1 No. 1.7 m
Length of unit penstocks PS1/PS2/PS3	30.79 m/27.16 m/31.62 m
Type	Surface
Number of units	3 (2x2.5 MW + 1x5 MW)
Dimensions of Powerhouse (LxWxH)	44.20 m x 11.50 m x 36 m
Center line elevation of powerhouse	EL. 168.00

148. The sequence of excavation, concreting along with the electro-mechanical works of APH will be similar to that of MPH. A penstock pipe of 2.7 m diameter emerges from the dam body of non-overflow block No. 17. A bell mouth intake will be constructed. The construction of bell mouth intake will be taken along with the dam. The construction of pressure shaft and APH will be same as that of the construction methodology for MPH.

IV. DESCRIPTION OF THE BASELINE ENVIRONMENT

A. Introduction

149. Situated on the River Kopili, a major tributary of River Brahmaputra, the proposed project lies east of Karbi Anglong and west of Dima Hasao of Central Assam Region (CAR). The area is popularly referred to as Hills District. The LHKEP envisages construction of a concrete gravity dam leading to submergence of land that will include human settlements, agricultural land, and forests as well as disturbance to existing flora and fauna.[10] The proposed project (dam site) is in the vicinity of the village Longku in autonomous district of Karbi Anglong. Figure 26 and Figure 27 presents the location maps of the project area.

150. The proposed project is one of the multi-stage developments program in the River Kopili valley. The River Kopili has two operational hydroelectric power projects upstream of the proposed project: The 75 MW Khandong HEP served by the Khandong reservoir and the 200 MW Kopili HEP served by the Umrong reservoir (on River Umrong).

151. Corresponding to the LKHEP, a power evacuation system envisages the construction of 50 km 220 kV Double Circuit (DC) transmission line (TL) from the Main Power House (MPH) site of LKHEP to an existing 132/33 kV Substation (S/S) at Sankardev Nagar (Lanka) and the construction of 20 km 33 kV Double Circuit (DC) TL from the Auxiliary Power House (APH) site of LKHEP to an existing 33/11 kV S/S at Umrangsu. The TL corridors are envisaged to by-pass some villages / settlements and avoid forests. The power evacuation system will also involve upgrading of an existing 132/33 kV S/S at Sankardev Nagar with existing 2 no. power transformers of capacity 2x25 MVA to 220kV with 2 no. inter-connected transformers (ICT) of capacity 2 x 160 MVA. The relevant switchgear proposed type is of Gas Insulated Substation (GIS). There is no land acquisition associated with this activity, and no major impacts on biodiversity are anticipated.

152. An environmental assessment for the power evacuation system has been conducted and included in Annex 31: Environmental Assessment of Power Evacuation System. Separate EMP has been prepared for transmission line component and presented in Annex 31.

153. In order to assess the impacts of the proposed project, a thorough investigation of the baseline environment in the project's area of influence (study area[11]) was conducted. A scoping matrix identified the relevant parameters that are likely to be affected as a result of the construction and operation works, followed by field visits at all sensitive locations, primary and secondary data collection, and discussions with stakeholders such as government officials, NGOs and affected people. This exercise was undertaken by WAPCOS[12].

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[10] Nearly 95 percent of the catchment area of the river Kopili are State (reserve) forests, and 05 percent is under cultivation and homesteads (DPR, September 2015)

[11] As per the methodology adopted for the EIA, the study area for the EIA study consists of the following: 1. Submergence area; 2. Area within 10 km of the periphery of the submergence area; 3. Area to be acquired for locating the various project appurtenances; 4. Area within 10 km of various project appurtenances; 5. Catchment area intercepted at the dam site extending up to diversion structure of LKHEP project; 6. Areas along the alignment of evaluation line (see Chapter I Introduction), and 7. Access road alignment. Note: the term study area and project area have been used interchangeably in this chapter.

[12] Note: ADB consultants led stakeholder consultations have also been held at various stages; detailed discussion and information are presented in Chapter IX: Consultation, Participation, and Information Disclosure.

Figure 26: Project Location Map

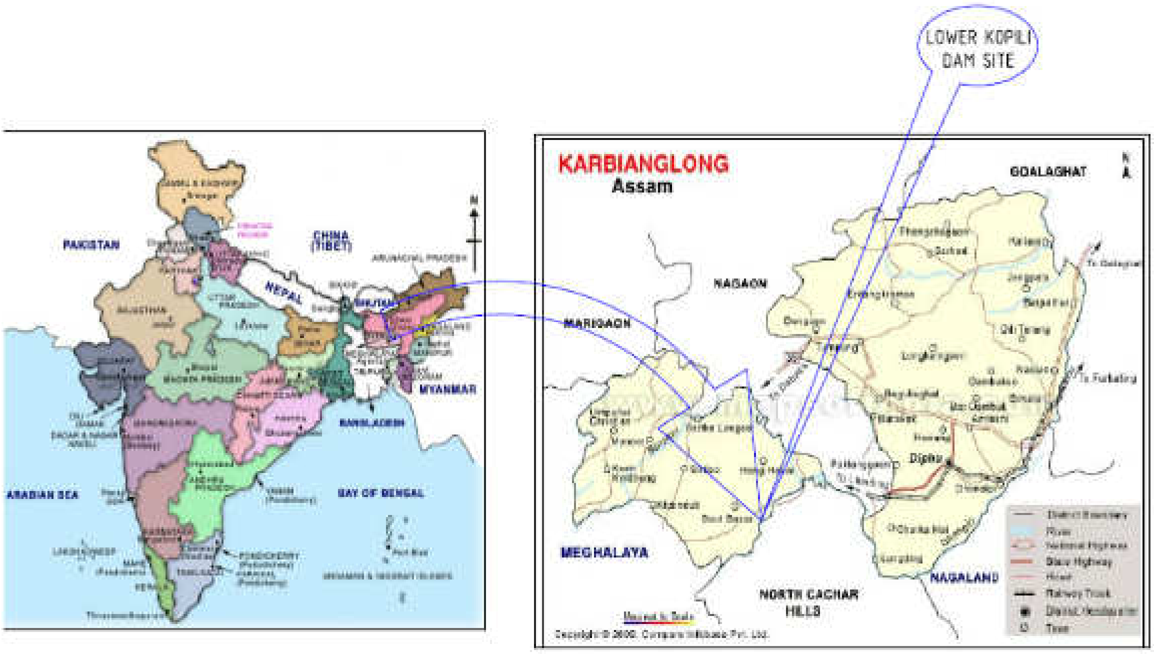
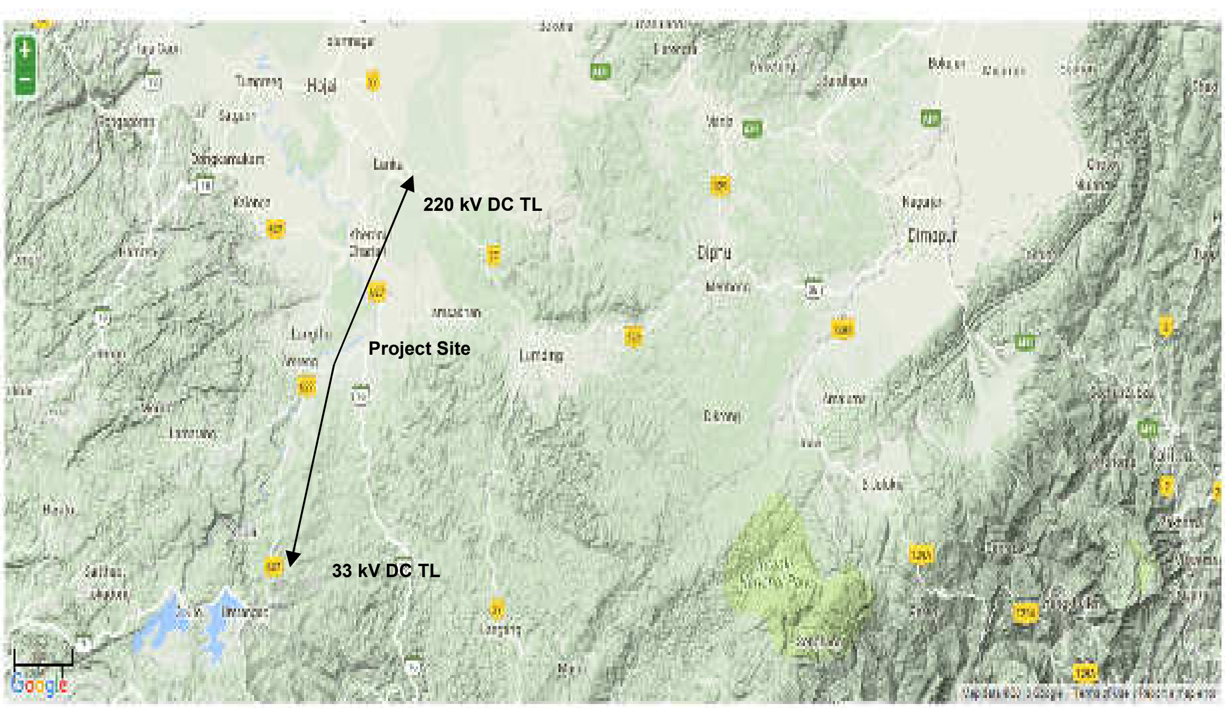


Figure 27: Map of Project Area (LKHEP and Proposed 220 kV DC TL & 33 kV DC TL Corridor



154. WAPCOS has prepared an EIA for the proposed project in September 2015 (finalized in April 2018). Primary and secondary data from the EIA prepared by WAPCOS Limited has been

utilized for the description of the baseline environment in the project's area of influence. This chapter has been arranged as follows:

- Physical Resources
- Biological Resources
- Socio-Economic Profile

155. WAPCOS conducted field studies in the 'study area' for 3 seasons (pre-monsoon, monsoon, and post monsoon) as per MoEF&CC approved ToR as shown below. The study area comprised of: a) Submergence area; b) Area within 10 km of the periphery of the submergence area; c) Area to be acquired for locating the various project appurtenances; d) Area within 10 km of various project appurtenances (Catchment area intercepted at the dam site extending up to diversion structure of LKHEP project; and alignments of transmission line and access road).

Season	Months
Monsoon	August 2014
Winter	December 2014 – January 2015
Summer	April 2015

B. Physical Resources

1. Physiography

156. Assam, situated at the foothills of the eastern Himalayas, is the largest state in northeast India and lies in the middle reach of the river Brahmaputra and Baraak. The State accounts for nearly 2.4% of India's total geographical area with an area of 78,550 km^2. It lies between latitude 24-28°'N and longitude 90-96°E. The State is bordered by the kingdom of Bhutan on the north and east respectively. Along the south border are Nagaland, Manipur, and Mizoram. Along the south-west is Meghalaya while along the west is West Bengal and Bangladesh.[13] Majority of the areas in Assam are floodplains of the River Brahmaputra. The State is divided in geographic zones namely: Lower Assam Region (LAR), Central Assam Region (CAR), and Upper Assam Region (UAR) with a total of 35 districts; the capital of Assam is Dispur. The proposed project is located east of district Karbi Anglong and west of district Dima Hasao[14] of Central Assam Region (CAR).

157. The topography in and around the proposed project area consists of hills covered with dense vegetation with low mounds and valleys with a general slope towards the north-east. The highest elevation is 356 m just beyond the southern limit of the proposed reservoir site (near origin of Saini Langso nala). Trend of major ridges in the area is N-S to NW-SE. At dam site, the bed level of Kopili River is ±170 m. River Kopili has perennial drainage in the area, which follows a SE to NW course at dam site with moderate to steep valley slopes (with local slope breaks) towards both abutments. In general, the drainage system is dendritic; however the near right angle swing of the SW-NE flowing river Kopili just after its meeting with Lonku nala indicates that at places it is structurally controlled. The flatter portions of hills are comprised of weathered rock mass while valley slopes are comprised of slope wash material with intermittent rock exposure. Alignments of the transmission line and access road mostly pass through plain to undulating terrain.

[13] Assam at a glance, Official Website of Assam, GoA http://www.assaminfo.com/
[14] Dima Hasao is also known as North Cachar.

2. Meteorology and Climate

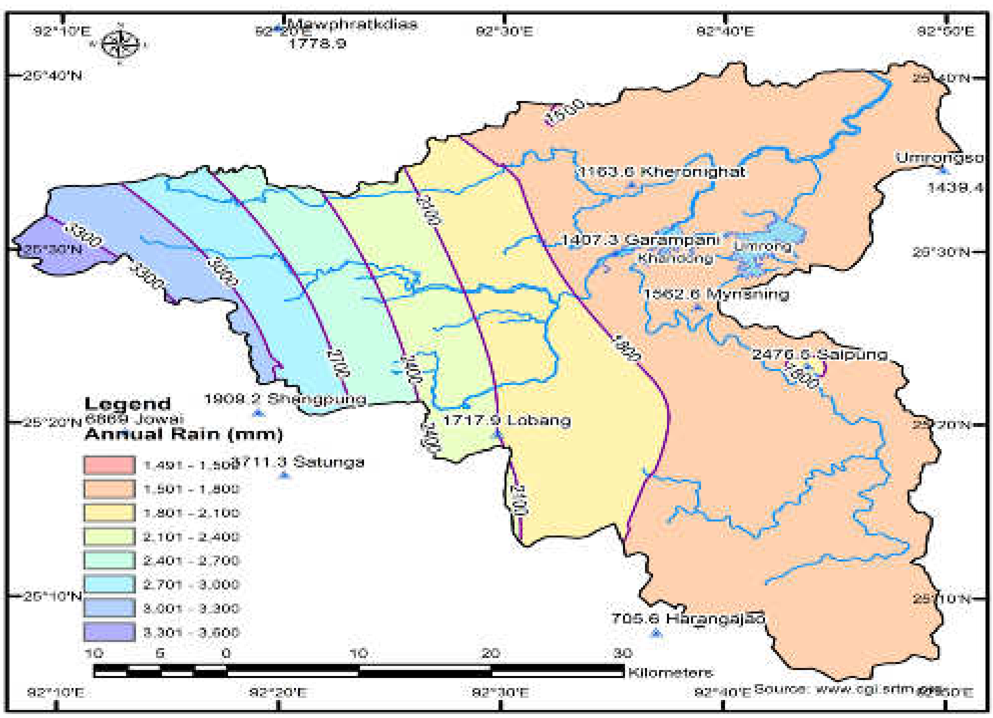
158. ***Climate***: The seasons in Assam are mainly divided into two: cool season from November to February and rainy season from June to September. Assam also has two short periods of spring from March to May and autumn from September to October. During the short spring season, Assam may receive some amount of rain, keeping the temperature low.

159. ***Temperature:*** Depending on the elevation, the high hills belong to temperate zone while low hills and valleys are in the sub-tropical agro climate zone. Temperature in the region varies generally from a maximum of 23°C to 32°C in summer to a minimum of 6°C to 14°C in winter.

160. ***Humidity:*** The average relative humidity, brought by the SW monsoon, varies between 73% and 84%.

161. ***Rainfall:*** The rainfall in the State is spread over 8 months (from March to October); heavy rainfall occurs in the months of June to September. The annual rainfall is more than 2,000 mm. The catchment of the river Kopili lies on the leeward side of the Borail, Khasi and Jaintia hills range of Meghalaya. Due to this, the rainfall is not uniform throughout the catchment area and gradually diminishes towards the lower reaches. The average annual rainfall of the upper catchment area (up to Khandong HEP dam site) is 2,192 mm while for the intervening catchment area up to the proposed project dam site (at Longku) it is 1,626 mm (See Figure 28). In the upper catchment area (up to Khandong HEP dam site), there are seven Rain Gauge (R.G.) stations[15] while in the same reach immediately below the reservoir of Khandong HEP dam site, there is one R.G. station at Umrongso in the Umrong Nallah sub-catchment. Based on the data analysed from these Rain Gauge stations, the mean annual rainfall over the catchment has been computed as 1,946 mm.

Figure 28: Mean Rainfall Distribution Graph



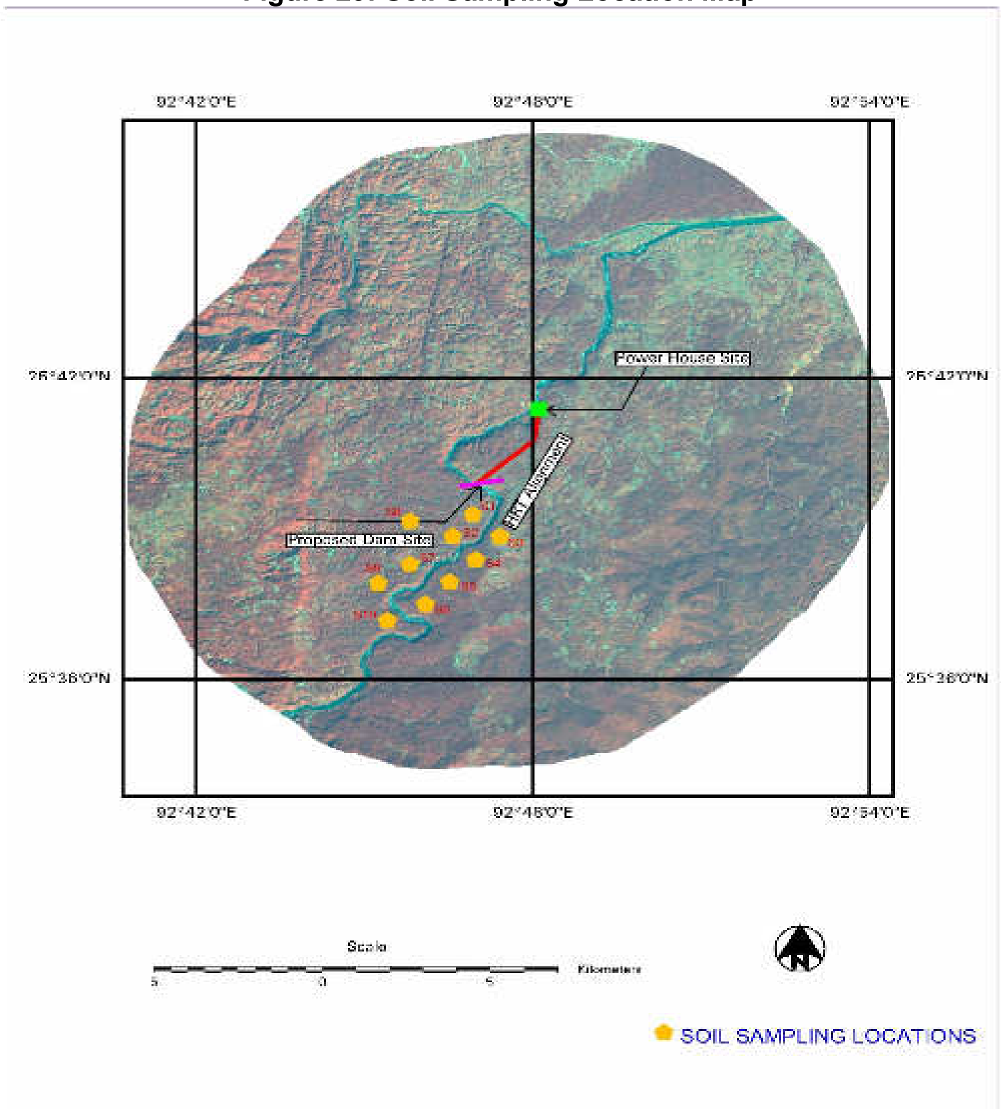
[15]Locations: (1) Shangpung, (2) Satunga (3) Mawphratkdias (4) Saipung (5)Garampani (6) Lobong (7) Mynsning.

3. Soil

162. The soils of Assam are very rich in nitrogen and organic matter. The northern areas, nearer to the river Brahmaputra, have new alluvium while the southern areas or areas near the foothills have old alluvium. The high fertility of soil makes it suitable for cultivating varieties of crops throughout the year such as cereals, pulses, oilseeds, plantation crops, etc.[16] The soils in the proposed project area particularly on slopes above 30° are generally shallow due to erosion and mass wasting (slope movement) processing. Such soils have medium to coarse texture.

163. In order to establish the soil quality at the project site, soil sampling was conducted in 2015 for three seasons (monsoon, winter and summer). The results are presented in Tables 42 to 44, respectively. The soil sampling location map is enclosed as Figure 29. Soils samples are analysed for physical properties at this stage. However prior to start of construction work, soil testing for chemical properties including heavy metals will be conducted.

Figure 29: Soil Sampling Location Map



16 http://asmenvis.nic.in/Database/Soil_1048.aspx

Table 42: Soil Quality In The Catchment Area For Monsoon Season

Parameters[17]	Stations									
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
pH	7.1	7.4	7.2	7.2	7.4	7.0	7.0	7.2	7.1	7.07
Electrical Conductivity (milli mhos/cm)	0.10	0.30	0.12	0.15	0.21	0.22	0.20	0.23	0.18	0.15
Nitrogen, (%)	0.20	0.15	0.26	0.20	0.20	0.25	0.25	0.20	0.10	0.12
Phosphates (mg/lg)	0.90	1.20	1.25	2.21	2.25	2.42	3.0	2.27	2.38	2.29
Potassium (mg/lg)	382.5	545.0	718.0	527.0	817.1	427.5	276.1	309.5	250.4	165.9
Organic matter (%)	2.40	0.85	2.16	2.15	0.70	0.65	0.84	0.84	0.72	1.20

Table 43: Soil Quality In The Catchment Area For Winter Season

Parameters	Stations									
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
pH	7.1	7.2	7.2	7.16	7.5	7.1	7.08	7.24	7.22	7.13
Electrical Conductivity (milli mhos/cm)	0.13	0.31	0.12	0.17	0.25	0.25	0.24	0.27	0.20	0.17
Nitrogen, (%)	0.21	0.16	0.27	0.23	0.23	0.26	0.26	0.21	0.11	0.12
Phosphates (mg/lg)	0.95	1.24	1.28	2.22	2.34	2.56	2.98	2.33	2.41	2.33
Potassium (mg/lg)	388.9	551.4	723.0	534.0	823.	432.0	280.7	314.8	252.2	172.1
Organic matter (%)	2.43	0.90	2.21	2.23	0.75	0.67	0.89	0.89	0.76	1.24

Table 44: Soil Quality In The Catchment Area For Summer Season

Parameters	Stations									
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
pH	7.1	7.2	7.2	7.16	7.5	7.1	7.08	7.24	7.22	7.13
Electrical Conductivity (milli mhos/cm)	0.13	0.31	0.12	0.17	0.25	0.25	0.24	0.27	0.20	0.17
Nitrogen, (%)	0.21	0.16	0.27	0.23	0.23	0.26	0.26	0.21	0.11	0.12
Phosphates (mg/lg)	0.95	1.24	1.30	2.25	2.36	2.59	3.1	2.33	2.41	2.33
Potassium (mg/lg)	388.3	555.0	725.0	534.0	823.1	432.0	280.0	313.0	256.1	172.3
Organic matter (%)	2.43	0.90	2.21	2.20	0.75	0.67	0.89	0.89	0.76	1.28

164. **WAPCOS Soil Sampling Results (2015):** Results of soil sampling suggest that soil depth across various locations in the catchment area range from 20 to 50 cm and the pH is within neutral range. The levels of Nitrogen, Phosphates and Potassium (NPK) indicate moderate to high soil productivity. The sodium levels do not indicate any potential for soil salinization or adverse impacts on soil productivity. In addition, it is unlikely that coal mining much further upstream has affected any soil characteristics in the project area.

165. In a HEP, no significant impact on soil quality is expected barring soil pollution at local level due to disposal of construction waste plus the risk of pollution incident, spillage of fuel, oil and chemicals during work and to a lesser extent in operation. For amelioration of such impacts appropriate management measures are recommended, as included in the EMP for the proposed project.

166. **Sediment Analysis**: As part of detailed project preparation, sediment analysis has been carried out. Sediment samples from various locations (upstream, dam reservoir, downstream) have been collected and petrographic examinations of sediments have been carried out in Geo-

[17] As part of pre-construction baseline data generation, soils will be tested for chemical properties including heavy metals.

science Laboratory of Assam Engineering Collage. Results of the sediment tests are tabulated below.

Sl. No.	Parameter / Constituent Mineral Present	% of Mineral Grains				
		u/s	Res	Res	Res	d/s
1.	Water Content (Litres)	1	1	1	1	1
2.	Silt Content (gm)	0.02	0.05	0.04	0.02	0.06
3.	Average Grain Size (mm)	0.045	0.045	0.045	0.045	0.045
4.	PPM	20	50	40	20	60
5.	Quartz	71.2	79.5	77.6	85.6	77.3
6.	Biotite	3.8	-	11.7	-	10.5
7.	Muscovite	14.8	16.4	-	9.6	7.4
8.	Feldspar	5.9	-	8.2	-	-
9.	Rock Fragments	2.4	2.6	-	-	2.5
10.	Foreign Materials (grass roots)	1.9	1.5	2.5	4.8	2.3

Source: Sediment analysis test report (2014), Assam Engineering College.

167. It can be seen from the table above that sediments mostly rich in quartz content (71-86%) followed by muscovite and biotile. Organic content (wood and grass roots) content only a small part (1.5 to 4.5%). Considering the presence of low organic content in the sediments the issue of sedimentation contamination with heavy metals is not anticipated. However, monitoring of heavy metal components in the sediment will be conducted during pre-construction stage, if needed, the sediment management plan will be prepared.

168. The characteristics of the above mineral and rock fragment constituents indicate that the sediments have been from metamorphic as well as sedimentary provenances. The shape and size of the grains indicate their short distance transportation and thus their sources are in the nearby areas.

4. Geology

169. The regional geology of the area was investigated by V. P. Sondhi, P. N. Mukherji and A.M.N. Ghosh of Geological Survey of India (GSI) between 1930 and 1953. The general geological succession as established by different researchers is presented in Table 45.

Table 45: Regional Geological Successions

Recent to Sub-Recent		Alluvium
Jaintia Group (Eocene)	Kopili Formation	Mainly shales with few silt stones & argillaceous limestone bed
	Sylhet Formation	Mainly limestone with shale beds
	Cherra Formation	Mainly sandstone with some shale beds
--------------------------------------Unconformity----------------------------------		
Precambrian		Granites
Achaeans		Granite gneisses, quartz biotite schist

170. **WAPCOS Geological Assessment Results (2015):** Results of geological assessment in and around the proposed project area are presented as follows:

171. **Geology of Dam Site:** The dam area has been geologically mapped on 1:1000 scale for the terminal area of both abutments. On the right bank/abutment, mapping has been carried out from u/s coffer dam to d/s coffer dam while on left bank/abutment, mapping has been carried out up to 100 m on either side of the dam axis between elevation El. 240 m and El. 255 m.

Around the river bed, the metamorphic rocks comprise of mainly leucocratic grey and pink granite gneisses belonging to the Archaean Gneissic Complex that have been traversed by younger intrusive of porphyritic and normal granites, pegmatite and quartz veins. Exposures of granite gneiss occur mainly on or along the river bed and at times granite gneissic rocks also occur on steep slopes. Sporadic exposures of Cherra sandstones occur on the abutments. The sandstones are overlying the granite gneissic rock as a cap. Apart from soil and slope wash material, off-white to pinkish white quartzitic sandstone is present as in-situ rock on both the abutments at higher elevation. Two other joint sets have been identified apart from the bedding joint in the sandstone outcrop on both abutments. On the right abutment between dam axis and d/s coffer dam, third set of joint has also been observed. Granite gneiss rocks are pink to grayish white in color and coarse-grained in nature. Small lenses of pegmatite also occur in granite gneisses. Due to weathering, the foliation is not clearly depicted on surface, but occasionally foliation is clearly depicted in fresh rock at a depth.

172. **Geology of Headrace Tunnel:** The slope around the HRT alignment is mostly covered with thick vegetation and few exposures of granite gneiss and Cherra sandstone. Sandstone with varying thickness occurs as a capping on the granite gneiss rock. The inferred contact between granite gneiss rock and sandstone lies at an elevation of 226 m (approximate), on the right abutment hill slope at chainage 36 m (taking intake point as 0 chainage) along the tunnel alignment. The trend of foliation plane in gneisses varies between N0150 and N1950 with dips of 700 in the easterly direction. Geology of Surge Shaft and Pressure Shaft Alignment: Based on surface geological mapping and traverses, area around the surge shaft and pressure shaft is mostly covered with overburden material with sporadic exposures of sandstone and gneiss rocks. Depth of overburden material varies between 9 m and 29 m. Excavation of surge shaft will be done in poor to very poor rock mass, at 33m depth. Beyond 33 m depth, the excavation of surge shaft will be done in poor to fair rock mass with occasional small patches of good granite gneiss rock. Surge shaft -pressure shaft alignment has been explored by 6 drill holes.

173. **Geology of Powerhouse and Switchyard Area:** The area is located on a nearly flat ground having gentle to moderate slope due northwest (towards river Kopili). Majority of the area is covered in top soil with few exposures of in-situ rock. Weathered pegmatite within gneissic rock towards river end is exposed. Rock is moderately hard and dissected with three joint sets apart from foliation (FJ). The area encompasses very steep slope towards eastern and south-eastern side while slope is gentle towards western and northern sides. General slope of powerhouse hill is towards west (towards river Kopili). Granite gneiss occurs towards western and south-western periphery of Powerhouse area. There is a large exposure of pegmatite towards north-western, central and north-eastern portion of the Powerhouse. General orientation of slope face is N0200-0300/ 850-900 i.e. roughly parallel to J3. At the base of cliff face, opening along foliation joint is observed which at places has resulted in overhangs and gravitational slumping. The crown portion of cliff face is covered by slope wash material.

174. **Geology of Reservoir**: This area has been mapped by GSI during FS 1984-85. However, the occurrence of a limestone body in the right bank of the river Kopili (about 4 km upstream of the dam axis) has raised concern. To evaluate the possible adversity, the area was studied in form of geological traverse and sub-surface investigations to note its extension along the u/s and d/s of the river. The bedding of the limestone trends N65^{o}E – S65^{o}W with a horizontal undulating dip towards NW and SE, i.e. into the river Kopili and into the abutment. Based on the evidence of 2 drill holes near Saini Langso and the regional geology, it has been inferred that limestone body has been encountered at areas away from the river Kopili. One of the holes has records of alternate beds of sandstone-shale-limestone at the top underlain by thick beds of nummulitic limestone. No boulder of limestone could be located further

downstream of the river. To ascertain the subsurface continuity and thickness of the limestone bed 2 drill holes 60 m apart have been completed. However in both drill holes sandstone and granite/granite gneiss have been encountered.

175. **Geomorphology of River Kopili in the Project Area**: The project area is represented by the Shillong Plateau, an extensive and well developed Paleocene sedimentary rock succession in its southern and south-eastern parts where Archaean gneissic and granites (Kopili Formation) are best exposed in Kopili valley of Jaintia Hills, Meghalaya and North Cachar Hills. The Archaean gneissic complex is the oldest group of rocks of Llate Eocene age. The gneissic inlier is composed of rocks with textures ranging from coarse-grained porphyritic slightly foliated granite to fine-grained strongly banded gneiss. The Eocene rocks which are restricted to lower Assam are known as the Jaintia series. River Kopili section, is located in the North Cachar Hills and Karbi Anglong districts where it attains a maximum thickness of about 500 m near Umrongso section (previously Garampani) and proposed project area. The Kopili Formation, the youngest litho-stratigraphic unit of the Jaintia series has been divided into three stages. The lower most “Therria” stage is composed of grits: coarse sandstone, dirty white clays and shale together with thin seams of coal. Quartzitic and calcareous sandstones are also predominant. The rocks are very well developed along the Kopili valley on the south-western part of North Cachar Hills. The above stage is overlain by the Sylhet limestone stage, the next higher group of rocks, consisting of mainly fossiliferous (nummulitic) limestone. The limestone rests on gritty sandstone that has locally undergone metamorphism to form Quartzities. The Sylhet limestones are overlain by the upper most Kopili stage consisting of mudstones, silts, shale and carbonaceous shale, with intercalations of sandstones.

176. Thus, formation is made up of alternations of shale and sandstone with thin bands of limestone, siltstone and marl. Mudstones and coal are also present. Coal is present below the excavation level of dam (and coal is not mined in the project area). The shale are generally black to grey to khaki in color, iron stained and are splintery in nature. Sandstone is ferruginous, some may be carbonaceous, fine grained and there are thin as well as thick bedded sections. Thin bands of siltstone, argillaceous limestone and lamellae of coal are also observed. It overlies the Garampani Limestone Formation and is overlain by the Barail sediments. However, in the Umrongso area, the Kopili Formation is covered by alluvial soil. Good quality limestones have been reported from many places in the district from the rock of Sylhet limestone stage. The zone varies in thickness from 7 m to 200 m at different places.

Image 1: Impact of Acidic water on Rocks

Image 2: Weathering of rocks / substratum

5. Natural Hazards

177. Assam is prone to natural hazards such as earthquakes, floods, landslides, cyclones and occasional droughts. The population is vulnerable to perennial floods, landslides and environmental degradations.[18] The GoA, through its State Disaster Management Authority, has made a comprehensive State Disaster Management Plan as well as District Wise Disaster Management Plan to counter such eventualities. The plan follows the mandate stipulated under the Disaster Management Act (2005) and Assam Disaster Management Rules (2010). The plan identifies the vulnerability of different parts of the State to different forms of disasters; and suggests the measures to be adopted for prevention and mitigation of disasters in a manner in which the mitigation measures are integrated with the development plan and projects.

178. **Seismicity:** The north-eastern region of India is an earthquake prone area. The region has experienced a large number of earthquakes of tectonic origin. The risk probabilities of earthquake are less over the entire Brahmaputra valley. The region of north-east India is seismically very active. Two major earthquakes of magnitude 8.7 and 8.6, occurred in 1897 and in 1950 respectively causing large scale damage of lives and properties. Sir Edward Gait (1933) has mentioned about the occurrence of destructive earthquakes in this region in 1548, 1596, 1607, 1642, 1663, 1696, 1714, 1869, 1882 and 1897. In the recent past, destructive earthquakes occurred in 1918, 1923, 1930, 1932, 1938, 1943, 1947, 1950 and 1988. Much of Assam lies in the Brahmaputra River Valley, except for a few southern districts. The northern and eastern parts of this valley are bounded by the Himalayan Frontal Thrust (HFT). In the eastern parts along with the HFT, there is the Lohit and Naga Thrusts. Among the large earthquakes in this region with occurrence of the events in 1869 and 1897, the 1897 earthquake is well known for the dramatic accounts of violent upthrow during the shock.

179. According to “Seismotectonic Atlas of India and its Environ (Seisat-14)” the Dhansiri–Kopili Fault trending NW-SE passes along the Kopili river for a considerable distance from the project area. The project area may be influenced by the NW-SE trending Kopili graben caused by a set of normal faults can be viewed by the fact that the outer boundary of the graben passes beyond at least 40 km west of the project. Dr. Mazumdar from his study (1995-97) concludes that the area is independent of major plate boundaries and the inter-crustal earthquake that has been limited to <6M with focal point much northwest of the area in Karbi Anglong, is governed by local tectonic stress regime. Thus, the overall seismicity level in the project area is moderate.

180. The Bureau of Indian Standards (IS-1893 Part 1, 2002) classified India into four seismic zones based on various scientific inputs including earthquake data from India Meteorological Department (IMD). The seismic zones in India are provided in Table 46. The seismic zones and the earthquake hazard map of India are shown in Figures 30 and 31 respectively.

Table 46: Seismic Zones in India

Seismic Zone	Intensity on Modified Mercalli Scale	% of Total Area
II Low Intensity Zone	VI (or less)	43
III Moderate Intensity Zone	VII	27
IV Severe Intensity Zone	VIII	18
V Very Severe Intensity Zone	IX (and above)	12

[18] Assam State Disaster Management Plan, http://sdmassam.nic.in/pdf/asdmp.pdf

181. The proposed project lies in seismic zone V. The site specific earthquake study has been completed by Department of Earthquake Engineering, IIT Roorkee. The recommendation by IIT Roorkee on site specific earthquake design parameters are based on the studies carried out related to the tectonics, regional geology, local geology around the site, earthquake occurrences in the region and the seismotectonic set-up of the area. The site specific design parameters for Maximum Credible Earthquake (MCE) and Design Basis earthquake (DBE) conditions[19] are recommended as 0.36g and 0.18g for horizontal and 0.24g and 0.12g for vertical ground motion, respectively.[20] The design has been reviewed by independent experienced dam expert appointed by ADB and found to be adequate (and routine dam inspections would be carried out, in any case). The foundations of the transmission towers have been designed keeping in view the seismic factors.

182. **Landslides:** Assam is located in the foothills of eastern Himalayas which are considered to be geologically unstable and seismically active. The State has a history of earthquakes and these are usually accompanied by damaging landslides in the region (GSI, 2011). The most recent major landslide triggered by torrential rains in Kharghuli, district Kamrup occurred in 2011; this district is not included in Tranche 3. Also there are no records of any landslide in the PIA (and none can be observed on recent GoogleEarth images). Table 47 present the list of key landslide events in Assam.

Table 47: List of Key Landslide Events in Assam in past years

Date	Type	District	Name of the Place	Cause of Landslide
5-8 Oct 2004	Land-slide	Kamrup	Guwahati Urban	Heavy concentrated rainfall
28 Aug 2009	Rock-slips and land slide	North Cachar Hills	Mahur and Phaiding	Torrential rains
12-Sep-10	Rock-slips and land slide	Lakhimpur, Dhemaji, Golaghat, and Bongaigaon	-	-
16-Jun-10	-	North Cachar Hills	Jatinga, Longrangjao, Mahur and Wadringdisa	Heavy rains
3-Jun-10	Mud-slide	Karimganj	Rongpur Village	-
2-Apr-10	-	Cachar	Dholai Block	Torrential downpour
23-Mar-11	-	Kamrup	Kharguli Area of Guwahati City	-

Source: Assam State Disaster Management Plan

183. **Floods:** Assam is prone to floods mainly because it receives heavy rainfall within a short time and numerous natural and anthropogenic factors inhibit the land and channels' natural coping mechanism. Additionally, the Rivers Brahmaputra and Baraak, the two major river systems in Assam, are in their early stage of maturity and are active agents of erosion. The Brahmaputra valley occupies most of the North Assam covering districts Goalpara, Kokrajhar, Dhubri, Kamrup, Nalbari, Barpeta, Nagaon, Darrang, Sonitpur, Sibsagar, Jorhat, Golaghat, Tinsukia, Lakhimpur and Dibrugarh. The Baraak valley occupies Lakhimpur through the Cachar Plains region. In July 2016, Assam experienced flash floods and heavy rains affecting districts Lakhimpur, Dhemaji, Nagaon, Morigaon and Jorhat with more than 80,000 persons. None of

[19] MCE defines the peak horizontal accelerations with 2% probability of exceedance in 50 years. DBE defines the peak horizontal accelerations with 10% probability of exceedance in 50 years. Determining MCE & DBE is part of the routine *probabilistic seismic hazard analysis* of the site.

[20] Chapter 6: Geology, WAPCOS EIA Study.

these districts are covered in Tranche 3. Further, the upstream dam provides flood protection, through discharge regulation. The flood hazard map of State is show in Figure 32.

184. Peak flood estimation for different return periods has been done using different approaches (L-Moment Approach, Stochastic Approach-Pearson Type III Distribution, Gumbel Distribution). Table 48 below shows that adopted flood discharge using Stochastic Approach.

Table 48: Adopted Flood Discharge using Stochastic Approach

Return Period (years)	Annual Peak Flow (m^3/s)	Non-monsoon (Nov-April) Flood (m^3/s)
25	4,220	720
50	4,800	815
100	5,375	-

185. **Droughts:** Several districts of Assam were affected due to drought-like situations in 2005 and 2006.[21] During the intense drought-like conditions that prevailed in 15 districts of Assam in the summer monsoon months of 2006 owing mainly to below normal (nearly 40%) rainfall in the region, more than 75% of the 26 million people with livelihoods related to agriculture were affected. Due to this condition, Assam suffered a loss of more than RS 1 billion from crop failure and other peripheral effects. The spell of drought in October 2008 until July 2009 also severely affected agriculture and production of hydropower in Assam including Karbi Anglong and Dima Hasao districts, where the project is located.

186. **Cyclones:** Along the west side of Assam is Bangladesh, which is prone to cyclone. Every year, about 60% of the area in Assam is affected by a cyclone episode in Bangladesh. Due to the location aspect, districts like Dhubri, Gaolpara, Hailakandi, Chachar and Karbi Anglong are more prone to cyclone/winds. Districts namely Kokrajhar, Bongaigaon, Kamrup, Barpeta, Nalbari, Darrang, Sonitpur, Nagaon, Marigaon, Lakhimpur, Dhemaji, Sibsagar, Jorhat, Golaghat, Dibrugarh, Tinsukia and Karbi Anglong are likely to experience wind speed of 50 m/s whereas districts like Hailakandi, Karimganj and Cachar have wind speed of more than 55 m/s and are more vulnerable to cyclonic storms. Occasional cyclones do occur in western Assam and their severity is more during monsoon. According to Building Materials and Technology Promotion Council in India (BMTPC) cyclone zonation, NW districts of Assam lying in zone of high damage where wind speed can reach up-to 47 m/s. Districts close to Bangladesh are in very high damage zone due to close proximity of Bay of Bengal (which is a cyclone basin). In this zone wind speed can reach up-to 55 m/s and can result into large scale damage. The cyclone and wind hazard map of State is show in Figure 33.

[21] Assam State Disaster Management Plan, http://sdmassam.nic.in/pdf/asdmp.pdf

Figure 30: Seismic Zones Map of India

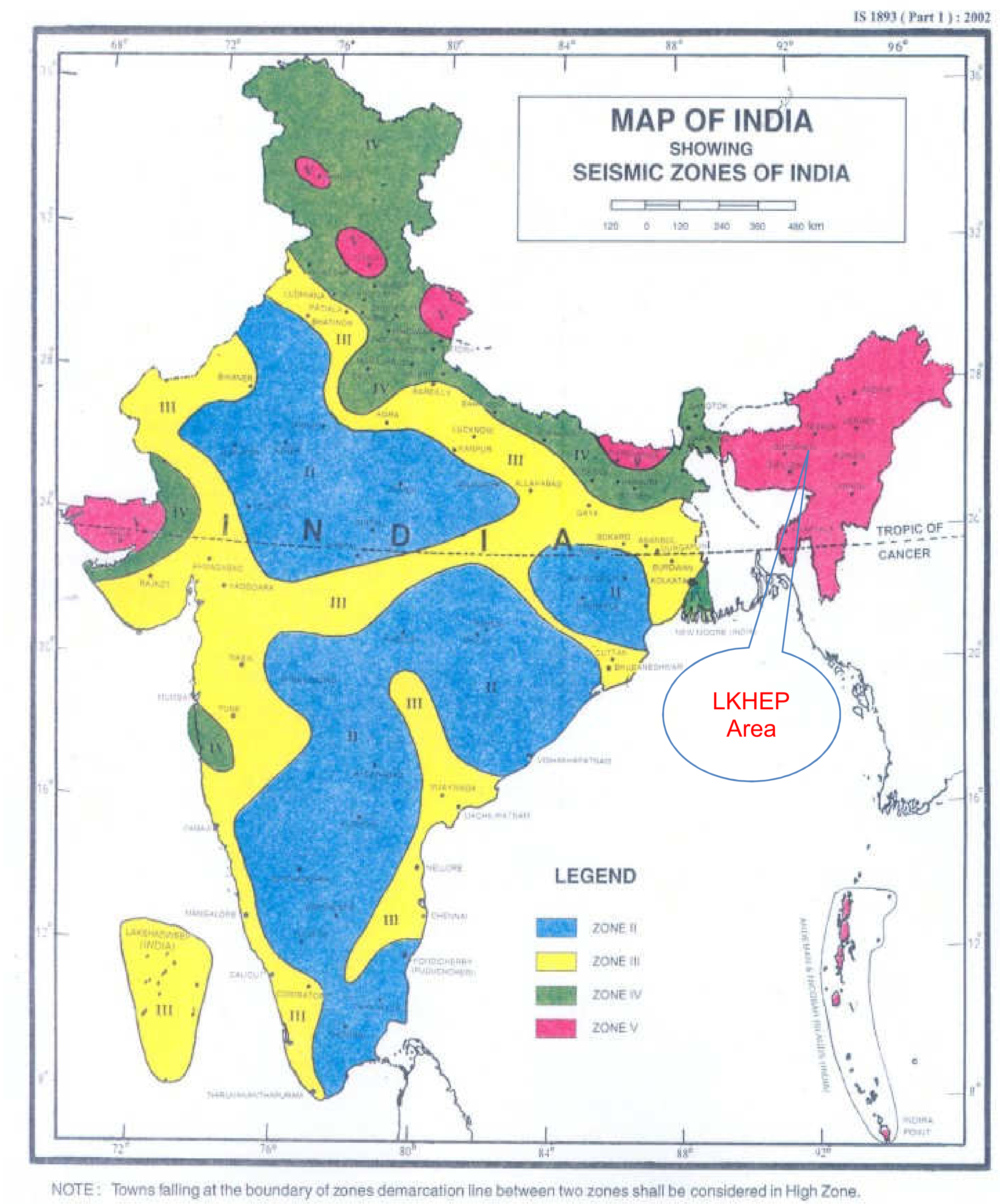


Figure 31: Earthquake Hazard Map of India

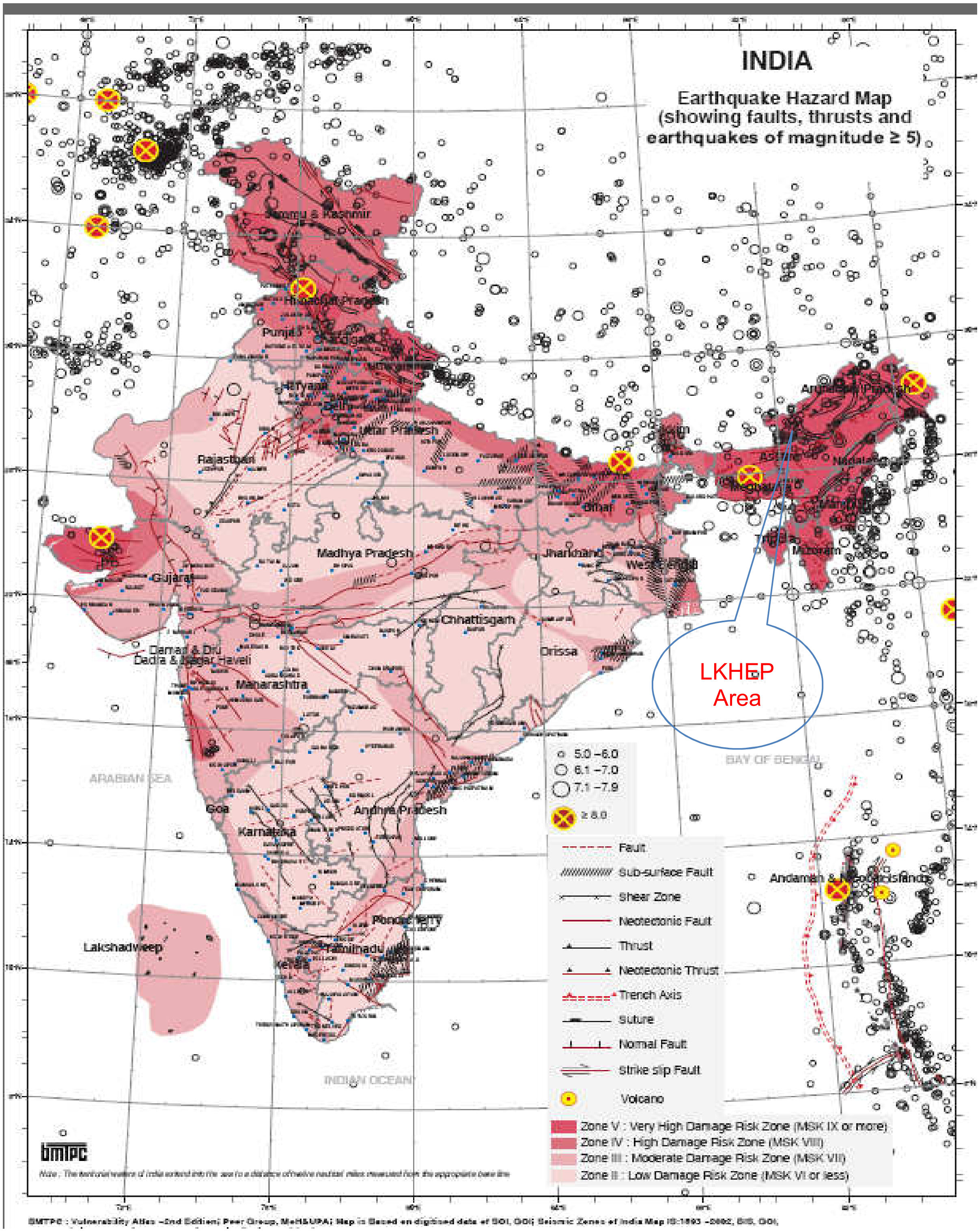


Figure 32: Flood Hazard Map of India

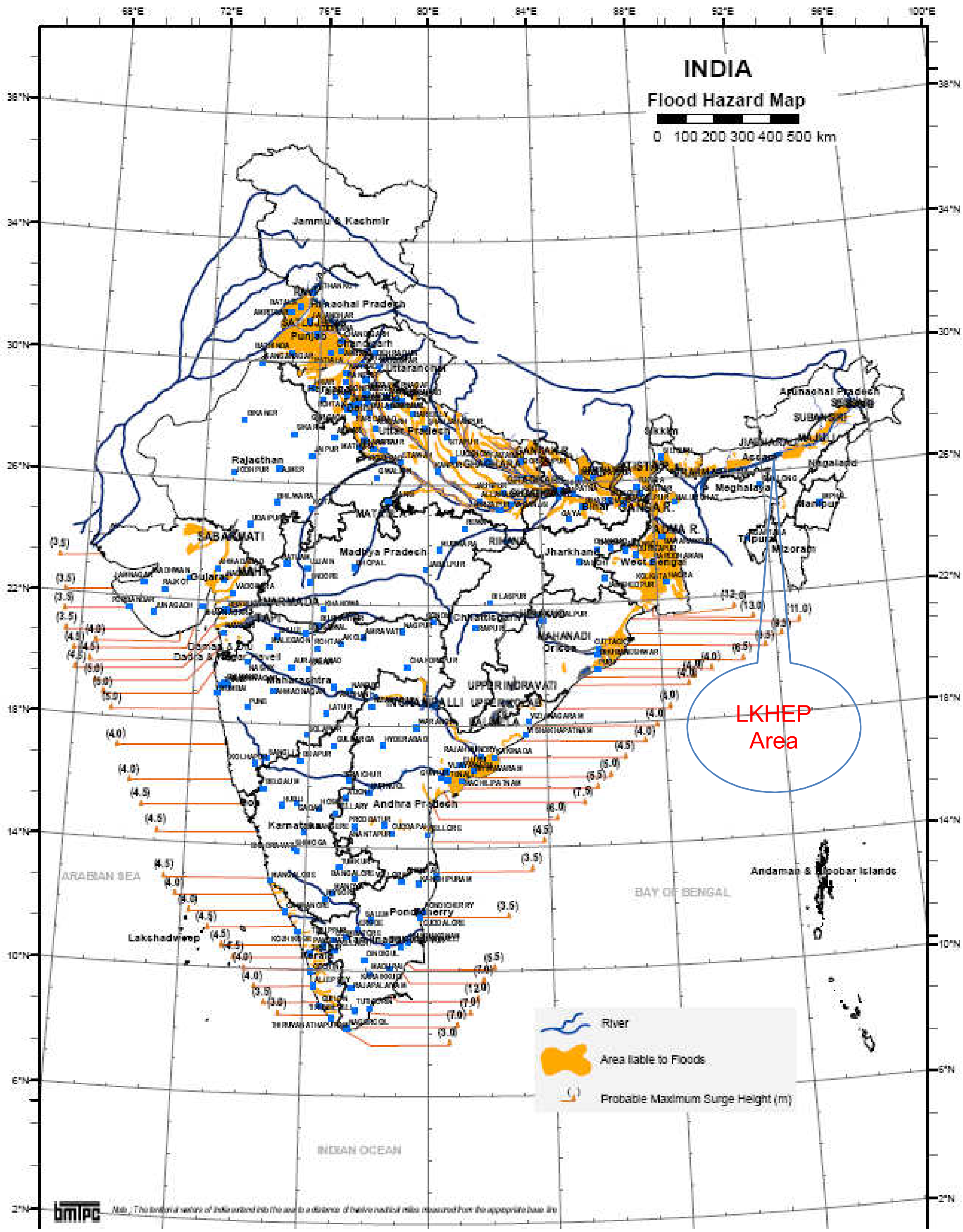
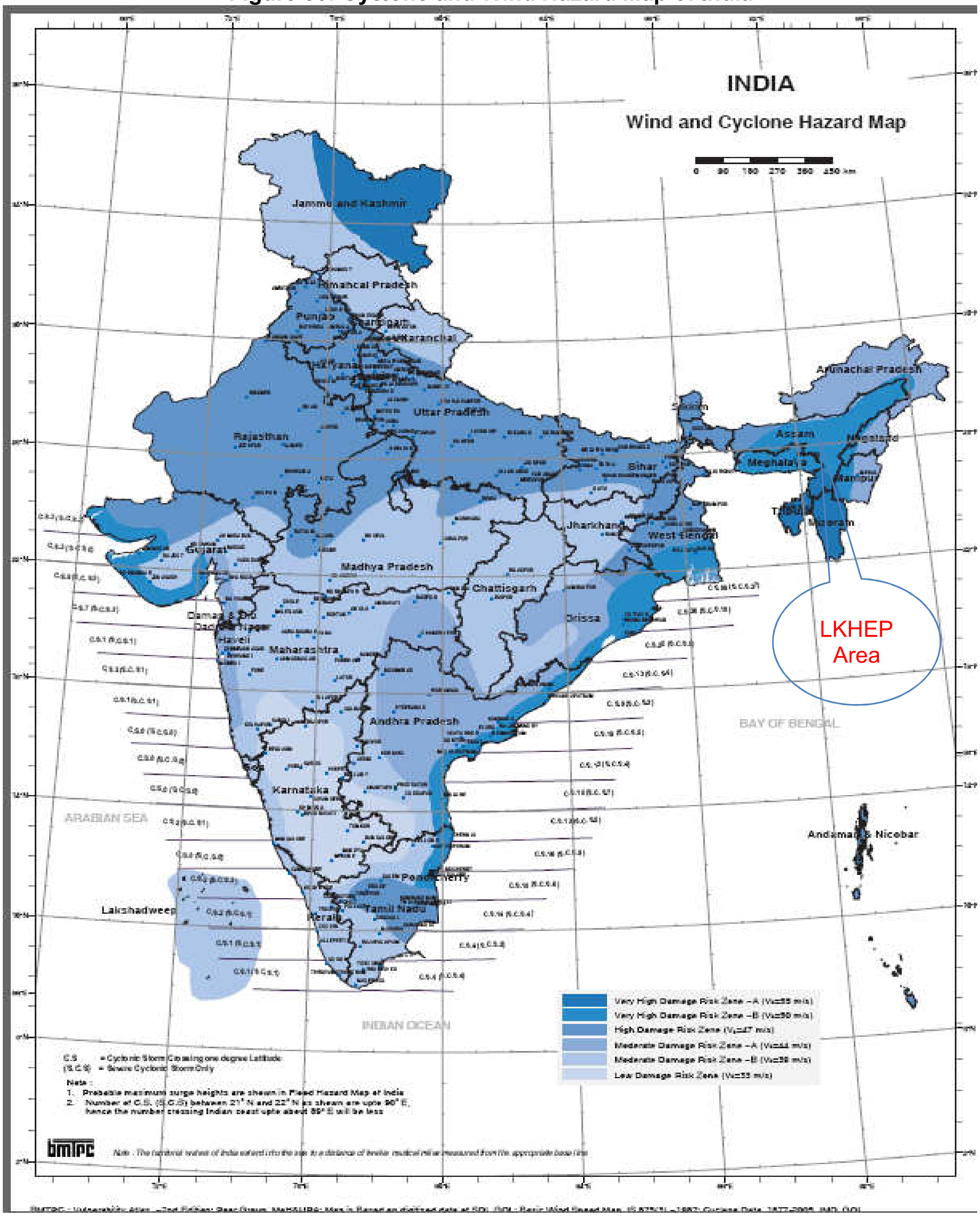


Figure 33: Cyclone and Wind Hazard Map of India



6. Air Quality

187. The National Ambient Air Quality Standards (NAAQS)[22] prescribed by the CPCB guides air quality parameters in India (see Table 49, also presented in Annex 2).

Table 49: National Ambient Air Quality Standards (note the project area is considered to be rural).

Pollutant	Time Weighted Average	Concentration in Ambient air ($\mu g/m^3$)	
		Industrial, Residential, Rural and Other Areas	Ecologically Sensitive Areas***
Sulphur Dioxide (SO_2)	Annual Average*	50	20
	24 hr**	80	80
Oxides of Nitrogen (as NO_2)	Annual Average *	40	30
	24 hr**	80	80
Particulate Matter: PM_{10} (<10 µm)	Annual Average *	60	60
	24 hr**	100	100
Particulate Matter: $PM_{2.5}$ (<2.5 µm)	Annual Average *	40	40
	24 hr**	60	60
Lead	Annual Average *	0.5	0.5
	24 hr**	1.0	1.0
Carbon monoxide mg/m^3	8 hr	2.0	2.0
	1 hr	4.0	4.0

* Annual Arithmetic mean of minimum 104 measurement in a year taken for a week 24 hourly at uniform interval.
** 24 hourly or 8 hourly or 1 hourly monitored values should meet 98 percent of the time in a year.
*** An ESA would be, for example, a bird breeding area, wetland, or wildlife reserve.

188. The State Pollution Control Board of Assam (PCBA)[23] conducts periodic evaluation of air pollution in the State under the National Air Quality Monitoring Program (NAMP) of the CPCB[24]. Under the NAMP, four pollutants – Sulphur Dioxide (SO_2), Oxides of Nitrogen as NO_2, Respirable Suspended Particulate Matter (RSPM/PM_{10}) and Fine Particulate Matter ($PM_{2.5}$) have been identified for regular monitoring at 7 monitoring stations across the area (frequency 16-hr, twice per week) including 4 monitoring stations in Guwahati. The PM_{10} and $PM_{2.5}$ in almost all the monitoring stations in Guwahati (an urban area) are above the prescribed standards set by the CPCB while the SO_2 and NO_2 were within the prescribed standards. The poor air quality is mainly due to vehicular emissions and exhaust from the brick kiln industries. The proposed project is situated in rural part of Assam where the main sources of air pollution are light vehicular traffic, dust arising from unpaved village roads, and domestic fuel burning.

189. To establish the current status of ambient air quality and future implications due to the proposed project, WAPCOS conducted ambient air quality monitoring (AAQM) across 3 stations in the project area for three seasons (monsoon, winter, summer) and the frequency of monitoring at each station was twice per week for four consecutive weeks. The parameters monitored were PM_{10}, SO_2 and NO_2. The results are presented in Tables 50 and 51. The ambient air quality sampling locations are presented in Figure 34.

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[22] The Central Pollution Control Board. http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php.
[23] Pollution Control Board Assam http://www.pcbassam.org/consent.htm#C1
[24] Central Pollution Control Board, India, http://www.cpcb.nic.in/air.php

Figure 34: Ambient Air Sampling Locations

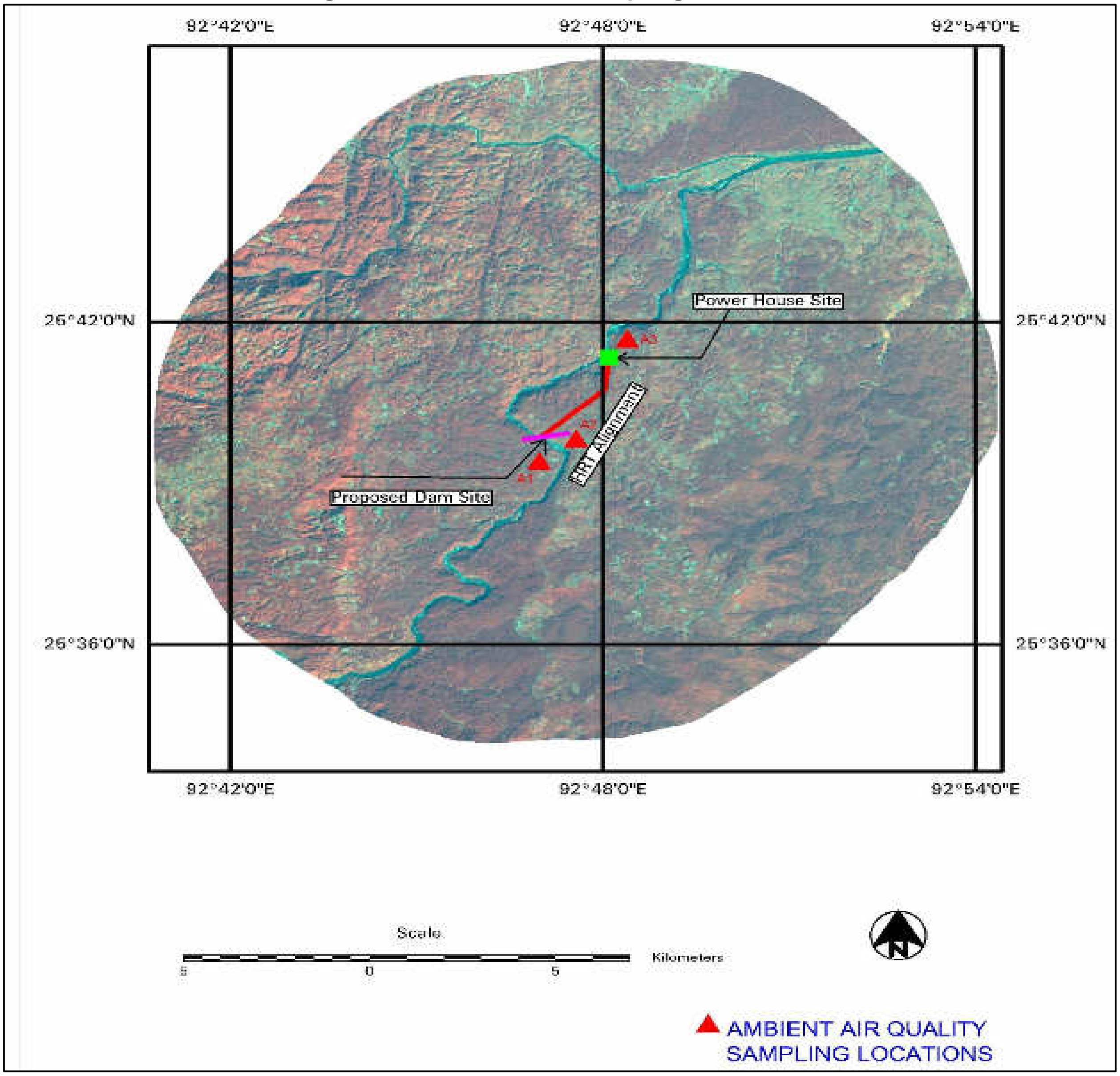


Table 50: Results of Ambient Air Quality Analysis for Three Seasons on 24 hour average

Sampling Station	PM_{10}(µg/m^3)	NO_2(µg/m^3)	SO_2(µg/m^3)
1. Monsoon Season			
Dam Site	24.2	5.7	< 5.0
	28.5	8.1	< 5.0
	27.2	8.2	< 5.0
	25.6	9.2	<5.0
	21.7	8.2	< 5.0
	24.8	8.6	< 5.0
	25.4	7.8	< 5.0
	22.6	9.1	< 5.0
Power house site	27.4	11.2	< 5.0

Sampling Station	PM_{10}(µg/m^3)	NO_2(µg/m^3)	SO_2(µg/m^3)
	30.4	11.4	< 5.0
	28.9	11.5	< 5.0
	28.5	12.6	<5.0
	27.6	11.7	< 5.0
	26.2	11.4	< 5.0
	24.1	10.4	< 5.0
	28.6	11.4	<5.0
Near Submergence Area	28.1	11.5	< 5.0
	27.4	11.8	< 5.0
	25.4	11.9	< 5.0
	27.5	11.7	<5.0
	25.6	11.6	< 5.0
	25.2	11.4	< 5.0
	26.2	10.6	< 5.0
	26.5	10.2	< 5.0
2. Winter Season			
Dam Site	25.1	12.1	< 5.0
	30.4	11.6	< 5.0
	25.2	14.2	< 5.0
	26.7	11.7	<5.0
	28.1	10.4	< 5.0
	30.1	11.1	< 5.0
	28.2	10.5	< 5.0
	28.4	12.1	< 5.0
Power House site	27.0	12.1	< 5.0
	25.1	13.4	< 5.0
	27.4	10.8	< 5.0
	26.2	9.7	<5.0
	24.9	11.1	< 5.0
	23.3	10.7	< 5.0
	26.1	10.2	< 5.0
	25.4	11.0	<5.0
Near Submergence Area	31.2	12.1	< 5.0
	27.2	11.4	< 5.0
	28.4	11.5	< 5.0
	26.1	12.6	<5.0
	25.2	11.7	< 5.0
	25.5	11.4	< 5.0
	25.2	12.0	< 5.0
	24.6	11.2	< 5.0
3. Summer Season			
Dam Site	27.1	10.8	< 5.0
	30.2	12.1	< 5.0
	28.4	11.4	< 5.0
	25.1	10.1	<5.0
	25.8	9.7	< 5.0
	30.1	10.5	< 5.0

Sampling Station	PM_{10}(μg/m^3)	NO_2(μg/m^3)	SO_2(μg/m^3)
	28.6	8.2	< 5.0
	27.1	10.1	< 5.0
Power house site	24.6	12.1	< 5.0
	27.6	11.8	< 5.0
	25.8	11.0	< 5.0
	25.4	11.0	<5.0
	25.5	10.7	< 5.0
	25.0	11.2	< 5.0
	30.5	11.5	< 5.0
	29.2	11.5	<5.0
Near Submergence Area	27.1	11.5	< 5.0
	28.2	11.2	< 5.0
	30.1	11.6	< 5.0
	30.7	11.8	<5.0
	25.4	12.4	< 5.0
	25.0	10.9	< 5.0
	24.8	11.6	< 5.0
	24.0	11.4	< 5.0

Table 51: Summary of Levels of Various Pollutants in Ambient Air Monitored (Unit: μg/m^3)

Station	Annual Average	Maximum	Minimum
1. PM_{10}			
Monsoon season			
Dam Site	25.0	28.5	21.7
Power House site	27.71	30.4	24.1
Submergence Area	26.49	28.1	25.2
Winter season			
Dam Site	27.8	30.4	25.1
Power House site	25.7	27.4	23.3
Submergence Area	26.7	31.2	24.6
Summer season			
Dam Site	27.8	30.2	25.1
Power House site	26.7	30.5	24.6
Submergence Area	26.9	30.9	24
2. NO_2			
Monsoon season			
Dam Site	8.1	9.2	5.7
Power House site	11.45	12.6	10.4
Submergence Area	11.34	11.9	10.2
Winter season			
Dam Site	11.71	14.2	10.4
Power House site	11.13	13.4	9.7
Submergence Area	11.74	12.6	11.2
Summer season			
Dam Site	10.4	12.1	8.2
Power House site	11.4	12.1	10.7
Submergence Area	11.74	12.6	11.2
3. SO_2			
Monsoon season			

Station	Annual Average	Maximum	Minimum
Dam Site	<5	<5	<5
Power House site	<5	<5	<5
Submergence Area	<5	<5	<5
Winter season			
Dam Site	<5	<5	<5
Power House site	<5	<5	<5
Submergence Area	<5	<5	<5
Summer season			
Dam Site	<5	<5	<5
Power House site	<5	<5	<5
Submergence Area	<5	<5	<5

190. **WAPCOS Ambient Air Quality Sampling Results (2015):** All parametres are below limits (see Table 46). The maximum PM_{10} level during all three seasons ranged between 28.1 – 31.2 $\mu g/m^3$. This is well below the permissible limit 60 $\mu g/m^3$ specified for rural areas – as project is on rural area. The SO_2 level observed was less 5.0 $\mu g/m^3$ across all the sampling locations which is well below the permissible limit of 50 $\mu g/m^3$ for rural areas. The highest NOx value was observed in the summer season at 14.2 $\mu g/m^3$. The NOx level observed at various sampling stations was much lower than the permissible limit of 40 $\mu g/m^3$ for rural areas. Overall, the ambient air quality in and around the project area is good. The values of these parameters were well below the permissible limits specified for industrial, residential, rural and other areas. The good air quality in the area may be attributed to the absence of industries, low vehicular traffic and low population density.

7. Noise Levels

191. The noise standards are prescribed by the MoEF&CC as shown in Table 52 (also presented in Annex 2).

Table 52: Noise Standards

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

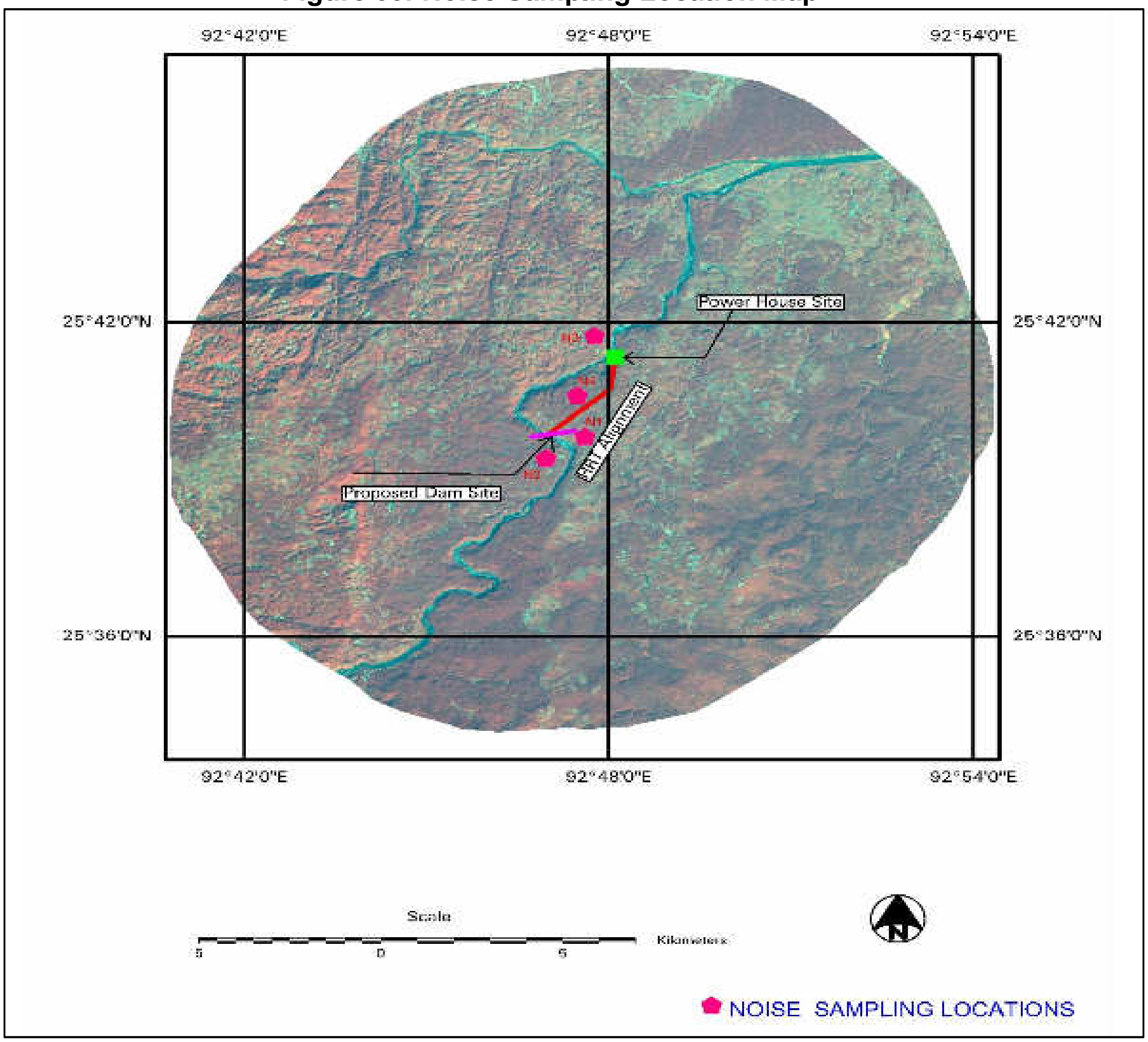
Note:

- Day time: 6 A.M. and 10 P.M.
- Night time: 10 P.M. and 6 A.M.
- Silence zone is defined as areas up to 100 meters around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by competent authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.
- Environment (Protection) Third Amendment Rules, 2000 Gazette notification, Government of India, date 14.2.2000.

192. Noise standards being implemented by the PCBA are the same as the standards prescribed in the National Noise Pollution (Regulation and Control) Rules (2000). Therefore MoEF&CC Standards will be applied to the Project. The PCBA does not conduct regular noise monitoring except during the occasion of Durga Puja in month of October when firecrackers are used throughout the State as a mark of celebration.

193. To establish the current status of noise levels and ramifications due to the proposed project, WAPCOS conducted hourly average equivalent noise monitoring (Leq (day)[25] across three seasons around residential areas in and around the proposed project. Being rural areas night time monitoring has not been conducted at this stage. However prior to start of the civil works, night time noise level baseline data will be collected by the contractor. There are no silent zones within PIA. The results are presented in Tables 53 to 56. The noise sampling locations are presented in Figure 35.

Figure 35: Noise Sampling Location Map



[25] LEQ - equivalent continuous sound level

Table 53: Hourly Equivalent Noise Levels For Monsoon Season

Location	Dam site	Near submergence area	Power house site	Along HRT Alignment
6-7 AM	32	32	32	33
7-8 AM	34	35	36	35
8-9 AM	34	35	36	36
9-10 AM	35	36	36	37
10-11 AM	36	38	39	38
11-12 Noon	38	39	40	39
12 noon – 1 PM	38	39	42	40
1-2 PM	40	40	39	41
2-3 PM	40	41	37	41
3-4 PM	39	40	38	41
4-5 PM	39	38	38	39
5-6 PM	38	36	37	37
6-7 PM	38	35	34	35
7-8 PM	35	33	33	33
8-9 PM	33	32	33	32

Table 54: Hourly Equivalent Noise Levels For Winter Season

Location	Dam site	Near submergence area	Power house site	Along HRT Alignment
6-7 AM	33	33	34	36
7-8 AM	35	35	34	37
8-9 AM	36	36	35	37
9-10 AM	35	37	37	39
10-11 AM	38	37	37	40
11-12 Noon	40	40	37	41
12 noon – 1 PM	38	39	38	40
1-2 PM	41	39	39	39
2-3 PM	41	41	40	41
3-4 PM	40	38	39	42
4-5 PM	38	38	38	42
5-6 PM	36	37	37	44
6-7 PM	35	35	35	40
7-8 PM	34	34	33	37
8-9 PM	33	33	33	35

Table 55: Hourly Equivalent Noise Levels For Summer Season

Location	Dam site	Near submergence area	Power house site	Along HRT Alignment
6-7 AM	36	35	35	36
7-8 AM	37	36	36	38
8-9 AM	38	38	38	38
9-10 AM	37	38	38	40
10-11 AM	38	38	38	40
11-12 Noon	40	40	37	42
12 noon – 1 PM	40	40	38	40
1-2 PM	42	39	39	39
2-3 PM	41	41	40	42
3-4 PM	40	39	39	42

Location	Dam site	Near submergence area	Power house site	Along HRT Alignment
4-5 PM	38	38	38	42
5-6 PM	36	37	37	43
6-7 PM	35	35	35	41
7-8 PM	35	35	35	38
8-9 PM	34	35	35	37

Table 56: Day Time Equivalent Noise Level At Various Sampling Locations

S. No.	Location	Zone	L_{day} (dB(A))
Monsoon season			
1.	Dam site	Residential	37.7
2.	Near Submergence area	Residential	37.4
3.	Power house site	Residential	36.9
4.	Along HRT Alignment	Residential	40.0
Winter season			
1.	Dam site	Residential	37.3
2.	Near Submergence area	Residential	37.5
3.	Power house site	Residential	37.5
4.	Along HRT Alignment	Residential	38.1
Summer season			
1.	Dam site	Residential	38.2
2.	Near Submergence area	Residential	38.0
3.	Power house site	Residential	37.5
4.	Along HRT Alignment	Residential	40.2

194. **WAPCOS Noise Sampling Results (2015):** The day time equivalent noise level in all seasons at various sampling stations were well within the permissible limit of 55 dB(A) as specified by NAAQS for the residential area (see Table 49; also presented in Annex 2). Being a rural area night time monitoring has not been conducted but as there are no activities taking place in night, the noise levels are expected to be lower than the day time noise in the project area, however, the night sample will be collected before civil work starts.

8. Hydrology

195. **Drainage:** The drainage system in Assam is governed by two major river systems: the River Brahmaputra and Baraak. Brahmaputra flows through a valley from east to west over a river length of approximately 650 km. Baraak flows westward from Lakhipur through the Cachar Plains region of Assam over a river length of approximately 130 km. River Kopili is a south (left) bank tributary of Brahmaputra. It originates in State of Meghalaya in the Borail hill range and drains a total area of about 16,421 km^2. Its basin is bound by the Jaintia hills in the West and the South Cachar and Mikir hills in the East. The catchment of the River Kopili lies on the leeward side of the Borail, Khasi and Jaintia hills range of Meghalaya. The river basin receives a good amount of rain fall and, as a result, is a perennial river. The basin comprises hills, low mounds, and narrow valleys which generally slop towards the northeast. The highest elevation at project location is 356 m just beyond the southern limit of the proposed reservoir of the LKHEP (located at Longku). Slopes are gentle which are mostly covered with bushes and trees.

196. The total catchment area of the Kopili basin is 2,076.62 km^2 while the Lower Kopili (uncontrolled) catchment area is 788 km^2. Up to 95% of the catchment area at the LKHEP dam site is State forests and 5% is under cultivation and homesteads.

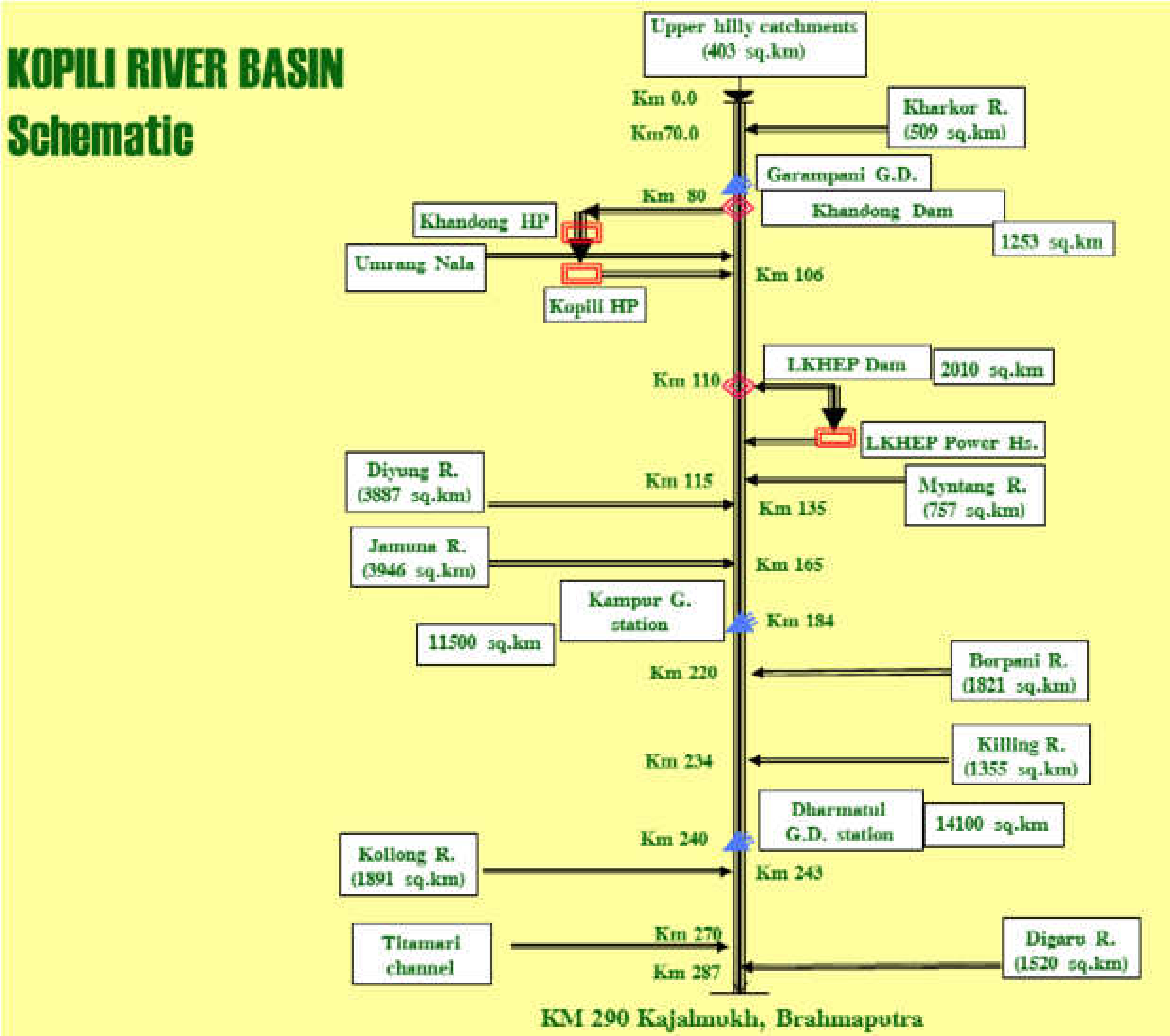
197. A detailed assessment of Hydrological Regime of Lower Kopili Basin has been carried out as part of the DPR. Detailed discussion on project hydrology (water availability, design flood, diversion flood and sedimentation, annual flows, etc.) is presented in Annex 3, and it has received concurrence from CWC, GoI.

9. Water Resources

198. **Surface Water Resources:** The two major river systems in Assam are the River Brahmaputra and Baraak. River Kopili is a south (left) bank tributary of Brahmaputra. The major tributaries of River Kopili are Kharkar, Myntriang, Dinar, Longsom, Amring, Umrong, Longku and Langkri. The State also harbors at least 3,500 freshwater wetlands (none of them are in LKHEP PIA); most of these wetlands are in the floodplains of Brahmaputra and Baraak and their tributaries and include beels, swamps and marshes.

199. The River Kopili has two operational hydroelectric power projects (river basin schematic is shown in Figure 36) upstream of the proposed project (LKHEP): The 75 MW Khandong HEP served by the Khandong reservoir and the 200 MW Kopili HEP served by the Umrong reservoir (on River Umrong). The water sources for the proposed project are (a) tailrace releases from the Kopili HEP at Umrong, (b) inflow from intermediate catchment between Khangdon and Longku dam sites (that also includes Umrang reservoir catchment); and (c) the spill from the Khangdon and Umrong Reservoirs. Note: the operation of the Lower Kopili power station will be independent of the operations of the Khandong and Kopili HEP in the upstream of the River Kopili as its corresponding storage reservoir will take into account the variations in regulated discharge from the other two reservoirs in the upstream.

Figure 36: Schematic of Kopili River Basin



200. **Ground Water Resources:** Assam is considered to have high potential for ground water resources. The Brahmaputra valley covering more than 70% of the total geographical area of the State contains a prolific aquifer system with water table at 5 meters below ground surface. The Baraak valley has a good potential for development of ground water resources. The recoverable recharge of ground water has been estimated at 2 million hectare meter per year.[26] The lifting of ground water through dug wells, tube wells, shallow tube wells and deep tube wells for irrigation, domestic and industrial use is common in Assam. There are no wells within the PIA of LKHEP.

10. Water Quality

201. **Surface Water Quality:** The surface water quality management in India is accomplished under the provision of Water (Prevention and Control of Pollution) Act, 1974. It follows a concept of “designated best use” (DBU). Additionally, the Bureau of Indian (Drinking Water Quality) Standards (BIS) (ISO 10500:2012) provides water quality criteria for drinking water for both

[26]Central Ground Water Board (1984) - Ground Water Estimation Committee, Ministry of Irrigation, GoI.

surface water and ground water. Annex 2 shows the water quality standards in India which also includes water quality criteria for Propagation of Wildlife and Fisheries.

202. Under the National Water Quality Monitoring Program (NWQMP)[27] and with the help of CPCB, PCBA has been regularly monitoring quality of surface water in various water sources across the State. As of 2011, there were 101 water quality monitoring stations in Assam (none of them are in LKHEP PIA) measuring parameters such as Conductivity, pH, DO, BOD, Total Coliform (TC) and Fecal Coliform (FC) on a monitor. Surface water quality monitoring results for river Kopili (January-December 2011) suggest that the river is meeting the desired criteria for Conductivity DO[28] and BOD[29].

203. **Ground Water Quality:** Under the NWQMP and with the help of CPCB, the PCBA has been collecting and monitoring groundwater (well-water) from 32 places (none of them are in LKHEP PIA) across the State on a semi-annual basis. Parameters analyzed are Temperature, pH, Conductivity, Fluoride, BOD, Nitrate/Nitrite. Groundwater quality monitoring results (2011) suggest that values for pH the range of 5.25-7.05 and the observed below 6.5 at Karbi Anglong.[30]

204. In order to establish the water quality baseline, in the project area, water quality sampling[31] was conducted in 2015 for three seasons (monsoon, winter, summer). The results are presented in Tables 57 to 59. The sampling locations were as follows and are presented in Figure 37.

- W1- u/s of dam site
- W2- Dam Site
- W3 - d/s of dam site
- W4- Power House site
- W5- d/s of Power house site

205. There are no major sources of organic pollution loading in the Kopili basin however inorganic pollution is expected from mining work which is mainly in Meghalaya state. The catchment has low population density with low cropping intensity. The low cropping intensity coupled with low agro-chemical dosing also means that the pollution load due to agro-chemicals

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[27] National Water Quality Monitoring Program is a Government of India program being implemented by Central Pollution Control Board. This is not related to LKHEP but baseline data is used regarding status of water quality in Kopili river.

[28] Note: As per the Status of Water Quality in India – 2011 Report, river Kopili is meeting the standard for pH. However, it is well known that the upper reaches of the river Kopili have been adversely affected by acid drainage from illegal mining in upstream areas and also affected operations of upstream Kopili HEP since 2006. A decision in 2014 by the National Green Tribunal (NGT) has reportedly resulted in curtailment of illegal mining upstream with concomitant improvements in water quality. Additionally, as part of a broader effort to ensure sustainable water resources development in the State, a separate ongoing study (under ADB funding) will identify engineered options to restore river water quality upstream of existing Kopili HEP operations and the proposed LKHEP project.

[29] The monitoring results obtained during 2011 under National Water Quality Monitoring Programme reflect that organic matter & bacterial population of fecal origin continue to dominate the water pollution problem in India. The major water quality concerns as revealed from the monitoring results are pathogenic pollution as reflected through indicators i.e. Total Coliforms (TC) & Fecal Coliforms (FC), organic matter as reflected through Biochemical Oxygen Demand (BOD) and salinity as reflected through conductivity.

[30] Status of Water Quality in India (2011), Central Pollution Control Board (CPCB).

[31] Sampling was mainly done for surface water sources during EIA. However as part of Water Quality Restoration Plan ground water samples have also been tested.

is quite low. The absence of industries implies that there is no pollution load from this source as well.

Figure 37: Water Sampling Location Map

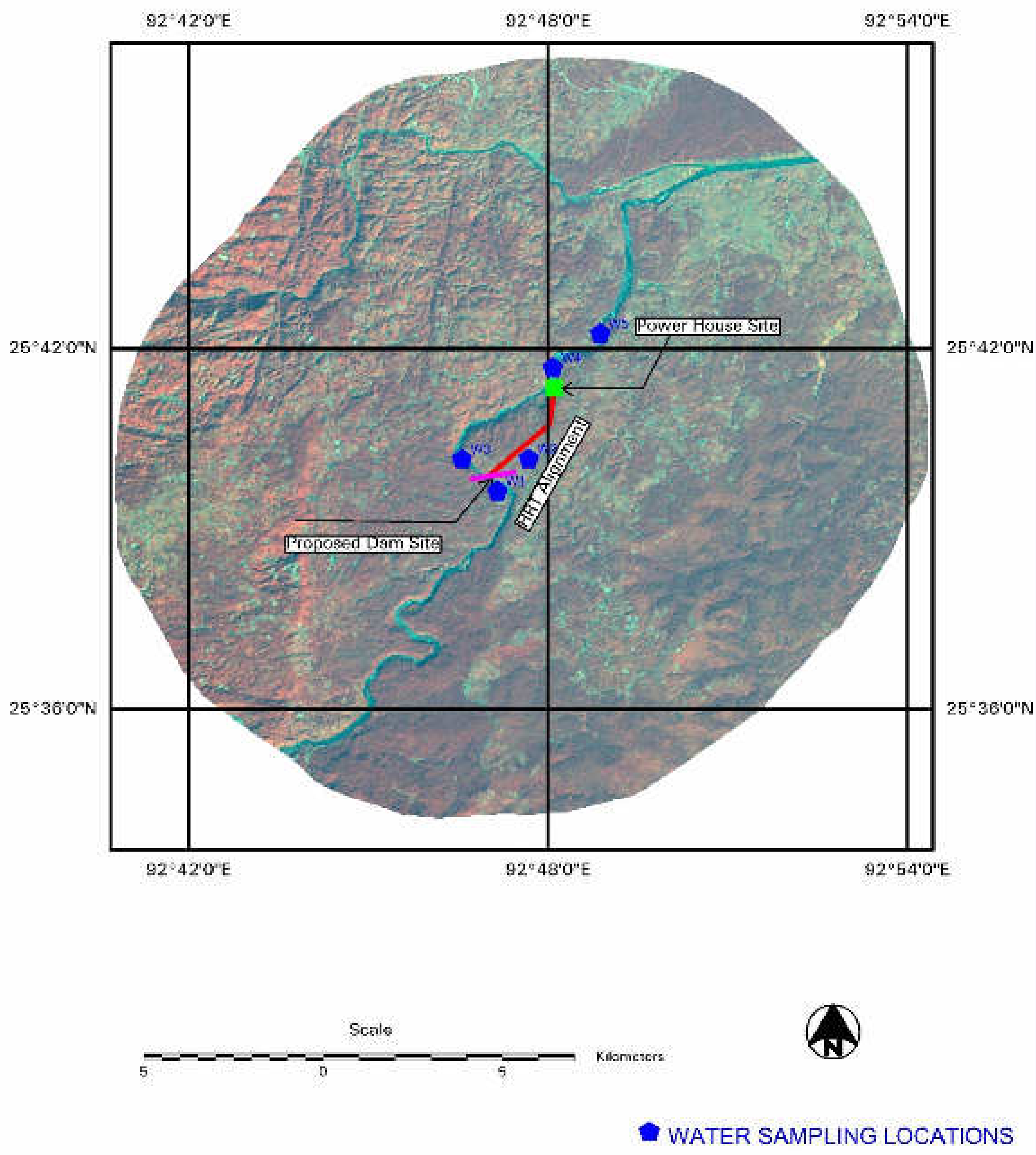

Table 57: Results Of Water Quality Analysis For Monsoon Season

Parameter	Unit	W1	W2	W3	W4	W5
pH	-	5.2	5.0	5.2	4.6	4.8
EC	μs/cm	70	72	70	62	65
TDS	mg/l	45	47	44	40	41
Nitrate as NO_3	mg/l	3.1	3.5	3.4	3.2	3.6
Phosphate as PO_4	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride as F	mg/l	0.8	0.8	1.0	1.0	1.0
Sulphate as SO_4	mg/l	4	5	4	4	4
Chloride as Cl	mg/l	16	18	16	20	18
Sodium as Na	mg/l	12	16	14	14	17
Potassium as K	mg/l	3.2	3.9	3.7	3.8	4.2
Calcium as Ca	mg/l	15.2	16.0	15.1	16.0	15.5
Magnesium as Mg	mg/l	3.3	3.2	3.3	3.3	3.3
Iron as Fe	mg/l	0.7	0.6	0.6	0.4	0.4
Copper as Cu	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc as Zn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic as As	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium as Cd	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium as Cr	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Cyanide as Cn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium as Se	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
COD	mg/l	3.8	3.7	3.6	4.1	3.7
BOD 3 days at 27°C	mg/l	1.9	1.9	1.8	2.1	1.9
DO	mg/l	4.8	4.5	4.6	4.7	4.7
Phenolic compound	mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease	mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform	MPN/ 100 ml	3	3	4	4	3
Total Hardness	mg/l	51.6	53.2	51.3	53.6	52.3
Nitrates	mg/l	1.2	1.4	1.4	1.3	1.3

Table 58: Results Of Water Quality Analysis For Winter Season

Parameter	Unit	W1	W2	W3	W4	W5
pH	-	4.0	4.0	4.2	3.6	3.8
EC	μs/cm	84	81	85	90	85
TDS	mg/l	62	59	62	66	63
Nitrate as NO_3	mg/l	3.0	3.1	2.7	2.8	3.0
Phosphate as PO_4	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride as F	mg/l	0.8	0.9	1.1	1.0	1.0
Sulphate as SO_4	mg/l	4	3.5	4	4	4
Chloride as Cl	mg/l	10	11	10	11	11
Sodium as Na	mg/l	11	13	13	14	15
Potassium as K	mg/l	2.7	2.9	2.7	2.8	3.0
Calcium as Ca	mg/l	12.6	13.2	14.1	12.7	13.0
Magnesium as Mg	mg/l	3.1	3.2	3.0	3.0	3.2
Iron as Fe	mg/l	0.7	0.8	0.8	0.7	0.7
Copper as Cu	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc as Zn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05

Parameter	Unit	W1	W2	W3	W4	W5
Arsenic as As	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium as Cd	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium as Cr	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Cyanide as Cn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium as Se	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
COD	mg/l	3.5	3.7	3.6	4.0	3.5
BOD 3 days at $27^{o}C$	mg/l	1.7	1.8	1.8	2.0	1.8
DO	mg/l	4.2	4.4	4.5	4.5	4.4
Phenolic compound	mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease	mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform	MPN/100 ml	9	9	8	8	8
Total Hardness	mg/l	44.2	46.5	47.6	44.1	44.9
Nitrates	mg/l	1.1	1.0	1.0	1.0	1.0

Table 59: Results Of Water Quality Analysis For Summer Season

Parameter	Unit	W1	W2	W3	W4	W5
pH	-	4.0	4.0	3.5	3.2	3.4
EC	μs/cm	90	92	90	90	94
TDS	mg/l	62	65	61	62	66
Nitrate as NO_3	mg/l	3.1	3.5	3.4	3.2	3.6
Phosphate as PO_4	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoride as F	mg/l	0.8	0.8	1.0	1.0	1.0
Sulphate as SO_4	mg/l	4	5	4	4	4
Chloride as Cl	mg/l	16	18	16	20	18
Sodium as Na	mg/l	12	16	14	14	17
Potassium as K	mg/l	3.2	3.9	3.7	3.8	4.2
Calcium as Ca	mg/l	15.2	16.0	15.1	16.0	15.5
Magnesium as Mg	mg/l	3.3	3.2	3.3	3.3	3.3
Iron as Fe	mg/l	0.7	0.6	0.6	0.4	0.4
Copper as Cu	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc as Zn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic as As	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium as Cd	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium as Cr	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Cyanide as Cn	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium as Se	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001
COD	mg/l	3.8	3.7	3.6	4.1	3.7
BOD 3 days at $27^{o}C$	mg/l	1.9	1.9	1.8	2.1	1.9
DO	mg/l	4.9	4.6	4.9	4.7	4.7
Phenolic compound	mg/l	BDL	BDL	BDL	BDL	BDL
Oil & Grease	mg/l	BDL	BDL	BDL	BDL	BDL
Total Coliform	MPN/ 100 ml	3	3	4	4	3
Total Hardness	mg/l	51.6	53.2	51.3	53.6	52.3
Nitrates	mg/l	1.2	1.4	1.4	1.3	1.3

206. **WAPCOS Water Quality Sampling Results (2015):** The pH level in the proposed project area ranged from 3.2 to 5.2. The pH level indicates the acidic nature of the water and is out of compliance with BIS and also unfit for use in construction related works. This is also below the water quality criteria of 6.5 to 8.5 given by CPCB in India for D class of water i.e. propagation of wildlife and fisheries The upper reaches of the river Kopili have been adversely affected by acid drainage from illegal mining in upstream areas and also affected operations of upstream Kopili HEP. A decision in 2014 by the National Green Tribunal has reportedly resulted in curtailment of illegal mining upstream with concomitant improvements in water quality. As part of a broader effort to ensure sustainable water resources development in the State, a separate study has identified engineered options to restore river water quality upstream of the existing Kopili HEP operations and the proposed project (the main initiative would be to enforce the illegal coal mining regulation).

207. The TDS level ranged from 40 to 47 mg/l, 59 to 66 mg/l and 61 to 66 mg/l in monsoon, winter and summer seasons respectively. The TDS levels were below the permissible limit of 500 mg/l specified for drinking water standards.

208. The hardness level was below the permissible limit of 200 mg/l specified for drinking water standards; indicating the soft nature of water due to low levels of cations like calcium and magnesium). The concentration of various cations (sodium, potassium, calcium and magnesium was low. Iron level (0.4-0.8mg/l) was below the permissible limit of 1 mg/l specified for drinking water standards. However, the acidic nature of water has led to the deposition of iron (red color) on the river bed.

209. The chlorides and sulphate levels were well below the permissible limit of 200 mg/l, specified for drinking water standards.

210. The concentration of various heavy metals was below the permissible limits (these will continue to be monitored in case the acidic Kopili water comes into contact with newly exposed bedrock, during project construction). Concentration of phenolic compounds, and oil and grease was low and this is expected for a region with no major sources of water pollution from domestic and/or industrial sources.

211. The Total Coliforms ranged from 3 to 9 MPN/ 100 ml across three seasons. The BOD values were well within the permissible limits; this indicates the absence of organic pollution loading in the basin. This is mainly due to the low population density, low cropping intensity, and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Kopili gets diluted.

212. Besides 2015 samples, six (five surface and one ground water) samples have been collected in January 2017 and analysed in the laboratory of Civil Engineering Department of Assam Engineering College, Guwahati. Results are presented in Table 59a below.

Table 59a: Analytical Results (Water Samples Collected in January 2017)

Parameter	Specifications	Sampling locations					
		Kopili river before confluence	Kopili river after confluence	Kharkar River	Longku Nala	LKHEP Dam axis	Well
Field pH	-	7.4	3.8	3.3	7.4	4.1	-
Lab pH	-	7.1	2.7	2.5	5.1	3.2	6.7
Field EC	-	40	440	480	60	140	-
Lab EC	-	30	42	920	150	150	120
Acidity (as CaCo3)	-	20	37.5	77.5	20	15	40
Total Alkalinity (as CaCO3) (mg/L)	600	30	10	10	70	40	30
Sulfide (mg/L)	0.02	0.01	0.26	0.7	BDL	0.09	0.002
Total Al (mg/L)	0.02	BDL	0.006	1.107	BDL	BDL	0.002
Total Mn (mg/L)	0.5	0.146	0.563	0.826	0.112	0.133	0.114
Total Fe (mg/L)	1	1.145	6.592	11.625	0.834	0.437	0.752
Ferric Iron-Fe3+ (mg/L)	-	0.595	0.781	3.974	0.142	0.014	0.084
Ferrous Fe [Fe2+] (mg/L)	-	0.55	5.811	7.651	0.692	0.423	0.668
Ca as CaCO3 (mg/L)	200	28	31	36	33	29	37
Mg as CaCO3 (mg/L)	150	39	44	42	46	48	43
Total Solids mg/L)	2000	180	340	214	230	280	290
Chloride mg/L)	500	44.02	46.86	51.12	41.18	48.28	45.44
Suspended Matter mg/L)	2000	40.0	100	54	50	90	80
Sulphates (SO4) mg/L)	500	26	29	32	36	37	39

213. Preliminary evaluation of this data set indicates that water quality in the Kopili River is affected by low-pH water from the Kharkar River. Sulfide levels are highest in the Kharkar River and in the Upper Kopili. Aluminum levels are highest in the Kharkar River (1.1 mg/L) but are lower than the maximum amount recommended for successful ALD and other passive treatment technologies (less than 25 mg/L). Total iron in all samples is also less than recommended maximum for passive treatment (10 mg/L). These initial results of all the river samples indicate that water quality is suitable for passive treatment design with some oxide flocculation collection and management necessary to maintain low turbidity and sedimentation accumulation.

11. pH Values of River Kopili and its Tributaries

214. The pH values of water samples collected from Kopili river and its tributaries corresponding to the date of sampling are presented in Table 60 and 61, respectively. Latest data collected from project area is presented in Table 61a.

Table 60: pH Value of Water in River Kopili

S. No.	Source of Sample	Date of Sampling	pH Value
1.	Kopili River Project Area	15/12/2012	3.7
2.	Kopili River Project Area	29/12/2012	3.4
3.	Kopili River Project Area	13/01/2013	3.4
4.	Kopili River Project Area	29/01/2013	3.4
5.	Kopili River Project Area	15/02/2013	3.3
6.	Kopili River Project Area	15/03/2013	3.3
7.	Kopili River Project Area	31/03/2013	3.3
8.	Kopili River Project Area	15/04/2013	3.6
9.	Kopili River Project Area	30/04/2013	3.4
10.	Kopili River Project Area	15/05/2013	3.5
11.	Kopili River Project Area	30/05/2013	3.5
12.	Kopili River Project Area	15/06/2013	4.1
13.	Kopili River Project Area	30/06/2013	3.9
14.	Kopili River Project Area	15/06/2013	4.1
15.	Kopili River Project Area	30/07/2013	3.6
16.	D/S of KHEP Powerhouse (NEEPCO)10KM U/S of Proposed dam site of Lower Kopili H.E Project (LKHEP)	02/09/2013	3.6
17.	Between Powerhouse (NEEPCO) & Dam Site of LKHEP about 6KM U/S	02/09/2013	3.6
18.	Diyungmukh (Dima Hasao District) about 25KM D/S of proposed dam site of LKHEP	02/09/2013	3.7
19.	At U/s of Khandong Dam (Reservoir Area – NEEPCO) About 25KM U/S of proposed dam site of LKHEP.	02/09/2013	3.4
20.	U/S of Umrong dam i.e. about 12KM U/S of proposed LKHEP dam site.	02/09/2013	3.5
21.	At Dam Site of LKHEP	04/09/2013	3.4
22.	U/S of Khandong dam (NEEPCO)	09/12/2013	3.5
23	U/S of Umrong Dam	09/12/2013	3.6
24	D/S of Kopili Power house (NEEPCO)	09/12/2013	3.7
25	Between Powerhouse (NEEPCO) & Dam Site of LKHEP about 6KM U/S	10/12/2013	3.8
26	Diyungmukh (Dima Hasao District) about 25KM D/S of proposed dam site of LKHEP	10/12/2013	3.8
27	Dam site LKHEP	10/12/2013	3.5
28	U/S of Khandong dam (NEEPCO)	02/01/2014	3.8
29	U/S of Umrong Dam	02/01/2014	3.7
30	D/S of Kopili Power house (NEEPCO)	02/01/2014	3.6
31	Between Powerhouse (NEEPCO) & Dam Site of LKHEP about 6KM U/S	03/01/2014	3.5
32	Diyungmukh (Dima Hasao District) about 25KM D/S of proposed dam site of LKHEP	03/01/2014	3.8
33	Dam site LKHEP	03/01/2014	3.5
34	U/S of Khandong dam (NEEPCO)	07/02/2014	3.8
35	U/S of Umrong Dam	07/02/2014	3.60
36	D/S of Kopili Power house (NEEPCO)	07/02/2014	3.5
37	Between Powerhouse (NEEPCO) & Dam Site of LKHEP	05/02/2014	3.9

S. No.	Source of Sample	Date of Sampling	pH Value
	about 6KM U/S		
39	Diyungmukh (Dima Hasao District) about 25KM D/S of proposed dam site of LKHEP	05/02/2014	3.7
40	Dam site LKHEP	05/02/2014	4.1
41	U/S of Khandong dam (NEEPCO)	01/03/2014	3.6
42	Between Powerhouse (NEEPCO) & Dam Site of LKHEP about 6KM U/S	01/03/2014	5.99
43	Diyungmukh (Dima Hasao District) about 25KM D/S of proposed dam site of LKHEP	01/03/2014	5.90
44	Dam site LKHEP	15/03/2014	3.20
45	Diyungmukh (Dima Hasao District) about 25KM D/S of proposed dam site of LKHEP	01/04/2014	5.1
46	Between Powerhouse (NEEPCO) & Dam Site of LKHEP about 6KM U/S	02/05/2014	4.10
47	Diyungmukh (Dima Hasao District) about 25KM D/S of proposed dam site of LKHEP (two tributaries Mynriang and Diyung join Kopili river at 14 km and 25km downstream from dam site respectively)	02/05/2014	6.5
48	Dam site LKHEP (rainy season)	30/05/2014	7.0
49	Dam site LKHEP (rainy season)	15/06/2014	6.80
50	Dam site LKHEP	30/07/2014	4.60
51	Dam site LKHEP	30/08/2014	4.60
52	Dam site LKHEP	30/09/2014	4.80
53	Dam site LKHEP	30/10/2014	5.10
54	Dam site LKHEP	30/11/2014	6.60
55	Dam site LKHEP	24/12/2014	5.20

Source: DPR

Table 61: pH Value of Water in Tributaries of River Kopili

S. No	Sources of sample	Date of Sampling	pH Value
1	Dongekpi Nala	24/09/2013	7.4
2	Kala nala	24.09/2013	7.4
3	Longku Nala	24/09/2013	7.3
4	Longsomipi	24/09/2013	7.1
5	Kala nala	11/12/2013	7.6
6	Longku Nala	11/12/2013	7.8
7	Longsomipi	11/12/2013	6.8
8	Longku Nala	03/01/2014	7.1
9	Kala nala	03/01/2014	6.8
10	Longku Nala	03/02/2014	7.8
11	Kala nala	03/02/2014	6.8
12	Longku Nala	01/03/2014	6.7
13	Kala nala	01/03/2014	6.7
14	Longku Nala	01/04/2014	6.8
15	Kala nala	01/04/2014	7.0
16	Kala nala	02/05/2014	7.1
17	Longku Nala	02/06/2014	7.4
18	Kala nala	02/06/2014	6.7
19	Longku Nala	02/12/2014	7.10
20	Kala nala	02/12/2014	6.60
21	Long so mipi	22/12/2014	7.20

Source: DPR

Table 61a: Recent Water Quality in River Kopili (Sampling date 18.10.2017)

Parameter	River Kopili		Umrang Reservoir	
	Longku	**Panimur**	**NEEPCO Office**	**Dam Site**
GPS Coordinates	25°39´58.4´´N	25°43´19.4´´N	25°30´55.3´´N	25°31´41.0´´N
	92°46´53.9´´E	92°49´22.2´´E	92°43´35.5´´E	92°42´48.4´´E
pH	6.76	6.86	4.54	4.62
Specific Conductivity (µs/cm)	93	98	107	121
TDS (mg/l)	47	49	53	60
Turbidity (FNU)	3.6	5.6	0.7	0.0
Temperature (°C)	26.8	25.01	25.46	25.26
DO (mg/l)	6.51	7.70	8.67	7.93

Source: MoEF&CC Sub-committee Report (October 2017)

215. **Alternative Sources of Water in the Project Area:** Water quality sampling test results indicate that the river Kopili is acidic in nature with pH value ranging between 3.3 – 5.2, rendering the water unfit for use in construction related work. Four independent water sources - independent tributaries of Lower Kopili river, have been identified in and around the project area for utilization in construction works. These are: Dong Ekpi Nala; Longku Nala, Kala Nala, and Longsomipi Nala. As per the recommendations of Central Soil and Materials Research Station (CSMRS), the water from these sources shall undergo chemical analysis from a reputed laboratory in light of its implications on the longevity of the structure and various components. Dong Ekpi Nala and Longsomipi are not perennial with low discharge, hence no chemical analysis was carried out as project will not use water from these streams. The chemical analysis of water samples collected from these Longku Nala and Kala Nala reveal a pH range between 6.7 and 7.4 that is an acceptable limit (pH range between 6.5 and 8.5) for utilization of these waters in construction works (see Table 62).

Table 62: Source of Construction Water

S No.	Name	Location (approx.)	pH Value
1	Dong Ekpi Nala (not perennial)	3.5 KM u/s of dam axis (Left bank)	7.4
2	Longsomipi Nala (not perennial)	4.2 km u/s of Dam axis, (Left bank)	6.8
3	Longku Nala	1.0 km u/s of Dam axis, Right bank	7.4
4	Kala Nala	6.0 km d/s of Dam axis, Right bank	6.7

Source: DPR

216. **Water Quality of River Myntdu Leshka:** As part of the MoEF&CC ToR issued (30 January 2014) for the project EIA study, the water quality of River Myntdu Leshka, and in and around the Myntdu Leshka dam site was also monitored[32] for three seasons across various sampling locations. The findings are presented in Tables 63 and 64. The pH level indicates acidic nature of the water. Iron is also higher side (1.14 and 1.29g/l) compared to prescribed limit of 1mg/l which indicates acidic nature of water. APGCL has consulted MSEB on measures being implemented by them to protect plant equipment and dam structures and considered same in design of LKHEP.

[32] Myntdu HEP located in Meghalaya state (upstream of KHEP) also facing problem of acid water causing damage to its equipments and dam structure. MoEF&CC has asked APGCL to check the water quality of this river in order to know what measures are being adopted my MSEB (owner of power plant) to protect plant machineries and dam structure, so that similar measures can be adopted for LKHEP.

Table 63: Results Of Water Quality Of River Myntdu Leshka

S. No	Season	pH Value
1	Monsoon Season	6.1
2	Winter Season	4.2
3	Summer Season	3.8

Table 64: Water Quality in and around Myntdu Leshka Dam Site

S. No.	Parameters	Unit	Station		
			Water from Myntdu Leshka dam	Water from Myntdu Hydro Power Dam	Water from near Hydro Power Station
1	pH		6.3	6.6	6.6
2	Conductivity	µS/cm	93	104	115
3	D.O.	mg/l	7.3	8.0	9.5
4	C.O.D.	mg/l	4.7	6.3	9.4
5	B.O.D.	mg/l	0.8	0.6	0.6
6	Total Hardness as $CaCO_3$	mg/l	36.0	28.0	40.0
7	Calcium as $CaCO_3$	mg/l	20.0	16.0	24.0
8	Magnesium as	mg/l	16.0	12.0	16.0
9	Chloride as Cl^-	mg/l	4.0	2.0	4.0
10	Sulphate as SO_4^{-2}	mg/l	6.7	9.5	7.5
11	Phosphate as PO_4	mg/l	0.1	0.1	0.1
12	Nitrate as NO_3	mg/l	0.2	0.4	0.2
13	Total Dissolved Solids	mg/l	60.0	66.0	76.0
14	Fluoride as F	mg/l	0.14	0.14	0.11
15	Sodium as Na	mg/l	0.41	0.26	0.88
16	Potassium as K	mg/l	0.06	0.08	0.06
17	Lead as Pb	mg/l	BDL	BDL	BDL
18	Zinc as Zn	mg/l	0.061	0.104	2.965
19	Copper as Cu	mg/l	0.023	0.003	0.008
20	Chromium as Cr (T)	mg/l	BDL	BDL	BDL
21	Cadmium as Cd	mg/l	0.006	0.005	0.004
22	Mercury as Hg	mg/l	BDL	BDL	BDL
23	Iron as Fe	mg/l	0.075	1.14	1.29
24	Oil & Grease	mg/l	BDL	BDL	BDL
25	Phenolic compound	mg/l	BDL	BDL	BDL
26	Arsenic as As	mg/l	0.088	0.096	0.071
27	Total Coliform	MPN/ 100 ml	910	360	300

12. Climate Change

217. Assam has an agrarian economy with 86% of its rural population dependent on agriculture and allied services as fisheries, livestock, forests, etc. which all together contribute 34% of the grass state domestic product (GSDP). Assam is vulnerable to climate change. Some of the projected climate risks for the State are changes in mean temperature, drought weeks, changes in spatial and temporal distribution of monsoon, increase in frequency and

intensity of rains/floods, etc. To address the above issues, the GoA has prepared the State Action Plan on Climate Change in 2015[33].

218. For the proposed project, a study was conducted to assess the impacts of climate change on the hydrologic regime of the flows as well as the sediment erosion and its loading into the LKHEP reservoir using different climate change scenarios. A climate risk and vulnerability assessment has been carried out for the project dated 23 December 2015. The details are discussed in Chapter VII and report is attached as Annex 8 of the EIA.

C. Biological Resources

219. This section presents the floral and faunal diversity of the project area based on the review of available secondary data and information, professional judgment, and preliminary field studies (surveys and assessment).

220. As recommended by the EAC of MoEF&CC, the biodiversity study for the LKHEP was conducted by a reputed institute in India (Centre for Inter-Disciplinary Studies for Mountain and Hill Environment – CISMHE, Delhi University, One of the top institutes recommended by the MoEF&CC).

1. Terrestrial Ecology

221. The description of the study area (site and sampling locations) for terrestrial ecology is presented Chapter 1 and detailed in Annex 4.

2. Flora

222. Discussions on flora are based on the detailed vegetation assessment conducted as part of field studies in 2015. Detailed discussion on methodology adopted for the floral survey, findings for vegetation type in the study area, list of plant species observed, and community structure are presented in Annex 4.

3. Forests

223. The total recorded forest area (RFA) of Assam is 26,748 km^2 constituting 35% of the total geographical area of the State while the forest cover is 27,645 km^2.[34] Out of 26,748 km^2 of recorded forest area, there are 312 Reserved Forests[35] (13,870 km^2, 52% of the RFA), 145

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[33] Assam State Action Plan for Climate Change, 2015http://envfor.nic.in/ccd-sapcc

[34] Recorded Forest Area (RFA) means geographic areas recorded as forests in Government records. Forest Cover means all lands, more than one hectare in area, with a tree canopy density of more than 10% irrespective of ownership and legal status. Such lands may not necessarily be RFA. It also includes orchards, bamboo and palm plantations (source: Forest Survey of India (FSI), 2013). In Assam approximately 900 km² of forest cover is not recorded and half of the recorded forest shows a canopy cover below 40% (source: Assam Project on Forests and Biodiversity Conservation (APFBC) - Feasibility Study December 2010).

[35] Reserved Forest means an area so constituted under the provisions of the Assam Forest Regulation (1891), having full degree of protection. In Reserved Forests all activities are prohibited unless permitted.

Proposed Reserved Forests[36] (3,103 km^2, 12% of the RFA), as well as Protected Areas[37] (3,925 km^2, 15% of the RFA) and Un-classed State Forests[38] (5,865 km^2, 33% of the RFA).[39]

224. **Forest Types in Assam:** Figure 21 presents the forest cover map of Assam. According to the Revised Classification of forest types of India by Champion and Seth (1968), Negi, (1989, 1996), Kanjilal (1934-1940), Rao & Panigrahi (1961), and Mudgal & Hajra (1999), the forests in the State may be divided into six major forest types:

- Tropical Wet Evergreen,
- Tropical Semi-Evergreen,
- Tropical Moist Deciduous,
- Sub-tropical Broad-leaved Hill,
- Sub-tropical Pine, and
- Littoral swamp Forests.

225. **Forest Types in the Study Area:** The proposed project falls in two forest divisions namely the Haflong Forest Division covering Dima Hasao (right bank of river Kopili) and the Diphu Forest Division covering Karbi Anglong (left bank of river Kopili).[40] The catchment area of proposed project covers almost all 6 major forest types (Note: the forest type is common along both right and left bank of the river Kopili). However, the forest types in the lower valley of the project area comprises of Assam valley tropical semi-evergreen forest, East Himalayan moist mixed deciduous forest, and tropical riparian fringing forest, whereas Cachar tropical evergreen forest, and Cachar tropical semi-evergreen forest occurs in the lower hills and adjoining Cachar around the Surma valley (see Table 66).

Table 65: Forest Type in the Study Area

Type	Description
1B/ C3 *Cachar Tropical Evergreen Forest*	The forest type is present in the slopes and lower hills of Cachar Hills around Surma valley. The important species found in the forest environment are *Aphanamixis chittagonga, Aquilaria agallocha, Artocarpus chama, Calophyllum polyanthum, Canarium bengalense, Dipterocarpus turbinatus, Mangifera sylvatica, Mesua ferrea, Sterculia villosa,* etc. Undergrowth comprises of evergreen shrubby bamboos, climbers, and palms. Important climbers include *Combretum, Derris, Entada, Gnetum, Pothos, and Thunbergia*. Shrubs found are *Bambusa balcooa, B. tulda, Chromolaena odoratum, Leeaaequata, Melocana bambusoides, etc*.

[36] Proposed Reserved Forests means an area that has been proposed for demarcation and notification as Reserved Forest. The claims for rights of the local communities need to be assessed before the process can be completed. Some PRFs in Assam are yet to be notified as Reserved Forests

[37] Protected Area (PA) means a National Park, a sanctuary, a conservation reserve or a community reserve notified under sections 18,35,36C of the Wild Life (Protection) Act,1972

[38] Un-classed State forest means an area recorded as forest but not included in Reserved or Proposed Reserved Forest category. Ownership status of such forests varies and may be vested in the State, Autonomous councils or it may even be community owned

[39] http://assamforest.in/forestGlance/assamForest_glance.php

[40] Note: The Krugming Reserve Forest (RF) falls in district Dima Hasao (under Haflong Forest Division) and the District Council RF falls in district Karbi Anglong (under Dipu Forest Division)

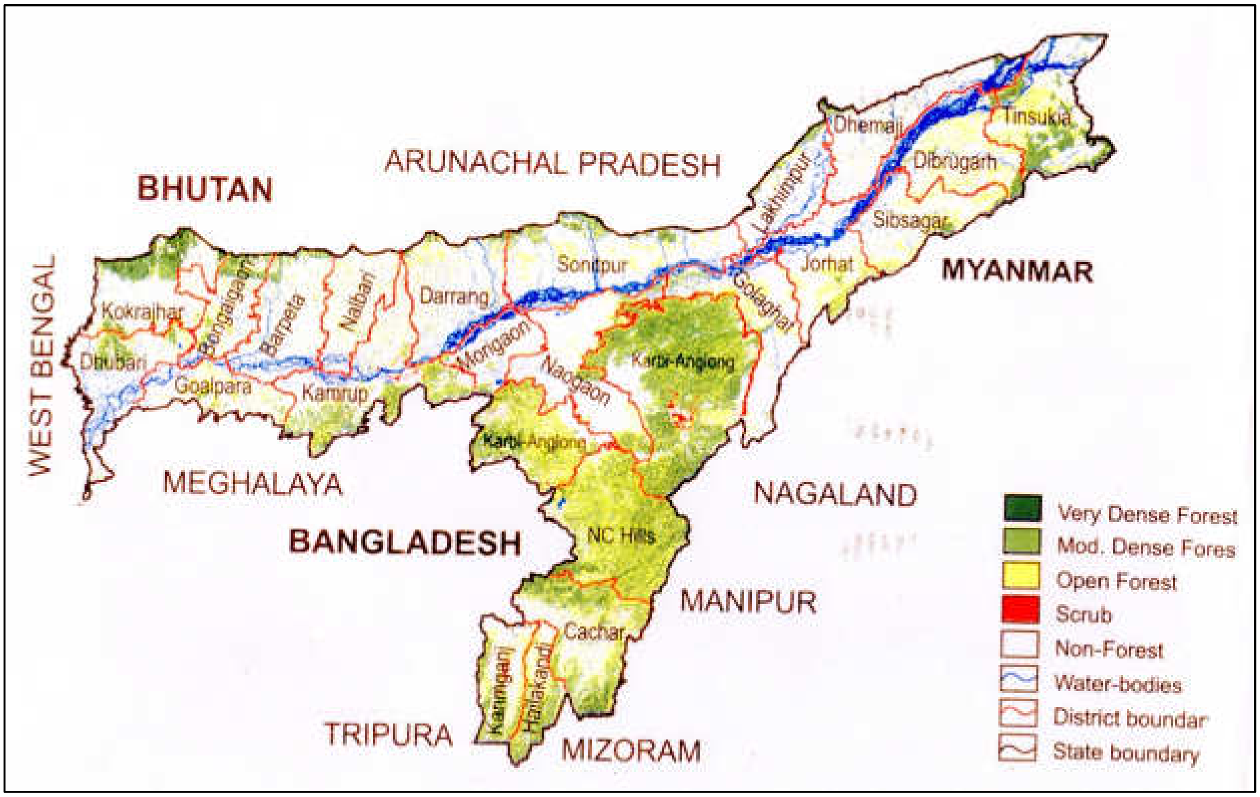
Type	Description
2B/C1 *Assam Valley Tropical Semi-Evergreen Forest*	The evergreen closed high forest is well developed in the heavy rainfall tract of the State and adjoining parts of northeast; the forest type is observed in the lower reaches of dam site and powerhouse site. It has varying proportions of deciduous trees and light alluvial soils. The important species found in (top storey) are *Ailanthus integrifolia, Aphanamixis polystachya, Artocarpus chama, Canarium bengalense, Castanopsis indica, Dysoxylum procerum, Garuga pinnata, Michelia champaca, Phoebe goalparensis, Pterospermum acerifolium, Sterculia villosa, etc*. Second storey consists of *Chukrasia tabularis*, *Mangnolia hodgsonii, Messua assamica, Syzygium cumini, etc.*
2B/C2 *Cachar Tropical Semi-Evergreen Forest*	The forest type is well developed in parts of northeast and in tracts with annual rainfall over 250 cm. The top storey is marginally dense with individual trees not more than 25 m in height. The soils along the foot hills are sandy loam turning into laterite. The important species found in top storey are *Adina cordifolia, Albizia procera, Artocarpus chama, Bombax ceiba, Chukrasia tabularis, Gmelina arborea, Palaquium polyanthum, Stereospermum personatum, etc.* Undergrowth comprises of bamboo species (*Bambusa tulda and Melocana bambusoides*) and climbers. Other shrubby species include *Chromolaena odoratum, Clerodendrum serratum, Leea aequata, Ficus scandens, etc*.
3C/C3B *East Himalayan Moist Mixed Deciduous Forest*	The forest type occurs in the foot hills and up to 500 - 650 m elevation; the forest type is observed in the upper reaches of dam site and powerhouse site. Rainfall is fairly heavy in the tract. The important species found in top storey are *Ailanthus integrifolia, Aphanamixis polystachya, Bombax ceiba, Gmelina arborea, Holarrhena pubescens, Lagerstroemia parviflora, Persea robusta, Schima wallichii, Sterculia villosa, Terminalia catapa, Tectona grandis, etc*. Second storey consists of moderate sized tree species like *Aphanamixis polystachya, Bauhinia purpurea, Bridelia retusa, Careya arborea, Dillenia pentagyna, Macaranga denticulata, Mallotus philippinensis, etc*. The rich undergrowth comprising of shrubs and herbs are *Aralia thomsoni, Clerodendrum viscosum, Chromolaena odoratum, Coffea bengalensis, Lantana camara, etc.* Epiphytes are few such as *Araliaceae, Asclepiadaceae and Orchidaceae*. Climbers and lianas are few, such as *Combretum decandrum, Dioscorea bulbifera, Mikania macrantha, Smilax aspera, Stephania elegans, etc*.
4E/RS1 Tropical Riparian Fringing Forest	This forest type is found along the banks of the large rivers in the hilly tracts of the State. The soils are well drained, sandy, or silty. Few tree species may be evergreen or deciduous viz., *Bischofia javanica, Ixonanthes khasiana, Flacourtia jangomas, Homonoia riparia, Pterospermum acerifolium, etc.* forming a narrow fringe in the hilly tracts along the bank of river Kopili.

226. **Forest Canopy Density**: In terms of forest canopy density classes, Assam has 1,444 km^2 supporting very dense forest (canopy cover above 70%); 11,404 km^2 of moderately dense forest (canopy cover between 40% and 70%); and 14,825 km^2 of open forest (canopy cover between 10% and 40%). The forests cover density for districts Karbi Anglong and Dima Hasao are presented in Table 66 and Figure 38. (also see Annex 4).

Table 66: Forest Cover for Districts Karbi Anglong and Dima Hasao (km^2)

District	Geographical area (GA)	Very dense forest	Moderate dense forest	Open forest	Total	% Total of GA	Scrub
Karbi Anglong	10,434	566	3,819	3,554	7,939	76.09	24
Dima Hasao	4,888	135	1,553	2,562	4,250	86.95	1

Figure 38: Forest Cover Map – Assam



- **Field Studies (2015) Findings – Flora**

227. **Vegetation Type in the Study Area:** About 172 species of angiosperms including trees, shrubs, climbers and herbs are recorded in the study area. The ground vegetation comprised of ephemeral, annual, and perennial species of grass, hedges, legumes and non-legume forbs. The upstream area of Longphu from the bank of river Kopili is moderately sloped with fairly dense Mixed Semi Evergreen forest. The impenetrable growth of large trees and evergreen shrubs provide rich habitat for wild elephants and other mammals.

228. **Rarity and Endemism:** In regions of Cachar, Khasia, and Jaintia Hills, rich habitats of rare, endemic and threatened species are gradually depleting due to natural and anthropogenic causes. The information of threatened flora species for the Assam region is inadequate and varies: Jain and Sastry (1983) reported 14 threatened taxa, **the Red Data Book of India** reported 43 (Nayar and Sastry, 1987-1991), and Barua (1995) reported 8 from the Assam region. These rare and endemic species include *Carex fuscifructus, Coelgyne rossiana, Dendrobium aurantiacum, Ixonanthes khasiana, Livistona jenkinsiana, Salacia jenkinsii*, etc. (Nayar and Sastry, 1987-1991). Of these, only two plant species namely *Ixonanthes khasiana* and *Salacia jenkinsii* are reported in the study area as discussed below. Besides these two species other species such as *Pterospermum acerifolium (*vulnerable-plant*), A. perviridis (*vulnerable-plant*), Aglaia hiernii (*near threatened -plant*), Bridelia assamica (*vulnerable-plant*), Cycas pectinate (*vulnerable-plant*), Ipomoea carnea* (rare-shrub*)* are also reported in the project area.

229. **Threatened Flora in the Study Area:** Threatened taxa are those species (including flora and fauna), which are vulnerable to endangerment in the near future. Threatened status of

any taxa is not a single category but is a group of the categories; like critically endangered, endangered and vulnerable. During the WAPCOS survey (2015) covering habitat of tropical and riparian zones in north Cachar hills, two populations of *Ixonanthes khasiana* and *Salacia jenkinsii* comprising 4-5 individuals each were found at the proposed dam site and submergence area along the Kopili river. These rare and endemic individuals showed a patchy distribution in about one square km area at an altitude of 230– 250 m. *Ixonanthes khasiana* (broadleaf evergreen tree) is a vulnerable species whereas *Salacia jenkinsii* (a woody climber) is an endangered species. There is no information regarding the precise location or of fresh collection. For *Ixonanthes khasiana*, the earlier reported distribution was placed at an altitude of 1,000-1,500 m indicating that species and corresponding biodiversity of the region may be under threat. Besides these two species, other species such as *Pterospermum acerifolium (*vulnerable-plant*), A. perviridis (*vulnerable-plant*), Aglaia hiernii (*near threatened -plant*), Bridelia assamica (*vulnerable-plant*), Cycas pectinate (*vulnerable-plant*), Ipomoea carnea* (rare-shrub*)* are also reported in the project area. **Recommendation**: regular monitoring of the representative forests in North Cachar and ex-situ and in-situ conservation measures for the above threatened species.

230. **Economically Important Plants in the Study Area:** Some of the important groups of economically important plants observed were medicinal plants, food plants, fibre yielding plants, etc., as described below.

231. **Medicinal Plants:** Medicinal plants recorded in the study area are presented in Table 67.

Table 67: Medicinal plants of the Study Area[41]

S. No.	Plant Species	Family	Vern./ Local Name	Part/s Used
1	*Flacourtia jangomas*	Flacourtiaceae	Coffee Plum	Leaves; Fruits
2	*Sida cordata*	Malvaceae	Khrenti	Roots
3	*Abroma angusta*	Sterculaceae	Gorkhia-Korai	Capsule
4	*Aegle marmelos*	Rutaceae	Bel	Leaves
5	*Murraya koengii*	Rutaceae	Gandhla	Leaves
6	*Micromelum integerrimum*	Rutaceae	Tanyinbo	Leaves
7	*Protium serratum*	Burseraceae	Kandidor	Fruits
8	*Azadirachta indica*	Meliaceae	Nim	Twigs
9	*Syzygium cumini*	Myrtaceae	Jaman	Bark
10	*Trevesia palmata*	Araliaceae	Bau	Fruits
11	*Eclipta alba*	Asteraceae	Bhangra	Leaves
12	*Holarrhena pubescens*	Apocynaceae	Dudhi	Seeds
13	*Wrightia arborea*	Apocynaceae	Khirni	Follicles
14	*Oroxylum indicum*	Bignoniaceae	Pharri	Bark
15	*Stereospermum chelonoides*	Bignoniaceae	Padal	Capsule
16	*Gmelina arborea*	Verbenaceae	Gambhar	Seeds
17	*Clerodendrum serratum*	Verbenaceae	Begyo	Roots
18	*Ocimum sanctum*	Lamiaceae	Tulsi	Whole plant
19	*Piper longum*	Piperaceae		Fruits
20	*Andrachne cordifolia*	Euphorbiaceae	-	Leaves
21	*Phyllanthus emblica*	Euphorbiaceae	Amla	Fruits
22	*Costus speciosus*	Araceae	-	Root

232. **Food plants:** Wild flowering species are found in diverse localities of Dima Hasao (North Cachar). The residing communities collect these in the form of fruits, flowers, rhizomes, tubers, for consumption. Some of the food plants include: *Ficus semicordata, Musa paradisiaca, Syzygium cumini, Zizyphus mauritiana, etc.* consumed raw; *Artocarpusintegrifolius, Bombax*

[41] Table 8.7

ceiba, Ficus spp., Moringa oleifera, Floral buds of *Bauhinia purpurea and Bombax ceiba etc*. used as vegetables; Shoots of *Bambusa spp. and Dendrocalamus hamiltonii* used for pickles and as vegetables; Rhizomes and tubers such as *Colocasia esculenta, Dioscorea spp, Curcuma spp, etc.* used as vegetables; Leaves of *Amaranthus, Athyrium, Girardinia, Urtica, etc*. used as vegetables.

233. **Fibre yielding plants:** The fibre yielding species include *Bombax ceiba, Bauhiniavahlii, Corchorus spp., Grewia sp., Sterculia villosa, etc*.

234. **Timber and fuel wood:** The timber yielding species include *Albizia procera* (Safed Siris), *Artocarpus chama* (Lutta), *Michelia champaca* (Tita Sopa), *Schima wallichii* (Chilaune), T*erminalia catapa* (Badam), etc. In addition to these trees, some woody bamboos like *Bambusa tulda, Calamus floribundus, Dendrocalamus hamiltonii, etc*. are also used.

235. **Horticulture:** The forest of Dima Hasao (North Cachar) are rich in some horticulturally important plant species such as *Aralia thomsoni, Bauhinia purpurea, Camellia kissi, Cycas pectinata, Dracaeana angustifolia, etc*.

- **Community Structure**

236. Discussions on community structure (density and abundance of woody vegetation, herbaceous vegetation accounts, and species diversity) in the study area are included in Annex 4.

237. Overall, the maximum numbers of trees were recorded from near the power house (PH) site (Kala nala, RB of Kopili and Phanglengsu nala on LB). In comparison, the proposed dam site (near Longphu, RB of river Kopili) and submergence/catchment area (upstream of Longphu Basti, on RB of river Kopili and Rongtarne village on LB of river Kopili) did not show as many tree species. This may be due to past and ongoing land use change (e.g. practice of Jhum cultivation) and extensive felling of trees for various purposes including timber (see Table 67). Jhum cultivation is a common practice undertaken by the residing (local) tribal communities and consists of tree felling and land clearing for use of cultivation, typically for 2 to 3 years. The communities then allow the land to regenerate for next 15-20 years as per local interaction.

238. Maximum diversity, abundance and species richness for herbaceous vegetation was recorded during the monsoon season.

- **Protected Areas**

239. Assam has 5 National Parks (NPs) and 18 Wildlife Sanctuaries (WLS). In total, these parks and sanctuaries cover 3,925 km^2 or 5% of the total geographical area of the State. Some of these areas are also Tiger Reserves for example Kaziranga, Manas and Nameri. Manas NP (2,837 km^2) and Dibru-Saikhowa NP (765 km^2) NPs are also Biosphere Reserves. Both Kaziranga NP and Manas NP are UNESCO World Heritage Sites. As per the information retrieved from the State Forest Department, the forest working plan of the districts, and due diligence conducted for the proposed project, Tranche 3 (including power evacuation facilities) does not affect any of the protected areas (or ecological sensitive areas (ESA)).

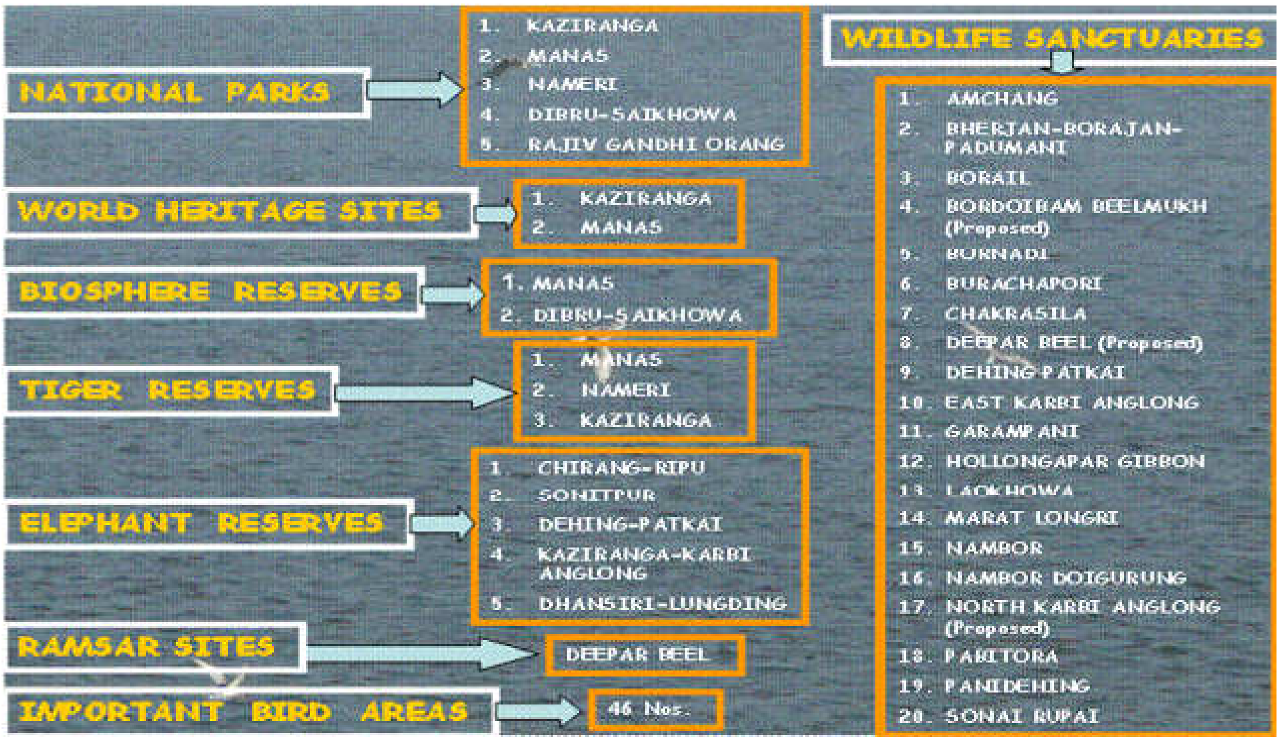
240. Figure 39 shows the list of all protected areas in Assam while Figure 40 shows the location of protected areas. Table 68 provides details of NPs and the approximate distance from the proposed project. It can be seen from the Table 68 that nearest protected area (Kaziranga

National Park) is 172 km away from the location of the proposed LKHEP. Also there is no direct hydrological connection between Kaziranga National Park and proposed Kopili river basin.

241. Extensive consultations have been undertaken with local forestry officials as well as local people. Local forest department has also confirmed that there are no environmentally protected areas within 50 km radius of the proposed LKHEP Project. Figure 41 show the Certificate issued by the forest department regarding presence of protected areas in the project region.

242. Assam has a freshwater lake (Dipor Beel), designated as a wetland under the Ramsar Convention (November 2002)[42]. The lake is situated south-west of Guwahati city in Kamrup district, is not affected by the proposed project as it is about 230 km away and hydrologically not connected with Kopili river.

Figure 39: Protected Area Network in Assam



[42] Ramsar Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. According to the Ramsar list of Wetlands of International Importance, there are 25-26 designated wetlands in India that are threatened; http://southasia.wetlands.org/OurWetlands/OverviewofallwetlandswithRamsarstatus/tabid/634/Default.aspx

Figure 40: Locations of National Parks and Wild life Sanctuaries in Assam

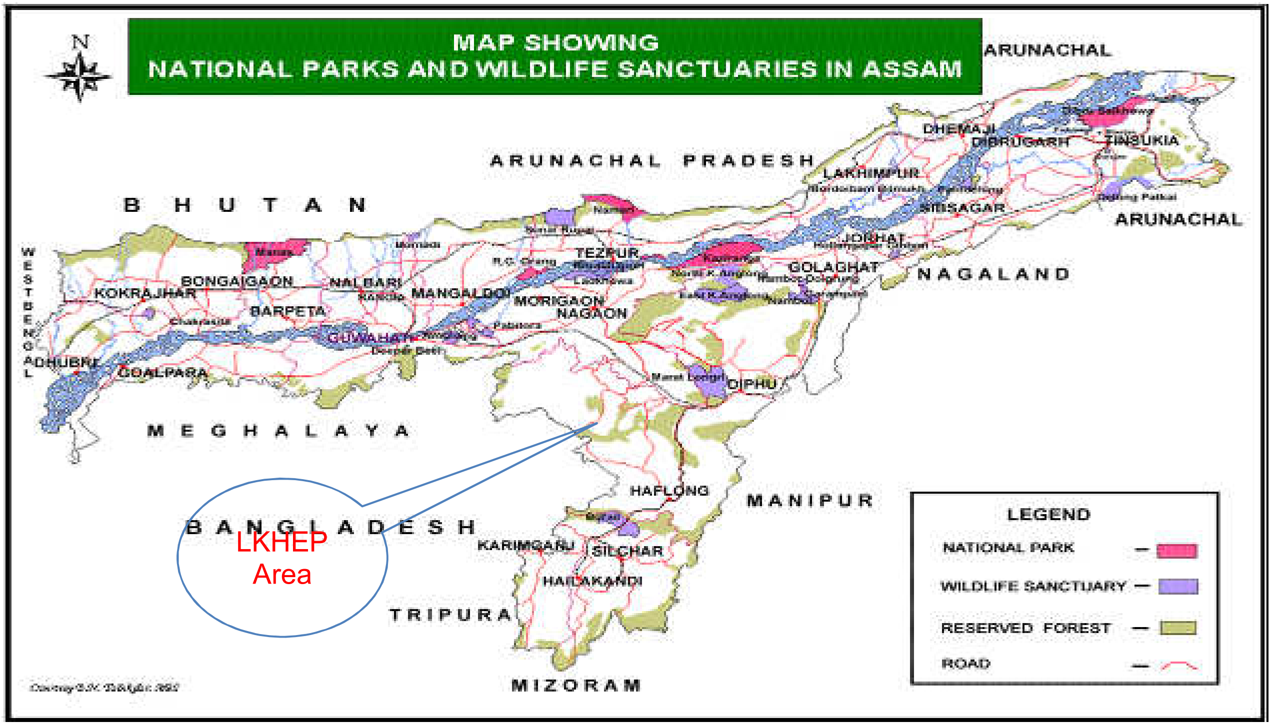


Table 68: Details of NPs and the Approximate Distance from the Proposed Project[43]

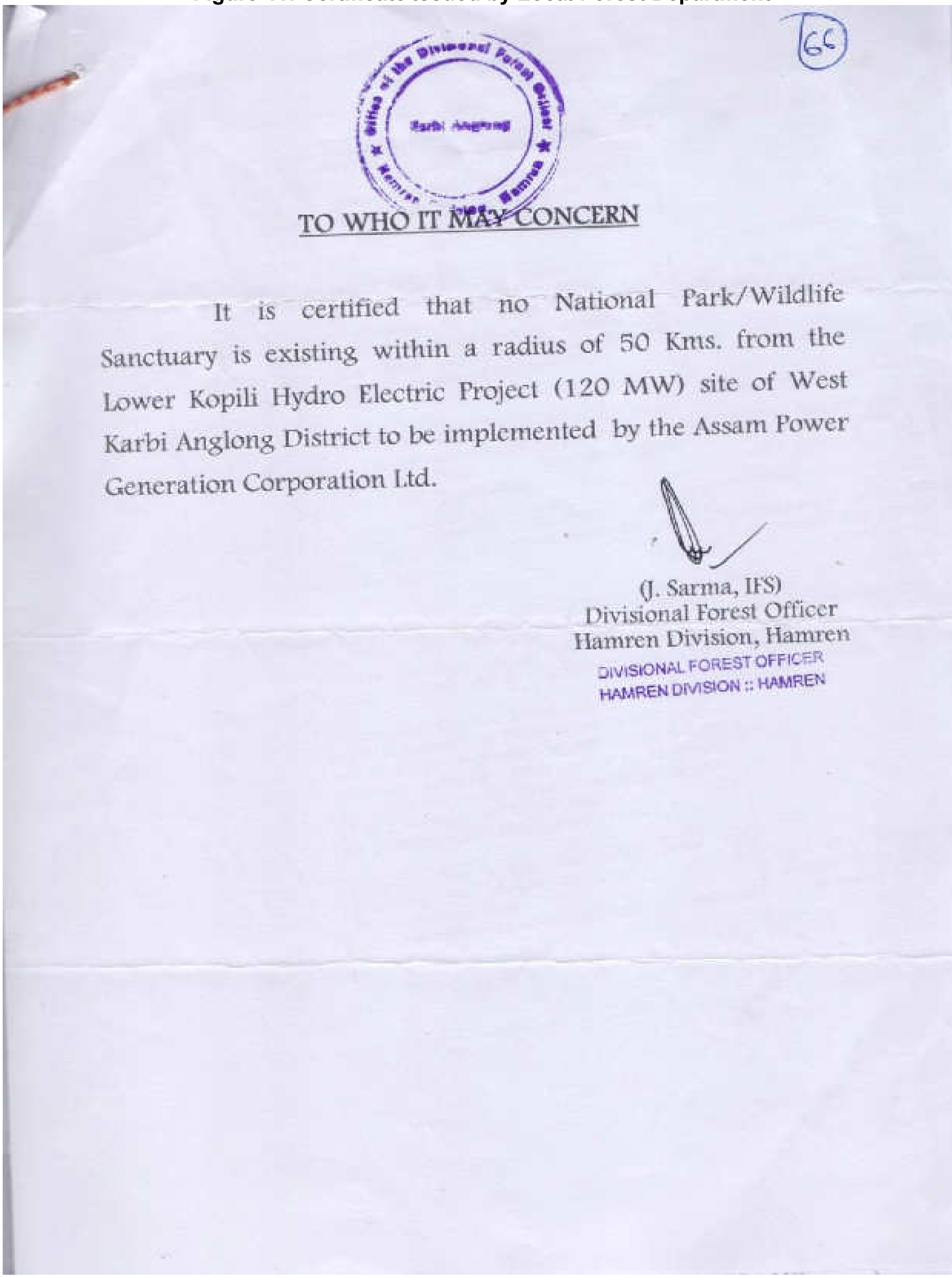
Name of National Park (NP)	Details of National Park	Nearest District	Approx. Distance of Nearest Town (km)	Approx. Distance of LKHEP area (in Longku) from NP Boundary (km)	Approx. Distance of Transmission Corridor[44] from NP Boundary (km)
Dibru-Saikhowa	Area – 640 km^2 Established in 1999; IUCN Category II Biosphere reserve	Tinsukia	21 km	511 km to Longku	468 km to Lanka 537 km to Umrangsu
		Dibrugargh	40 km		
			173 km		
Kaziranga	Area – 471 km^2 Established in 1905; notable for Indian Rhinos and UNESCO World Heritage Site; IUCN Category II Declared as Wildlife Sanctuary in 1940 and as a Tiger	Golaghat	93 km	172 km to Longku	128 km to Lanka 198 km to Umrangsu
		Nagaon	104 km		

43 Note: The distance between NP and evacuation lines has also been ascertained to ensure the proposed transmission corridor does not infringe on any protected areas.

44 The power evacuation system consists of: One new double circuit (DC) 220 kV transmission line from the Main Power House (MPH) Site of LKHEP (at Longku) to an existing 132/33 kV Substation (S/S) at Sankardev Nagar (Lanka); line length: 50 km; Location: Districts Dima Hasao, Nagaon; and one new Single Circuit (S/C) 33 kV transmission line from the Auxiliary Power House (APH) site of LKHEP to an existing 33/11 kV Substation (S/S) at Umrangsu; line length:20 km; Location: District: DimaHasao.

Name of National Park (NP)	Details of National Park	Nearest District	Approx. Distance of Nearest Town (km)	Approx. Distance of LKHEP area (in Longku) from NP Boundary (km)	Approx. Distance of Transmission Corridor[44] from NP Boundary (km)
	reserve in 2006				
Manas	Area – 950 km^2 Established in 1990; notable for UNESCO World Heritage Site; IUCN Category II	Kokrajhar	122 km	365 km to Longku	321 km to Lanka 390 km to Umrangsu
		Chirang			
		Udalgiri			
		Baksa			
		Udalgiri			
		Bongaigaon	80 km		
Nameri	Area – 137 km^2 Established 1978; notable for Tiger Project; IUCN Category II	Tezpur partly covering Nagaon	35 km	195 km to Longku	151 km to Lanka 220 km to Umrangsu
		Sontipur	-		
Orang	Area – 78 km^2 Established in 1999; notable for Bird Sanctuary; IUCN Category II	Tezpur	32 km	220 km to Longku	176 km to Lanka 246 km to Umrangso
		Mangaldoi	40 km		

Figure 41: Certificate Issued by Local Forest Department



66

Karbi Anglong

TO WHO IT MAY CONCERN

It is certified that no National Park/Wildlife Sanctuary is existing within a radius of 50 Kms. from the Lower Kopili Hydro Electric Project (120 MW) site of West Karbi Anglong District to be implemented by the Assam Power Generation Corporation Ltd.

(J. Sarma, IFS)
Divisional Forest Officer
Hamren Division, Hamren
DIVISIONAL FOREST OFFICER
HAMREN DIVISION :: HAMREN

243. The proposed project does not affect areas included under International Union for Conservation of Nature and Natural Resources (IUCN)[45] Level II category. However, stakeholder consultations and field observations confirmed that the rich biodiversity of the area. Affected stakeholders confirmed the presence (and movement) of Asian elephants, Chinese pangolins, monkeys, stags, deer, wild boars, jackals, bears, and woodpeckers in and around the study area.[46] A critical habitat assessment has been carried out. Potential impacts on biodiversity has been assessed by mapping the proposed study area with respect to (i) IUCN and India's Red list, (ii) protected areas / biological corridors, (iii) important species and biodiversity areas, (iv) forests, and (v) other potentially sensitive habitats. For distribution and habitat requirements of endangered species, a detailed analysis and species-specific data was noted. Details of assessment and mapping of species grid are provided in Annex 5.

4. Fauna

244. Discussions on fauna are based on field studies carried out in 2015. Detailed discussion on methodology adopted for the faunal survey, findings for faunal diversity and composition, list of species observed are presented in Annex 4.

- **Mammals**

245. Assam's mammalian diversity is represented by 193 species that are widely distributed in the region with the exception of the One-horned Rhinoceros, Water Buffalo, Pigmy Hog, Swamp Deer, Golden Langur, and Hoolock Gibbon that have their distribution limited to isolated pockets and protected areas in the State. Out of 15 primate species in India, 9 are found in Assam such as the Hoolock Gibbon, the Golden Langur, Capped Monkey, Rhesus Macaque, Pigtail Macaque, Stump-tailed Macaque, Assamese Macaque, and Slow Lorries.

- **Field Studies (2015) Findings – Mammals**

246. A total of 21 mammalian species grouped under 13 families were confirmed in the study area. The primate fauna is represented by *Macaca mulatta*. Viverridae comprises of 2 species, common and widely distributed in India. They inhabit the dense and inner parts of forests, and are not a common presence in the close surroundings of project area. Herpestidae comprises of 2 species: *Herpestes urva* and *Herpestes edwardsii*, common and widely distributed in India as well and in the surroundings of the project area (are spotted along the road sides, agricultural fields and near the settlement areas). Cervidae comprised of 1 species (Sambor), common and widely distributed in India as well as reported from the project area (inhabiting dense and inner parts of forests). Bovidae is represented by Bos gaurus and occupies open forests in the lower

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[45] IUCN provides a comprehensive analysis of the global conservation status, trends, and threats to species viz the IUCN Red List (or Red Data List); the Red list establishes a baseline from which to monitor the change in status of species; provides a global context for the establishment of conservation priorities at the local level; and on a continuous basis, monitor the status of a representative selection of species (as biodiversity indicators) that cover all the major ecosystems of the world. http://www.iucnredlist.org/about/overview

[46] The Krugming Reserve Forest (RF) in Dima Hasao and the District Council RF in Karbi Anglong is home to wild elephants among other animals. The affected communities experience frequent movement of elephants from Longku side and Panimur side – both situated on the right bank of River Kopili in Dima Hasao. Wild elephants also cross left bank to right bank from within the District Council RF in Karbi Anglong up to and across to Dima Hasao. The movement of wild elephants is typically intensified during the rainy season when these animals move out from the Reserve Forest area in search of food to other nearby areas. Note: the forest ranger Panimur did not know of a specific elephant corridor. Additionally, the Reserve Forests also hosts animal species such as Stag (moso), Chinese Pangolin, Deer (meesai), Wild Boar, Monkeys (magusa), Jackal, Birds such as the wood pecker (daojgaima), and some reptiles.

reaches especially flood plains. Manidae includes *Manis pentadactyla*, highly restricted in distribution and inhabiting the lower hills (mainly teak forests). Rodents include 1 species of mouse, 2 species of rats, and 3 species of squirrels with possibility of many more species of rodents; these species are common in the settlement area, agricultural fields and bamboo forests. Chiroptera (Bats) comprises of 3 species.

247. **Threatened Mammals in the Study Area:** Stakeholder consultations held in June 2015 confirmed that the biodiversity in the project area (including the large forest patch between the upper Kopili and the proposed project) is rich; consultations confirmed the presence of elephants in and around the project area surrounding Longku (note: there are no known demarcated elephant corridors in the area) as well as of the Chinese Pangolin. Under IUCN conservation status, elephants are considered as endangered (EN) while Chinese Pangolins are considered as Critical (CR); both are on Schedule I of the Indian Wildlife Protection Act (1972) which is the highest protection accorded to species in India. Besides these two species, *Trachypithecus pileatus (*Capped Langur), *Rusa unicolor (*Sambar), and *Bos gaurus (*Gaur) considered as vulnerable under IUCN list, are also reported in the project area.

248. For a list of mammalian species recorded in the study area, please refer to Annex 4.

- **Avifauna**

249. Assam is one of the “endemic bird areas” in the world; the State harbors more than 900 species and sub-species. The State host 17 endemic species and 8 species – Critically Endangered (CR); 9 species – Endangered (EN); 29 species – Vulnerable (VU); 31 species - Near Threatened (NT). The 17 endemic species include the Manipur Bush Quail, Marsh Babbler, Snowy throated Babbler, Tawny breasted Wren Babbler, Blyth’s Tragopan, Beautiful Sibia, Grey Sibia, Black Breasted Parrot-bill, Chest runt Breasted Partridge, Rusty Breasted Short-wig.

- **Field Studies (2015) Findings – Avifauna**

250. While the avifauna information for North Cachar Hills (Dima Hasao) and Jaintia Hills is plentiful, it is inadequate for the direct area of concern (i.e. proposed project and surrounding areas). The climatic conditions, topographic and forest covers in the proposed project and surrounding areas suggests rich diversity of avifauna. During the primary survey a total of 59 species grouped under 24 families were confirmed in the study area. Except for a few species like *Spelaeornis longicaudatus* (Tawny-breasted Wren Babbler) that is endemic to the left bank of the river Brahmaputra (not to Kopili river) This species is not found during field surveys – but reported by local people) all other species are widely distributed especially in northeast region and adjacent countries like Myanmar and Bhutan. Widespread resident species are predominant, accounting for nearly 52% of total species in the study area and these are followed by the local resident species, accounting for nearly 32% of total species. Most common species observed during the primary survey were *Merops leschenaultia* (Chestnut Bee-eater), *Motacilla alboides* (White Wagtail), *Columba livia* (Rock Pigeon), *Streptopelia chinensis* (Spotted Dove), *Treron phoenocoptera* (Bengal green Pigeon), *Acridotheres tristis* (Indian Myna), *Corvus splendens* (Common Crow), *Dicrurus adsimillis* (North Indian Black Drongo), *Pycnonotus atriceps* (Black headed Bulbul), *Pellorneum albiventre* (Assam Brown Babbler) and *Passer domesticus* (House Sparrow).

251. Dicrurus adsimillis (North Indian Black Drongo) is the only local migrant species in the study area. There are no congregatory species in the area. There are only three species namely *Tringa glareola* (Spotted Sandpiper), *Ficedula parva* (Red-throated Flycatcher) and

Acrocephalus dumetorum (Reed Warbler), which are considered as widespread winter visitor in the study area, but no breeding visitors reported.

252. **Threatened Avifauna in the Study Area:** All observed/recorded species are considered as Low Risk/Least Concerned in IUCN RED List and covered under Indian Schedule IV (means least protected species) of the IWPA (1972) with the exception of *Sitta Formosa (*Beautiful Nuthatch) that is covered as vulnerable under IUCN list, and two species (*Aviceda leuphotes and Pavo cristatus*) that are covered under Schedule I[47] of the IWPA (1972). Most of the avifauna species recorded are local and widespread resident except *Spelaeornis longicaudatus* (Tawny-breasted Wren Babbler) that is reported in the project area (but not found during field surveys) is endemic to the left bank of the river Brahmaputra (not to the Kopili river).

253. For a list of avifauna recorded in the study area, please refer to Annex 4.

- **Reptiles**

254. Given the topography and climate conditions, the proposed project and surrounding areas is favorable for herpeto-fauna especially reptiles. However, the area is relatively less researched and information on the reptiles is rare. From published literature (Das et al., 2009) and other research sources, a total of 32 species grouped under 11 families were reported from the study area.

- **Field Studies (2015) Findings – Reptiles**

255. Family Agamidae calotes emma, Calotes jerdoni and Japalura planidorsata are distributed in open forests while majority of other species are found in settlements and garden areas. Family Gekkonidae are commonly distributed. Family Varanidae is represented by 2 species: *Varanus bengalensis* (Common Indian Monitor) and *Varanus salvator* (Water Monitor); both are common in the study area (project component areas). Family Scincidae includes 5 species, all are common in settlements and forests. Among snakes, *Python molurus* of Pythonidae is not common in study area, however, it is reportedly observed in the inner forests of the surrounding areas. *Ptyas mucosus* (Dhaman or Rat snake), *Ophiophagus hannah* (King cobra), *Naja kaouthia* (Common cobra), *Bungarus fasciatus* (Banded krait) and *Bungarus caeruleu* (Common krait) have common occurrence near settlements and forests.

256. **Threatened Reptiles in the Study Area:** Most observed/recorded species are considered as Low Risk/Least Concerned in IUCN RED List; except two species *Python molurus* (Burmese Python) and *Ophiophagus hannah* (King cobra) covered as vulnerable in IUCN list. *Python molurus* and *Ophiophagus hannah* are also covered under Schedule I and Schedule II of the IWPA (1972), respectively.

257. For a list of reptiles recorded in the study area, please refer to Annex 4.

- **Amphibians**

258. Given the topography and climate conditions, the proposed project and surrounding areas is favorable for amphibian fauna. However, the area is relatively less researched and information is rare. From research sources, a total of 19 species grouped under 6 families were reported from the study area. All species are common and widely distributed in the sub-continent. None of the species is endemic to India as well as North-Eastern region of India.

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[47] Schedule 1 species in India has maximum legal protection under Wildlife Protection Act 1972. The species includes critical as well as endangered species.

- **Field Studies (2015) Findings – Amphibians**

259. During the primary data collection (survey), 2 species namely *Duttaphrynus melanostictus* (Asian common toad) and *Hylarana tytleri* (Common Green Frog) were spotted from the study area. In addition to the above, two other species of frogs were spotted at the power house site and forest area (upstream of the barrage), however, these could not be identified.

260. **Threatened Amphibians in the Study Area:** All observed/recorded species are considered as Low Risk/Least Concerned in IUCN RED List while 5 species (family Ranidae) are covered under Schedule IV[48] of the IWPA (1972).

261. For a list of amphibians recorded in the study area, please refer to Annex 4.

- **Field Studies (2015) Findings – Butterflies**

262. About 60 butterfly species were recorded from the study area of which a total of 56 species grouped under 5 families were identified during primary survey. All recorded species are common in occurrence and widely distributed. None of the recorded species have restricted distribution or are endemic to the region.

263. The abundant species found are:

- *Eurema blanda silhetana* (Three Spot Grass Yellow),
- *Eurema hecabe contubernalis* (Common Grass Yellow),
- *Vindulaerotaerot*a (Crusier),
- *Appias lyncida hippoides* (Chocolate Albatross),
- *Princeps polytes* (Common Mormon),
- *Parantica sita* (Chestnut Tiger),
- *Orsotrioenamedusmedu*s (The Nigger),
- *Vindulaerotaerota* (Crusier),
- *Mycalesisperseus* (Common Bushbrown),
- *Junonia lemonias* (Lemon Pansy) and
- *Caletacaletadecidia* (Angled Pierrot)

264. The rare species in the study area are:

- *Leptocircuscuriuscurius* (White Dragontail),
- *Polyura eudamippus* (Great Nawab),
- *Athyma kanwa phorkys* (Dot-Dash Sergent), and
- *Udara albocaerulea* (Albo Cearulean)

265. **Threatened Butterflies in the Study Area:** Lepidopteran fauna is marginally included in the IUCN and IWPA's list. Only one species *Junonia almana* (Peacock Pansy) is included under the Low Risk/Least Concerned category of IUCN; this species was not among the common and abundant species of study area. A total of 4 species are included in the IWPA (1972) list:

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[48] Schedule IV species in India are protected under Wildlife Protection Act 1972. This schedule does not include critical as well as endangered species.

Euthalia telchinia (Blue Baron), *Neptis magadha khasiana* (Spotted Sailer) and *Mycalesis malsarida* (Plain Bush brown) are included in Schedule I (most protected) while *Pelopidas assamensis* (Great Swift) is included in Schedule IV (least protected). None of these species are common in occurrence or abundant in the study area.

266. For a list of butterflies recorded in the study area, please refer to Annex 4.

5. Aquatic Ecology

267. Discussions on aquatic ecology are based on field studies conducted in 2015 as part of field surveys. Detailed discussion of the study area, methodology adopted for the aquatic ecology survey, findings for species diversity, density, and richness are presented in Annex 4.

268. The north-east including Assam has 266 species (recorded and reported) belonging to 114 genera under 38 families and 10 orders (Sen, 2003). Out of 266 species, 196 fish species have potential ornamental value (Dey et al., 2002). In Assam, the Brahmaputra drainage system is recognized as one of the hot spots of fresh water fish biodiversity, with constant threat of over exploitation of its aquatic resources and fish diversity.

269. The aquatic ecology in and around the proposed project and surrounding areas (river Kopili) has been affected grievously by acid drainage due to illegal and uncontrolled rat hole coal mining upstream in State of Meghalaya. India's National Green Tribunal (NGT) passed a directive in April 2014 to ban rat hole mining in Meghalaya leading to some improvement to the downstream aquatic ecology. However, the issue continues to need attention (illegal mining continues).

6. Field Studies (2015) Findings

270. The health of aquatic ecosystem of river Kopili was assessed by recording different biotic communities namely zooplankton, phytoplankton, and phytobenthos under micro flora and fauna; macro-invertebrates and macrophytes under macro flora and fauna; and vertebrate group represented by fish fauna.

271. Overall, the species density, richness and diversity of different biotic communities of river Kopili is quite low compared to other healthy river systems, due to the acidic nature of the water. Zooplankton density ranged from 23 to 103 cells/l with maximum density at site S4 (river Amring). Phytoplankton density was less upstream than downstream, ranging from 175 to 624 cells/l and represented by blue green algae, green algae and diatoms (with no variation in between groups). Phytobenthic density ranged from 64 to 200 cells/cm^2. Macro-invertebrates' density ranged from 11 to 44 individuals/m^2. The low density and diversity of different biotic communities is attributed to impact of acidic water on the substratum and habitat structure due to acid drainage from illegal and uncontrolled rat hole mining upstream in State of Meghalaya. Though, impact seemed to decrease towards downstream areas.

272. For a list of biotic communities recorded in the study area including species density, richness and diversity, please refer to Annex 5.

273. A total of 22 fish species belonging to 12 families were reported in the Panimur stretch. Of the 12 families recorded, Cyprinidae was the largest family accounting for nearly 48% of the total species. A total of 4 fish species namely *Garragotylagotyla, Daniorerio, Puntius sophore* and *Barilius bendelisis* were caught in side streams along the downstream influence zone (near PH site and 4 km downstream of PH site), while no fish were present or caught in the immediate vicinity of the proposed dam site. Consultations with local communities confirmed the absence

of fish in the river Kopili. Additionally, there are no migratory fish species observed in Kopili River or its tributaries.

274. **Threatened Ichthyofaunal Species**: Out of 22 fish species reported (near the project area, but not in the Kopili at the dam and powerhouse sites), a total of 20 species are included in the IUCN Red List (IUCN, (2014). A total of 19 species are categorized under 'least concerned' while a one species – *Anabus testudineus* has been placed under 'data deficient' category. None of the species are endemic or restricted range to the Kopili and Brahmaputra basins.

275. For list of ichthyofaunal composition recorded in the study area and corresponding conservation status, please refer to Annex 5.

D. Socio-economic Environment

1. Governance

276. The proposed project is situated in the Karbi Anglong and Dima Hasao Autonomous Districts. The Dima Hasao and the Karbi Anglong Autonomous Districts constituted under the provisions of the Schedule VI of the Constitution of India have the autonomy to legislate and administer subject areas such as land, revenue, transport, public works, primary education, customary laws, fisheries, forests, planning and development, marketing (and other subjects that are assigned under the Schedule VI). No State, Union law or regulation applies to an autonomous district council (ADC) area unless the Governor of Assam specifically approves the same. A Deputy Commissioner, appointed by the Governor of Assam runs the civil administration and maintains law and order in each autonomous district.[49]

2. Demography

277. Dima Hasao covers an area of 4,888 km^2, and has a total population of 214,102. The Karbi Anglong covers an area of 10,434 km^2 with a total population of 906,313 (2011 Census Report, GoI).

278. Both districts are sparsely populated with 92 persons per km^2 in Karbi Anglong and 44 persons per square km in Dima Hasao. The average population per square km in both districts (71.5 persons per km^2) is substantially lower than that of Assam (398 persons per km^2, as per 2011 Census Report, GoI).

279. The sex ratio of females to males in Karbi Anglong is 951:1000 while in Dima Hasao, it is 932:1000.

3. Tribal Groups

280. In Dima Hasao and Karbi Anglong, 70.9% and 59.4% of the total population is Tribal, respectively; in total constituting 14% of tribal in Assam. The tribes living in the Dima Hasao are Dimasas, Zeme Nagas, Biate, Hmars, Kukis, Hrangkhawls, Vaipheis, Karbis, Khasi-pnars and Khelmas. The tribes in the Karbi Anglong are Rengmas, Dimasas and Koch. Gorkhas, Kuki-Chin People such as Kukis, Hmars and Mizos, Garos, Tiwas, Khasis and Chakmas.

[49] Details are included in Resettlement and Tribal Development Plan document

4. Literacy

281. The schools and colleges of Assam are either run by the state government or private organization. Literacy in Dima Hasao is 77.54 % that is higher than the State average of 72.19 % while literacy in Karbi Anglong is 69.25% that is lower than the State average. Overall, literacy is higher for males than females in both districts: in Karbi Anglong, the male literacy is 76% and female literacy is 63% while in Dima Hasao, male literacy is 83% and female literacy is 71% (see Table 69).

Table 69: Demographic Profiles of Karbi Anglong and Dima Hasao Districts of Assam[50]

Description	Karbi Anglong	Dima Hasao
Population	906,313	214,102
Rural Population	799,277	151,606
Urban Population	107,036	62,496
Male	490,167	110,802
Female	466,146	103,300
Decadal[51] Growth Rate (percentage)	17.58	13.84
Area (km^2)	10484	4888
Population Density (km^2)	92	44
Sex Ratio (females per 1000 males)	951	932
Average Literacy (percentage)	69.25	77.54
Male Literacy (percentage)	76.14	83.29
Female Literacy (percentage)	62.5	71.33
Scheduled Tribes in district Population (percentage)	59.4	70.9
District scheduled tribal population as a percentage of the Sate Population	13.9	3.9

5. Occupation, Employment and Income

282. As per the Social Impact Assessment (SIA) survey (December 2015), the main occupation of households[52] (78%) is farming on leaseholds with involvement of both men and women. Income from the cultivation of land is supplemented by working as agricultural laborers seasonally (16%) and by engaging in allied agricultural work such as raising pigs, chicken small businesses. There are no fishing activities in the PIA (no fish in the Kopili due to the low pH). There are no landless daily wage workers and very few affected persons (APs) due to the proposed project are engaged in white collar employment such as government service and private sector employment (see Table 70 and Table 71).

283. Only 5% of households fall below poverty line (BPL category)[53]. More than two-thirds of households earned between Rs 30,000 and Rs 100,000 a year. 17% of households earned more than Rs 100,000 each a year (see Table 72).

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[50] Source: Census of India, 2011

[51] Decadal means 10 years; here it is Census Year 2011 over 2001 Census Year

[52] Reference to households are those (households) located in project affected villages of districts Dima Hasao and Karbi Anglong

[53] As per new definition the poverty line, recommended by GoI, a person spending Rs 32 or more a day in rural areas, and Rs 47 or more a day in towns and cities, should not be considered as poor (recommendation of an expert panel headed by former RBI Governor C Rangarajan). This supersedes the previous Suresh Tendulkar panel’s recommendations in 2011-12 that fixed the poverty line at Rs 27 or more a day in rural areas, and Rs 33 or more in urban areas per person a day.

Table 70: Main Occupations of the Households[54]

Main Occupation	Number of Households	Percentage
Farming	150	78
Agricultural labor	31	16
Allied agricultural work	2	02
Nonagricultural labor	2	01
Government Service	3	01
Private sector	2	01
Trade / business	2	01
Total	**192**	**100**

Table 71: Occupational Status of Aps by Gender[55]

Employment	Main Occupation				Subsidiary Occupation			
	Male	%	Female	%	Male	%	Female	%
Farming	185	75	60	37	62	34	45	69
Agricultural Labor	51	20	41	25	06	04	01	02
Allied Agriculture	01	01	56	35	107	58	17	26
Non Agricultural Labor	02	01	02	01	00	00	00	00
Govt. Service	04	01	01	01	03	02	00	00
Private Service	03	01	02	01	03	02	00	00
Trade / Business	02	01	00	00	01	01	00	00
Total	**248**	**100**	**162**	**100**	**183**	**100**	**65**	**100**

Table 72: Annual Income of the Affected Households[56]

Annual Income (Rs)	Number of Households	Percentage
Up to 20,000	09	05
Above 20,000 and Below 30,000	16	09
Above 30,000 and Below 50,000	86	46
Above 50,000 and Below 100,000	42	23
Above 100,000 and Below 200,000	20	11
Above 200,000	12	06
Total responded	185	100
No Response	07	

6. Land Use[57]

284. The land use pattern of the study area presented in Table 73 while the classified imagery is presented in Figure 42 and 43. The major land use categories in the study area are Dense Vegetation and scrubs, accounting for 67.07% and 12.07% of the total study area, respectively. The open vegetation is 11.22% while settlements account for about 0.16% of the study area.

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[54] SIA Survey, December 2015
[55] SIA Survey, December 2015
[56] SIA Survey, December 2015
[57] The land use pattern of the study area has been studied through digital satellite imagery data. The land use pattern has been studied through satellite imagery data. Remote sensing satellite data of Resource Sat- 2 Satellite (LISS-IV, Sensor, path 111, row 53 C & D) Data of was procured from National Remote Sensing Agency (NRSA), Hyderabad. The data was processed through ERDAS software package available with WAPCOS. Ground truth studies were conducted in the area to validate various signals in the satellite images and correlate them with different land use domains.

Table 73: Land Use Pattern in the Study Area

S.No	Category	Area (ha)	Area (%)
1	River /Water bodies	7,486	1.50
2	Dense Vegetation	33,4972	67.07
3	Open Vegetation	56,048	11.22
4	Agricultural Land	39,795	7.97
5	Scrubs	60,287	12.07
6	Settlements	814	0.16
	Total	**499,402**	**100.00**

Figure 42: Classified Imagery of the study area for Lower Kopili HEP

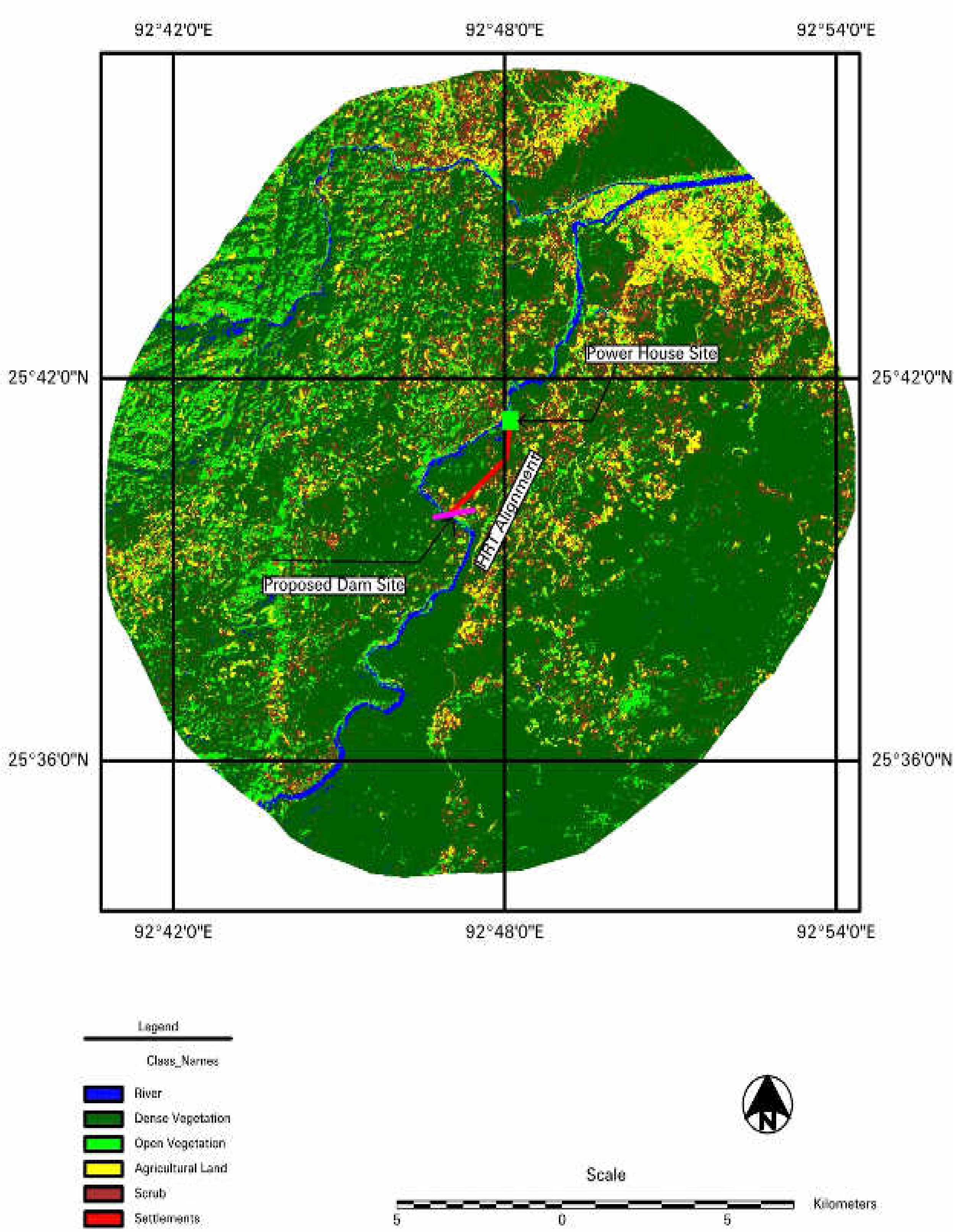
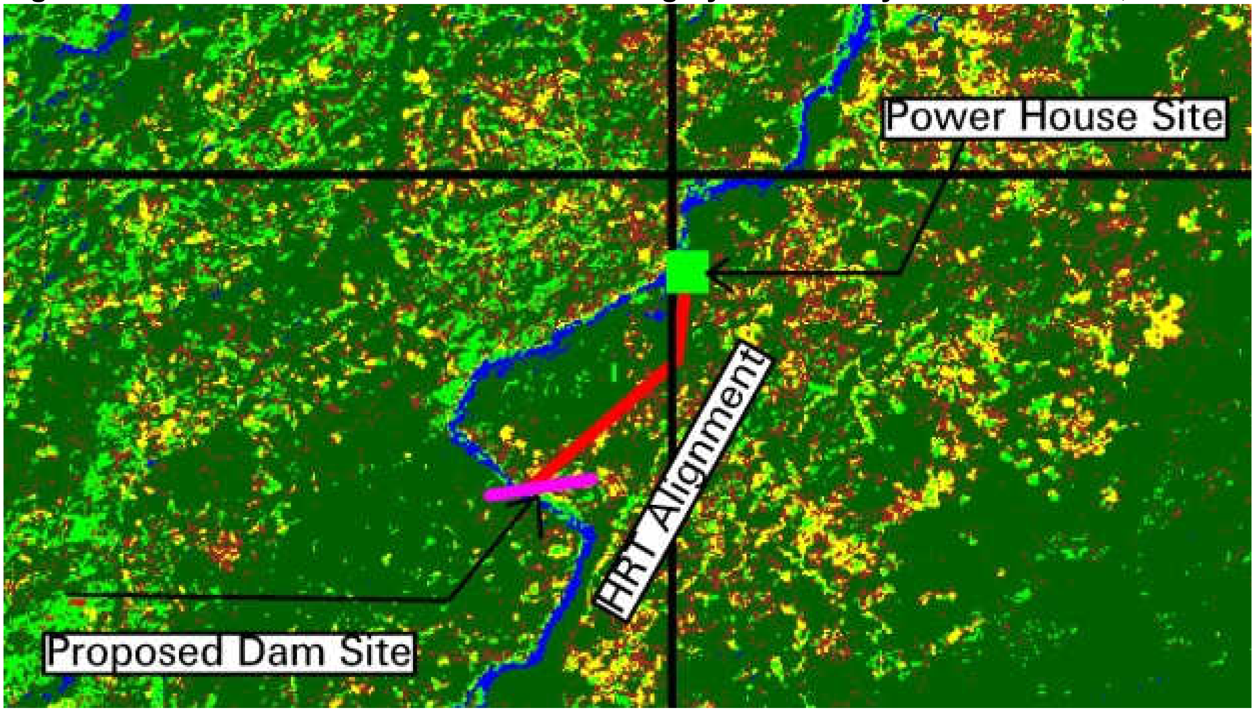
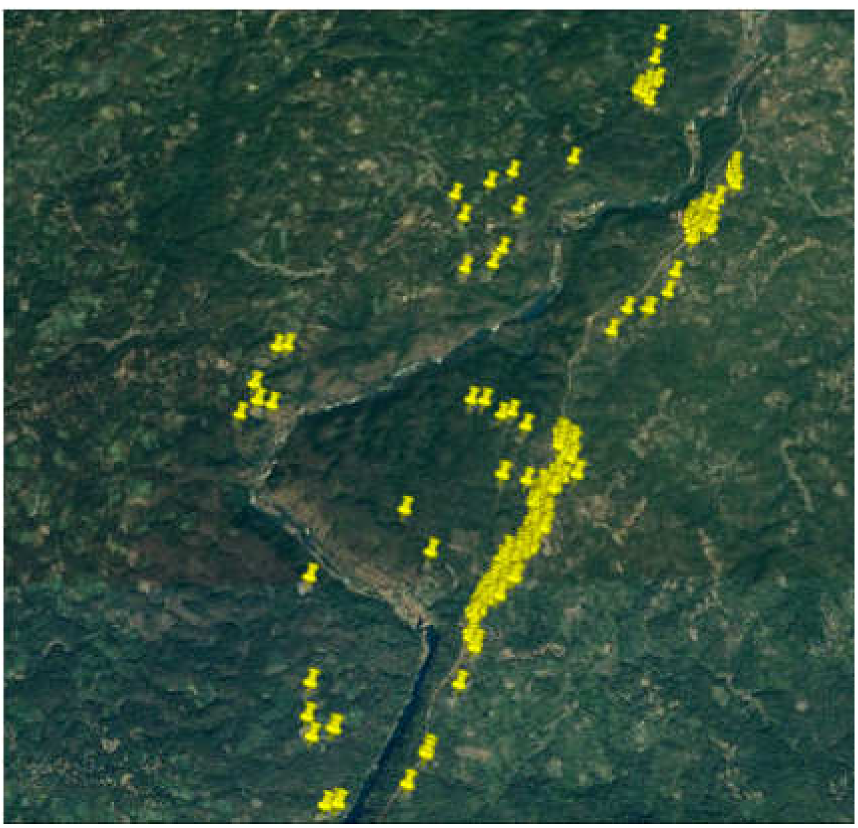


Figure 43: Zoomed in version of Classified Imagery of the study area for LKHEP, and





7. Cropping Pattern

285. Rice under rain-fed conditions is the major crop cultivated in the project area followed by sugarcane. More than 55% of households cultivate vegetables on their homesteads. About 30% of households cultivate pulses for which there is a good demand in local and external markets. Fruit cultivation is limited as the farmers cannot get water during the dry season (see Table 74).

Table 74: Major Crops Cultivated

Type of crop[58]	Number of Households	Percentage
Rice	192	100
Pulse	55	29
Sugar cane	145	76
Vegetable	110	57
Fruits	20	10

8. Water Supply And Sanitation

286. Assam ranks low in terms of accessibility and availability of safe drinking water supply compared to the national average. Majority still depend on water from rain, streams and rivers for drinking and other domestic and agricultural purposes. For example only 1% of households in the study area are connected to water supply program. Overall, the population in the State with access to safe drinking water is 77.55% compared to an all India figure of 88%.

287. As per the SIA survey (December 2015), two-thirds of households in the study area obtain water from ring-wells[59] while half of the households obtain spring water, and about 3% obtain water from local streams and tributaries of Kopili – river water (which is used for all purposes except for human consumption due to contamination). None of these sources are located within 500m of project infrastructure. These sources are for washing and cleaning, 46% of the households' access water from ring-wells, 30% uses spring water, and remainder use river water. About 38% of households who rear cattle use ring-well water for feeding (cattle) while the rest use river water or spring water (see Table 75).

Table 75: Sources of Water and Usage by Households[60]

Source	Drinking		Washing & Cleaning		Cattle Feeding	
	No of Households	%	No of Households	%	No of Households	%
Ring-wells	132	71	88	50	73	56
Springs	48	25	58	34	51	39
Pipe borne	01	01	01	01	01	01
River/stream	06	03	26	15	05	04
Total responded	187	00	173	00	130	00
Not responded	05	00	19	00	62	00
Total	**192**	**100**	**192**	**100**	**192**	**100**

[58] It is predominantly a forest area, and paddy cultivation is done as a part of *jhum* cultivation system in dry hilly land in the plain terrain areas depending mainly on rainfall which is often irregular. The average annual rainfall in the two districts is 2,000 mm.

[59] Ring-wells are the only suitable water supply option at present in hilly, coastal, arsenic affected and declining water table areas. They are deeper than dug wells and as a result less prone to water contamination.

[60] SIA Survey December 2015

288. The total sanitation coverage (rural plus urban) in Assam is 15 % compared to the national sanitation coverage of 18%. The unhygienic situation and practices in Assam, especially by the disadvantaged section of the society, have caused heavy pollution of the available water sources, soil, and air in the State. The Assam Public Health Engineering Department has identified 5 thrust areas for better outreach in both sanitation and water supply. These are (i) Ensuring Access to Safe Water; (ii) Promoting Environmental Sanitation; (iii) Reforming Water Supply and Sanitation Sector; (iv) Creating Opportunities for Youth Involvement, and (v) e-governance.[61] There are various programs under each thrust area and these are undertaken in phases I, II and III. For example, under the Reforming Water Supply and Sanitation Sector thrust area, district Karbi Anglong has been identified for the Total sanitation Campaign (TSC).

9. Public Health

289. The National Rural Health Mission (NRHM) Assam chapter started in 2005 and since then the State has made efforts to promote health care services to the population. Some of which are Rural Health Practitioners (RHP), Boat Clinic, Boat Ambulance, Mobile Medical Unit (MMU), ASHA Radio Program, Sarathi-104 (Health information helpline & Complaint Redressal system), Riverine Hospital, Operation smile (free surgery for children with cleft lip and cleft palate), free operations for children with Congenital Heart Disease, Susrusha financial assistance for kidney transplantation, Sanjeevani (Village Health Outreach Program), and NCD (national program on prevention and control of cancer, diabetes, cardiovascular disease, stroke etc.), etc. Table 76 presents the list of health care facilities in districts Karbi Anglong and Dima Hasao.[62]

Table 76: Health facilities in Dima Hasao and Karbi Anglong

S. No	District	Type of Public Health Infrastructure						
		Medical College	DH	SDCH	CHC	PHC	SC	Total No. of Health Institutions (Public)
1	Karbi Anglong	0	1	1	5	47	152	206
2	Dima Hasao	0	1	0	2	11	65	79

290. **Health Status of Households:**[63] Between years 2012-2015, about two-thirds of households were affected by malaria while about one-third of households were affected by jaundice, and about 4% of households were affected by cholera. Some cases of skin diseases, tuberculosis, and gallbladder problems are also reported in the project area (see Table 77). Due to such diseases particularly malaria and jaundice, men and women did not engage in productive work and children did not go to school over a long period of time in each year. As part of the project specific measures such as awareness programs and distribution of anti-malaria pills during construction phase will be undertaken for malaria prevention.

[61] http://aphe.gov.in/(S(12ykon45mck54gj3pwtppnq5))/Thrust_Areas1.aspx

[62] National Rural Health Mission (NRHM), http://www.nrhmassam.in/executive-summary.phpDH-District Hospital, PHC-Public Health Center, CHC-Civil Health Center, SDHC-Sub-Divisional Civil Hospital, SD – State Dispensary, SC-Sub center

[63] SIA Survey, December 2015

Table 77: Major Diseases Suffered by Affected Households[64]

Type of Disease	No of Household	Percentage
Malaria	124	65
Jaundice	67	35
Cholera	07	04
Skin Diseases	01	01
Tuberculosis	01	01
Gallbladder Stones	01	01
Number of Households – 192		

291. **Type of Medical Treatment, Access to Health Care:** About 57% of households depend on allopathic treatment, 40% of households depend on local or indigenous treatment while 3% depend on homeopathy. Only 18% of households have access to private physicians who live within a reasonable distance of 0.5 to 3 km.

292. In Karbi Anglong, 13% of households visit the Government hospital located at a distance of about 6 – 8km from villages. In Dima Hasao, 86% of households visit the Government hospital located 21 to 35km from villages. However, villagers tend to seek treatment from the local village physicians who are not formally trained as medical practitioners. About 79% of households had access to primary health care centre at Langku, located 0.5 to 4 km from villages (see Table 78).

Table 78: Accesses to Health Care Facilities[65]

Place of Treatment	Private Doctor	Government Hospital		Primary Health Care Centre at Langku
		Karbi Anglong	Dima Hasao	
No of households	34	24	166	152
Percentage	18	13	86	79
Access to health (in Km)	0.5 – 3	6-8	21-35	0.5 – 4

10. Physical Cultural (and Archaeological) Resources

293. No physical and cultural (and archaeological) resources are affected by the LKHEP. Table 79 presents the list of monuments/sites as provided by the Archaeological Survey of India (ASI)[66] for Dima Hasao (also referred to as North Cachar Hills). There are no monuments / sites listed by ASI in Karbi Anglong. The closest monument is more than 120 km away from the project area of influence.

[64] SIA Survey, December 2015
[65] SIA Survey, December 2015
[66] http://asi.nic.in/asi_monu_alphalist_assam.asp

Table 79: Monuments / Sites in Assam, ASI

S No	Name of monuments/ sites	Location (Distance from LKHEP)	District
1	Cachari ruins, i. A small unfinished dwelling house ii. Baradwari iii. East wall iv. Singh Darwaza v. Temple of Ranahandi and 7&8 two small temples vi. Shan Mandir	Khaspur (280km)	Cachar
2	Rock-cut temple	Maibong (150km)	North Cachar Hill
3	Two inscribed stones	Maibong (150km)	North Cachar Hill
4	Bolosaon Group monoliths	North Cachar Hill (120km)	North Cachar Hills
5	Derebara Group monoliths	North Cachar Hill (120km)	North Cachar Hills
6	Khartong Group of monoliths	North Cachar Hill (120km)	North Cachar Hills
7	Kobak Group monoliths	North Cachar Hill (120km)	North Cachar Hills

V. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Introduction

294. Based on LKHEP details and the baseline environmental status, potential impacts due to construction and operation of the proposed project have been identified. This Chapter addresses the basic concepts and methodology for conducting a scientifically based analysis of the anticipated positive and negative impacts likely to accrue as a result of the proposed project, and the corresponding mitigation measures. The EIA for quite a few disciplines is subjective in nature and cannot be quantified. The impacts have been quantified to extent possible, for non-tangible impacts, qualitative assessment has been undertaken.

295. The project activities and corresponding potential impacts on environmental parameters are presented in Table 80.

Table 80: Project Activities/Potential Environmental Impacts

S. No.	Project Activities	Soil & Land	Geology	Hydrology	Water quality	Air quality	Noise	Flora/ Fauna	Employment and OHS	Socio- Culture and Community H&S
A.	**Construction Phase**									
1.	Site preparation including tree cutting	√			√	√	√	√	√	
2.	Earthwork and excavation including blasting and drilling (sediments mobilized)	√	√	√	√	√	√	√	√	
3.	Construction of dam across river Kopili	√		√	√	√	√	√	√	
4.	Construction of surge chamber	√	√	√		√	√	√	√	
5.	Construction of power house	√	√			√	√		√	
6.	Widening and construction of access roads	√				√	√	√	√	
7.	Disposal of muck and construction wastes	√	√		√	√	√	√		
8.	Transportation of construction materials					√	√	√	√	
9.	Operation and maintenance of construction equipment	√			√	√	√		√	
10.	Disposal of sewage and solid waste from labor camps	√			√			√		
11.	Acquisition of private land	√								√
12.	Acquisition of forest land	√						√		√
13.	Migration of labor	√			√	√	√	√	√	√
14.	Emergency during Construction								√	√
B.	**Operation Phase Activities**									
1.	Diversion of water for hydropower generation			√	√			√		
2.	Equipment maintenance	√			√	√	√		√	
3.	Disposal of sewage and solid waste from project colonies	√			√			√		
4.	Mushrooming of allied activities such as commercial activities, tourism etc.	√			√	√	√		√	√
5.	Emergency due to dam failure								√	√

296. The potential environmental impacts and corresponding mitigation measures have been assessed for pre-construction, construction and operation stages of LKHEP as discussed below.

B. Environmental Impact –Pre-construction Stage

1. Loss of Land

297. LKHEP involves change in land use due to land acquisition for construction of various project components. The total land area acquired is 1,577 ha (see Table 81). The largest project component is the storage reservoir; submerging about 552 ha of land. The submergence area of the reservoir will include human habitats, agricultural land and forests. Remaining 1,025 ha land acquired is for project infrastructure facilities such as buildings, roads, resettlement sites, etc. No land acquisition involved for access roads and transmission lines.

Table 81: Total Land Requirement for the Project

Project Component	Area (ha)
Project infrastructure (Power house, Dam and other key installations)	355
Reservoir	552
Roads, buildings and other project facilities	72
Resettlement and relocation including project township etc.	75
Land for other purposes (recreational facilities)	523
Total	**1,577**

Source: WAPCOS Ltd 2015

23. The category of the land acquired for the project are presented in Table 82. About two–thirds of the land are revenue land where paddy (172 ha) and highland crops (882 ha) are cultivated. In both autonomous districts, the partially affected – land due to the project components, especially by the reservoir – will be considered as fully affected land for the purpose of compensation, resettlement, income restoration and improvement assistance programmes.

Table 82: Land Category Earmarked for Acquisition for the Project

District	Forest Land (ha)	Revenue Land (ha)	Total (ha)
Dima Hasao	478	909	1,387
Karbi Anglong	45	145	190
Total	**523**	**1,054**	**1,577**

Source: Project Files at APGCL

298. About 88% of land acquisition is in the Dima Hasao district, affecting a total of 1,555 land parcels. About 172 ha of paddy land and 737 ha of dry land/horticultural land will be acquired.

299. About 12% of land acquisition is in Karbi Anglong district, affecting two main villages: Langropemi and Chirimthepi. Most of the affected land are plantations (29 ha) and homesteads (110 ha). The remaining required residual land has civil structures stand such as water pumps and wells.

300. The loss of land and livelihood will be compensated as per the provisions made in RTDP document, prepared for LKHEP.

2. Change in Land use

301. The land required for tunnel adits, muck disposal area, construction camps, etc. will change the land-use of the area temporarily till the end of the construction phase. Permanent change in land use shall be due to the reservoir, dam structure, power house, colonies and

other ancillary structures. The head race tunnel (HRT) and tail race tunnel (TRT) are underground and will not change the land use.

302. The change in land use and topography due to LKHEP are unavoidable. No mitigation measures are required that relate solely to changes in land use but livelihood restoration and ecological offsets (especially maintaining and monitoring the large forest patch between the upper Kopili HEP and the proposed project) are proposed as part of RTDP and EMP. Possible impacts that are related to changes in topography such as erosion or sedimentation, are considered separately.

3. Displacement of People

303. LKHEP will submerge about 552 ha of land affecting 1,842 households (HH) of which 18 will be physically displaced. Six HH will lose structures other than dwellings (see Table 83). The number of physically displaced HH in Dima Hasao district reduced from 27 to 18 after final estimates of land requirements and their precise locations. The 18 displaced HH will be resettled at identified locations in the project area as par provisions of RTDP. The resettlement sites were identified during the preparation of the DPR. The total area of the resettlement sites is 5 ha.

Table 83: Number of Households Affected by Land Acquisition for the Project

	Economically Displaced		Economic and Physical Displaced		Structures Affected		Total	
District	HH	Persons	HH	Persons	HH	Persons	HH	Persons
Dima Hasao	1,587	7,459	18	85	06	28	1,611	1,611
Karbi Anglong	231	1,059	00	00	00	00	231	1,059
	1,818	**8,518**	**18**	**85**	**06**	**28**	**1,842**	**8,631**

Source: Project Files at APGCL; HH = households

304. ADC of Dima Hasao and Karbi Anglong have issued provisional no objection certificates for land acquisition in favour of the EA. The details of Project Affected Person (PAP) are reported in the RTDP document, prepared for LKHEP.

305. The displaced people will be compensated as per provisions made in the RTDP and is in compliance with both ADB's SPS 2009 requirements and GoI and GoA legal provisions for compensation.

4. Acquisition of Forest Land

306. About one-third of the land or 523 ha to be acquired for the project is forest land (see Table 82). The category of forests include primary reserve forests, reserve forests, and land under social forestry. Category wise break down of the forests to be acquired is tabulated below.

Category of Forest	Area to be acquired (Ha)
National Park	Nil
Wildlife Sanctuary (WLS)	Nil
Reserved Forest (RF)	76.98
District Council Reserved Forest (DVRF)	433.406
Unclassed State Forest (USF)	12.64
Proposed Reserve Forest (PRF)	Nil

Total	523.046

307. The EA is in the process of acquiring the forest land as per the Forest Conservation Act of India. Proposals for forest clearance have been submitted to the State Forest Department and Assam State Government and it is under processing at State Forest Department level.

308. During construction and operation of the project, there may be attempts by workers to fell trees and collect wood from nearby forests for various purposes. These will be prevented by adopting suitable mitigating measures as per provisions made in EMP including strict penalties. A compensatory afforestation (CA) plan has been prepared (to be confirmed by forest department) to compensate loss of the forest area.

5. Encroachment into Nature Reserves and Wildlife Habitat

309. There are no environmentally sensitive areas (legally protected areas) within the PIA. Also there are no designated migratory or wildlife movement corridors in the PIA. However based on public consultations the local communities reported the presence (and movement) of Asian elephants, Chinese Pangolins and other animals in the PIA.

310. A critical habitat assessment has been undertaken and a biodiversity conservation and management plan (Annex 9) has been prepared to address likely adverse impacts on flora and fauna due to the project and associated transmission lines and access roads.

6. Loss of Archaeological/Cultural Heritage Sites

311. There is no archaeological or cultural heritage sites within the PIA.

7. Disruption of Hydrological Balance

312. The flow of water downstream of the dam site at the HRT portion, about 5.6 km stretch, will be affected due to LKHEP. A minimum perennial flow of 5.345 m^3/s (20% of average lean season flow as e-flow) in this stretch will be ensured by providing an opening in the dam structure. This minimum flow discharged from the reservoir will be further supplemented by flow of the Kala Nala which joins Kopili River between the Dam Site and Power House Site. The water from this stretch of river is not drawn for any purpose and access to the river bed on this stretch is difficult as the slope is very steep. Moreover, settlements are far away and located at a higher altitude. Therefore, reduction of flow in this particular stretch of the river will have no impact on water use by any community. After the TRT confluence point, the river will receive its original flow downstream. However, flow in about 8.3 km section further downstream (between end of HRT to confluence point of Mynriang river to Kopili river) will also be affected during peaking power operation, with no discharge from the TRT (during the lean season); however impacts will not be so significant, as small streams will contribute to river flow in this section. A catchment area treatment plan (Annex 10) has been formulated to maintain the hydrological balance in the downstream basin following the GoI and GoA guidelines.

8. Risks due to Earthquake

313. LKHEP is located in the seismic zone–V as per IS 1893-2002. The seismic parameters for the design of civil structures has been taken from Kopili HEP (construction stage) located upstream of the proposed project. The site specific earthquake study has been completed by an independent agency (Department of Earthquake Engineering, IIT Roorkee) and it is also

reviewed by ADB appointed independent dam expert. The site specific design parameters for MCE and DBE conditions are recommended as 0.36g and 0.18g for horizontal and 0.24g and 0.12g for vertical ground motion, respectively. A dam break analysis and a disaster management plan has been prepared to address emergency situations as a result of possible dam failure. An emergency response plan has been prepared (which also includes communication mechanism during emergency) to deal with in emergency situation such as dam failure.

9. Environmental Risks due to Future Developments

314. The project on its completion could create conditions favorable for setting up of new small-scale industries in the surrounding areas and promoting the area as a tourist destination, mainly due to better access, and creation of a reservoir. However, setting up of new industries in the area has to be well planned and regulated by the local and state administration to prevent any adverse effect on the environment. A cumulative and induced impact assessment has been carried out separately (see Chapter VI) and suitable mitigation measures are proposed.

10. Climate Change Impacts and Risks

315. The project is High Risk for Multi-Hazard Index and Climate Impacts. The main hazards to the project include: 1) Earthquake; 2). Flood; 3). Landslide; 4). Lightning; 5). Cyclones. Suitable mitigation measures are included in the design of project components (including transmission line tower foundations) to deal with impacts and risks associated with change in the climatic conditions.

C. Environmental Impacts - Construction Stage

316. The construction stage impacts due to the proposed project are covered under Physical, Biological and Socio-economic Environment as presented below:

1. Physical Resources

1.1 Water Environment

317. The water environment includes a discussion on i) water quality, ii) impacts on hydrological regime, iii) impacts of sedimentation, and iv) water resources, and downstream users.

1.1.1 Water Quality

318. The major sources of surface water pollution during construction phase are:

- Surface Runoff over exposed soil and the risk of spills/leaks
- Sewage from labor camps/residential colonies
- Effluent from crushers
- Pollution due to muck disposal
- Effluent from tunneling sites
- Effluent from batching plants
- Effluent from fabrication units and workshops
- Acidic Kopoli river water interacting with deeper exposed bedrock.

319. **Surface Runoff and Spills:** Water quality impacts during construction are likely to arise through the exposure of soil surfaces to erosion and associated sediment laden runoff. The primary areas of concern for soil erosion and sedimentation will be from construction of the access road, construction of the main dam, re-regulation dam, transmission line, workers camps and quarries. Possible faecal contamination from latrines and runoff from vehicle maintenance areas also pose a risk to the aquatic environment. The runoff from the construction sites will have a natural tendency to flow towards river Kopili or its tributaries due to natural gradient/topography of the area. The runoff may contain a high sediment load which may affect downstream areas and users. The high sediment run off in the river may increase turbidity, reduce light penetration as well as photosynthetic activity of aquatic plants. This is likely to have an adverse impact on the primary biological productivity of the affected downstream stretch of river Kopili. Note: due to low pH or acidic nature of lower Kopili river, the biological productivity in the project area at present is negligible. Hence, the runoff is not expected to affect the photosynthetic or biological activity. However, adequate measures will be implemented to minimize impacts due to runoff (see the EMP for details).

320. **Sewage from labor camps/colonies:** The construction phase is likely to last for a period of 4 years. The peak labor strength during project construction phase is estimated at about 800 workers and 200 technical staff. The employment opportunities in the area are limited. Thus, during the construction phase, local hiring will be given preference for unskilled/skilled category, as viable. Observations of construction phase of similar hydroelectric projects suggest that while the major works are “contracted out” who in turn bring their own skilled labor, the unskilled labor category is typically filled by local level employment. The construction phase also leads to mushrooming of various allied activities to meet the demands of the migrant labor population in the project area.

321. The following assumptions have been made for assessing the migrated labor population (workers and technical staff) in the project area:

- 50% of workers and 10% technical staff migrating into the area are married.
- In 50% of the family of workers both the husband and wife will work.
- In 100% of the family of technical staff, only husband will work.
- About 2% of total migrating population has been assumed as service providers and shall be with families.
- Family size has been assumed as 4.

322. Considering the above assumptions, the total increase in population is estimated as approximate 2,800 (see Table 84).

Table 84: Increase in total population due to migration of labor during construction phase

S. No.	Description	NOs	Family Size	Population
1.	Peak Migrant Workers 800 Nos			
	Single	400	1	400
	Married	400	4	1,600
	Subtotal			2,000
2.	Peak Technical Staff 200 Nos			
	Single	180	1	180
	Married	20	4	80
	Subtotal			260
3.	Service Provides 60 Nos			
	Married	60	4	240

S. No.	Description	NOs	Family Size	Population
	Subtotal			240
	Total			**2,760, say 2,800**

323. The migration of labor population during construction phase is estimated as 2,800 (see Table 80). Considering per capita water supply as 135 lpcd, the domestic water requirement has been estimated as 0.38 mld. Considering sewage generation as 80% of the total water supplied, quantum of sewage generation is expected to be 0.30 mld. A sewage treatment plant will be commissioned for treatment of sewage (to meet the CPCB standards) generated from labor camps, prior to final disposal (construction work sites will use portable toilets, to be cleaned out regularly). The treated sewage will used as fertilizers and treated effluent may be used for irrigation requirements in areas marked for afforestation under greenbelt development plan (see EMP for details).

324. **Effluent from crushers**: During the construction phase, at least one crusher will be commissioned at the quarry site by the hired contractor. It is proposed that only crushed material will be brought at the construction site. The capacity of the crusher shall be of the order of 500 tph. Water is required to wash the boulders and to lower the temperature of the crushing edge. About 0.1 m^3 of water is required per ton of material crushed. The effluent from the crusher would contain high-suspended solids. A total quantity of 50 m^3/hr of effluent is expected to be generated from various crushers. The effluent, if disposed without treatment, can lead to increase in the turbidity levels in the receiving water bodies (Note: the natural slope in the area is such that the effluent from the crushers will ultimately find its way in to river Kopili). Therefore, the effluent from crushers will be treated in settling tank(s) to meet the CPCB standards, before disposal (see EMP for details).

325. **Pollution due to muck disposal**: The major impact on water quality arises when the muck is disposed along the river bank. Suitable muck disposal sites located at least 500 m away from the river have been identified. The muck will be generated via activities such as road-building, tunnelling, and other excavation works. The unsorted waste if going into the river channel will lead to the turbidity of water continuously for long time periods. The high turbidity is known to reduce the photosynthetic efficiency of primary producers in the river, low biological productivity and negative impact on aquatic life. Therefore, muck disposal will be conducted in line with the Muck Disposal Plan (see EMP for details).

326. **Effluent form tunneling sites**: During tunneling works, the ground water will flow into the tunnel along with construction water (used for various works like drilling, shotcreting, etc.). The effluent thus generated during tunneling works contains high suspended solids. Normally, water is collected in the side drains and drained into nearby water bodies without treatment. However, a settling tank of adequate size will be constructed nearby to collect effluent before discharge (see EMP for details).

327. **Effluent from batching plants:** During construction phase, batching plants will be commissioned for production of concrete. The operation and cleaning of batching plants will result in generation of small volume of effluent containing high suspended solids. The effluent will be treated (in a settling pond, to meet the CPCB standards) prior to disposal to ameliorate the marginal impacts likely to accrue on this account (see EMP for details).

328. **Effluent from fabrication Units and workshops**: The fabrication units and workshops will generate effluents containing high suspended solids, as well as oil and grease. The effluent will be treated (to meet the CPCB standards) prior to disposal (see EMP for details).

329. **Ground water pollution**: The effluent generated from the project construction activities (and camps) will be collected and treated. Therefore the impacts on ground water quality are not anticipated from the project construction work. Further, hazardous materials will be stored in a lined and bermed area, to avoid spillage and groundwater contamination.

330. The main materials used for construction could also be a potential source of water contamination. Specifications and/or labeling of the materials should indicate which substances would be potential contaminants, such as heavy metals. Some metal elements could leach from components used as construction materials, or from the geochemistry of foundation rocks where anaerobic reaction occurs.

331. Based on the geological characteristics at the main dam site (limestone, sandstone, mudstone and conglomerate) and the mountainous topography, the leakage of the impoundment water is expected to be very limited. The siltation in the reservoir would also enhance the blockage of the leakage. Therefore, the underground water is not expected to be significantly impacted from the reservoir development in terms of quantity. No hazardous minerals are found in the area, so the underground water quality is also not expected to be significantly impacted.

1.1.2 Impacts on Hydrologic Regime

332. **Impact due to Peaking Power Operation:** LKHEP is likely to fill the reservoir up to its live storage capacity, which would then be used for peaking power. This will lead to reduction in flow downstream from the dam (except for e-flow) and a further 8.3 km below the tailrace outlet, when the reservoir is filling and there is only e-flow and tributary discharge, with a risk of adverse impacts on downstream riverine ecology. The drying effect will be most pronounced in non-monsoon seasons and lean seasons. To mitigate the adverse impacts, the following e-flows shall be released:

- **Monsoon Season (May to September):** 30% of the average flows during 90 % dependable year
- **Non-monsoon Non lean Season (October and April):** 25% of the average flows during 90% dependable year
- **Lean Season (November to March):** 20% of the average flows during 90% dependable year

333. As per the recommendations of MoEF&CC for river valley projects, 20% of the average flow of four consecutive leanest months in a 90% dependable year should be maintained as e-flow during the lean season. During the monsoon period, 30% of inflow has to be released. December 2004 to March 2005 was identified as the period having lowest average inflow for four consecutive leanest months, with monthly average discharges computed as 27.83, 26.02, 26.58 and 26.46 cumecs respectively. The average discharge of these four months is 26.72 cumecs. The environmental release, computed as 20% of the average flow of four leanest months, is derived as 5.345 m^3/s, as detailed under Annex 34 Derivation of E-flow.

334. The annual flow volume estimates for the period 1979-80 to 2009-2010 have been considered to arrive at the 90%, 75% and 50% dependable hydrologic years. Long term river flow series was established in the form of ten-day discharge values; computed from the available daily discharge data. The 50% and 90% dependable years were worked out as 1998-1999 and 2004-05 with annual flow volumes as 1,801.2 MCM and 1,715.2 MCM respectively. The design discharge for power generation is 112.71 m^3/s.

335. The MoEF&CC recommended 10 daily flow (10-day periods, in sections I, II, and III) series for the 90% dependable year are presented in Table 85 and the recommended e-flows are presented in Table 86. Average 10-daily discharges based on this series provided by CWC have been shown in Figure 44. The flow duration curve based on all 10-daily discharge data is presented in Figure 45.

Figure 44: Average 10-daily Discharges Based on Series Provided by CWC

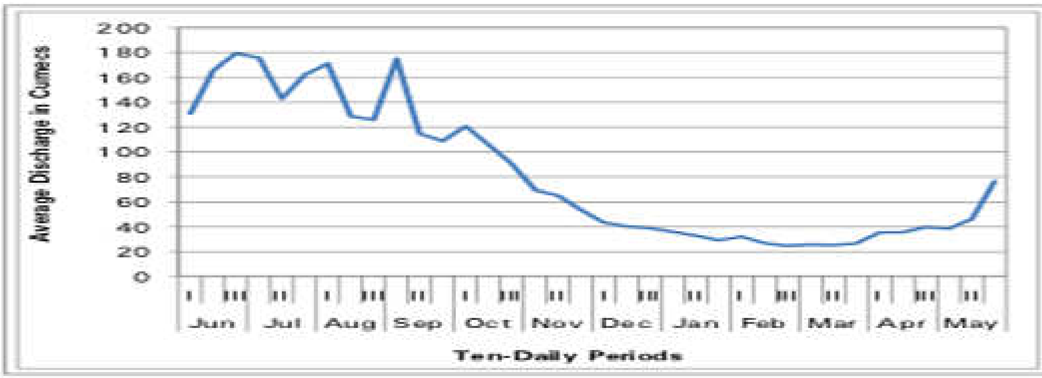


Figure 45: Ten-Daily Flow Duration Curve Based on Series Provided by CWC

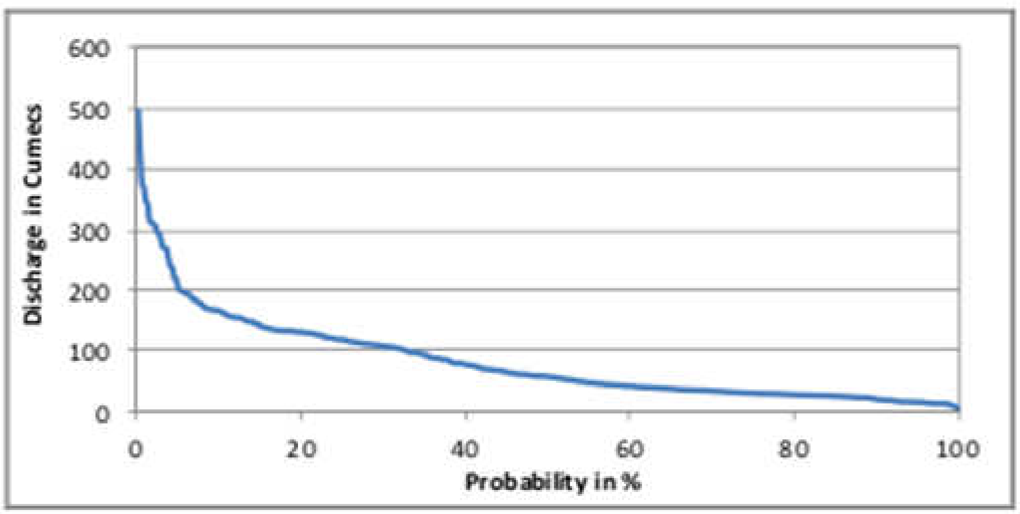


Table 85: 10 daily flow series for 90% dependable year

Month	10-daily period	Discharge (cumec)
June	I (1hr)	6.54
	II (11hr)	79.95
	III (21hr)	41.28
July	I	63.76
	II	84.02
	III	74.09
August	I	130.34
	II	75.96

Month	10-daily period	Discharge (cumec)
	III	43.02
September	I	132.54
	II	86.02
	III	133.25
October	I	106.21
	II	86.35
	III	50.32
November	I	44.38
	II	37.50
	III	18.79
December	I	22.30
	II	22.11
	III	23.07
January	I	21.83
	II	18.87
	III	21.35
February	I	21.69
	II	20.09
	III	21.94
March	I	20.61
	II	21.68
	III	21.07
April	I	16.08
	II	15.98
	III	16.31
May	I	53.43
	II	81.94
	III	116.88

Source: WAPCOS EIA

Table 86: Recommended Environmental Flows (e-flows)

Month	Period	Inflow	EF	EF to be released	Turbine release for 24 hrs	Actual EF released through Aux.PH	Spill[67]
		(m^3/s)	(%)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
Lean Season, 90% DY							
December	I	22.30	20	4.46	17.84	4.46	Nil
	II	22.11	20	4.42	17.69	4.42	Nil
	III	23.07	20	4.61	18.46	4.61	Nil
January	I	21.83	20	4.37	17.46	4.37	Nil
	II	18.87	20	3.77	15.10	3.77	Nil
	III	21.35	20	4.27	17.08	4.27	Nil

[67] This table show data is for a specified year used for the simulation. However during high flow periods, there will be spill from reservoir for which spillways are proposed. River will not be regulated for all year round.

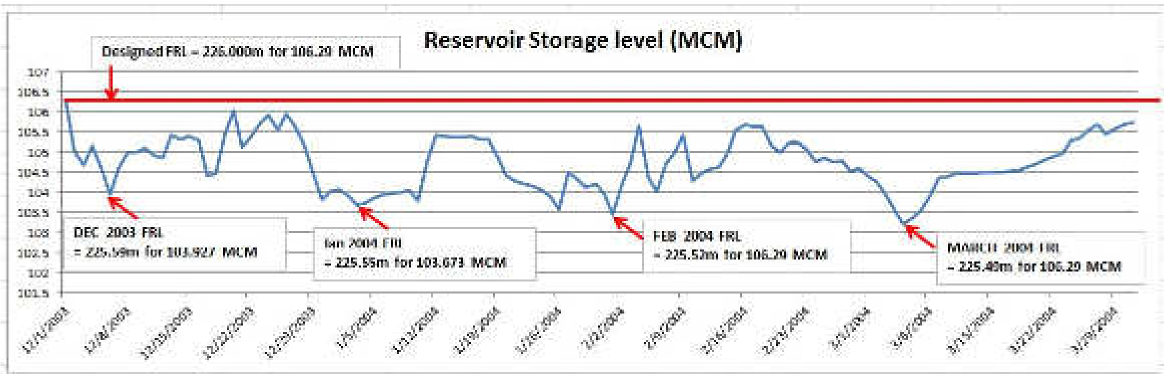
Month	Period	Inflow	EF	EF to be released	Turbine release for 24 hrs	Actual EF released through Aux.PH	Spill[67]
February	I	21.69	20	4.34	17.35	4.34	Nil
	II	20.09	20	4.02	16.07	4.02	Nil
	III	21.94	20	4.39	17.55	4.39	Nil
March	I	20.61	20	4.12	16.49	4.12	Nil
	II	21.68	20	4.34	17.34	4.34	Nil
	III	21.07	20	4.21	16.86	4.21	Nil
Avg.		**21.4**		**4.3**	**17.1**	**4.3**	
Non-Monsoon Non-Lean Season, 90% DY							
October	I	106.21	25	26.55	84.97	26.55	Nil
	II	86.35	25	21.59	69.08	21.59	Nil
	III	50.32	25	12.58	40.26	12.58	Nil
November	I	44.38	25	11.10	35.50	11.10	Nil
	II	37.50	25	9.38	30.00	9.38	Nil
	III	18.79	25	4.70	15.03	4.70	Nil
April	I	16.08	25	4.02	12.86	4.02	Nil
	II	15.98	25	4.00	12.78	4.00	Nil
	III	16.31	25	4.08	13.05	4.08	Nil
May	I	53.43	25	13.36	42.74	13.36	Nil
	II	81.94	25	20.49	65.55	20.49	Nil
	III	116.88	25	26.55	93.50	26.55	Nil
Avg.		**53.7**		**13.4**	**40.3**	13.4	
Monsoon Season							
June	I	6.54	30	1.96	4.58	1.96	Nil
	II	79.95	30	23.99	55.97	23.99	Nil
	III	41.28	30	12.38	28.90	12.38	Nil
July	I	63.76	30	19.13	44.63	19.13	Nil
	II	84.02	30	25.21	58.81	25.21	Nil
	III	74.09	30	22.23	51.86	22.23	Nil
August	I	130.34	30	39.10	91.24	39.10	Nil
	II	75.96	30	22.79	53.17	22.79	Nil
	III	43.02	30	12.91	30.11	12.91	Nil
September	I	132.54	30	39.76	92.78	39.76	Nil
	II	86.02	30	25.81	60.21	25.81	Nil
	III	133.25	30	39.98	93.28	39.98	Nil
Avg.		**79.2**	**30**	**23.8**	**55.4**	**23.8**	

Source: WAPCOS EIA

336. The power house will be comprised of 2 units of 55 MW each (MPH) and 2 units each of 2.5 MW and 1 unit of 5 MW (APH). The APH shall be operated to meet the requirement of the e-flow into the river Kopili downstream of the dam site.

337. To compute e-flow from daily reservoir operation A simulation model of the LKHEP reservoir was developed (using HECRes-SIM of the Hydrologic Engineering Center of US Army Corps of Engineers). The operation of the reservoir was simulated during lean months from December 2003 to March 2004, which were designated as the lean months for a 90% flow dependable year (DPR, 2015). Figure 46 show the simulation results.

Figure 46: Reservoir Operation Simulation during 1 Dec 2003 – 31 March 2004



338. Table 87 summarizes the operation results for the four months. It is noted that it is possible to release the minimum e-flow of 5.345 m^3/s throughout the designated lean period of December 2003 to March 2004. The two units of the main power plant will be able to operate for at least 3 hours without compromising the mandatory e-flow.

Table 87: Summary of Reservoir Operation during December 2003 to March 2004

Month	Minimum Environmental Flow released	Minimum (Maximum) Operation hours of Main Power Plant (2 X 55 MW)		Maximum allowed lowering from FRL
	(m^3/s)	Unit-1 (hours)	Unit-2 (hours)	(m)
December 2003	5.345	6 (9)	6 (9)	0.413
January 2004	5.345	3 (6)	3 (6)	0.477
February 2004	5.345	3 (9)	3 (9)	0.478
March 2004	5.345	3 (6)	3 (6)	0.515

339. A simulation of reservoir operation was carried out during the monsoon period to assess its impact on flood flows. The monsoon period of the year 2003 was found to be a high flow year. The simulation results shows that the operation of the LKHEP reservoir will not increase the river flows during the monsoon season. During the high flows days from June 1 to July 31, both the power plants will be operated with the installed capacities for most of the days, except a few days. Table 88 shows the summary of power plant operation hours.

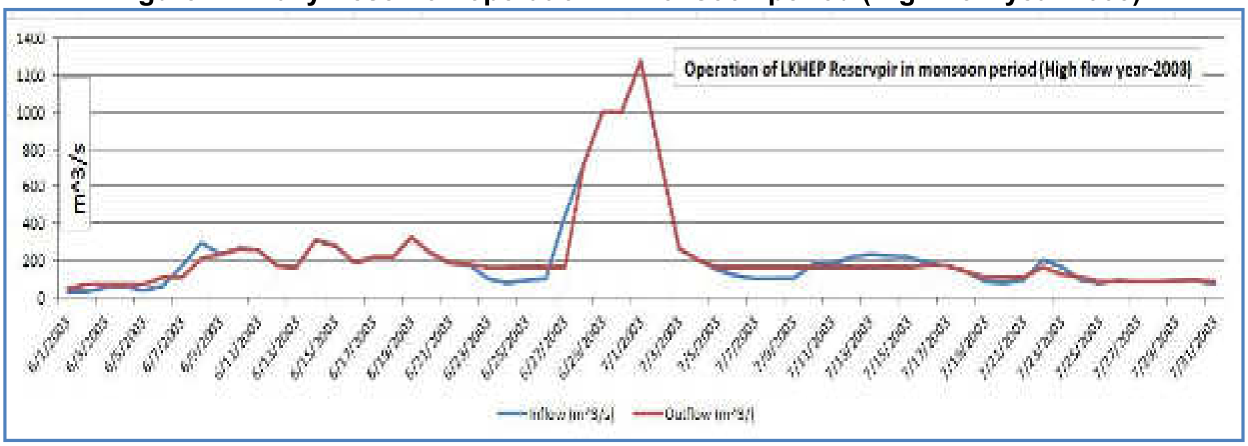
Table 88: Summary of Daily Reservoir Operation during June-July 2003

	Main Power Plant operation		Aux Power Plant Operation		
	Uinit-1 (55 MW)	Unit-2 (55MW)	Unit-1 (2.5 MW)	Unit-2 (2.5 MW)	Unit-3 (5 MW)
Dates of 24 hour operation	June 8 – July 17; July 22		All days from 1 June-31 July		

Dates of 12 hours operation	June 6-7	June 6-7	All days from 1 June-31 July
Dates of 9 hours operation	July 18-22	July 18-22	All days from 1 June-31 July
Dates of 6 hours operation	July 20-31	July 20-31	All days from 1 June-31 July
Dates of 3 hours operation	June 1-5	June 1-5	All days from 1 June-31 July

340. Figure 47 shows the results of reservoir operation during the monsoon period simulated for the high flow year (2003). It can be concluded that the reservoir operation will not increase the downstream flow. This results can also be seen as the result of combined operation of the Kopili HEP (Khandong dam) and the proposed LKHEP.

Figure 47: Daily Reservoir operation in monsoon period (High flow year 2003)



1.1.3 Facts and Figures on e-flow for LKHEP

341. A detailed review and analysis of the e-flow requirements of the Lower Kopili HEP has been undertaken in order to cross-check if the e-flow proposed by MOEF&CC for LKHEP is sufficient to maintain ecological balance in the downstream section of Lopil River. The facts and figures of the E-Flow for LKHEP are discussed in following sections.

342. **A. Understanding on Kopili River System (as a whole), Lower Kopili Hydropower dam Site and its catchment**- Kopili is a south banka tributary of Brahmaputra which originates in the Borail Range Mountains in Meghalaya at an altitude of about 1600 m and has a total length of ***290 km*** up to its confluence with Brahmaputra. ***The total catchment of Kopili River is about 20,997 km²*** which is depicted in Figure a and Figure b.

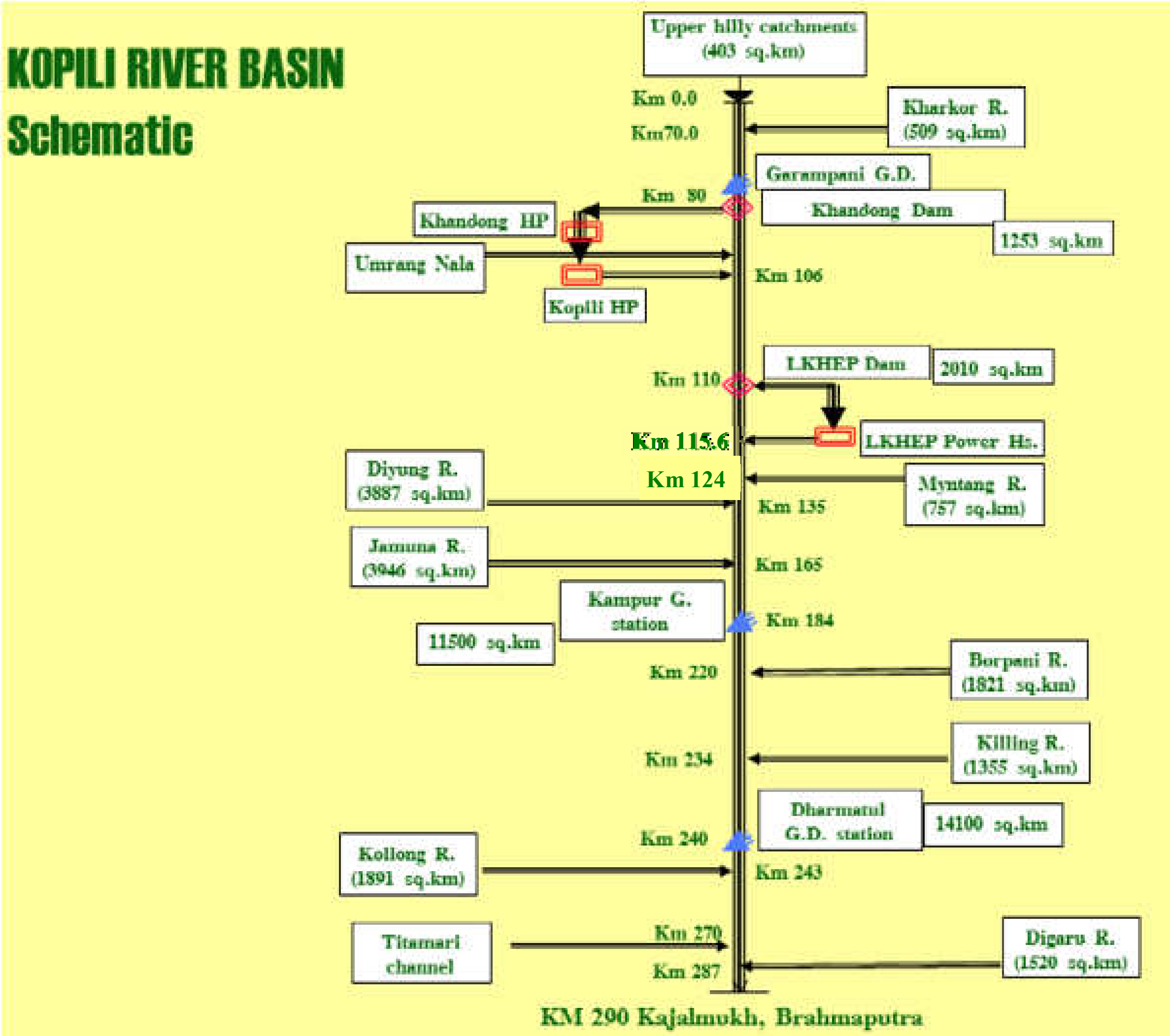


Figure a: Schemetic of Kopili River Basin

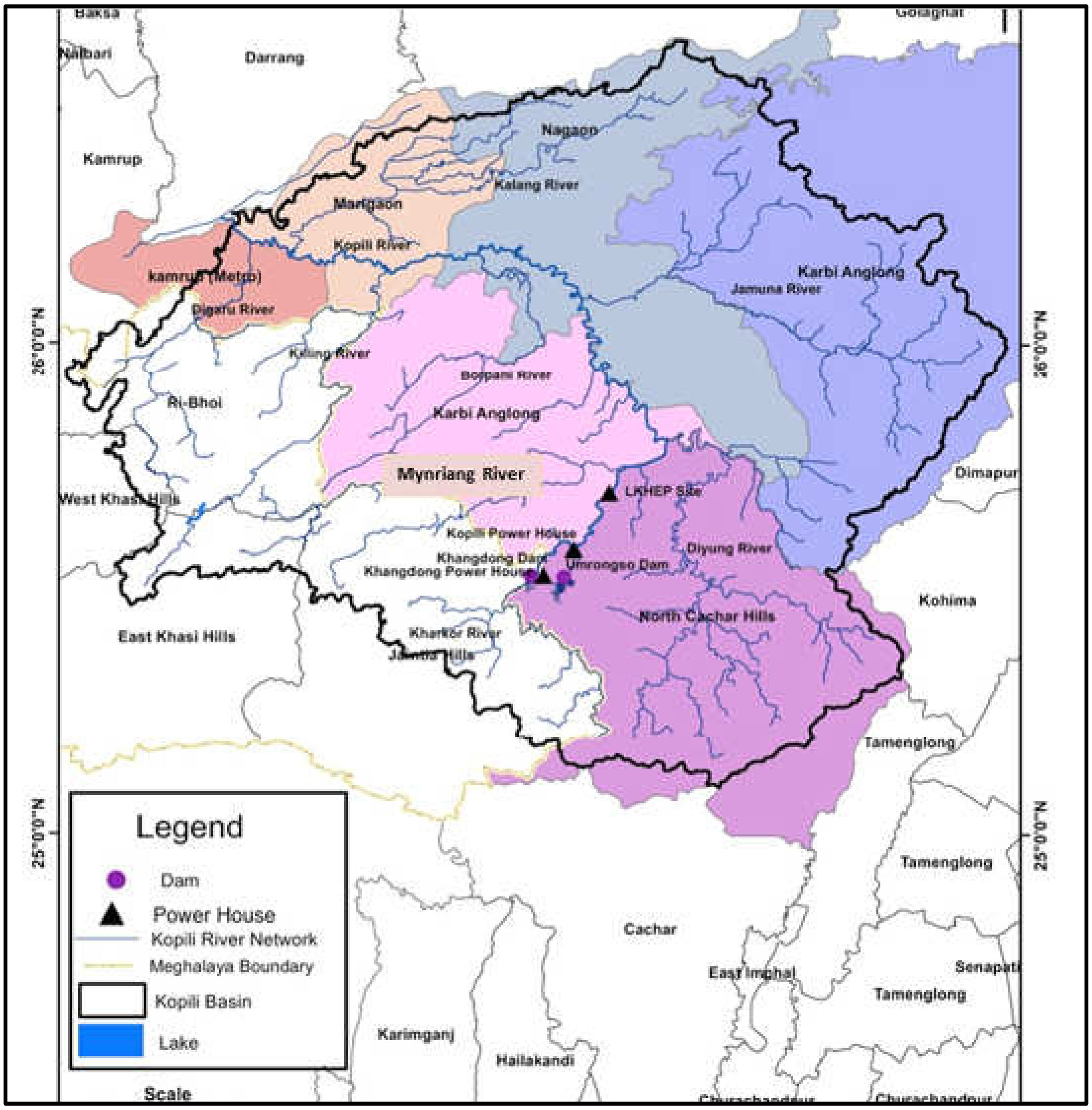


Figure b: Catchment Area of Kopili River

*343. Lower Kopili River Hydropower Dam catchment area of **2010 Km²** is a part of Kopili River System which has only 10 % of entire catchment of Kopili river and approx. **200 km river length and 90% catchment area located at downstream of the LKHEP dam**. Therefore, **significant amount of water will be added in the river by the downstream tributaries** viz. Mynring Diyung, Jamuna, Myntriang, Borpani, Killing and Kallang rivers which generally cause flood rather than limits downstream* riparian *water uses.*

1. Applicability of environmental flow mainly limits between LKHEP dam sites to the confluence of Mynriang River as significant amount of water added by the river at the confluence.

2. For computation of E-Flow, MoEF&CC, GoI Guidelines and recommendations were applied for estimation of E-flow for the project. As per the Terms of Reference for study of environmental impact assessment issued by MoEF&CC, the recommended Environmental Flows to be released are given as follows:

- Monsoon Season- May to September - 30% of the average flows during 90 % dependable year.
- Non-monsoon Non-lean Season- October & April - 25% of the average flows during 90% dependable year.
- Lean Season- November to March - 20% of the average flows during 90% dependable year.

344. **B. Scientific Background on setting of above Norms by MoEF&CC, GoI for all the Hydropower projects.** The MoEF&CC, GoI, has been giving environment clearances to all the river valley projects since 2007–08 under the condition that certain minimum flows have to be maintained in the river throughout the year. The proposed minimum flow requirement was 10% of the observed minimum flow, which was later revised in 2010 to 20% of the average flow observed in the four lean season months at 90% dependability. In 2011, the Expert Appraisal Committee (EAC) of the MoEF&CC for the river valley projects stipulated maintenance of higher flows during the monsoon in addition to the minimum flows. At the beginning of 2011, a number of studies were carried out by several government and non-government agencies to assess e-flows in the Indian river basins, especially the Himalayan and the Eastern Himalayan river basins[68].

345. In the year 2011-12, Wildlife Institute of India (WWI) conducted a study to determine the minimum e-flows requirement only for the dry zones created by the hydro-electric projects (HEPs) in the Alaknanda and Bhagirathi basin which are also a critical habitat of the flagship species, namely the golden mahseer and the snow trout. The study used methods a combination of Building Block Methodology (BBM) and Habitat Rating Method for assessment of e-flows. Within the BBM, an Environmental Management Class (EMC) for the river stretches was defined to recommend the e-flows requirements. Based on the above study, 24 projects had high impact and were recommended to be scrapped and minimum e-flows requirements in the other dry zones (other than the mahseer and snow trout zone) of the hydropower plants recommended as:

- 20% of monthly average flow from November to March
- 25% of monthly average flow in October and April
- 30% of monthly average flow from May to September

346. ***Building Block Methodology (BBM)*** is a prescriptive approach, designed to construct a flow regime for maintaining a river in a predetermined condition. BBM has advanced the field of environmental flow assessment in an entirely new direction, being a holistic methodology that addresses the health (structure and functioning) of all components of the riverine ecosystem, rather than focusing on selected species as do many similarly resource-intensive international methodologies. **BBM *is also recommended in the good practice handbook published by IFC/World Bank Group for assessment of E-Flow for Hydropower Project and the same has been adopted for the above Wildlife Institute of India (WII) study to recommend E-Flow requirements***.

347. *By understanding the issues related to data availability, accuracy of data, time, resources and availability of subject area expert for each project to carryout E-flow modelling, MoEF&CC adopted similar WII recommendations on E-flow which is being used since then in each hydropower project.*

348. *In the recent office Memo of MoEF&CC, Govt. of India dated 9th August 2018 which was related standardization of Environmental Clearance conditions, it is stated that E flow should release*

[68] E-flow for Indian Rivers, 2017 published by Published by: Forum for Policy Dialogue on Water Conflicts in India, Pune

as per ToR conditions or minimum 15% of the average flow of four consecutive leanest months whichever value is higher shall be released as Environmental Flow.[69] *In the present LKHEP project, minimum e-flow is to be considered for release as per ToR conditions which is much higher than prescribed Office memo condition.*

349. **C. Based on MoEF&CC guideline, in Present LKHEP project, E-Flow estimation has been done.** For the 90% dependable year 2004-05, December to March was identified as the period with lowest average flow for four consecutive months, with monthly average discharges estimated as 27.83, 26.02, 26.58 and 26.46 m3/s, respectively. The average discharge of these months is 26.72 m3/s. The environmental release for the lean period, computed as 20% of the average flow of the ***four leanest months, is 5.345 m^3/s***.

- During the monsoon period (considered as June to September), 30% of inflow calculated on the basis of 90% dependable year will have to be released. The average discharges for the months of June to September for the 90% dependable year 2004-05 are 76.6 m^3/s, 107.9 m^3/s, 117.2 m^3/s and 151.2 m^3/s respectively. The average monsoon flow is calculated as 113.2 m^3/s. Therefore, the environmental release during the monsoon period is ***33.970 m^3/s.***

- For the non-lean, non-monsoon period, environmental release has to be 25% of the inflow, calculated on the basis of 90% dependable year, as recommended by the Environmental Appraisal Committee. For the 90% dependable year 2004-05, the average discharge of the non-lean non-monsoon months of April, May, October and November are 29.6 m^3/s, 97.6 m^3/s, 95.1 m^3/s and 47.1 m^3/s respectively. The average discharge during the period is 67.3 m^3/s. The environmental release for this period has been considered at the rate of 25% of the average discharge, i.e. ***16.835 m^3/s***

350. Flow computations have been carried out using the data from 1959 to 2016. The computed flows at the LKHEP site have three characteristics due to the impact of the upstream Kopili HEP.

- Pre-Kopili HEP Period: 1959 – 1983: Natural flow
- Transition Period: 1984-1996: Flows affected by the operation of the 1st one unit of KHEP
- Post-Kopili HEP Period: 1997-present: Flows affected by the full operation of KHEP

351. Analysis of the mean monthly flows in during the three periods was carried out for the above three periods. As expected, the impact of operation of the Kopili hydropower system, by releasing regulated from the Khandong and Umrang ***reservoirs, is positive on the down steam river flows at the LKHEP site***. The mean monthly flows in the lean season are increased while the peak flows during the monsoon season are reduced.

352. Based on above, it can be concluded that estimation of E flow carried out in the study has scientific basis and done as per the Ministry of Environment, Forests and Climate Change recommendations and guidelines. Looking to the present scenario at Lower Kopili River dam site where there is no critical and endangered lotic species exist, recommended e-flow will serve the ecological requirement by following MOEFCC norms. It is also to be noted that ***200 km river length and 90% catchment located downstream of the dam*** *and* ***significant amount of water will be added in the river by the downstream tributaries*** *which will gives immense opportunity for flourishing the ecological habitats, niche and enhance downstream riparian uses.*

[69] http://www.moef.gov.in/sites/default/files/ECStandardization.PDF

353. **Impacts due to Optimum Reservoir Operation Levels:** The Full Reservoir Level (FRL) has been set at 226 m. The Minimum Draw Down Level (MDDL) has been set at 202 m. The reservoir will be operated in a way that the FRL is maintained throughout the year, except for periods of lowering due to release of water to generate power during diurnal peaking operation in the non-monsoon months for up to 3 hours. The reservoir water level is estimated to rise to the FRL again over the remaining hours of a day, before start of the next diurnal peaking operation. The normal Tail Water Level (TWL) has been set at 104 m, worked out as depth of water flowing over outfall of Tail Race Channel with width of 25 m and bed level of 102 m, during LKHEP operation at full capacity. The minimum TWL has been considered as 102.8 m, corresponding to 1 machine running at 50% load. The peaking operation will be ramped up slowly so there will not be any sudden change in flow downstream.

354. For energy estimation, the weighted average gross head has been considered as the difference between sum of 2/3 of the difference between FRL and MDDL, added to the MDDL, and the maximum TWL [202+2x(226-202)/3-104=114 m] throughout the year. This is a conservative assumption because the HEP will operate in true run-of-the–river mode during monsoon season because of availability of sufficient discharge for generation. The water level in the reservoir will be maintained at FRL throughout the monsoon ensuring higher gross head (which has been neglected to arrive at a conservative estimate).

355. **Mitigation Measures**: Following mitigation measures are recommended to minimize the impacts on the hydrological regime in and around LKHEP:

- During construction, there should not be significant change in the flow (river discharge will be directed around the dam work site). The suitable period for construction will be during low flow season.
- During operation, the minimum downstream flow rate released from the dam will be 5.345 m^3/s, and the minimum downstream water depth will be maintained at 0.5 m. This is computed as 20% of the average flow of the four leanest months.
- Watershed management planning upstream of the proposed dam must be managed and monitored for ensuring that the reservoir water quality is maintained. The Measures for water pollution control (Annex 26) has been developed as part of EIA study and budgetary provisions are made in the EMP for piloting the proposed measures.
- The possibility of flash floods during the monsoon season (May to September) should be included in all safety plans for the construction sites. To avoid loss of construction materials and loss of life due to flood waters, appropriate measures to store materials safely must be taken, e.g. construction materials for both the diversion channel and the dam structure must be carefully stored.
- water levels at major locations especially downstream from the dam site must be monitored continuously. a monitoring plan has been included in the proposed dam break analysis and disaster management plan (Annex 30).
- Training in emergency response and evacuation must be given to local communities/residents residing downstream from the proposed dam site.

1.1.4 Impacts of Sedimentation

356. The Sediment load of upper stage Kopili reservoir analyzed by the Central Water Commission (CWC) was estimated to be 281 m^3/km^2/year (0.59 acre feet/square mile/year) at Garampani. Silt composition was considered to be 50% fine, 25% medium, and 25% coarse. Given the proximity and similar nature of catchment of the proposed project on the same river (situated about 20 km downstream of the upper stage Kopili HEP), the same sediment load is

assumed for the project reservoir. The new zero elevation and area of the reservoir are EL174 m and 0.23 Mm^2, respectively.

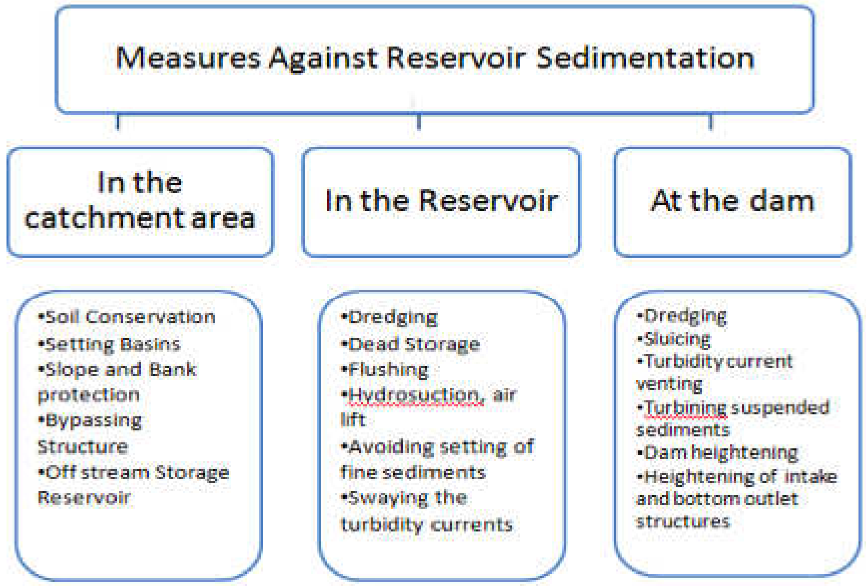
357. As a part of DPR preparation, sedimentation studies have been carried out. Following the CWC recommendation, a siltation rate of 1mm per year (0.1Ha-m/square km /year) has been considered. It has been carried out for a reservoir design life of 70 years, in stages of 10 years. Blocks of 15 years were chosen for the initial years to reduce computation. Revised Area–Capacity–Elevation curves of the reservoir after operation of the reservoir for 15, 30, 45, 60 and 70 years have been plotted to get the New Zero Elevations.

358. As suggested by the CWC, the sedimentation studies ignored the trapping of sediment in the upper reservoirs, as they are designed for power generation only and continuous (throughout the year) flushing is carried out (to flush out the deposited sediments) by sluice spillways. Therefore, a sediment contribution at the rate of 0.1Ha-m/square km/year from the entire catchment area of 2,076.62 km^2 was considered as reaching the proposed project reservoir. The New Zero Elevation after 70 years of reservoir operation has been estimated as 207.241 m. However, the actual sedimentation is expected to reach much lower levels as under sluice spillways are included. The MDDL is fixed at EL 202.00 m. Necessary design arrangements have been included for flushing of sediment deposited in the vicinity of power intake by providing low level sluice spillways in the dam nearer to the intake. The invert level of the intake tunnel is set at EL 186.00 m. Crest level of the Sluice spillways is set at EL 181.00 m. Sill level of the power intake for the APH is set at EL 194.65 m, i.e., at a much higher elevation.

359. Considering the lack of existing data on contamination of river sediments with heavy metals, it is recommended to monitoring of sediment quality (including heavy metals) at pre-construction stage. (once prior to start of construction at upstream, submergence and downstream locations). In case the results of monitoring shows contaminations of river sediments with heavy metals, a water quality management plan (including treatment measure - flushing operation, using bypass tunnel, silting weir and dredging etc.) will be prepared to deal with sedimentation quality.

360. Key considerations and common measures being implemented in hydropower projects for reservoir sedimentation management are discussed below.

361. **Reservoir Sedimentation Management**. The measures that can be adopted for reservoir sediment management can be broadly classified as i) large scale sedimentation flushing operation, ii) sediment control for dam using bypass tunnel, and iii) sediment management using silting weir and dredging. Figure below shows some of the measures against reservoir sedimentation. These measures are also recommended by the Government of India (Ministry of Water Resources, River Development and Ganga Rejuvenation) under draft policy on sedimentation management (July 2017).



- **Land Management and Soil Conservation Techniques**. Check dams, settling basins, vegetation covers, agricultural practices, etc. may be adopted to control sedimentation.

- **Bedload management.** Bedload relocation (dredging) and artificial bedload supply, etc. Flood Control Programs - Detention basins (holding ponds), energy dissipaters in channels (culvert outlet controls, forced hydraulic jumps, drop structures, stilling wells, etc. Land use controls: these are used to reduce storm runoff), Embankments/dyke/levee construction, Periodic flushing of rivers, etc. may be used to control the sediments.

- **Reservoir Operation**. Reservoirs particularly in upper reaches, should be operated in such a manner that first floods, having high silt load, are allowed to pass through without storage and river flows in later phases of the monsoon are only stored for use during non-monsoon season. This would require quantitative long term forecast with decision support system to be established for optimum reservoir operations.

- **Silt Flushing**. It has been observed that major part of silt is trapped in reservoirs made on any river. In absence of silt, rivers downstream of such reservoirs become degrading. Therefore, appropriate silt flushing arrangements are required to provide sufficient sediment to the river downstream of reservoir. It will also increase useful life of reservoir.

1.1.5 Impacts on Water Resources and Downstream Users

362. Construction of dam will lead to the formation of a reservoir. The passage of flow through a reservoir will lead to the reduction in peak flow. The lean season flow in the river too will be regulated, however during high flow water will be released from reservoir spillways. The river stretch downstream (for 5.6 km from dam to tailrace and 8.3 km from tailrace to confluence point with next river) of the dam site up to the confluence point of tail race discharge will have reduced flow due to peaking power. The reduction in flow of the river in the intervening stretch is not likely to have any adverse impact on the downstream users. This is mainly because of the fact that no settlement exists near this stretch; thus there will be no dependency on the water of river Kopili in the specific stretch. However, less flow in the river stretch can have impacts on the

riverine ecology. Apart from the above, a water reservoir will be formed due to construction of dam, which can be utilized for tourism, fisheries development, creation of new biodiversity and other purpose. Thus it will have positive impacts on water resources.

1.2 Impacts on Air Environment

363. The major sources of air pollution during the construction phase of LKHEP are from the following sources:

- Emissions (dust and particulates) due to fuel combustion in various construction equipments.
- Emissions (dust) from construction of roads.
- Emissions (dust) from quarrying and crushers.
- Emissions (dust) from blasting operations.
- Fugitive emissions due to increased vehicular movement and other sources.
- Emissions from muck disposal (mostly dust).

364. **Emissions due to fuel combustion in various construction equipments:** The operation of various construction equipments requires combustion of fuel (such as diesel). The major pollutant due to diesel combustion is SO_2, along with Particulate Matter ($PM_{2.5}$). The short-term increase in SO_2, and $PM_{2.5}$, will be sporadic (depending on daily work patterns) and in localized areas. Hence, no major lasting impact on air quality is anticipated.

365. **Emissions from construction of access roads:** Construction of about 13 km of new access roads within LKHEP (in the forest area west of the highway, well away from houses) will lead to emissions and fugitive dust (from operation and movement of construction vehicles, earthwork (excavation) and handling construction material). Suitable mitigation measures are included in the Annex 35 EMP and EMoP for road component.

366. **Emissions from quarrying and crushers**: During the construction phase, at least one crusher will be commissioned at the quarry site by the contractor involved in construction activities. The operation of quarries and crushers is likely to generate SPM. One crusher each is likely to be commissioned near the proposed quarries for dam and the power house, where there will be no major settlements or individual receptors. Hence, no major adverse impacts are anticipated. However, during the layout design of crushers, it will be ensured that the labor camps, colonies, etc. are located on the prevailing windward side and outside the impact zone (about 2 km away from the crusher plant).

367. **Emissions from blasting operations**: Blasting will result in vibration through rock layers and may cause loosening of rocks/boulders. The overall impact due to blasting operations (since it will be done for tunneling work only) will be restricted well below the surface and no major impacts are envisaged at the ground level. For tunneling works, generation of dust is anticipated during blasting and this will be captured via a ventilation system with a dust handling system. In the predominant downwind direction, dust may settle on vegetation. Appropriate control measures including vibration monitoring have been included in the EMP.

368. **Fugitive emissions due to increased vehicular movement**: During the construction phase, there will be increased vehicular movement for transportation of various construction materials and equipment to the project site, and transportation of muck / construction waste from the project site to designated dump sites. The maximum number of vehicles are estimated

as 20 vehicles per hour, causing air pollution due to dust (SPM) as well as Hydrocarbons, SO_2 and NOx. An air modeling study for hydrocarbon (HC) emissions was conducted and the results of the study are presented in Table 89.

Table 89: Increase in hydrocarbon concentration due to vehicular movement

Distance (m)	Increase in HC concentration (μg/m^3)
10	2.00
20	1.00
30	0.70
40	0.50
50	0.40
60	0.33
70	0.28
80	0.25
100	0.20

369. The results indicate that the ground level HC emissions do not travel over long distances. Also there are no receptors within 50 m of the road. Thus, no major adverse impacts are anticipated.

370. **Fugitive emissions from other sources:** Fugitive emissions (dust) are also expected from storage areas for construction materials like sand, fine aggregate etc. However, the impacts due to fugitive emissions are expected to be low, since appropriate dust suppression measures (such as water sprinkling and use of tarpaulins) will be employed (see EMP for details).

371. **Dust emission from muck disposal:** The loading and unloading of muck in the form of crushed rock pieces, stone, etc., will result in some dust emissions. However, this is not expected to be significant as most of the disposal sites will be within the forest area near the work sites and away from residential areas.

372. **Mitigation Measures:** Three principles: prevention, suppression and containment, will be adopted to control dust and other emissions. The impact on air quality will be temporary and controllable. The contractor(s) will implement air pollution control measures (Annex 24) that include methods for dust suppression due to crushers, batching plants, blasting operations, loading and unloading of muck for disposal as well as from other construction activities such as construction of access roads, work camps, etc. The following measures will be used:

- Through a planned site layout, construction equipment, machinery and dust causing activities will be located at least 500 m away from sensitive receptors.
- An appropriate location for stockpiles (away from sensitive receptors) will be selected, taking wind direction into consideration.
- Blasting activities will not be carried out close to villages or work camps; in any case, it will be carried out during the day time only.
- All vehicles will be required to switch off engines when at a halt, with no vehicle idling.
- All vehicles will be washed or cleaned before leaving the project site to remove dust.
- Loads entering and leaving the project site will be covered by tarps if they are expected to contribute to dust emissions.
- Construction equipment utilizing fuel for combustion will be inspected on a regular basis and adjusted as required to minimize pollution levels as specified by CPCB.
- In an event construction equipments are used underground, suitable ventilation systems

will be provided to avoid air pollution and capture of toxic gases released from excavated rock during underground works. Specialized plans will be developed by contractor for underground works.

- Sprinkling of water on unpaved roads will be administered to reduce incidences of dust especially in the vicinity of villages. This will be done at least 2 times per day during the dry season, and frequency will be increased depending on observations/monitoring.
- Sprinkling of water as needed for dust suppression caused by wind.
- Cutting equipment will use water as a suppressant, or employ other practical ventilation systems.
- Securely cover skips and minimize drop heights.

373. Air monitoring in and around construction areas will be routinely conducted as per EMoP. Monitoring of parameters will be specified as per applicable NAAQS of India as well as World Bank/IFC standards (see EMP for details).

374. Additionally, the site specific EMP and its sub-plans are proposed for mitigation and minimizing of environmental impacts as well as serve as guidelines for health and safety and other precautions during construction works.

1.3 Noise Impacts

375. The main sources of noise during construction activities are from earth moving machinery, quarrying, blasting, and vehicular movement. The noise impacts are highly dependent on the sound source, the topography, land use, ground cover of the surrounding site, and climatic conditions. Topographic barriers or vegetated areas can shield or absorb noise. These are covered as follows:

- Noise due to operation of construction equipments
- Noise due to increase in vehicular movement
- Impacts on labor
- Noise due to drilling
- Noise due to blasting
- Impacts of vibration

376. **Noise due to operation of construction equipments:** The typical noise level due to operation of various construction equipments are presented in Table 90.

Table 90: Noise level of various construction equipments

Equipment	Noise level dB(A)
Earth moving	
Compactors	70-72
Loaders and Excavator	72-82
Dumper	72-92
Tractors	76-92
Scrappers, graders	82-92
Pavers	86-88
Truck	84-94
Material handling	
Concrete mixers	75-85
Movable cranes	82-84

Equipment	Noise level dB(A)
Stationary	
Pumps	68-70
Generators	72-82
Compressors	75-85
Other	
Vibrators	69-81
Saws	74-81

377. A worst-case scenario that assumes that all construction equipments will generate noise from a common point has been considered to predict noise levels during the construction phase (see Table 91; most noise measurements at the project area were around 40 dB(A)). The impacts of noise levels due to operation of equipments will be temporary in nature and limited to construction phase. Note there will be attenuation in noise levels as the sound wave pass through barriers (such as via construction materials, air absorption, rain, atmospheric inhomogeneities, and vegetative cover. The noise transmission loss values for common construction materials are presented in Table 92.

Table 91: Increase in noise levels due to operation of various construction equipment

Distance (m)	Reference Ambient noise levels dB(A)	Increase in noise level due to construction activities dB(A)	Increase in ambient noise level due to construction activities dB(A)
100	40	75	35
200	40	69	29
500	40	61	21
1,000	40	55	15
1,500	40	51	11
2,000	40	49	9
2,500	40	47	7
3,000	40	46	6

Table 92: Transmission loss for common construction materials

Material	Thickness of construction material (inches)	Decrease in noise level dB(A)
Light concrete	4	38
	6	39
Dense concrete	4	40
Concrete block	4	32
	6	36
Brick	4	33
Granite	4	40

378. There are no habitations close to the dam site (the nearest settlement with around 8 households is 0.8 to 1.0 km away; these will be moved in any case, due to resettlement required for the reservoir area); however blasting operations will be limited to day time. Note: blasting can have adverse impacts on wildlife, especially along the alignment of the tunnel portion. Appropriate measures are included in EMP to minimize impacts on wildlife. Noise levels will be monitored regularly at nearest receptor locations both during normal construction as well as during blasting activities. Any increase in noise level above IFC permissible standards will be corrected immediately with provisions of appropriate measures.

379. **Noise impact due to increased vehicular movement**: During the construction phase, there will be significant increase in vehicular movement for transportation of construction

equipments and materials, estimated as 20 vehicles per hour. At present, there are no vehicular movement near the dam site.

380. Impact on noise level due to increase in vehicular movement was conducted using Federal Highway Administration (FWHA) model. The modeling results are presented in Table 93.

Table 93: Increase in noise levels due to increase in vehicular movement

Distance (m)	Ambient noise level dB(A)	Noise levels due to increased vehicular movement dB(A)	Increase in ambient noise level due to increased vehicular movement dB(A)
10	40	66	26
20	40	61	21
50	40	55	15
100	40	51	11
200	40	47	7
500	40	43	3
1,000	40	41	1

381. **Impacts on labor**: The impacts on labor/workers/operating personnel that are subjected to continuous exposures of high noise levels (above 85 dB(A)) will be curtailed by following recommendations of IFC EHS Guidelines for Occupational Health and Safety. PPEs will be provided for all workers. The exposure period of affected persons will be limited as per the maximum exposure period specified in Table 94.[70]

Table 94: Maximum Exposure Periods specified by OSHA

Maximum equivalent continuous Noise level dB(A)	Unprotected exposure period per day for 8 hrs/day and 5 days/week
90	8
95	4
100	2
105	1
110	½
115	¼
120	No exposure permitted at or above this level

382. **Noise generated due to drilling**: The noise levels monitored at a 10 m distance from the drilling source and operator's cabin is presented in Table 95.

Table 95: Noise generated due to drilling

Equipment	Noise level at source dB(A)
Standing idle (inside cabin)	70-72
Standing idle (10 m radius)	72-74
On load (inside cabin)	78-80
On load (10 m radius)	82-84

[70] The noise levels during various construction activities have been compared to standards prescribed by Occupational Safety and Health Administration (OSHA), that are being implemented in India through rules framed under the Factories Act. It can be observed (Refer Table 88) that for an 8-hour duration, equivalent noise level exposure should be less than 90 dB(A).

383. The Director General of Mines Safety in its circular no. DG (Tech)/18 of 1975, has prescribed the noise level in mining operations for workers in 8 hour shift period with unprotected ear as 90 dB(A) or less. IFC EHS standard for occupational health and safety of heavy industry is 85 dB(A). Similar norms will be considered for construction phase of LKHEP. The labor/workers/operating personnel who may be exposed to noise levels greater than 85 dB(A), will not work in these areas beyond 6 to 8 hours and will make use of PPEs. Thus, due consideration will be taken to minimize adverse effects to workers operating drills or involved in high noise generating activities.

384. **Noise generated due to blasting**: Noise generated by blasting is instantaneous, site specific and depends on type, quantity of explosives, dimension of drill hole, degree of compaction of explosives in the hole and rock. Recommended details of maximum charge /delay to minimise noise due to blasting is presented in Table 96.

Table 96: Noise generation due to blasting with maximum charge/delay

No. of holes	Maximum charge/delay (kg)	Total charge (kg)	Distance (m)	Noise level dB (A)
42	1	42	250	76-85
44	1	44	250	76-86
46	1	46	250	74-85
48	1	48	400	70-75

385. Based on the above specifications (see Table 91), noise level due to blasting operations is expected to be of the order of 75-86 dB(A). Since, the nearest receptors (about 8 residential houses) are about 0.8 to 1.0 km away, the incremental noise due to blasting operations is expected to be 50-60 dB(A). Depending on the charge, blasting is likely to last for periods of 4 to 5 seconds, noise levels over this period would be instantaneous and short in duration. Considering attenuation due to various sources, even the instantaneous increase in noise level is expected to be attenuated by at least 10-20 dB(A). Hence, noise level due to blasting is not expected to cause any significant adverse impacts (and these receptors, local residents, will be resettled from the reservoir area, in any case).

386. **Mitigation Measures**: There are no habitations/residential houses/communities in the immediate vicinity of the project site. Therefore the primary noise impact would be on the labor/workers/operating personnel, on some communities that have been proposed to be resettled by the project (8 households within about 0.8 to 1.0 km away from project site, outside the reservoir area, as noted above), and wildlife in the larger vicinity of the project area. Recommended mitigation measures for noise impacts are as follows:

- Appropriate and sufficient PPE shall be provided to all labor/workers/operating personnel.
- All noise generating construction equipments/machinery shall have sound control devices (e.g., exhaust mufflers).
- Mufflers shall be used for all fuel driven construction equipments/machinery, and these shall be maintained and serviced as per the manufacturer's maintenance schedule.
- Construction works that result in high noise generation will be limited to day time (7 AM – 6 PM) in order to minimize community disturbance.
- Vehicular movement will be restricted to day time (7 AM – 6 PM) in order to minimize community disturbance. Noise monitoring shall be conducted as per EMoP.
- Noise barriers will be installed at the construction camp and near villages along access roads if noise levels are found to exceed standards during noise monitoring.

- Site Specific EMP (SEMP) shall be implemented to reduce noise impact. The SEMP shall provide the project map layout, indicating transportation/expected vehicular movement, blasting sites, worker camps, nearby habitations/villages, and approximate wildlife (elephant) corridors, if any and noise monitoring stations.
- A schedule for blasting operations with details of time of blast (specific hour in a given day), period of blast (in seconds), and procedures will be made available to nearby communities. Warning signs will be posted, and trespassing to the blasting area shall be strictly prohibited.

387. **Impacts of Vibration:** To control vibrations due to blasting activities, EPC contractors shall be required to retain a qualified blasting specialist to develop a site specific blasting program that will assess, control, and monitor air blasts and ground vibrations from blasting operations. This program shall include, at a minimum, the following measures:

- The contractor shall use current state-of-the-art technology to assure that blast-related vibrations at offsite residential, other occupied structures, and adjoining forested areas (outside the periphery of the acquired total forest land) are as low as possible, consistent with blasting safety procedures. Under no circumstance shall the blast vibration as measured at selected/earmarked locations (e.g. on the ground adjacent to a residential structure), be allowed to exceed the frequency-dependent limits specified in the Alternative Blasting Level Criteria contained in USBM Report of Investigations 8507.
- The contractor shall monitor and record air blast and vibration within 330 m (1000 feet) of worker camps, other occupied structures, and adjoining forested areas (outside the periphery of the acquired total forest land) to verify that measured levels are within the recommended limits at those locations. If blasts and vibrations are found to exceed recommended limits, alternative blasting or excavation methods shall be employed to comply with the limits.
- Air blast and vibration monitoring shall also be made at the nearest offsite residential or other occupied structure. If vibration levels are expected to be lower than those triggering the seismograph at that location, or if permission cannot be obtained to record at that location, recording shall be accomplished at some closer offsite location in line with the structure. Specific locations and distances where air blast and vibration are measured shall be documented in details along with measured air blast and vibration amplitudes.

1.4 Impacts on Land Environment

388. The major impacts anticipated on land environment during construction phase are as follows:

- Quarrying operations
- Operation of construction equipments
- Soil erosion
- Muck disposal
- Land acquisition
- Changes in land use
- Impacts due to construction of access roads

389. **Quarrying operations:** The construction of LKHEP will involve handling of large quantities of different materials. The estimated quantities of principal construction materials are presented in Table 97. The details of quarries for fine and coarse aggregates are presented in Tables 98 and 99, respectively.

Table 97: Coarse and Fine Aggregates Required in Wearing and Non-Wearing Surfaces

S. No.	Type	Wearing surface (m^3)	Non-Wearing surface (m^3)	Total
1.	Coarse Aggregate	72,000	759,000	831,000
2.	Fine Aggregate	36,000	378,000	414,000
	Total	**108,000**	**1,137,000**	**1,245,000**

Table 98: Quarries selected for Fine Aggregates

Quarry No.	Location	Haulage Distance	Type of Aggregate	Estimated Quantity
'A	Near Sudariang Nala (existing quarry) Lat: $25^0$35'30" N Long: $92^0$44'30" E'	10 km u/s of dam axis	Fine Aggregate	40,500 m^3/year
'C'.	Near Langpher Nala, Panimur (existing quarry) Lat: $25^0$42'49" N Long: $92^0$50'21" E	7 km d/s of proposed Power house	Fine Aggregate	55,000 m^3/year

Table 99: Quarries selected for Coarse Aggregate

Quarry No.	Location	Haulage Distance	Type of Aggregate	Estimated Quantity
'B'.	Near Kala Nala Lanka Umrangshu (existing quarry) Lat: $25^0$41'53.56" N Long: $92^0$48'47.50 E	3 km d/s of proposed Power house	Coarse Aggregate	1,558,037 m^3

390. The quarrying activities will lead to impacts as follows:

- Creating pits or quarries will require the removal of virtually all natural vegetation, top soil and subsoil to reach the aggregate underneath. Thus, vegetal cover is lost from quarrying sites.
- Engineering activities associated with quarrying such as pits and surface depressions will disrupt the existing flow of surface water as well as alter the natural drainage pattern.
- Blasting associated with quarrying may occur daily or as needed. Noise generation due to blasting will generally increase with respect to the amount of explosives used, atmospheric conditions, and with proximity of barriers to the blast. The area in front of a blast commonly receives more noise than the area behind the blast.
- Dust from quarrying activities including transport.
- Noise generation due to operation of earth-moving equipment and vehicular movement will also increase during quarrying activities. Opening of the quarries will cause visual impacts because of cutting a portions of hillsides.
- Over time, exposed rocks after hill cutting will erode due to natural winds, rains, etc., slowly weather, could become a potential source of landslide.

- Un-closed quarries may also cause acid mine drainage due to exposure of rocks to atmospheric conditions.

391. To prevent soil erosion and landslides across quarrying sites, appropriate slope stabilization measures will be implemented. Quarry slopes will be maintained at a slope ratio 1:1, covered with topsoil of at least 30 cm and turfed with grass, herbs, shrubs, and local trees of high ecological and economic value. If required, retaining walls will be constructed for ensuring slope stabilisation. At the end of the construction phase, all quarry sites will be restored through engineering and biological measures. In case of acid mine drainage problem, limestone treatment will be provided as part of quarry restoration measures.

392. **Operation of construction equipments:** During construction phase, various construction equipments will be brought to the project site. These will include crushers, batching plant, drillers, earthmovers, rock bolters, etc. The siting/storage of these construction equipments will require significant amount of space. Additionally, land will be acquired on temporary basis (i.e. for the duration of project construction) for storage of quarried material prior to crushing, crushed material, cement, rubble, etc. Siting/storage of construction equipments, materials etc. will follow the specified Site Layout Plan. Various criteria for site selection are as follows:

- Proximity to the site of use
- Sensitivity of forests in the nearby areas
- Proximity from habitations
- Proximity to potable water source

393. The site layout plan will ensure siting/location of construction equipments and materials at least 1 km away from settlements, environmentally sensitive area to that any adverse impacts on the environment are minimal. Note that these quarries already exist/operate.

394. **Sedimentation/soil erosion**: The runoff from the construction sites will have a natural tendency to flow towards river Kopili or its tributaries due to natural gradient/topography of the area. The runoff may contain a high sediment load which may affect downstream areas and users. The high sediment run off in the river may increase turbidity, reduce light penetration as well as photosynthetic activity of aquatic plants. This is likely to have an adverse impact on the primary biological productivity of the affected downstream stretch of river Kopili. Note: due to low pH or acidic nature of lower Kopili river, the biological productivity in the project area at present is negligible. Hence, the runoff is not expected to affect the photosynthetic or biological activity.

395. Most erosion from construction occurs due to the removal of protective ground cover and vegetation by activities that require land clearing. It is anticipated that, until the ground is stabilized through natural or artificial means, the Project will result in increased sediment yields through greater erosion and subsequent sediment discharge. This has frequently been observed on other projects, whereby after the vegetation has been removed and watershed areas have been converted to other land uses, increased sediment discharges and associated adverse effects result and can persist for some time.

396. The proposed LKHEP will involve the construction of a variety of associated major facilities, including HEP power plant facilities, as well as support infrastructure such as roads, bridges, and transmission lines. Consequently, there is potential for adverse impacts from

erosion, and careful implementation of sediment control measures will be required. As some of the details on the locations of the workers' camp, landfill, and quarry are all still being finalized, it is not possible to precisely estimate the potential erosion and sediment discharge from these works. If site-specific management plans (SEMPs) are properly developed and suitable mitigation measures are implemented, such erosion impacts due to construction would likely be significantly reduced and controlled.

397. Consequently, it is essential that appropriate mitigation measures be implemented, with best management practices followed. Whenever feasible, construction, particularly land clearing activities, should be conducted during dry periods to help minimize erosion impacts. Moreover, care needs to be taken during road construction and excavation works at the dam site.

398. In the general Project area, Erosion and Sediment Control Design Plans should be prepared prior to the work commencement. These should contain:

- Conceptual design of erosion and sediment controls to be implemented on-site in accordance with the requirements of the Project.
- Water quality monitoring in accordance with the requirements of a water quality monitoring plan.
- All vegetation on the slope above full supply level (FSL) shall be retained to protect the slope areas.

399. Erosion and sediment control plans will be included in the site-specific management plans to be prepared for each construction site. The erosion and sediment works will be implemented prior to the commencement of any construction works on the site.

400. Erosion and sedimentation should be controlled during the construction phase of the HEP power plant. Wherever possible, land clearing and vegetation removal should be conducted with as small footprint as possible to ensure as much of the original ground cover is maintained in its existing condition.

401. Suitable measures to control sedimentation and erosion resulting directly or indirectly from the Project include the following practices:

- Soil erosion and sediment control practices should be installed prior to any major soil disturbance.
- All areas disturbed by construction activities will be, as far as reasonably possible, landscaped to reflect natural contours and restore suitable drainage paths.
- Soil and spoil removed during the construction process will be stockpiled separately and stabilization measures implemented. The stockpiles will be constructed with smooth slopes and free draining patterns. Topsoil stockpiles will be deep ripped to provide for moisture retention and regrowth. Appropriate measures will be installed in between the stream and the stockpile to control runoff where necessary.
- Stockpiles will not be located on drainage lines, in floodway zones, or in other areas important for the conveyance of floodwaters during major floods.
- Potential problems with erosion along the base of waste or soil surplus piles must be considered in planning the location of such sites.
- Waste or surplus materials shall not be placed in areas subject to potential flooding and inundation, or in manmade or natural watercourses.

402. In terms of erosion control, the major effort at construction sites for the Project will focus on the management of erosion of excavated surfaces, especially during the wet season when the volume of runoff is expected to be high. The SEMPs which include a sub-plan for Erosion and Sediment Control will be prepared by the Contractor to apply to all the construction sites. It will include environmental management and pollution control techniques for all areas of activity, including drainage measures for underground works. The Plan will meet the appropriate standards, and include development of drainage works, sediment traps, diversions, culverts and other structures designed to treat water to an acceptable quality before discharge into natural and/or constructed watercourses. (A general Erosion and Sediment Control Plan is provided in **Box A**). The environmental management and pollution control techniques for all drainage measures are as follows:

- Water management plans to meet the appropriate standards, including development of drainage works, sediment traps, diversions, culverts and other structures designed to treat water to an acceptable quality before discharge into natural and constructed watercourses. These structures will be constructed prior to commencement of earthworks if necessary. Regular inspection and maintenance will be conducted to monitor their efficiency. The volume of turbid water will be kept to the minimum and the discharge regulated. Turbid water from the construction areas will be directed to the sediment settling areas.
- Sedimentation controls will be implemented in the form of sedimentation basins, silt trap fences, or similar measures where appropriate, depending upon the size of the watershed area, and other physical and environmental constraints.

403. The following measures are also recommended to control erosion:

- Soil erosion and sediment control practices will be installed prior to any major soil disturbance, or in their proper sequence.
- Soil and spoil removed during the construction process will be stockpiled separately and stabilization measures implemented.

BOX A: GENERAL EROSION AND SEDIMENT CONTROL PLAN FOR SEMP	
A.	**Design and implementation of erosion and sediment controls**
A.1	Erosion and Sediment Control Design Plans will be prepared prior to the work commencement, which will contain the following in greater detail: i. Conceptual design of erosion and sediment controls to be implemented on-site in accordance with the requirements of this sub-plan. ii. Water quality monitoring points in accordance with the requirements of Water Quality Monitoring Plan (as required).
A.2	Erosion and Sediment Control Plans will be included in the SEMPs and Monitoring Plan prepared for each construction site.
A.3	The erosion and sediment control works will be implemented prior to the commencement of any construction works which may cause soil disturbance at the site.
B.	**Measures to control erosion**
B.1	The extent of areas to be cleared will be minimized as far as deemed practical.

B.2 The use of existing cleared areas will be maximized.

B.3 Areas within the construction areas not required to be disturbed by construction activities will be maintained in their existing condition or equivalent to status quo ante.

B.4 'Sensitive erosion areas' are defined as follows:

i. Areas with slopes > 30%

ii. Areas within 30 m of a bank of a natural watercourse

iii. Cut and fill slopes in areas of slope instability or erodible geology

B.5 The location of works in sensitive erosion areas will be minimized.

B.6 Where possible, works in sensitive erosion areas will be restricted to the dry season.

B.7 Clearing of sites will be undertaken in the same sequence as the initiation of construction sites in order to minimize disturbances.

C. Stockpile management measures

C.1 Temporary topsoil stockpiles will be developed in accordance with the following:

i. Stockpiles will be constructed with smooth slopes and free draining patterns.

ii. Stockpiles will not be located on drainage lines or in floodway zones other areas important for the conveyance of floodwaters during major floods.

iii. Stockpiles will be deeply ripped to provide for moisture retention and re-growth.

iv. Stockpiles will be constructed and stabilized, including provision of drainage and erosion control measures.

v. The height of stockpile with a berm will be determined appropriately by the locations occupied.

vi. In windy conditions, watering of stockpiles will be carried out if excessive dust generation is evident.

vii. Diversion banks will be constructed uphill of stockpiles where there is a potential for runoff to erode the base of the stockpile.

viii. Appropriate measures will be installed in between the stream and the stockpile to control runoff where necessary.

C.2 Topsoil spoil removed from the site will be piled and saved for the use of revegetation and eco-restoration activities.

C.3 Long term spoil placement sites will be managed in accordance with the requirements of Spoil Disposal measures.

D. Design specifications for erosion and sediment control

D.1 Retention and preservation of existing vegetation along watercourses will be maximized to reduce flow velocities and act as a sediment filter.

D.2 Sedimentation controls will be implemented in the form of sedimentation basins, silt trap fences or similar where appropriate depending upon the size of the catchment area, and other physical and environmental constraints.

D.3 Release of discharge will only occur after monitoring as required to meet the requirements of

D.4 Water Quality Monitoring Plan.

E. Maintenance and inspection of erosion and sediment controls

E.1 Sediment collection devices will be built prior to the commencement of any construction works which may cause soil disturbance at the site and will be maintained until the completion of activity.

E.2 Sediment collection devices (including sediment basins, silt trap fences or similar) will be cleaned with appropriately frequency because of its sustainable effect.

E.3 At least one month prior to the anticipated commencement of the wet season, a review of the effectiveness and adequacy of the existing erosion and sediment controls will be made by PMC and PMU environment experts and any necessary modification and/or augmentation of controls carried out.

F. Use of designated access road

F.1 Access to and within construction sites will be limited to designated access roads and internal haul roads.

G. Wastewater from tunneling works

G.1 Wastewater generated during tunneling works – either from rain infiltration or groundwater seepage – will be treated in accordance with Water quality monitoring plan.

H. Recommended erosion and sediment control methods and tools

H.1 For erosion control:

- **Cat tracking:** Groove the slope using tracked equipment to create a series of ridges and depressions that run across the slope and along the contour (drive up and down the fall line).
- **Erosion mats:** Protective mulch blankets or turf reinforcement mats used to temporarily stabilize and protect disturbed soils. Install to manufacturer instructions and recommendations.
- **Loose straw:** Used to temporarily protect exposed soils until vegetation is established. Break straw bales into flakes, pull apart flakes and scatter over **exposed soils.** Applying loose straw is a more cost-effective alternative to erosion mats, but does not stabilize the slope surface.
- **Tarps and coverings:** Temporary cover to protect exposed soils. All coverings should be removed, reused, or recycled after use.
- **Grass seed:** Grass seeding of exposed soils is required during all maintenance and construction activities to provide short and long-term erosion and sediment control.
- **Bioengineering:** Provides additional stability and soil retention to maintained roads, deactivated roads, landslide scars, stream banks or riparian zones with live hardwood cuttings. Consider using where grass seed will not adhere to steeper slopes or ravelling occurs.
- **Rock armor:** Angular rock placed to form a barrier between flowing water and erodible soils. Rock should be large enough to resist movement under anticipated flows.
- **Temporary diversion of water:** Diversions are used where it is possible to redirect water flow around an area where work is being conducted. This will assist in lessening the impact of erosion from flowing water near the work site (with the diversion being constructed from non-erodible materials).

H. 2 For Sediment Control:

- **Work site isolation:** Similar to the goal of diverting water for erosion protection, work site isolation diverts watercourse flow around the work site to minimize the introduction of any deleterious substances into the water and any potential effects to fish and fish habitat.
- **Pumping and diverting:** A pumped diversion is suitable for intermittent and low flow streams that can be pumped. Pump capacity must be sufficient to handle the flow in the ditch. Temporary dams are constructed upstream and downstream of the work area.
- **Silt fencing:** A silt fence is a temporary barrier designed to retain sediment on the construction

site. It consists of a geotextile attached to a supporting post that is trenched into the ground. The fence retains sediment primarily by halting the flow and promoting deposition on the uphill side of the fence. Runoff is also filtered as it passes though the geotextile.

- **Catchment basin:** An area characterized by all runoff being conveyed to the same outlet to allow coarser particles to settle out.
- **Straw bales:** A straw bale is a bundle of straw, tightly bound with twine or wire and used as a barrier that is placed on a level contour to intercept sheet flows. Straw bales pond sheet-flow runoff, allowing sediments to settle out.
- **Non-woven geotextiles:** Non-woven geotextiles are resistant to tears, soil chemicals, puncture, ultraviolet light exposure, and are virtually unaffected by hydrocarbons, mildew, rot and freeze-thaw. The non-woven geotextiles provide tensile reinforcement, filtration, separation, and stabilization in road construction, and prevention of soil movement.

404. **Landslides and Reservoir Slope Stability.** Reservoir Rim treatment measures are proposed to protect reservoir slopes from erosion and landslides. These Rim treatment measures are formulated to mitigate the geo-environmental hazards in the reservoir area. The aim of the plan is to reduce sedimentation into the reservoir, and therefore to mitigate the effects of debris flows on extreme slopes and extreme events such as landslides, as follows:

- to prevent land degradation/soil erosion;
- to enhance the quality of reservoir by reducing siltation; and,
- to stabilize soil to prevent landslides and landslip zones around the reservoir.

405. Treatment measures will include various approaches, as described below.

- **a. Maintaining vegetation on slopes.** All vegetation on the slope above full supply level (FSL) shall be retained to protect the slope areas. Whereas trees and vegetation below the FSL shall be partially trimmed at low height, instead of completely clearing, to minimize chances of erosion and landslide during low reservoir level.
- **b. Slope stabilization.** After the construction of the dam, slope stabilization works on both banks of the river (at least where there is soil, rather than bare rock) will be required to stabilize the soil and prevent landslides or debris falling into the reservoir. This will entail the construction of retaining walls, gabion toe walls, wire crates, or breast walls. Proper drainage along the slopes is required to reduce risk of landslides and erosion.
- **c. Use of geotextiles.** Coir geotextiles can be used on the stabilized slopes for erosion control. As coir geotextiles last for approximately 3 – 5 years (depending on the weight), by the time the product degrades, it converts itself into humus enriching the soil.
- **d. Plantation with local fast-growing species.** The slopes can also be stabilized by planting fast growing local species that can colonize loose soil. The type of vegetation cover is the most important factor to minimize the magnitude of potential landslides, so selection of species can be done in tandem with the Compensatory Afforestation program. The vegetation will form the green belt around the reservoir while at the same time providing important habitat for wildlife species that might inhabit the area.

406. **Muck disposal**: The total quantity of muck generation is estimated as 1.005 million m^3. Considering, 40% swell factor, the total muck that will be handled is 1.407 million m^3. About 30% muck shall be used in construction. Thus, only 0.985 million m^3 of muck is estimated for disposal at the pre-designated disposal sites. The holding capacity of pre-designated disposal

sites is estimated as 1.032 million m^3. Retaining wall of maximum 7 m height is proposed and muck is disposed up to a height of 10-12 m with 360 of slope.

407. The component wise muck generation and identified disposal areas are presented in Tables 100 and 101, respectively. The pre-designated muck disposal sites is presented in Figure 48.

Table 100: Component wise Muck Generation

Project Component	Quantity of Muck/Debris generated (m^3)	Quantity of muck with 40% swell factor (m^3)	Total Quantity of muck/debris including swell factor (m^3)	Estimated quantity of muck/debris proposed to be utilized 30% of total muck considered) (m^3)	Estimated quantity of muck/debris proposed to be dumped (m^3)	Name of the dumping site as shown in the plan
μ/s Coffer Dam	10,894	4,357	15,251	4,575	10,676	AREA 1
D/s Coffer dam	5,199	2,080	7,279	2,183	5,096	
Diversion Channel	51,473	20,589	72,062	21,618	50,443	
Dam	434,542	173,817	608,359	182,507	425,851	
Power House	28,141	11,256	39,397	11,819	27,577	AREA 2
Surge Shaft	21,561	8,624	30,185	9,055	21,129	
Valve house	54,667	21,867	76,534	22,960	53,573	
Tail Race	71,830	28,732	100,562	30,167	70,393	
Auxiliary Power House Tailrace	76,615	30,646	107,261	32,178	75,082	AREA 1
HRT & Adits	221,716	88,686	310,402	93,120	217,281	AREA1 & AREA 2
Pressure Shaft	27,458	10,983	38,441	11,532	26,909	AREA 2
Auxiliary Pressure Shaft	980	392	1372	412	960	AREA 2
Total	**1,005,076**	**402,029**	**1,407,105**	**422,126**	**984,971**	

Figure 48: Map of Muck Disposal Sites

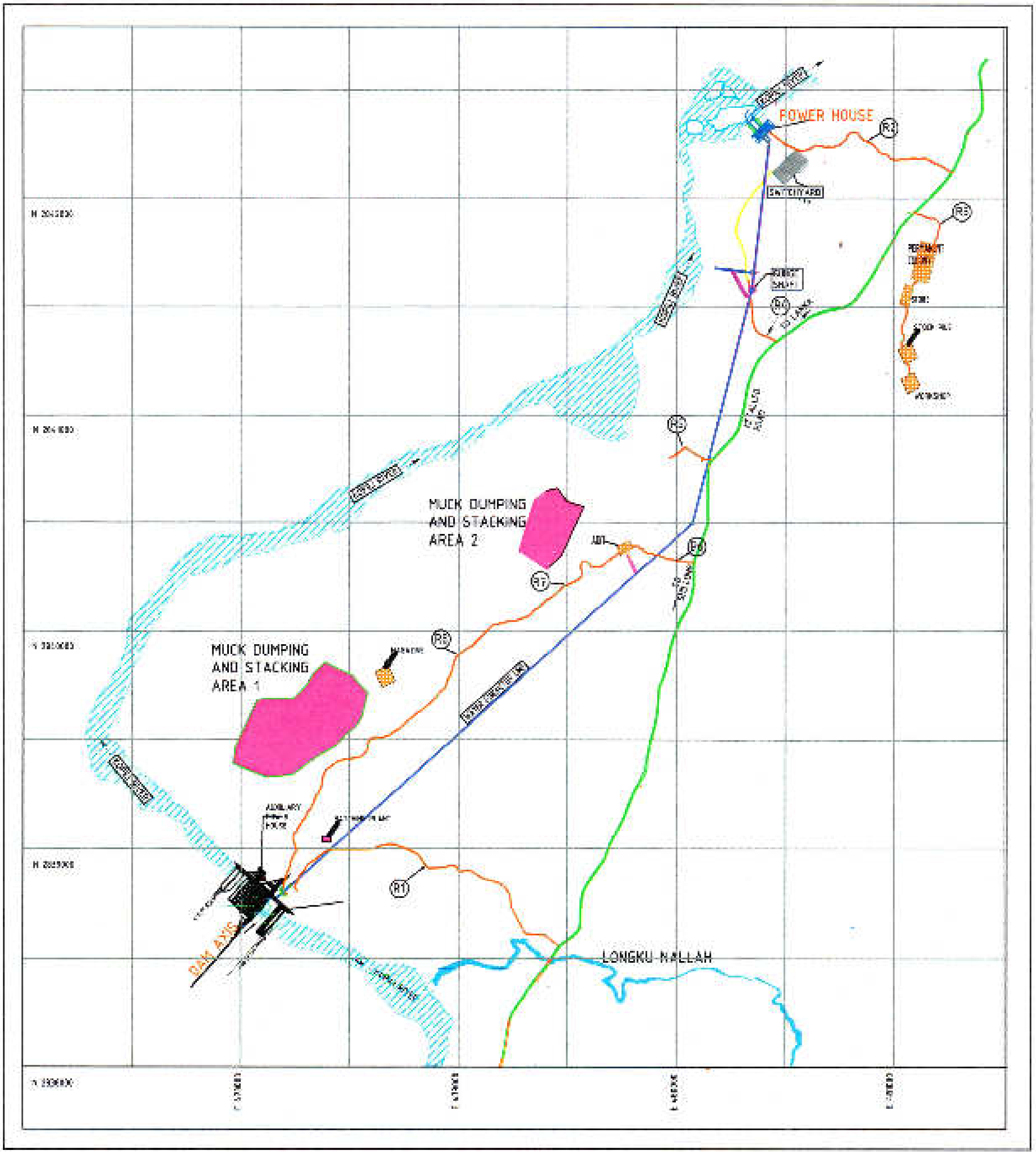


Table 101: Muck Disposal Area and Capacities

Specifications	Dumping Area A 1	Dumping Area A2
Area (m^2) approx.	60,000	52,000
Capacity (m^3) approx.	561,000	471,250
Distance from HFL (m) approx.	800	540

408. Muck, if not securely transported and dumped at pre-designated disposal sites, will result in environmental impacts, such as:

- Muck, if not disposed properly, may be washed into the Kopili or its tributaries river causing negative impacts on its aquatic ecosystem.
- Without adequate stabilisation measures, the muck may move along with runoff and create landslide like situations. Boulders/large rocks may enter the river water body thereby affecting the benthic fauna, fisheries and other components of aquatic biota.
- Muck disposal starts in low lying areas that fills up due to muck stacking, thereby affecting the natural drainage pattern of the area. This may lead to water logging/accumulation or partial flooding and also result in a breeding habitat for mosquitoes.

409. The disposed muck shall be piled at an angle of repose at the disposal sites with due engineering considerations and phyto-remedial measures for materials stabilization such as design (plan and cross sections), re-vegetation through “Integrated Biological and Biotechnological Approach”, and afforestation with local plant species. The cost for remediation of muck disposal sites include slope turfing, ground preparation, manure application, providing 5 cm of soil cover, building a retaining wall, transportation and carriage, fencing, maintenance, and irrigation. The Muck Disposal Plan including cost estimates are presented in Annex 13.

410. **Land Acquisition**: The total land requirement for the project is 1,577 ha (see Table 102). The ownership status of land to be acquired is presented in Table 103.

Table 102: Component-wise Land Area Requirement for the project

S. No.	Name of the Components	Area (ha)
1.	Project Component & Infrastructures	355.00
2.	Submergence	552.00
3.	Infrastructure	72.00
4.	R&R	75.00
	Sub-Total	**1,054.00**
5.	Land for other purposes (Recreational facilities, helipad etc.)	523.00
	Total	**1,577.00**

Table 103: Ownership Status of Land to be Acquired for the Project

S. No.	Name of the District	Forest Land (ha)	Private Land (ha)	Total (ha)
1.	Dima Hasao	478.0	909.0	1,387.0
2.	Karbi Anglong	45.0	145.0	190.0
	Total	**523.0**	**1,054.0**	**1,577.0**

411. Compensatory Afforestation Plan has been formulated and is covered in EMP. Measures for compensation (land and structures of the project affected families) are covered in RTDP document.

412. **Land Use Change:** There will be a significant land use change due to the project which involves construction of dam, reservoir, land acquisition of both reserve forests and private land holdings. The total land area required for project components like dam structure, power house and other appurtenances is 1,577 ha. The project reservoir area is 552 ha, which in pre-project scenario is the river, river bed, reserve forest, and private land. Similarly, quarry sites and muck

disposal sites will result in land use change of the area. Measures to control land use change are detailed in EMP including reclamation of quarry and muck disposal sites at the end of construction phase.

413. **Impacts due to road construction:** The project site can be reached by road from Guwahati on the National Highway (NH-52) up to Lanka (distance of approximately 180 km). From Lanka up to dam site area, the State Highway exists (for a distance of approximately 33 km) and further up becomes the PWD road (Longku-Garampani) that shall be the main access road (total length from Lanka to project site is 48 km) to the project. Several smaller access roads are proposed from the PWD road to various project components, e.g. dam complex and Power House, and etc. (length of approximately 13.10 km). The Lanka-Garampani road will also be improved up to Umrangsu (60 km) as part of the project.

414. New access roads to the various project components will be constructed as presented in Table 104 for a total length of 13.10 km. Additionally, bridges and culverts will be constructed as presented in Table 105.

Table 104: Proposed Roads in the Project Area

S. No.	Description	Length (km)
1	Lanka-Garampani road to dam site & Rehabilitation area, dyke & intake shaft top including existing road diverted	5.52
2	Explosive magazine road	0.84
3	Lanka-Garampani road to Power House	1.21
4	Approach road to colonies	0.37
5	Road to rock Quarry area	1.19
6	Road to Dumping area	0.61
7	Road to Adit portal	1.22
8	Road to Hydro mechanical workshop	0.10
9	Road to Electro mechanical workshop	0.03
10	Road to Surge Shaft	1.85
11	Road to proposed bridge	0.16
	Total	**13.10**

Table 105: Proposed bridges and culverts in the Project Area

Description	Number
No. of bridges	3
No. of culverts	10

415. One bridge (BRG 3) of span 60 m will be constructed on the PWD road on Longku nala, one bridge (BRG 1) of span 48 m will be constructed on the existing road at a nala crossing; one bridge (BRG 2) of span 11 m will be constructed across the diversion channel to pass over the upstream coffer dam.

416. Since most of the new access roads will be aligned on the hill slopes, it will lead to generation of debris/muck from hill cutting and removal of vegetation and trees from hill slopes. Suitable slope stabilization measures such as bioengineering measures (planting of soil binding tree species) will be implemented. Soil erosion from road/bridge construction activities will also lead to increase in turbidity in river water which could reduce the photosynthetic activity to some

extent. Adequate measures are included in EMP to ameliorate these adverse impacts. The new roads will also provide better connectivity to the villagers of the region.

417. The construction of new access roads may lead to the following impacts:

- Removal of trees and vegetation cover on slopes and re-working of slopes in the immediate vicinity of new access roads may encourage landslides as well as increase the erosive action of water leading to soil erosion and formation of deep gullies. Quantities of soil and rock may move down the slopes into the river, and in some cases, the entire road may be washed out.
- Construction of new access roads may increase the accessibility of a hitherto undisturbed areas resulting in greater human interferences and subsequent adverse impacts on the ecosystem.
- Increase in air pollution due to vehicular movement and construction activities.

418. Specific EMP and EMoP have been prepared for road work component and attached as Annex 35.

2. Ecological Resources

2.1 Impacts on Terrestrial Flora

419. The main impacts on terrestrial flora during construction work of LKHEP would be due to increased human interferences in the project area and due to diversion of forest land.

420. **Increased human interferences**: The direct impact of construction activities of LKHEP is limited in the vicinity of the construction sites only. It is estimated that during construction phase a large population (2,800) including technical staff, workers and families are likely to congregate in the project area. Although the contractor will provide adequate sources of fuel to the workers, some workers and population groups may use fuel wood for cooking purpose. A preliminary estimate indicates that about 2,500 people out of 2,800 are likely to use fuel wood, if no alternate fuel is provided to them. This may lead to a total loss of 36,000 trees over a project construction period of 4 years. The estimation is shown as below.

*	Average fuel wood consumption	:	20 kg pcd
*	Average population size over project construction phase	:	2,500
*	Average consumption per day	:	50 tons/day or 18,250 tons/year
*	For a construction period of 4 years	:	73,000 tons or 91,250 m^3.

- One tree produces about 2.5 m^3 of wood, thus, about 36,000 trees will be cut to meet the fuel wood requirements to the labor population, over a construction phase of 4 years.

421. To minimize loss of trees, it is proposed that contractor will provide community kitchens to workers. These community kitchens will use LPG or diesel as a fuel. Besides fuel wood workers may also cut trees for construction of their houses and other needs. It is proposed that contractor will provide sufficient accommodation in labor camps with requisite facilities. Contractor’s agreement will have clauses for strict penalties on use of trees. The details are covered in EMP.

422. **Diversion of forest land**: The project will require diversion of about 523 ha. Of forest land. The tree density in the submergence, dam and power house sites ranged from 270 to 330

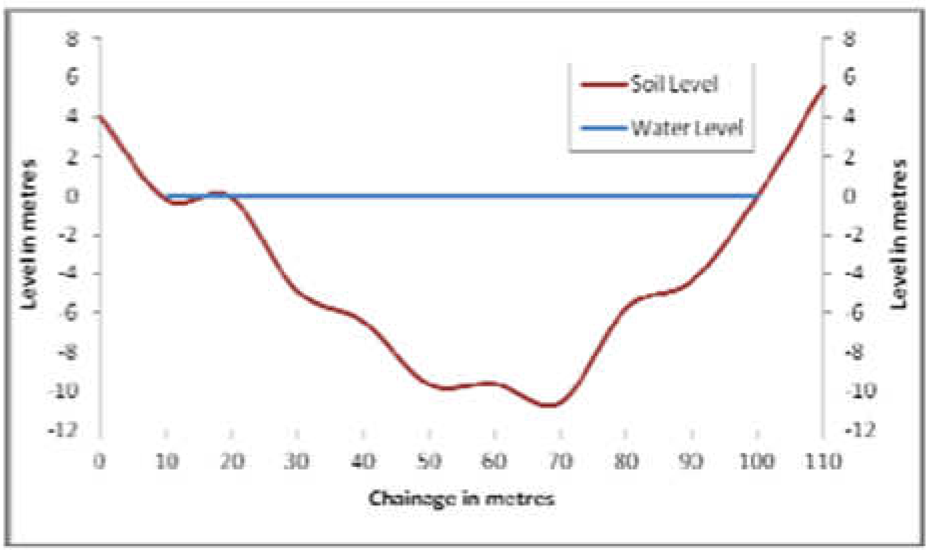
per ha, which represent low to moderate tree density forest. To compensate the loss of trees and vegetative cover, a biodiversity conservation and management plan (Annex 9) has been prepared. It is proposed that a total of (523* 2) 1,046 ha of degraded forest land will be afforested. The afforestation work is to be done by the Forest Department.

2.2 Impacts on Terrestrial Fauna

423. The main impacts on terrestrial fauna during construction work of LKHEP would be disturbance to wildlife, impacts on migratory routes, and impacts on avi-fauna.

424. **Disturbance to wildlife**: The total land required for the project is 1,577 ha of which about 552 ha comes under submergence (including river bed). As most of the submergence lies within the gorge portion (1:250 slope – Figure 49 shows the cross section of river) therefore there will not be any significant adverse impacts on wildlife movement due to creation of reservoir. The immediate project area including submergence area are not reported to serve as habitat for wildlife nor do they lie on any known migratory route. However movement of Asian Elephants and presence of other wild animals including Chinese Pangolin are reported in the surrounding area by local people. Continuous monitoring and strict penalties are proposed to minimize any adverse impacts on the wildlife.

Figure 49: Cross Section of Kopili River at Dam Site



425. During construction period, large number of machinery and construction workers shall be mobilized, which may create disturbance to wildlife population in the project area. The operation of various equipments will generate significant noise, especially during blasting which may have adverse impacts on faunal species. The noise may scare the fauna and force them to migrate to other areas. Likewise siting of construction plants, workshops, stores, labor camps etc. could also lead to adverse impact on fauna of the area. During the construction phase, accessibility to area will lead to influx of workers and inflow of the people associated with the allied activities. Increase in human interference could have an adverse impact on terrestrial ecosystem. The other major impacts could be the blasting to be carried out during construction phase.

426. To minimize any harm due to poaching activities from immigrant labor population, strict anti-poaching surveillance measures such as awareness, regular monitoring, camara traps, strict penalties etc. are proposed. Other measures such as rescue and release of wildlife

species encountered during construction works: the contractor will be required to contact the forest office in case any wildlife/avifauna are encountered or injured by accident during construction works. The forest officials will undertake rescue, treatment, and release of wildlife immediately as per protocols followed by the Wildlife Division of Department of Environment and Forest and Prevention of Cruelty to Animals Act, 1986. The ecological expert of the project team will coordinate with forest department in rescue, treatment, and release process. These measures are proposed in biodiversity conservation and management plan included as a part of EMP.

427. **Impacts on migratory routes**: The faunal species observed in the project area are not migratory in nature. Also there are no reported migratory route of wild animals in the project area.

428. **Impacts on avi-fauna**: The project area and its surroundings are rich in avi-fauna. However, water birds are not very common in the area. The main reason for this phenomenon is that water birds generally require quiescent or slow moving water environment. However, in the proposed project area and its surroundings due to terrain conditions, water flow is swift, which does not provide suitable habitat for the growth of water birds. With the damming of the river, a reservoir of an area of about 552 ha will be created, with quiescent/tranquil conditions. The reservoir banks will have wet environment throughout the year which can lead to proliferation of vegetation e.g. grass, and etc. along the reservoir banks. Such conditions are generally ideal for various kinds of birds, especially, water birds. This is expected to increase the avi-faunal population of the area. Some impacts on bird habitat is expected due to submergence of some of the forest strip (currently along the river) in reservoir.

429. **Impacts on Threatened and Endangered Wild Animals**: In the project area and its surroundings presence of Asian Elephants and Chinese Pangolin are reported. Under IUCN conservation status, Asian Elephants are considered as endangered (EN) while Chinese Pangolins are considered as Critical (CR); both are on Schedule I of the Indian Wildlife Protection Act (1972) which is the highest protection accorded to species in India. Besides these two species, *Trachypithecus pileatus (*Capped Langur), *Rusa unicolor (*Sambar), and *Bos gaurus (*Gaur) considered as vulnerable under IUCN list, are also reported in the project area.

430. Because of these facts, the critical habitat assessment has been performed in order to determine if project area itself is critical for survival of these threatened species. This assessment is based on the latest IUCN data and maps for the key species of concern, as well as recent research reports and surveys for specific animals. It has also been supported by habitat and wildlife surveys in the proposed project footprint areas; working plans of forest divisions in the project areas; opinions of wildlife and species experts (including officials from wildlife division of Assam forest department and field staff of respective forest divisions in the project area; discussion with WWF India in the early phase of the EIA and again during this critical habitat assessment was developed), as well as review of wildlife staff and local community scientific and anecdotal information on wildlife in the project area. The objective of this critical habitat assessment is to: (i) determine if critical habitat is present in the project area; and, (ii) determine if there will be any measurable adverse impacts, following the definitions and requirements within ADB's SPS, 2009. In order to identify if the project area is critical for the survival of threatened species, quantitative thresholds for critical habitat determination described in the IFC Performance Standard 6, Guidance Note 2012 have also been used as guidance (see below). Specifically, the IFC describes critical habitat in two tiers.

431. Detailed critical habitat assessment for all listed species is provided in Annex 5. Critical habitat assessment and proposed mitigation measures for two critical species in the project area, i.e. Asian Elephants and Chinese Pangolins, are described below.

2.3 Critical Habitat Assessment for Elephants and Chinese Pangolins

432. **Background:** The footprint of the LKHEP will affect forest habitat in the area surrounding the worksites and the access roads. As such, a critical habitat assessment was undertaken, as part of the EIA, to determine the possible consequences of construction activity and permanent loss of forest habitat on animal (and plant) species of concern. The assessment suggested that two animal species (with IUCN CR and EN conservation status; see table below) will require special consideration with targeted mitigation and monitoring measures. These are: the Asian elephant (*Elephas maximus*) and the Chinese pangolin (*Manis pentadactyla*). This part provides some context information for these two species and proposed measures to mitigate possible project impacts on these species.

Taxonomic Group	Species	Common Name	IUCN Red List Category Schedule I (India)	Presence in the Project Area
Mammal	*Manis pentadactyla*	Chinese Pangolin	CR Schedule 1	Yes: reported by locals.
Mammal	*Elephas maximus*	Asian Elephant	EN Schedule I	Yes: not sighted during the ground survey, but reported by locals in the project area (mostly at river crossings, such as near Langku, upriver).

433. **Asian Elephant:** While Assam has national parks, wildlife sanctuaries, and reserved forests, all of which in theory should provide natural habitat for elephants, there is still an ongoing reduction in forest cover in the state which has reduced the elephant population (now estimated at 500[71]). At the same time, there has been an increasing rate of human/elephant interactions, resulting in both human and elephant mortalities. While elephants have a preferred habitat in forests and wild grasslands, they are increasingly invading tea gardens, many of which are adjacent to the forest habitat that elephants prefer (see Figure 50). Clearly, the best conservation strategy for elephants is to maintain forest cover and to ensure contiguity between habitat patches, through the maintenance of protected corridors. Recent studies suggest that 30-40% forest cover in a given area is a critical threshold, below which elephant populations in Assam are much more severely stressed.[72] LKHEP, in this context, could be adding further stress on elephants, by further reducing (albeit slightly) forest cover in Assam.

434. Figure 50 show the elephants in tea gardens in Assam, in their natural forest habitat, and river crossing.[73]

[71] Times of India, 2017.
[72] Chartier, L., R.J. Ladle, and A. Zimmermann. 2011. Habitat loss and human-elephant conflict in Assam, India: does a critical threshold exist? www.researchgate. Net.
[73] From BBC, 2018 and the Assam-Haathi Project, 2018.

Figure 50: Elephants in tea gardens in Assam, in their natural forest habitat, and river crossing

435. **Chinese Pangolin:** Chinese pangolins (*Manis pentadactyla*; see Figure 51) are scattered throughout South and East Asia and may often be confused (due to similar appearance) with other pangolin species (such as *Manis javanica*). They seem to have a wide distribution, preferring forest habitat, but also occurring in grasslands. They are not often observed (being nocturnal) but are nevertheless hunted successfully and traded illegally (mostly for the hard scales). While densities of Chinese pangolins in the project area may be low, nevertheless the further reduction of forest cover and the risk of poaching (from project construction workers) may be an additional stress on the Chinese pangolin population in Assam.

Figure 51: Image of Chinese Pangolin

436. **Forest Habitat in the Project Area:** Figures 52 show the project footprint, and the project zone of influence (including worksites, access roads, and the reservoir) and its relationship with adjacent forest habitats. It is clear that the conservation focus of the LKHEP should be the very large contiguous forest that is present south (upstream) from the project area. This area is about seven times larger than the combined LKHEP and reservoir area, and still relatively pristine in many areas.

Figure 52: Project Infrastructure and Worksites

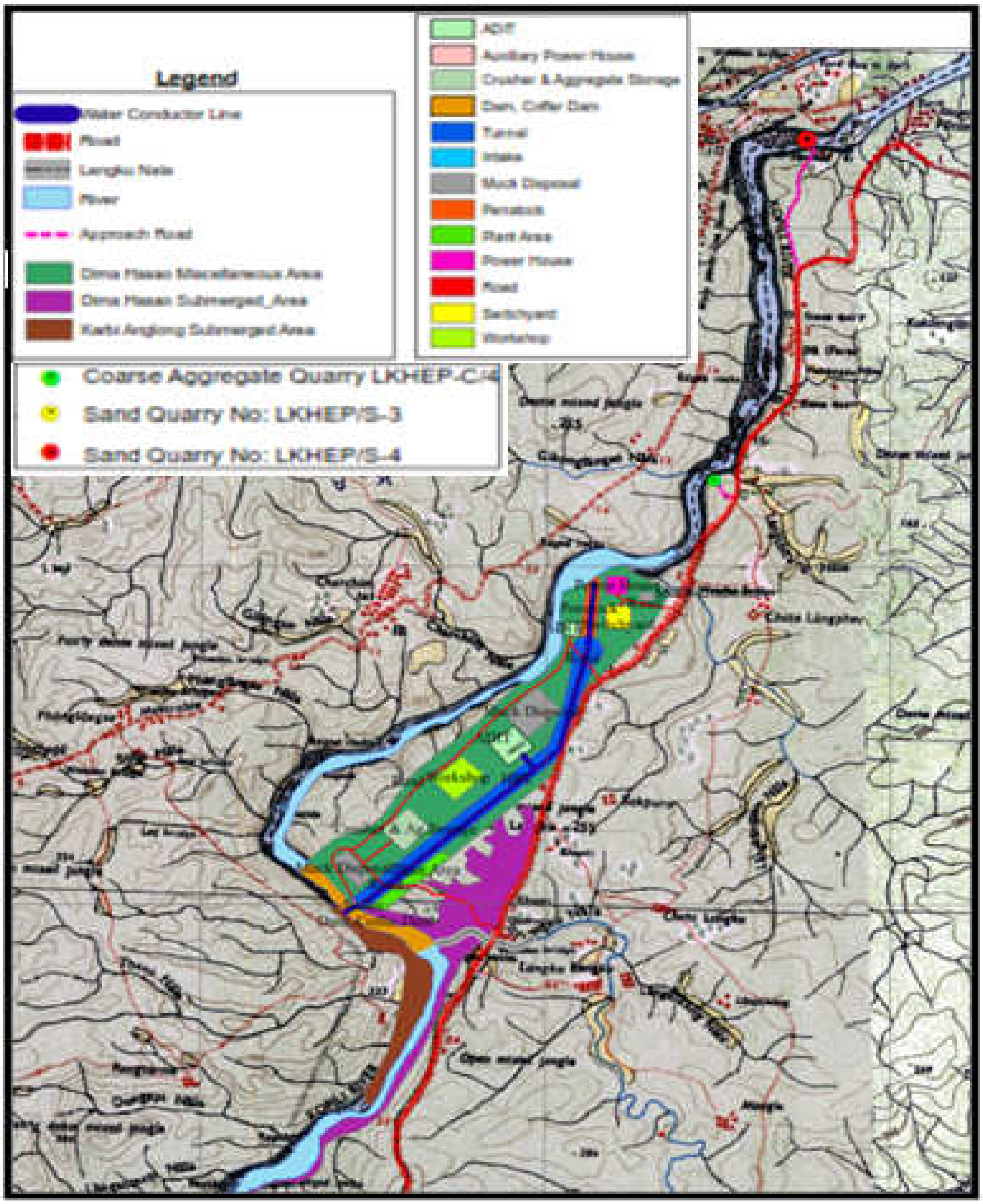


Figure 53: LKHEP Reservoir Area

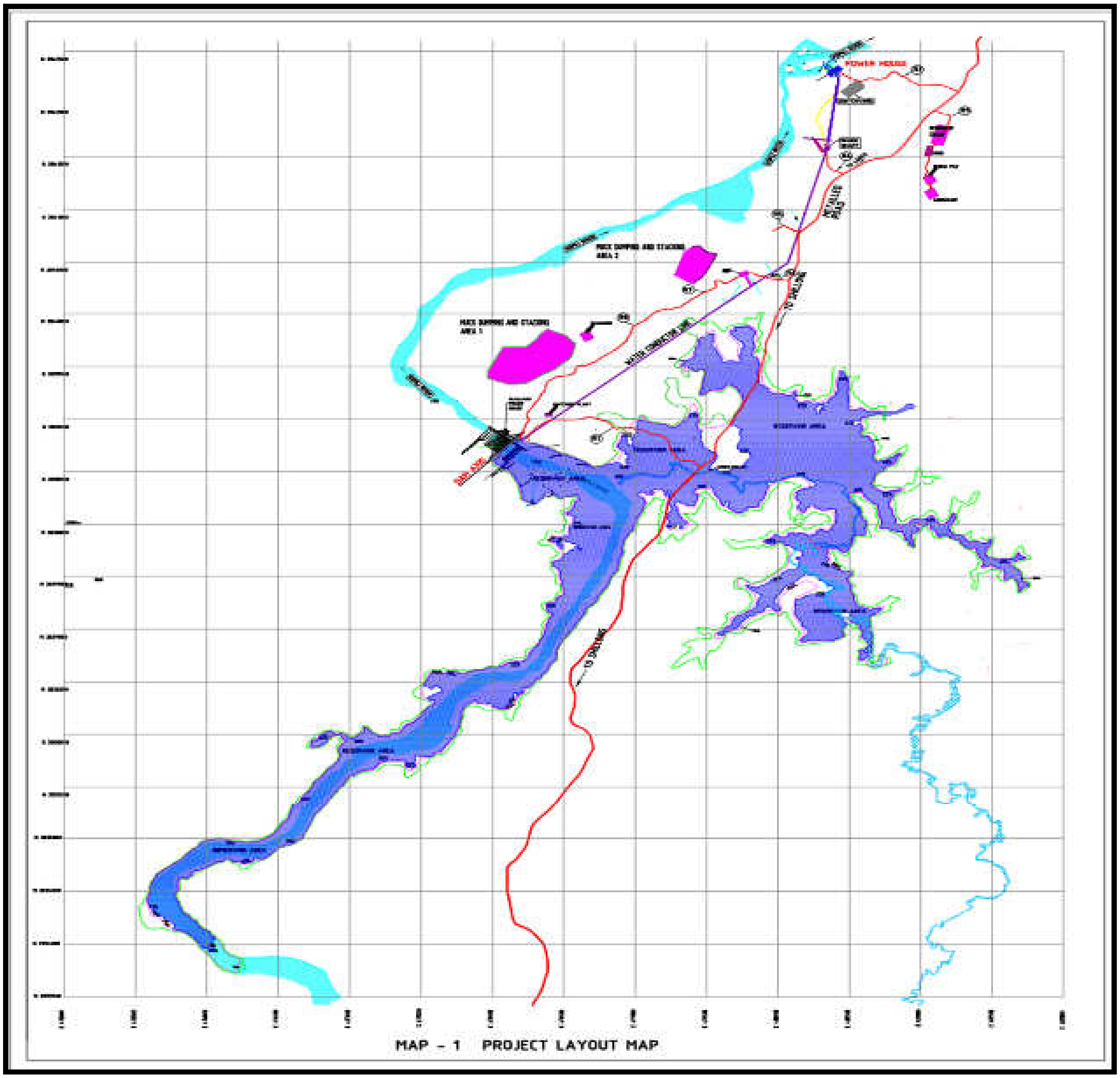
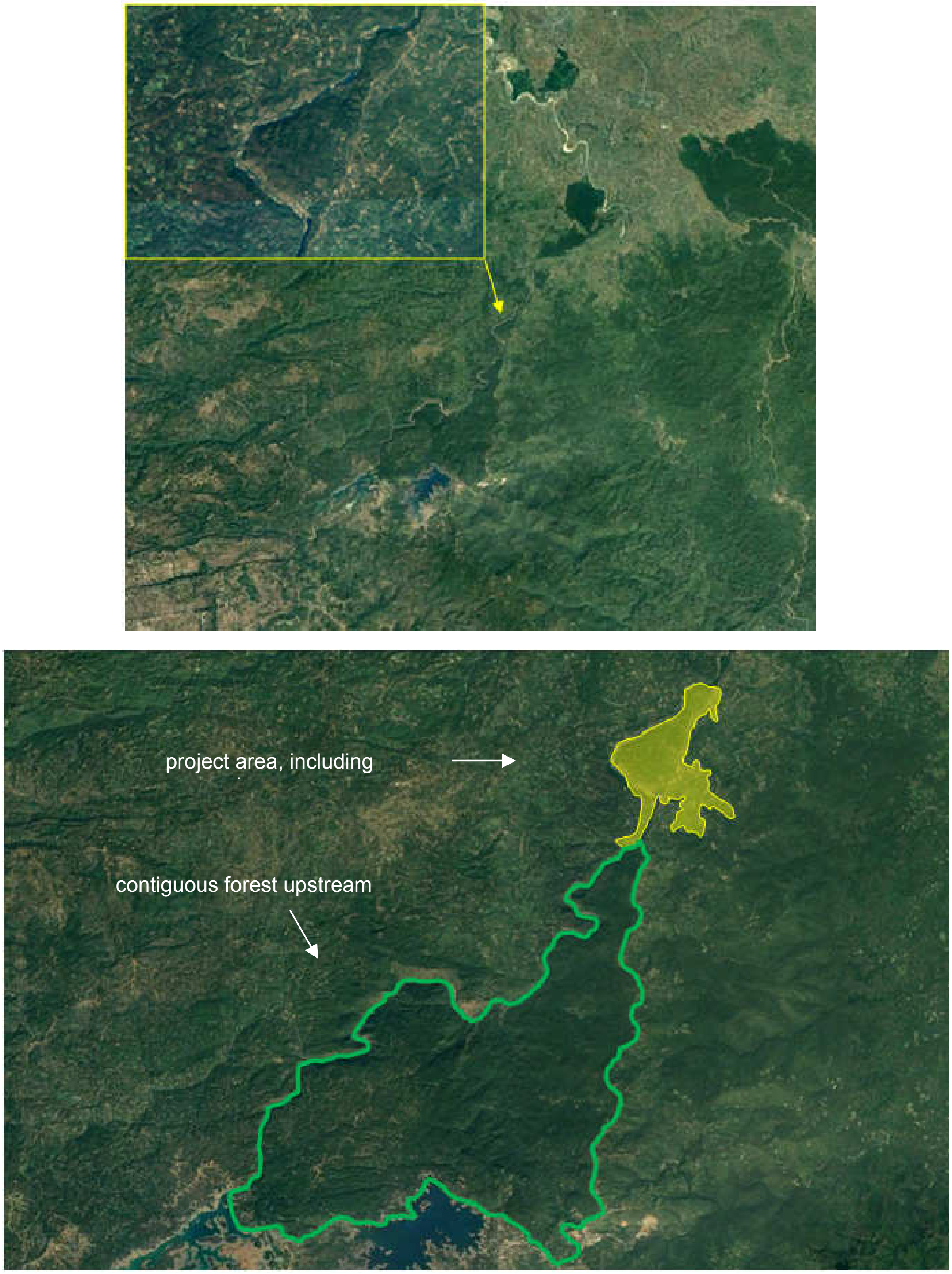


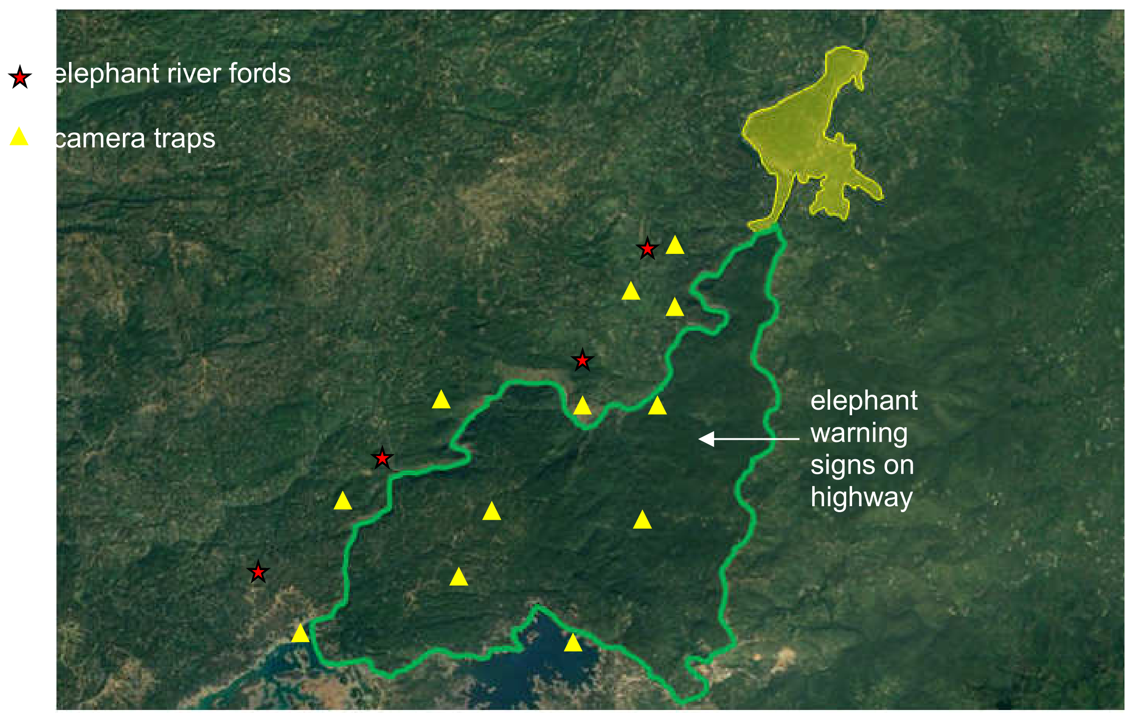
Figure 54: The LKHEP Project Area and the Adjacent Forest Habitat



437. **Proposed Mitigation Measures for Asian Elephants and Chinese Pangolins:** Little is known of either the Asian Elephants or Chinese pangolin in the project area. While these animals have been sighted, and there is reference to elephants crossing the Kopili River, upstream near Longku and further downstream near Panimur, the frequency, seasonality, number of animals, and direction of movement are not documented. Therefore, the first mitigation measure, which would apply to both elephants and pangolins, is to maintain a log of anecdotal observations of these animals (location, time, number of animals) and build up a map base of observations. These observations can come from either local communities or construction workers; in both cases, some awareness-raising about protection of these animals and potential project/wildlife observations would be necessary, and a mechanism put in place to collect observations (or allow reporting by texting, Instagram, or other media). A reasonable map base could be developed over the 3-4 years of project construction.

438. Related to this would be a camera trap program, in which camera traps (perhaps up to 12, triggered by animal movements in the day or night; see Figure 55) would be installed at specific locations throughout the forest patch south of the project area, covering areas adjacent to the river, the highway, and in the inner core of the forest. These cameras might detect elephants (daytime) and pangolins (night time). They would have to be installed and monitored by a relevant Government Agency (Department of Forests, perhaps). The information from the proposed anecdotal information map base, noted above, could be used to adjust camera trap locations over time, to optimize the frequency of animal encounters. Camera traps could also be located at the proposed elephant river fords, described below. The camera trap data might indicate particular areas within the large forest patch south of the project area that could be further protected and enhanced.

Figure 55: Proposed Mitigation Measures for Elephants and Pangolins



439. The only anecdotal information regarding elephants in the project area indicates river crossings at two locations, upstream and downstream from the project area; the exact locations are not specified and need to be determined. As noted previously, ongoing collection of observations and anecdotal information will help pinpoint river crossing areas that are important to elephants. They tend to habitually use certain locations which are amenable to their crossing; for example: shallow water, low-slope clearings on either bank, and avoiding boulders and cobble, which make their footing difficult. It is possible that the reservoir flooding will affect a river crossing area that elephants currently use. In any case, subject to confirming areas that might be important for elephant crossing, it is proposed to construct up to four fords across the Kopili River along the 26-km stretch between the upper end of the LKHEP reservoir and the Khandong dam (see Figures 56 and 57). These fords would facilitate the linkage between the prime forest habitat south of the project area and less optimal habitat (patchy forest and farmland) west of the Kopili River (it is assumed that elephants going east just cross the National Highway, although this activity has not been recorded).

440. Figure 56 shows the Kopili River just upstream from the LKHEP dam site (during lean season when river discharge is minimal; this is not really passable for elephants, due to the boulder shores).

Figure 56: Kopili River just upstream from the LKHEP dam site

441. The concept of providing fords is to make river crossing easier for elephants, assuming that it is constrained now, and that the LKHEP reservoir may further reduce crossing options that elephants currently have (this is conjecture that needs to be confirmed with the observations, anecdotal information, and the camera trap data noted previously). Figure 57 shows an example of a river ford. It is essentially a concrete pad that allows the river to flow over, while maintaining a water depth of 1-1.5 meters, suitable for elephants crossing. As can be seen in Figure 56, most areas along the Kopili River would be challenging for elephants (Figure 58 shows areas that could be developed as fords).

442. The third aspect related to elephants and pangolins conservation would be installation of signs along the National Highway, warning motorists of the possible presence of elephants/pangolins and the need to speed down.

443. Figure 57 shows examples of potential ford areas along the Kopili River south of the LKHEP reservoir area (shallow water with clearings on the edge of the river, suitable for elephant crossing).

Figure 57: Examples of potential ford areas south of the LKHEP reservoir area

Figure 58: Example of a River Ford

444. In summary, the proposed mitigation measures related to conservation of Asian elephants and Chinese pangolins are as follows:

- Asian Elephants: development of a map base by collection of anecdotal information, field observations (workers and local communities), camera trap data to determine areas that may be important to elephants; development of river fords in areas that may help link the forest habitat east of the river with forest patches and farmland west of the river; and, warning signs along the highway.
- Chinese pangolins: development of a map base by collection of anecdotal information, field observations (workers and local communities), and camera trap data, to help identify specific areas that might need further protection; and, warning signs along the highway.

445. As with all mitigation and conservation measures for wildlife during project construction and operation, constant monitoring and adjustment of programs are required. Those activities that do not create new information for effective habitat/wildlife management would have to be modified or dropped, and those that show promise can be further adjusted for optimal results.

446. A biodiversity conservation and management plan (Annex 9) has been prepared to support measures for conservation of critical habitats in the project area. Conservation actions as proposed by IUCN (during construction and during the initial project operation) such as conducting a comprehensive survey and monitoring in and around the project area to establish range, distribution and population status of vulnerable and critical habitats in the project area for assessing its habitat requirements and identifying threats are proposed.

2.4 Aquatic Flora

447. Wastewater generated (0.30 mld) from domestic sources (worker camps) will be discharged in the river, which may cause adverse impacts on aquatic flora. To control this it is proposed to construct a sewage treatment plant so as to avoid adverse impacts on riverine ecology.

2.4.1 Impacts on Aquatic Fauna

448. The main impacts on aquatic fauna during construction work of LKHEP would be impacts due to extraction of construction material, impacts due to discharge of sewage from labor camps/colonies, and impacts due to human activities.

449. **Impacts due to extraction of construction material:** The project will require a large quantity of construction material like stones, pebbles, gravel and sand. It is proposed to source some of the construction material from borrow areas in the river bed – existing sand quarries 3 km downstream of power house. The extraction of construction material from river bed will affect the river water quality due to increase in the turbidity levels. This is mainly because the dredged material gets released during one or all the operations mentioned below:

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

450. The cumulative impact of all the above operations will increase the turbidity levels. Good dredging practices can however, minimize turbidity. The dredging and deposition of dredged material may affect the survival and propagation of benthic organisms. The Phytobenthos in river borrow areas were represented by filamentous algae – Cyanophyceae (blue green) and Chlorophyceae (green) and Non-Filamentous algae – Bacillariophyceae. Filamentous algae was similar between phytoplankton and phytobenthos. The chief component of the zooplankton community across the project area are Rotifers and cladocera larvae. Macro-invertebrates fauna are represented by 15 species belonging to order Ephemeroptera, Diptera, Odonata and Hemiptera. The macro-benthic life which remains attached to the stones, boulders etc. gets dislodged and is carried away downstream by turbulent flow. The areas from where construction material is excavated, benthic fauna gets destroyed. In due course of time, however, the area gets recolonized, with fresh benthic fauna. The density and diversity of benthic fauna, will however, be less as compared with the pre-dredging levels.

451. The second important impact is on the spawning areas of fishes. Almost all the cold water fish breed in the flowing waters. In the project area (Panimur stretch but in tributaries) Cyprinidae family of fish is the largest family accounting for nearly 48% of the total species. Panimur stretch has been designated as picnic spot with 8 to 10 m height water fall on a rocky substratum, which enters in to a wider valley. The habitat changes from rocky substratum to sandy banks with a large pool habitat downstream as it approaches the confluence with river Amring. This confluence results in mixing of acidic water of river Kopili with alkaline water of river Amring, thus helping the river Kopili to sustain life in downstream areas. The spawning areas of these fish species are found amongst pebbles, gravel, sand etc. The eggs are sticky in nature and remain embedded in the gravel and subsequently hatch. Any disturbance of stream bottom will result in adverse impacts on fish eggs. Even increase in fine solids beyond 25 ppm will result in deposition of silt over the eggs, which would result in asphyxiation of developing embryo and also choking of gills of young newly emerged fry. Although there are no spawning grounds reported near proposed sand quarry sites, appropriate measures including fish management measures are included in the biodiversity conservation plan prepared for the project.

452. **Impacts Due to Discharge of Sewage from Labor Camp/Colony**: The proposed LKHEP envisages construction of a project colony at village Hawai (at least 1 km away from village settlement) and labor camps. If untreated wastewater from colony/labor camps is discharged in the river, it will pollute the river. It is proposed to commission a small sewage treatment plant for treatment of domestic sewage before its disposal into the river. Due to perennial nature of river Kopili, it maintains sufficient flow throughout the year which is sufficient to dilute the treated sewage from residential colonies. This discharge will be limited to construction period only. It is also proposed to use treated water for agricultural/green belt development purpose.

3. Social Environment

3.1 Increased Incidence of Water-Related Diseases

453. An estimated 2,800 laborers, technical staff and their families will aggregate in the project area during construction phase. Most of the laborers will be accommodated in the dormitories at labor camps. Laborers coming from outside project are potential carriers of certain diseases. It is proposed to undertake complete screening of workers health prior to the

construction. Also contractor will ensure that proper sanitary facilities (septic tanks, bathrooms, waste collection bins etc.) are provided at labor camps. Besides, adequate training and awareness programs for the workers are included in the EMP.

454. **Excavations:** Accumulation of rain water in excavated borrow pits may act as a breeding ground for various vectors and mosquitoes. Since the requirement of borrow areas in this project is limited, no additional habitat for mosquito breeding will be created due to excavated pits. It is proposed to rehabilitate (close) borrow areas by fumigation and other measures are suggested in EMP.

455. **Inadequate facilities in labor camps:** Labor camps without adequate facilities for potable water supply and sewage treatment could lead to outbreak of epidemics of water-borne diseases. Adequate measures for the supply of potable water and treatment of effluent/waste from labor camps are recommended as a part of EMP.

3.2 Impacts Due to Construction Power

456. To meet the construction power requirements it is proposed to construct a 33 kV overhead distribution line from Umrangso to project site. Total length of the line is 20 km. The 33 kV voltage level will be stepped down to 11 kV/415 V via. Distribution transformer. Necessary substations will also be installed at all strategic locations. Besides the project will also mobilize DG sets for all key locations for smooth functioning of construction activities. The DG sets will only work in case of non-availability of grid power.

457. Since the reliability of construction power is essential to meet the target dates of construction of project, it is further proposed to augment the reliability of system to install four of DG sets of 4 MVA capacity. These DG sets can meet the urgent load requirement of various critical locations like HRT, power house, pressure shaft etc.

458. The impacts due to construction of 33 kV distribution line will be minimized by aligning the distribution line parallel to the existing roads and use of best practice construction measures. The operation of DG sets could lead to increase in air pollution on account of diesel consumption. The diesel has an ash content of less than 1%, thus, adverse impacts on account of particulate emissions would be low. The sulphur content is of the order of 3 to 4% in diesel, this could lead to increase in NOx and SO_2 lands in ambient air. The DG sets to be procured under the project will meet CPCB and IFC emission standards (presented in Annex 2). The stack height of DG sets will also be kept in accordance with CPCB norms which prescribes the minimum height of stack to be provided with each generator set.

459. Appropriate mitigation measures are included in EMP to control and mitigate impacts associated with the construction of 33 kV distribution line from Umrangso to project site and emissions from operation of DG sets.

3.3 Protection of Concrete & Steel from Acidic Water

460. The pH level in Kopili river ranges from 3.2 to 5.2 rendering it unfit for use in construction works and highly corrosive for concrete structures. The acidic water shall also have a serious impact on the durability of the project components (equipments) and thus various preventive measures have been discussed (and included in the DPR) to reduce the impact of acidic water such as:

- All reinforcement near the water front shall be of stainless steel with corrosion resistant properties.
- Use of epoxy coated reinforcement or corrosion resistant reinforcement.
- Corrosion resistant painting shall be applied to the reinforcement bar.
- Metallic trash rack with its embedment shall be of stainless steel.
- Steel liner in pressure shaft shall be painted with corrosion resistant paint.
- All pipes in power house or elsewhere shall be of stainless steel.
- Use of high density concrete (HPC) on water exposed surfaces will be used in dam structure.
- All concrete in contact with direct water shall consist of 5-6% Silica fumes (micro silica).
- Concrete mix with suitable admixtures such as metakaolin along with fly ash (about 30-35%) shall be used to resist the acid attack.
- Use of polyurethane spray on water exposed concrete surface.

461. All suggested provisions have been agreed and shall be implemented during the detailed engineering stage. However the costs of such provision shall be incorporated in the DPR.

462. Additional studies were also undertaken as part of a supplemental environmental impact assessment (SEIA). A water quality restoration plan has been prepared as part of SEIA to EIA study which included possible measures to control pH. The measures suggested under this study will be implemented by APGCL as part of LKHEP, as long as there are State Authorities' coordination and involvement.

3.4 Downstream Impacts

463. Since LKHEP is planned as a run-of-river scheme (with reservoir draw-down and storage for peaking power production), the diversion of water for hydropower generation will result in change in the hydrological regime of the area, such as drying or reduced flow in the river stretch downstream. During the lean season, hydroelectric generation will result in some drying of about 13 km below the dam (with just e-flow and tributary discharge), due to storage of water for MDDL to FRL for peaking power generation. There are no major users of water in the intervening stretches, as the river stretch flows through a gorge. Also, the water of river Kopili is highly acidic in LKHEP. Thus, riverine fisheries is not found in the area. As a result, there are no major users of water of river Kopili in LKHEP. Thus, no major adverse impacts are anticipated on downstream water users. It is proposed to release minimum e-flow.

464. To minimize likely impacts on downstream river, it is proposed to release minimum e-flow as recommended by MoEF&CC. The number of peaking hours in various months for 90% dependable year in LKHEP is given in Table 106.

Table 106: Number of peaking hours available for 90% dependable year for LKHEP[74]

Month	Discharge in 90% Dependable year (cumec)	Rated discharge (cumec)	Environmental Flows (cumec)	Discharge available in 90% Dependable year for peaking operations (cumec)	No. of hours of peaking operation (hours)

[74] This table show data used for a specified year used for the simulation. However during high flow periods (monsoon period), there will be release from reservoir for which spillways are proposed. The plant will operate as peaking power mostly during lean period i.e. December to March.

Month		Discharge in 90% Dependable year (cumec)	Rated discharge (cumec)	Environmental Flows (cumec)	Discharge available in 90% Dependable year for peaking operations (cumec)	No. of hours of peaking operation (hours)
June	I	6.54	112.7	1.96	4.58	1.0
	II	79.95	112.7	23.99	55.96	11.9
	III	41.28	112.7	12.38	28.90	6.2
July	I	63.76	112.7	19.13	44.63	9.5
	II	84.02	112.7	25.21	58.81	12.5
	III	74.09	112.7	22.23	51.86	11.0
August	I	130.34	112.7	39.1	91.24	19.4
	II	75.96	112.7	22.79	53.17	11.3
	III	43.02	112.7	12.91	30.11	6.4
September	I	132.54	112.7	39.76	92.78	19.8
	II	86.02	112.7	25.81	60.21	12.8
	III	133.25	112.7	39.98	93.27	19.9
October	I	106.21	112.7	26.55	79.66	17.0
	II	86.35	112.7	21.59	64.76	13.8
	III	50.32	112.7	12.58	37.74	8.0
November	I	44.38	112.7	11.10	33.29	7.1
	II	37.50	112.7	9.38	28.13	6.0
	III	18.79	112.7	4.70	14.09	3.0
December	I	22.30	112.7	4.46	17.84	3.8
	II	22.11	112.7	4.42	17.69	3.8
	III	23.07	112.7	4.61	18.46	3.9
January	I	21.83	112.7	4.37	17.46	3.7
	II	18.87	112.7	3.77	15.10	3.2
	III	21.35	112.7	4.27	17.08	3.6
February	I	21.69	112.7	4.34	17.35	3.7
	II	20.09	112.7	4.02	16.07	3.4
	III	21.94	112.7	4.39	17.55	3.7
March	I	20.61	112.7	4.12	16.49	3.5
	II	21.68	112.7	4.34	17.34	3.7
	III	21.07	112.7	4.21	16.86	3.6
April	I	16.08	112.7	4.02	12.06	2.6
	II	15.98	112.7	4.00	11.99	2.6
	III	16.31	112.7	4.08	12.23	2.6
May	I	53.43	112.7	13.36	40.07	8.5
	II	81.94	112.7	20.49	61.46	13.1
	III	116.88	112.7	29.22	87.66	18.7

Source: DPR

465. It can be seen from Table 101 that number of hours for which peaking power will be available, in 90% dependable year, shall range from 6.2 to 19.9 hours in monsoon season (June to September). In non-monsoon season (October to November and April to May), peaking will be available for a period of 3 to 17 hours and 2.6 to 18.7 hours respectively.

466. In lean season (December to March) peaking power will be available for a period of 3.2 to 3.9 hours in 90% dependable year.

467. About 8.3 km section of the river (from TRT to confluence point of Mynriang river) will be affected by peaking operation. The modification of downstream river flow characteristics (regime) by an impoundment shall have adverse effects upon fish species. However being highly acidic river the riverine ecology including fisheries are not developed in the river. Therefore impacts due to modification of hydraulic regime are not expected to be very significant.

468. Additional studies are also being undertaken as part of SEIA. A catchment area treatment plan (Annex 10) has been prepared as part of this EIA which will have measures to control pH. The measures suggested under this study will be implemented by APGCL as part of LKHEP.

3.5 Historical and Cultural Heritage Sites in the Project Area

469. There are no sites of any historical or cultural heritage exists in the project area. A few local caves are observed in Longku Nallah. However local communities confirmed that these caves have no religious or historical significance. Therefore impacts on historical and cultural heritage from the project is negligible. However during construction excavations if any sites or structures of historical or cultural significance are found in the project areas, appropriate mitigation and conservation measures shall be implemented. Chance find (items uncovered during project construction) procedures are included in the EMP.

D. Environmental Impacts - Operation Phase

1. Water Environment

470. The main sources of water pollution during LKHEP operation are effluent from project colony, impacts on reservoir water quality, eutrophication risks, and impacts on river bed stability.

471. **Effluent from project colony**: There will not be any large scale construction activity during operation of the project. Effluent generated from project colony (where O&M staff will be residing) could cause river pollution if discharged directly in the river. It is estimated that about 50 families (200 people) will be residing in the project colony and about 0.03 mld of sewage will be generated. The total BOD loading will be order of 9 kg/day. Therefore, it is proposed to provide biological treatment facilities including secondary treatment units for sewage which will keep the BOD load of final effluent to <1 kg/day and within the permissible limit of 3 mg/l. Also the treated effluent will be used for agricultural/green belt development in the project area so there will not be any discharge to the river. Therefore there will not be any significant adverse impacts on river water quality due to effluent from project colony.

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

project, most of the land coming under reservoir submergence is barren, with few patches of trees. During the operation phase, total GHG emissions from the Project are estimated to be approximately 12,169.4 ton CO_2 per year[75], from 552 ha inundation of reservoir area. It is proposed to clear the trees before filling up of the reservoir to minimize the decomposition of organic matters.

473. Reservoir Clearing: There are four options for reservoir clearing: (1) do nothing, (2) cutting trees without removal, (3) cutting trees with removal, and (4) clearing trees by burning. Cutting trees with removal and clearing trees by burning have been proposed for valuable tree species and for other non-valuable species, respectively. Both options can maximise income and minimize adverse impacts of high initial oxygen demand after water filling.

474. The followings are recommended effective practices for reservoir clearing:

- Removal of maximum commercially viable timber, except in some designated buffer zones.
- All remaining timber, after commercial and salvage logging operations have been completed, will be cut as necessary and burnt.
- Avoid removing stumps, as disturbed soil may release far more nutrients in water.

475. Considering the low population density in the catchment area of LKHEP, the adverse impacts in reservoir from pollution load are minimum.

476. A catchment area treatment plan (Annex 10) has been developed to manage the water quality of the reservoir. This will be implemented and monitored to ensure water quality of the reservoir and downstream river as well as ground water quality. Regular monitoring of ground water and soil quality is proposed to check leaching of chemicals due to exposing acid water to fresh soils and geology.

477. **Eutrophication risks**: Another potential significant impact during operation in the reservoir is eutrophication problem, which occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. However fertilizer use in the project area is negligible. Even in the post-project phase, use of fertilizers in the catchment area is not expected to rise significantly. Thus problems of eutrophication are not anticipated due to the project.

478. **Impacts on River Bed Stability**: During the construction a large quantity of construction material like stones, pebbles, gravel and sand would be needed. Some amount of material is available in the river bed. The extraction of construction material will lead to formation of pits. Normally, deposition of material takes place at sites where velocity reduces on account of flattening of slopes leading to increase in cross-sectional area. Such sites are used for extraction of construction material. With passage of time these pits will be stabilized due to settlement of silt and sediments. Therefore, no major impacts are anticipated on river bed stability during operation.

2. Ecological Environment

2.1 Terrestrial Fauna

[75] This is estimated from hydropower reservoir emission factors of 60.4 kg CO_2/ha per day (22.046 ton CO_2/ha per year) that has variance around ± 145%. Emission factor used from 'Good Practice Guidance for Land Use, Land-Use Change and Forestry,' IPCC National GHG Inventories Programme, 2003.

479. **Increased accessibility**: Improved accessibility to the project area (due to better road conditions and construction of new access roads) may increase human interferences (power plant staff as well as local people who may come for poaching etc.) people leading to marginal adverse impacts on the terrestrial ecosystem. However, considering the manpower requirement during project operation (50 families or 200 people), increase in human population is not expected to be significant. The manpower during operation will be living in project colony, with all the modern amenities such as playgrounds, school, health centre, and market etc. Thus, pressure due to the project personnel on the forests of the area is not expected to be significant. Strict penalties (as per Indian Wildlife Protecion Act 1972) will be enforced in case of illegal activities (poaching, hunting) in the forest areas.

480. **Presence of Wildlife/Elephant Corridor:** There is no permanent corridor for elephant or wildlife crossing the rivers as reported by the concerned Range Official of Forest Department, GoA. Movement of wildlife will be monitored during operation and in case of wildlife movement corridors are identified, measures recommended in biodiversity conservation and management plan (Annex 9) will be implemented.

2.2 Aquatic Flora

481. The construction of a reservoir as a part of any HEP bring about significant changes in the riverine ecology, as the river transforms from a fast-flowing water system to a quiescent lacustrine environment. Such an alteration of the habitat would bring changes in physical, chemical and biotic life. The micro-biotic organisms especially diatoms, blue-green and green algae before the operation of project, have their habitats beneath boulders, stones, fallen logs along the river, where depth is such that light penetration can take place. But with the damming of river, these organisms may perish as a result of increase in depth.

2.3 Aquatic Fauna

482. **Impacts on Riverine Fisheries:** The pH level of Kopili river is acidic in nature, therefore availability of fish species in the river at PIA is very rare (in fact, none were observed in the main section of the river between the dam site and the power house). During field investigations a total of 4 species are found from the downstream part of PIA (near power house and 4 km downstream of powerhouse site). During peaking operations about 8.3 km section of river (further downstream from TRT) will be affected by reduced flow. However water in this section is also acidic (pH 3.5-4.5) and presence of aquatic life is rare. In the immediate surroundings of proposed dam site, none of the fish could be landed during the primary survey. Consultations with local communities are confirmed that presence of fish species in the river in project area are very rare. Absence of fish diversity in the vicinity area can be attributed to the acidic water of coal mining activities, which affect the water quality adversely.

483. **Impacts on Fish Migration:** No migratory fish species are reported in the project area, hence, no impacts on this account are anticipated.

484. With the implementation of water quality restoration plan, it is expected that pH level of water in the river will be increased which will support riverine ecosystem including fisheries. A fish habitat management plan (Annex 11) has been developed. Implementation of this plan will improve fisheries in the river (however, it will require a long period of Government agency planning and coordination, over possibly 10 years).

485. The construction of a reservoir replaces the riverine ecosystem by a lacustrine ecosystem. The vectors of various diseases breed in shallow areas not very far from the reservoir margins. The magnitude of breeding sites for mosquitoes and other vectors in the impounded water is in direct proportion to the length of the shoreline (which is about 6km). The increased risk of malaria will require a mosquito eradication and malaria intervention program, to coincide with State initiatives of this nature.

E. Conclusions Regarding Potential Impacts, Mitigation, and Project Acceptability

486. The impact assessment noted in Sections A-D above indicates that there are no significant negative environmental and socio-economic impacts associated with the proposed LKHEP that cannot be mitigated to negligible or acceptable levels. All significant issues were screened out during the consideration of alternative locations. The diversion of water for hydropower generation will result in change in the hydrological regime of the area, however minimum e-flow (20% of average lean season flow at the dam, and increasing continuously downstream) will be guaranteed for maintaining ecological habitat.

487. The project footprint is 523 ha. of Reserve forest land does not contain discrete management unit (DMU) for unique or critically vulnerable flora and fauna. Experience with similar projects in North East region indicates that the temporary negative impacts due to pre-construction preparation and construction works can be managed with “Best Practices” and measures to address issues such as: minimize sediment mobilization, reduce noise and air quality issues, and contain waste (management and disposal). Diversion of 523 ha. of Reserve forest land will be compensated via Compensatory Afforestation (CA) scheme in coordination with the Assam State Forest Department. The impacts on wildlife will be managed via a Biodiversity Conservation and Management Plan. These are the main factors in maintaining environmental impacts at an acceptable and manageable levels.

488. There is full local community acceptance of the project. Affected persons/households will be compensated as per provisions of RTDP developed for the project. The project will bring in significant power service reliability to the State and lead to local and national economic benefits while resulting in GHG emission reductions which is estimated to be 370,640 t CO_2e per year (far higher than the GHG emissions that may be associated with construction equipment and reservoir methane (CH_4) production, as is usually the case with HEPs).

489. All required mitigation measures and monitoring are documented in EMP which also includes a Biodiversity Conservation and Management Plan. The EMP will become the *modus operandi* for the project, ensuring that predicted impacts are well-managed and monitored, and that accountability for mitigation performance is in place.

490. Given the observations and conclusions from the EIA, the project appears to be acceptable for implementation, as designed according to GoI and ADB environmental standards and policy requirements.

VI. Cumulative and Induced Environmental Impacts

491. A detailed cumulative impact assessment has been undertaken for LKHEP under financing from Tranche 2 of the MFF. Complete CIA report is included in SEIA. Key cumulative and induced impacts are summarized in following sections.

A. Introduction and Scope of Assessment

492. The GoI and GoA have requested the ADB to provide $200 million loan funding from the MFF to support investment in the current project (120 MW LKHEP).[76] This assessment covers reasonably foreseeable cumulative and induced impacts attributable to the ADB-funded investments in electric power generation.[77]

493. The proposed project will receive water from (i) tail race water released from the existing Kopili power plant, (ii) incremental flow from the river catchment area between Khandong dam and the proposed LKHEP dam (including flow from catchment between Umrong dam and LKHEP), (iii) any reservoir spill from Khangdong and Umrong reservoirs. The proposed project is designed to operate as a run-of-river power plant, and proposed to have a total capacity of 120 MW, in two power plants: the MPH will be rated at 110 MW and the APH will be rated at 10 MW. The MPH would receive water diverted at the dam in Longku on Kopili river, while the APH is located at the bottom of the dam at Longku, using water released at the bottom of the dam to maintain the minimum river flow downstream of Longku. The MPH is expected to operate at full capacity (base load) during high flow (rainy) season, and operate in peaking mode during the low flow (dry) season. The APH would operate throughout the day, when water is released from the bottom of the dam to maintain the e-flow. Table 5 shows the basic information about the project. Power output will be evacuated to the existing Sankardev nagar substation (see Figure 26).

494. Induced impacts are from those activities and projects that would not proceed without the ADB funded investments. Cumulative impacts are defined as potential environmental effects from activities and projects that take place in parallel in the same project area and with possible economic linkage to the project. The impact of a single project on an environmental factor may not be significant, but the impacts of parallel projects may combine to induce irreversible environmental impacts. The purpose of cumulative and induced impacts assessment is to identify the combined effects and the limiting and mitigating factors to ensure that cumulatively the impacts will not exceed the carrying capacity of the environment.

495. For the purpose of this assessment, the primary spatial context selected is the Kopili river valley both upstream and downstream of the proposed project that may be directly or indirectly affected by the project (see Figure 59). Since the power generated by the project will be fed into the State grid through 220kV power evacuation system, the secondary spatial context selected is the connected service area of the Assam power utilities, comprising part of the State in terms of area, population, and consumer categories. The temporal context selected is the near-term development period, i.e., 2015-2025. Potential impacts are considered on the basis of economic dependency, and degree of certainty that the collateral activities will proceed

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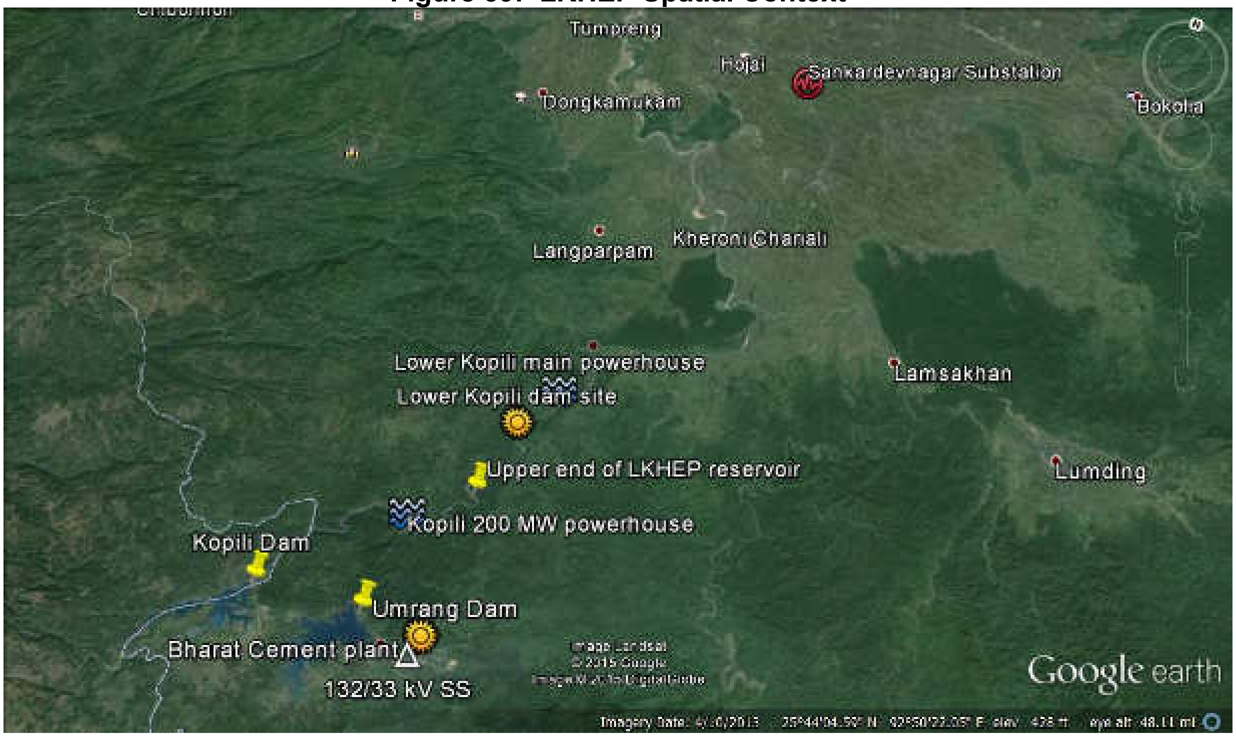
[76] The Assam Power Sector Investment Program (MFF-083) was approved by ADB's Board in June 2014. Tranche 1 is financing a 70 MW gas-fired replacement power plant at Lakwa; Tranche 2 is financing distribution system expansion and upgrades.

[77] This section complements supplemental assessment work covering cumulative impacts, integrated water resource management, and water quality restoration being funded under Tranche 2.

as planned. In this case, some additional power sector investments are seen as certain and/or reasonably foreseeable, and the domestic consumer category is expected to dominate demand growth.

Figure 59: LKHEP Spatial Context



496. Impacts and effects are categorized as additive, compensatory, synergistic, and masking. Additive impacts increase environmental stress, e.g., additional pollution loads from new industrial plants. Compensatory effects offset negative impacts, and may include specific environmental management and ecological preservation activities implemented on a regional or sectoral basis, e.g., common effluent and waste treatment plants in industrial estates. Synergistic effects mutually reinforce effects of the core project and could be positive or negative. Masking effects arise from activities that are not linked to the core project, but may occur as a result of the project; e.g., road improvements implemented in parallel with the new hydropower plant that will facilitate more traffic and trade.

497. In the context of electric power sector development in India, most of the ADB funded projects are addressing under-served areas with suppressed energy demand. In Assam, generation, transmission, and distribution projects are being induced by economic growth, and not *vice versa*. This project will account for less than 5% of Assam's projected peak load at the time the HEP is commissioned (also see Chapter VIII: Analysis of Alternatives of this EIA).

498. For the proposed project, the scope of cumulative and induced impacts assessment will cover a brief overview on (i) first order impacts on agricultural and forest lands, biodiversity, and water resources; and a more detailed discussion on (ii) second order impacts related to "downstream" energy consumption in various consumer categories; and (iii) associated (transmission) facilities. The first order impacts, which occur in the primary spatial context, are discussed briefly below, and are assessed in more details in a SEIA being commissioned by the

Project Management Unit (PMU).[78] The second order impacts, which occur in the secondary spatial context, are considered in general terms with respect to demand forecasts and recent electricity sales by consumer category (or sector).[79] In terms of overall environmental impacts, the key issue for evaluation of the associated facilities and "downstream" economic development is whether ambient environmental quality objectives/standards will be maintained within GoI standards in the spatial and temporal context.

B. First Order Impacts

1. Major Impacts

499. The major impacts will occur in the reservoir area and the partially de-watered section of the Kopili river between the dam and the MPH (receiving e-flow and tributary discharge) and further downstream during peaking power operation (where e-flow and tributary discharge will be the only water in the river, during reservoir filling, until other river confluences contribute). The reservoir will have a maximum extent of about 6 km upstream of the dam; backwater effects are expected upstream of the reservoir, but the extent will vary as the reservoir level changes on a seasonal and daily basis (especially in the dry season with low flow). The flow diversion will partly de-water 5.6 km during normal operation and further 8.3 km downstream during peaking power operation, of the Kopili river. Below the MPH and the tailrace outlet, normal flow will be restored (except during peaking operation, as noted above). Detailed hydrological modeling and monitoring have been carried out to assess the impacts upstream of the dam and downstream of the power house. The project site has been selected in part because the disruption to the hydrologic regime caused by the existing upstream Kopili HEP is expected to be negligible, as the clear section of the river between existing Kopili HEP and LKHEP dam site is only about 5 km (which is already impacted by existing HEP). In effect, the project will extend the hydrologic disturbance caused by the upstream Kopili HEP further downstream by at least 10 km. The impacts will be masked by inflows from the catchment area downstream of the MPH, including perennial tributaries to the Kopili river. Table 107 summarizes the project catchment area relative to the total catchment area of the Kopili river and its tributaries. Figure 60 shows the river schematic. Based on the relative size of catchment area, the downstream hydrologic disruption may be greatly diminished at the confluence of Kopili river with the Jamuna river; impacts of the Kopili HEP and the project are not expected to be observable at the confluence of the Kopili river and Brahmaputra river.[80]

500. Agricultural lands, forest lands, and the biodiversity will be significantly impacted by the reservoir and the de-watered section of the Kopili river. Aerial imagery and site reconnaissance indicates that the greatest physical impacts occur due to reservoir operations, with relatively lesser impacts due to partial de-watering between dam and powerhouse. The Kopili river flows through a steep-sided valley from the existing Kopili HEP area down towards the Panimur Proposed Forest Reserve area (location of the Panimur forest ranger outpost/guest house), below which the topography is less steep. The de-watered section is in the steep-sided valley that has no habitations and not used for agriculture. At full level, the reservoir will rise above the

[78] This supplemental work will be funded through the MFF-083 Tranche 2 loan, and is expected to be completed by the fourth quarter of 2017. The existing upstream Kopili hydropower plants at Khandong and Umrong are not associated facilities.

[79] Development indicators are included in the Design and Monitoring Framework to evaluate the overall economic impact of the project and the overall investment program supported by the MFF.

[80] Actual flow data would provide a more realistic indicator of the extent of downstream disruption, but are not readily available. However, it is known that the Kopili River lean season discharge is only 0.6% of the Brahmaputra River average lean season discharge (near Guwahati); according to Assam WMD.

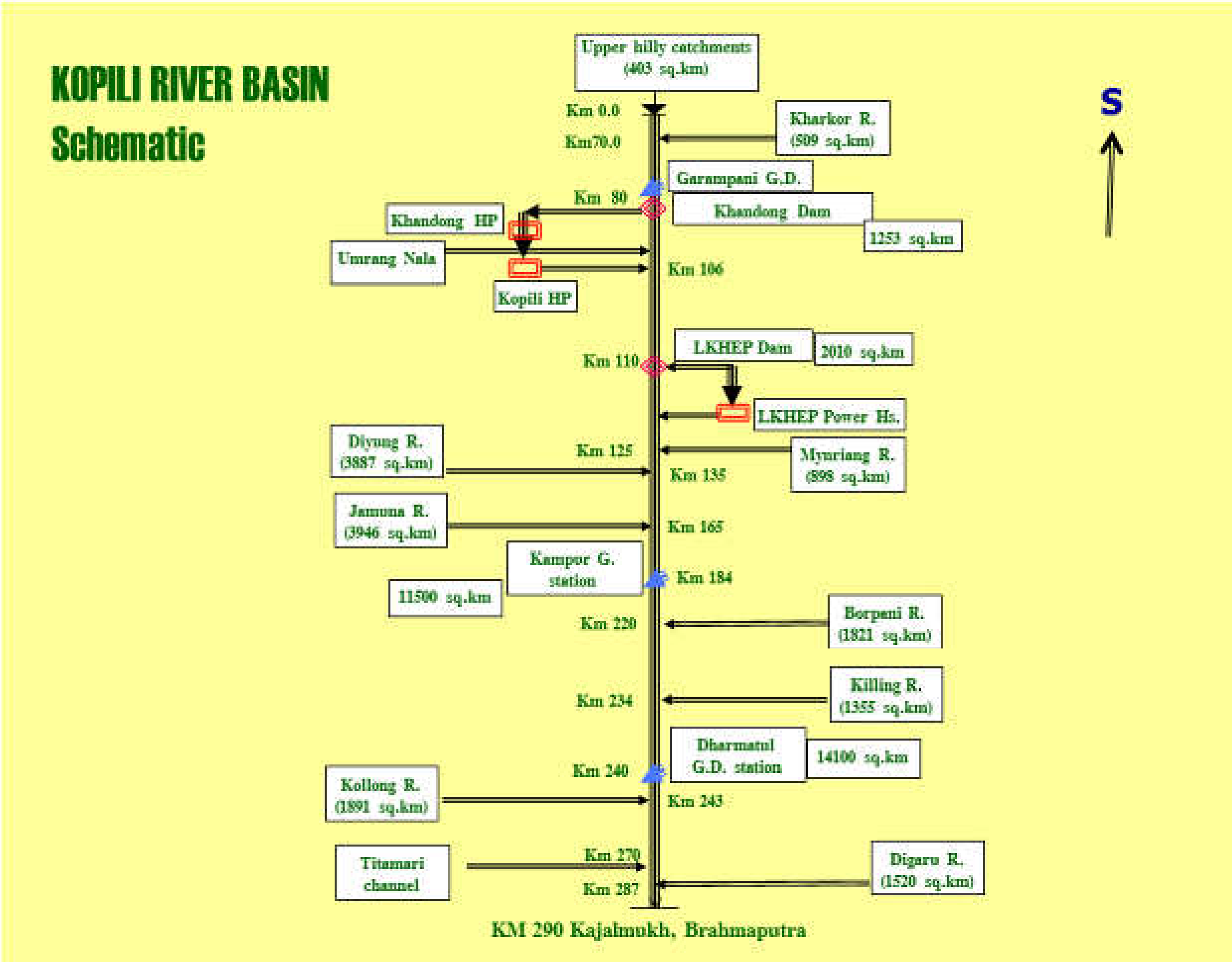
valley walls and extend onto the right bank of the river; this extended reservoir area and the right bank of the river adjacent to the de-watered section will be permanently altered by construction of the dam, power house, and other facilities as well as seasonal rise and fall of the reservoir level.

Table 107: Kopili Basin Catchment Areas

Sub-catchment / tributary	Distance from origin (km)	Area (sq.km)	Cumulative Area (sq.km)	Ratio of LKHEP Catchment Area to Cumulative Catchment Area
Head water catchment	0	403	403	-
Kharkar River	70	509	912	-
local nalas and catchment up to Khandong dam	0-80	341	1,253	100%
LKHEP dam site	90	757	2,010	62%
Mynriang River	125	898	2,908	43%
Diyung River	135	3,887	6,795	18%
Jamuna River	165	3,946	10,741	12%
Borpani River	220	1,821	12,562	10%
Killing River	234	1,355	13,917	9%
Kallang River	243	1,891	15,808	8%
Digaru, Titamari channel & lower floodplain	243-287	1,709	17,517	7%
Kopili River channel	290	3,480	20,997	6%
TOTAL	**290**	**20,997**		

Source: LKHEP IWRMP Report (2017)

Figure 60: Kopili River Basin Schematic

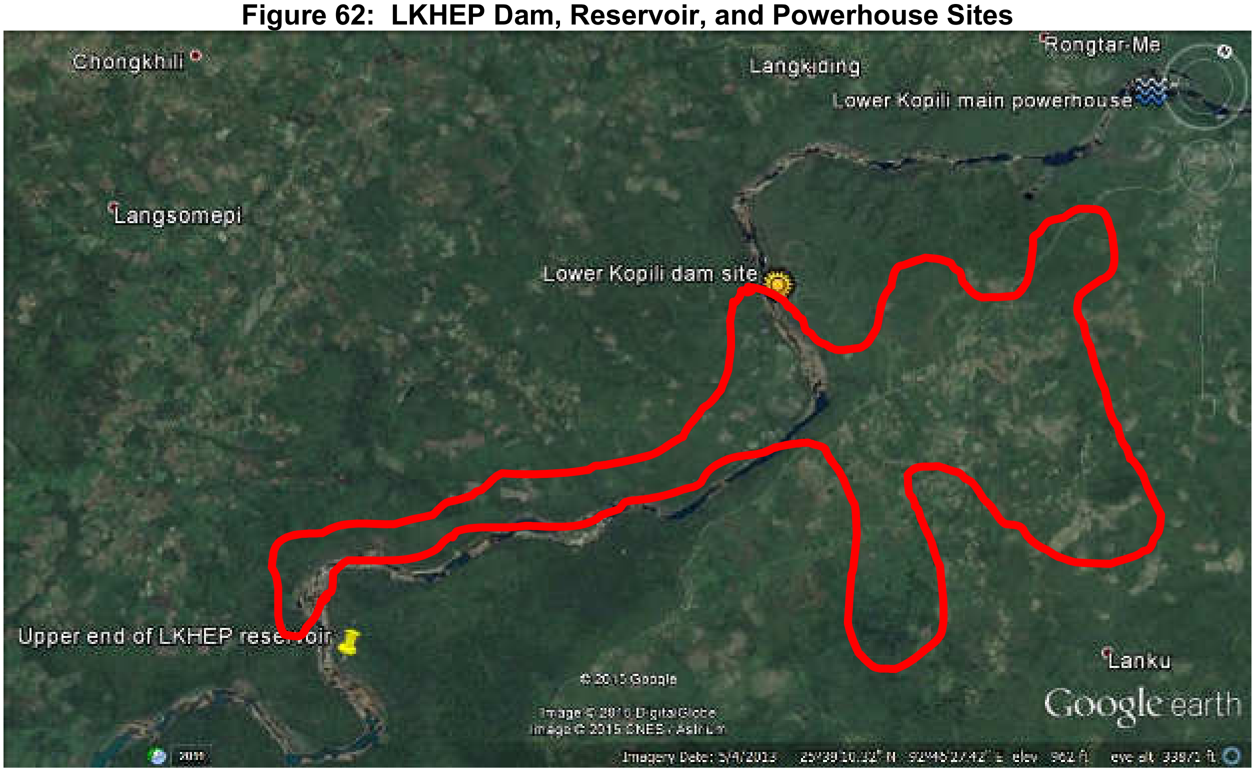


501. The potential impacts may be anticipated both qualitatively and quantitatively based on reconnaissance of the existing Kopili HEP dams and reservoirs and their influence on the project area. Figure 61 presents an aerial view of the existing Khandong dam and reservoir during low-flow season; the reservoir footprint is slightly larger than that of the proposed project. Figure 62 presents an aerial view of the proposed project reservoir area, dam, and power house sites–MPH and APH (note: aerial images are from the same elevation as that for the Khandong dam and reservoir). Figure 63 presents an aerial view of the river valley around the Kopili HEP 200 MW power house; the color change in the river channel indicates where full flow is restored to the river. In Figure 63, the vegetation patterns upstream and downstream of the power house are not visibly different.

502. Figure 64 presents a view of the Kopili channel just downstream of the Khandong dam taken during low flow season; the change in color of bedrock indicates the approximate high flow level. Figure 65 presents the Kopili river during low flow season, looking upstream from the project dam site; Similar to Figure 64, the change in color of bedrock indicates the approximate high flow level. In Figures 65, the lighter colored area of rocks have been affected by acid drainage from illegal coal mining in the upstream areas in the neighboring state of Meghalaya.

Figure 61: Kopili [Khandong] Dam and Reservoir

Figure 62: LKHEP Dam, Reservoir, and Powerhouse Sites



Note: the 2 images above are taken from approximately the same eye elevation. The red line in Figure 29 shows a very rough approximation of the reservoir area for purposes of comparison with Figure 28.

Figure 63: Kopili River Channel at Kopili HEP 200 MW Powerhouse

Figure 64: Kopili River Channel Looking Downstream from Khandong Dam

Figure 65: Kopili River Channel Looking Upstream from LKHEP Dam Site

503. The project area is not considered as a biodiversity “hot spot,” although there are sensitive species and reserved forest areas (see Chapter XI: Environmental Management Plan and Annex 9 Biodiversity Conservation and Management Plan for mitigation and conversation measures). About 600 ha. of forest land, including reserve forests on both sides of the river, will be cleared or directly impacted; these impacts will be offset by compensatory afforestation (CA) at 2:1 ratio in other identified areas under the purview of the Assam State Forest Department. Outside of the main river channel, the reservoir area will expand and contract with seasonal flow and storage behind the dam; some of this reservoir area could be used during the dry season, e.g., for animal grazing.[81] Some biodiversity offset could be achieved via fisheries (assuming the acid issue can be addressed upstream) and constructed wetlands in the reservoir area, as proposed in the water quality restoration plan and biodiversity conservation plan.[82]

2. Greenhouse Gas Implications

504. The project will provide additional new power, displacing the grid mix which is dominated by fossil-fuels and petroleum-fueled back up generation. Based on the design output of 452 gigawatt-hours per year (GWh/y) and a grid emissions factor of 0.82 tons carbon dioxide equivalent per MWh (tCO_2e/MWh), GHG emissions reduction is estimated to be 339,968 tCO_2e

[81] Reconnaissance of the existing Khandong and Umrong reservoirs indicates that grazing in the reservoir area during the dry season is possible.

[82] This concept is evaluated in the WQRM and IWRMP reports (supplemental environmental assessment) funded under Tranche 2.

per year.[83] Primary pollutant emissions will be reduced as follows: 103 t/year particulate matter ($PM_{2.5}$), 945 t/y NO_2, and 3230 t/y SO_2.[84]

505. Construction of the project will require cement, electricity, and petroleum fuels which represent an embedded emissions "debt" at the front end of the project and estimated to be 385,630 tCO_2e, not including emissions due to permanent forest cover loss. Total GHG emissions from the inundation of 552 ha of reservoir area is estimated to be approximately 12,169.4 ton CO_2e per year. Reservoir GHG emissions will be further reduced as the proposed design will minimize or prevent reservoir stratification (the implementation of vegetation clearance prior to the reservoir impoundment will reduce the release of CH_4 and CO_2 owing to decomposition of organic matter during operation and corresponding problems of GHG emission), and the power density is greater than 10 Watts per m^2 of reservoir area.[85] The estimated annual emissions reduction is 339,968 tCO_2e; the emissions debt is recovered in 1.04 years of operation at design energy output, and there will be a net reduction of about 350,000 tCO_2e per year. The GHG balance is presented in Table 108.

Table 108: Greenhouse Gas Emissions Balance

GHG Emissions Sources and Sinks	Amount (t/y)
SOURCE: Construction Activities Embedded emissions from cement 718,000 m^3 concrete (WAPCOS EIA Volume 1, Table 2.4), 2.32 tons/m^3; cement is 15% of concrete; cement production emits 0.9 tCO_2e/ton cement, some of which is recovered when the cement (CaO) reacts with air and water to form cement ($CaCO_3$) Embedded emissions = 718,000 x 2.32 x 0.15 x 0.9 = 224,877 tCO_2e 224,877 tCO_2e/25 years = 8,995 tCO_2e/y Electricity consumption during construction 2.705 MW (WAPCOS EIA Volume 1, Table 2.5) running at 8,760 h/y for 5 years; Grid emissions factor at 0.82 tCO_2e/MWh Emissions = 2.705 x 8,760 x 5 x 0.82 = 97,153 tCO_2e 97,153 tCO_2e/25 years = 3,886 tCO_2e/y Emissions from petroleum fuels during construction Fuel consumption during construction: 3 MW of diesel gensets running at 4,000 h/y for 5 years; emissions factor at 1.06 tCO2e/MWh Emissions = 3 x 4,000 x 1.06 x 5 = 63,600 tCO_2e; 63,600 tCO_2e/25 years = 2,544 tCO_2e/y	8,995 + 3,886 + 2,544 = 15,425
SOURCE: Permanent Forest Cover Loss Forest loss: Using coefficient of 5.13 tCO2e per year per hectare of lost forest x 600 ha = 3,078 tCO_2e/y.	3,078
SOURCE: Inundation of Reservoir Reservoir area inundation: Using hydropower reservoir emission factors of 60.4	12,169.4

[83] The estimate does not include consideration of black carbon emissions from diesel-fired back up generation or from coal-fired power plants in the grid mix. Black carbon emissions are shorter-lived in the atmosphere than CO_2 but have much higher global warming potential.

[84] Based on emissions factors for Indian coal fired power plants published in: M. Cropper, S. Gamkhar, K. Malik, A. Limonov, and I. Partridge. 2012. *The Health Effects of Coal Electricity Generation in India*. Resources for the Future DP 12 -25. Washington, DC.

[85] Above this threshold, the Clean Development Mechanism Executive Board does not require consideration of reservoir emissions to be eligible for registration; power density for LKHEP is 21.7 W/m^2.

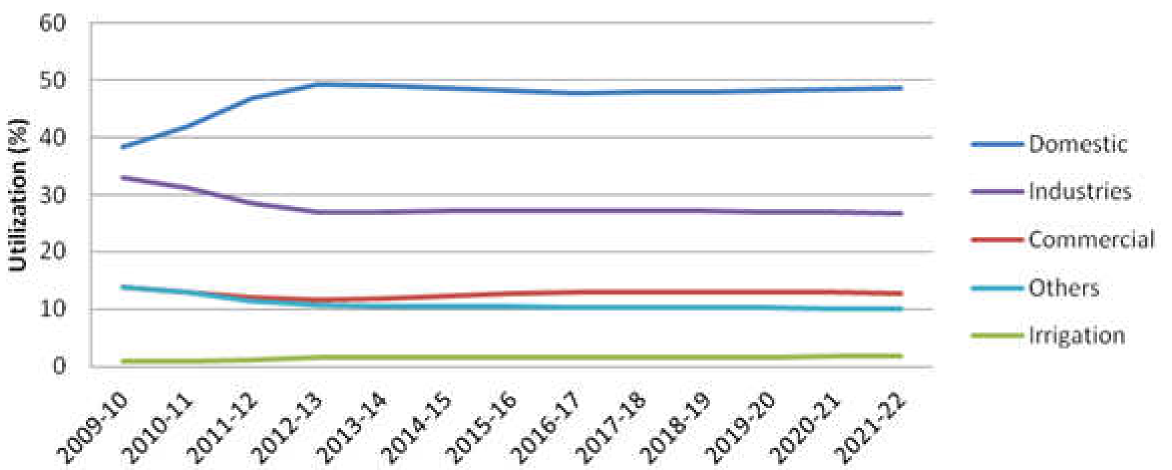
kg CO_2/ha/day[86] (22.046 tCO_2/ha/year) that has variance around ± 145% x 552 ha	
SINK: Power generation 452,000 MWh/y x 0.82 tCO_2e/MWh	- 370,640
TOTAL NET ANNNUAL GHG REDUCTION	**- 339,968**

Notes: Emissions due to forest loss are partially offset by afforestation/reforestation. Grid emissions factor is from Central Electricity Authority, Government of India. 2014. *CO2 Baseline Database for the Indian Power Sector, User Guide, Version 10.0,* December 2014 Government of India, Ministry of Power, Central Electricity Authority, Sewa Bhawan, R.K.Puram, New Delhi-66. Accessed on 14 December 2015 from: http://cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver10.pdf

C. Second Order Impacts

506. Graph 1 presents the projected electricity demand by major consumer categories from 2009-10 through 2021-22. Four major consumer categories account for most of the current and projected electricity demand: domestic, high tension industrial, commercial, and bulk supply. Low tension industrial, public waterworks, irrigation, and public lighting accounted for only 3.8% of total consumption in 2014-15. Available forecasts show that domestic consumption will continue to experience the fastest growth of any consumer category. From 2014-15 going forward, domestic use accounts for the largest share of total consumption and is expected to remain stable at about 48-49%. High tension industrial demand is the second largest category and is expected to remain stable at about 27% of total. Commercial consumption is expected to remain around 12-13%.

Graph 1: Utilization by Consumer Category (%)



507. Table 109 and graph below present the consumption forecasts from 2009-10 through 2021-22, showing overall growth of 221%. From 2014-15 going forward, domestic growth is projected at 71%, commercial at 46%, industrial at 24%, and agriculture at 45%. Water works and street lighting are projected to grow 20% and 21%, respectively. Table 110 and graph below present the sales data from APDCL for the most recent three years data available (2012-13 through 2014-15), which show consistent trends with the projections as presented in Table 109 and Graph 1.[87]

[86] Good Practice Guidance for Land Use, Land-Use Change and Forestry, IPCC National GHG Inventories Programme, 2003.

[87] The values shown in the 2 sets of figures and table are not fully consistent, as they are prepared by different agencies. Table 110 shows actual sales and do not account for transmission and distribution losses.

1. Domestic and Commercial Growth

508. Domestic and commercial consumption mainly refers to lighting, refrigeration, air conditioning, and other appliances. The total output due to project operation would be sufficient to cover 8.9% and 33.7% of domestic and commercial demand in 2021-22, respectively. As presented in Table 108, domestic growth was 22% from year 2012-13 to 2013-14, and 31% from 2013-14 to 2014-15. Domestic growth is expected to follow trends as shown in Graph 2 and 3. Commercial growth was 12% from year 2012-13 to 2013-14, but only 3.6% from 2013-14 to 2014-15. Commercial growth is expected to continue at a relatively modest pace as presented in Graph 2. Growth in these two categories, i.e. domestic and commercial, is due in part to new urbanization and redevelopment of existing urban areas. The long-term environmental impacts will be determined mainly by rational land use planning, land zoning enforcement, traffic management, and expansion of water, sanitation, and solid waste treatment and management services.

2. Industrial Growth

509. Future industrial growth appears to be a certainty based on the GoA’s economic development plans, but growth in electricity consumption has been comparable to commercial consumers. As presented in Table 110, high tension industrial growth was 3.5% from year 2012-13 to 2013-14, and 4.8% from 2013-14 to 2014-15. Industrial consumption is mainly for motive power and chemical processes (e.g., cement, oil refining, fertilizer production, and pulp and paper production). The industrial sector is also the largest user of captive power plants that are mainly diesel-fired except for some facilities in Upper Assam that use natural gas. The total output from project operation would be sufficient to cover 17.5% of industrial demand in 2021-22. The nearest heavy industrial facility is the cement plant at Umrangso, which is supplied by the existing Kopili HEP. Based on the power evacuation system, the cement plant at Umranso will not receive power from LKHEP, but industrial plants connected to the Sankardev nagar substation will benefit.

Table 109: Electricity Forecast (18th EPS, 2011) [Million kWh (MU) except as noted]

Consumption Categories	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Domestic	1251	1582	2136	2581	2805	3003	3216	3443	3722	4024	4351	4704	5086
Commercial (& misc.)	450	494	549	611	680	757	842	937	1014	1088	1166	1251	1341
Public Lighting	6	9	12	16	20	25	31	37	43	51	59	69	79
Public Water Works	51	56	61	67	73	80	87	95	103	111	119	128	137
Irrigation	32	38	51	78	86	94	104	114	126	138	152	167	184
Industries LT	67	75	85	95	107	119	133	147	162	178	194	212	231
Industries HT	1004	1109	1213	1322	1437	1557	1683	1815	1953	2098	2250	2409	2576
Bulk Supply	396	422	449	478	509	543	578	615	655	698	743	792	843
Total Consumption	**3257**	**3785**	**4556**	**5248**	**5717**	**6178**	**6674**	**7203**	**7778**	**8386**	**9034**	**9732**	**10477**
T & D Losses (MU)	1591	1353	1524	1684	1716	1731	1741	1744	1835	1928	2023	2120	2221
T & D Losses (%)	32.82	26.34	25.07	24.29	23.09	21.89	20.69	19.49	19.09	18.69	18.29	17.89	17.49
Energy Requirement (MU)	**4848**	**5138**	**6080**	**6932**	**7433**	**7909**	**8415**	**8947**	**9613**	**10314**	**11057**	**11852**	**12698**
Annual Load Factor (%)	56.24	55.01	55.21	55.41	55.61	55.81	56.01	56.21	56.41	56.61	56.81	57.01	57.21
Peak Load (MW)	984	1066	1257	1428	1526	1618	1715	1817	1946	2080	2222	2373	2534
Peak Load growth (%)		8.33%	17.92%	13.60%	6.86%	6.03%	6.00%	5.95%	7.10%	6.89%	6.83%	6.80%	6.78%
Unrestricted Energy Requirement & Peak Load at Power Station Bus-Bars													
Energy Requirement (MU)	4848	5403	5877	6392	6953	7562	8225	8947	9615	10313	11058	11852	12699
Peak Load (MW)	984	1100	1196	1300	1414	1537	1671	1817	1946	2080	2222	2373	2534
Patter of Utilization (%)													
Category	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**
Domestic	38.41	41.8	46.88	49.17	49.07	48.62	48.19	47.79	47.85	47.99	48.15	48.34	48.54
Commercial	13.82	13.05	12.06	11.65	11.9	12.25	12.62	13.01	13.04	12.97	12.91	12.85	12.8
Irrigation	0.98	1	1.12	1.49	1.5	1.53	1.56	1.59	1.61	1.65	1.68	1.72	1.76
Industries	32.88	31.29	28.48	27	26.99	27.12	27.21	27.24	27.2	27.14	27.06	26.94	26.79
Others	13.91	12.86	11.47	10.69	10.54	10.48	10.42	10.37	10.3	10.25	10.2	10.15	10.11
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100

Graph 2: Energy Consumption Forecast 2009-2022

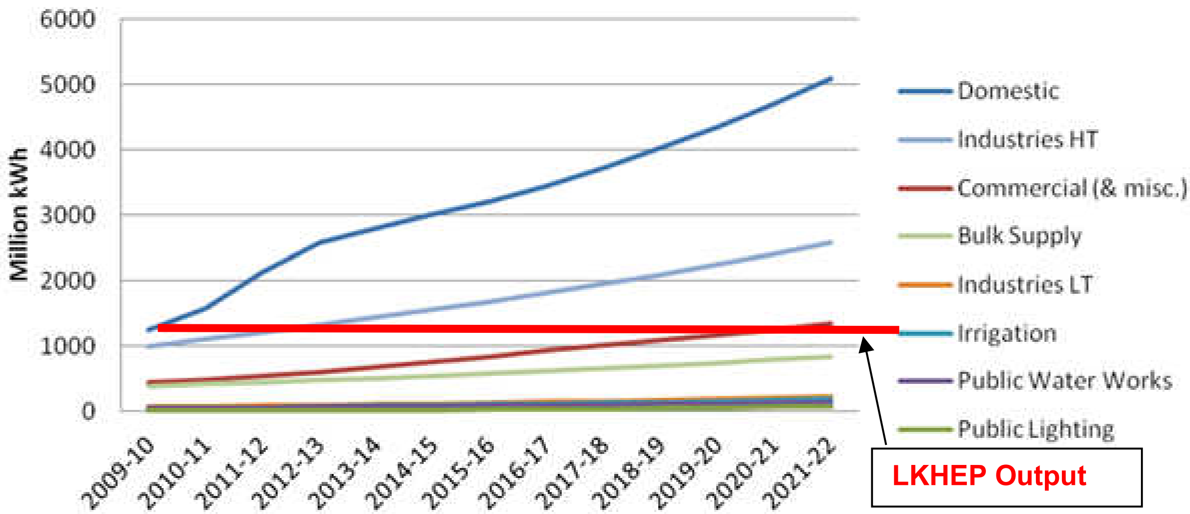
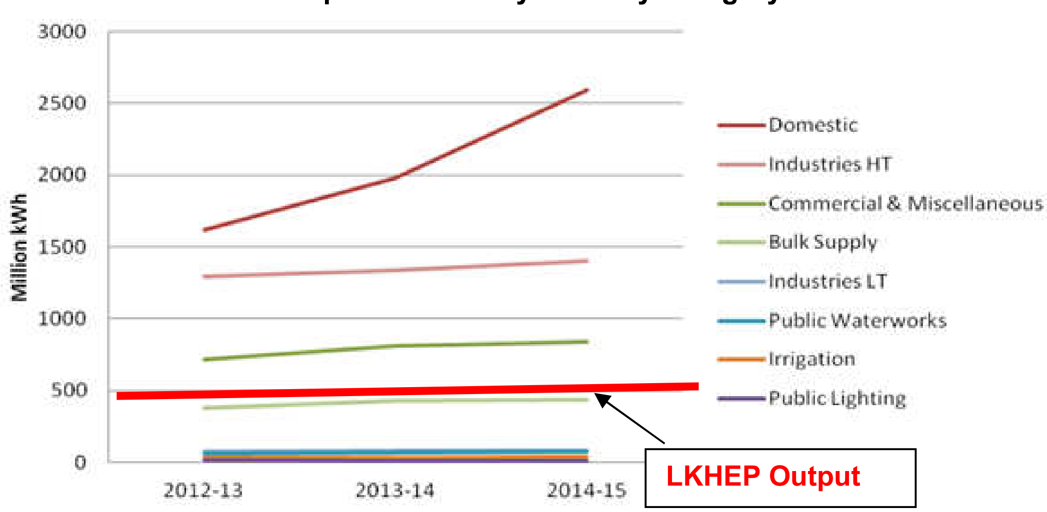


Table 110: Electricity Sales 2012-2015

Categories	2012-13	2013-14	2014-15	2014-15 Share (%)	LKHEP Output Relative to 2014-15 Sales (%)
Domestic	1620	1980	2591	47.26%	19%
Commercial & Miscellaneous	721	809	838	15.29%	60%
Public Lighting	17	13	13	0.24%	3846%
Public Waterworks	63	72	75	1.37%	667%
Irrigation	35	36	39	0.71%	1282%
Industries LT	73	81	82	1.50%	610%
Industries HT	1295	1340	1404	25.61%	36%
Bulk Supply	382	433	440	8.03%	114%
Total	**4206**	**4764**	**5482**	**100%**	

Graph 2: Electricity Sales by Category



510. Environmental impacts of industrial growth are mainly due to primary pollutants affecting air quality, wastewater, solid wastes, and hazardous pollutants (e.g. from petro-chemical manufacturing). Heavy industries could benefit from cleaner production technology upgrades, and could employ distributed generation systems for power supply, which could have compensatory effects if natural gas or RE technologies are employed. The primary mitigating factors are land use planning (industrial estates) and enforcement of existing EIA, EMP, and GoI/GoA environmental regulations.

3. Agricultural Development

511. Agricultural productivity increases are reasonably foreseeable. As presented in Table 110, irrigation growth was 2.9% from year 2012-13 to 2013-14, and 8.3% from 2013-14 to 2014-15. Irrigation is limited by availability of power supplies, and most farmers can only produce one crop per year. Based on the projection presented in Table 109 the total output due to project operation would be sufficient to increase electricity for irrigation by a factor of 2.7 in year 2021-22, and facilitate double cropping (i.e. two crops per year). This potentially increases the magnitude of groundwater withdrawal, but such an increase is inherently limited by the total area of cultivated land and availability of water in the groundwater table. However, comparison of Tables 109 and 110 shows that the projected irrigation growth has been over-estimated, with forecast consumption of 94 million kWh in 2014-15 versus actual sales of only 39 million kWh in 2014-15.

512. As of 2009-10, only about 22% of groundwater resources were being exploited, and growth in electricity sales for irrigation have been much lower than forecast, so any additive effects should be minimal. Assuming that all output due to project operation went towards irrigation, the total groundwater withdrawal could still be sustainable assuming that other sectors are not exploiting groundwater withdrawal at similar rates. Major environmental impacts (synergistic effects) could result from an increase in chemical fertilizer applications, but the incremental expense to farmers would be a limiting factor. Increased cropping should improve farmers' incomes, which is consistent with economic development objectives.

D. Associated Facilities and Related Power Sector Investments

513. If a facility is economically and technically dependent on ADB's direct investment, then it is considered to be an "associated facility" and is subject to due diligence. In the context of safeguards compliance, due diligence is limited to a determination of whether the facilities are in compliance with the host country regulatory requirements and ADB's SPS 2009 requirements. Due diligence may logically include a review of potential financial risks. The safeguards categories of the ADB investments are determined independently.[88]

514. Power sector investments related to LKHEP funded by ADB include: (i) a 70 MW replacement power plant at Lakwa (MFF-083 Tranche 1); (ii) distribution system expansion and upgrades (MFF-083 Tranche 2); and (iii) LKHEP and power evacuation system to connect power from LKHEP to the State grid. The power evacuation system will be constructed and operated by AEGCL. ADB, GoA and GoI are engaged in preliminary discussions regarding future ADB funding of the transmission system.

[88] The ADB Rapid Environmental Assessment checklists do not include associated facilities. Determination that an associated facility is present does not change the category of the ADB-supported investments. ADB standards cannot be imposed readily on the associated facilities.

515. The 70 MW Lakwa power plant is an inside-the-fence supply-side efficiency improvement project to replace 60 MW of an obsolete generating plant. The available natural gas supply for the plant will not increase, but the power capacity and energy output will increase, resulting in reduced emissions intensity. The Lakwa power plant has been fully appraised by ADB, with funding approved in 2014. The distribution system outputs financed under Tranche 2 have also been fully appraised by ADB, with funding approved in 2015. No outstanding environmental issues have been identified for either tranche till 2015.

1. Other Power Plants

516. The proposed project is part of the near- to medium-term generation expansion program for Assam. APGCL operates about 378 MW of generation capacity in the State. About 1,628 MW of net new capacity are at different stages of development, of which about 40% is from the currently proposed supercritical coal project at Margherita in eastern Assam (see Table 111). When the construction of LKHEP is completed, circa 2022, it will account for less than 5% of forecast peak load of 2,534 MW.

Table 111: Assam Power Generation Capacity Under Development

Project	Capacity	Status
Bongaigon Thermal Power Station (Coal) – NTPC Ltd.	500 MW	250 MW to be commissioned in October 2015, of which 130 MW is dedicated to APGCL under power purchase agreement; additional 500 MW is expected to be sold to other states outside of Northeast Region.
Revival of Chandrapur Thermal	60 MW	JV with private sector. Environmental clearance received. Coal linkage awaited.
Margherita Supercritical mine-mouth coal	660 MW	Proposed as Joint Venture with NEEPCO (51%) and APGCL (49%). Coal linkage awaited. DPR under preparation.
TOTAL COAL	***1,220 MW***	No other coal-fired power plants have been identified
Namrup Replacement Plant Combined Cycle gas turbine	100 MW	65% complete; open cycle commissioning expected by year-end 2015
Lakwa Replacement Plant – internal combustion engine natural gas	70 MW	Contract award for principle equipment by year-end 2015; funded by ADB (MFF-083, Tranche 1)
40 MW Titabor Power Project	40 MW	Further development pending confirmation of gas allocation.
30 MW Cachar Power project	30 MW	APGCL awarded gas supply on open tender for ONGCL. Gas linkage confirmation awaited.
TOTAL Natural Gas	***70 MW***	Net addition of 70 MW of capacity due to lack of available gas supplies
Myntriang Stage-1 (3x3 MW); Enhancement of Stage II (1.5 MW) -	10.5 MW	Approximately 57% project work is completed. Commissioning is expected by December 2015.
Borpani Middle Stage II HEP	24 MW	DPR approved by APGCL Board in December 2014.
Borpani Middle Stage I HEP	21 MW	DPR under preparation
Borpani Middle Stage I – barrage toe powerhouse	12 MW	DPR under preparation
Amring HEP	21 MW	n/a
Upper Karbi Longpi	60 MW	n/a
Lower Kopili HEP	120 MW	Environmental clearance granted in Q4 2017.
Total Hydropower	***268.5 MW***	LKHEP represents 45% of hydro capacity under development
Namrup Solar	2 MW	Co-located with Namrup thermal plant. To be proposed under JNNSM. DPR under preparation.
Lakwa Solar	2 MW	Co-located with Lakwa thermal plant. To be proposed under JNNSM. DPR under preparation.
Amguri Solar PV	60 MW	n/a [JNNSM – not APGCL]
Suryataap Solar	5 MW	Off-take tariff set in September 2015; commissioning date unknown

Total Solar	***69 MW***	
GRAND TOTAL	**1,627.5 MW**	LKHEP represents 8.7% of total capacity under development

Notes: Projects by APGCL except as noted. Status details from APGCL Tariff Order dated 24 July 2015 (pages, 16-18) and APDCL Tariff Order dated 24 July 2015 (page 54).

517. Assam imports electricity from outside of the Northeast Region of India mainly through Power Purchase Agreements (PPA) executed by the APDCL. Imports will continue for a foreseeable future as the 1,628 MW capacity expansion would cover 65% of the peak load of 2,534 MW forecast for year 2021-22. In addition to the projects summarized above (Table 111), APDCL has signed PPA to procure 118 MW power from the Nikachhu hydropower station in Bhutan[89] through Power Trading Corporation of India, Ltd. (PTCIL) for a period of 25 years effective from July 2019. APDCL has also requested that the Central government to allocate 500 MW of power from the HEPs at Punatsangchhu-I&II and Mangdechhu in Bhutan. APDCL has signed a power sales agreement with the Solar Energy Corporation of India to procure 20 MW of solar capacity from April 2016.

2. Impacts Summary

518. Figure 66 illustrates first and second-order impacts and corresponding limiting and mitigating factors; the second-order impacts can be assessed by assuming that all of the project energy output is directed to a single consumer category, with the greatest potential impact on agricultural activities. Table 112 characterizes the impacts with respect to additive, compensatory, synergistic, and masking effects. When completed, the project power capacity will contribute 4.7% of the estimated 2021-22 peak load, and energy output will contribute 4.3% of 2021-22 total consumption. The project will take 4 years to complete construction, and civil work is not likely to begin until end of the 2019 fiscal year (at the earliest). Therefore, the project's power and energy contributions will be realized only after fiscal year 2023-24.

[89] The Nikachhu project approved in January 2015, is being financed with support from ADB.

Figure 66: LKHEP Cumulative and Induced Impacts

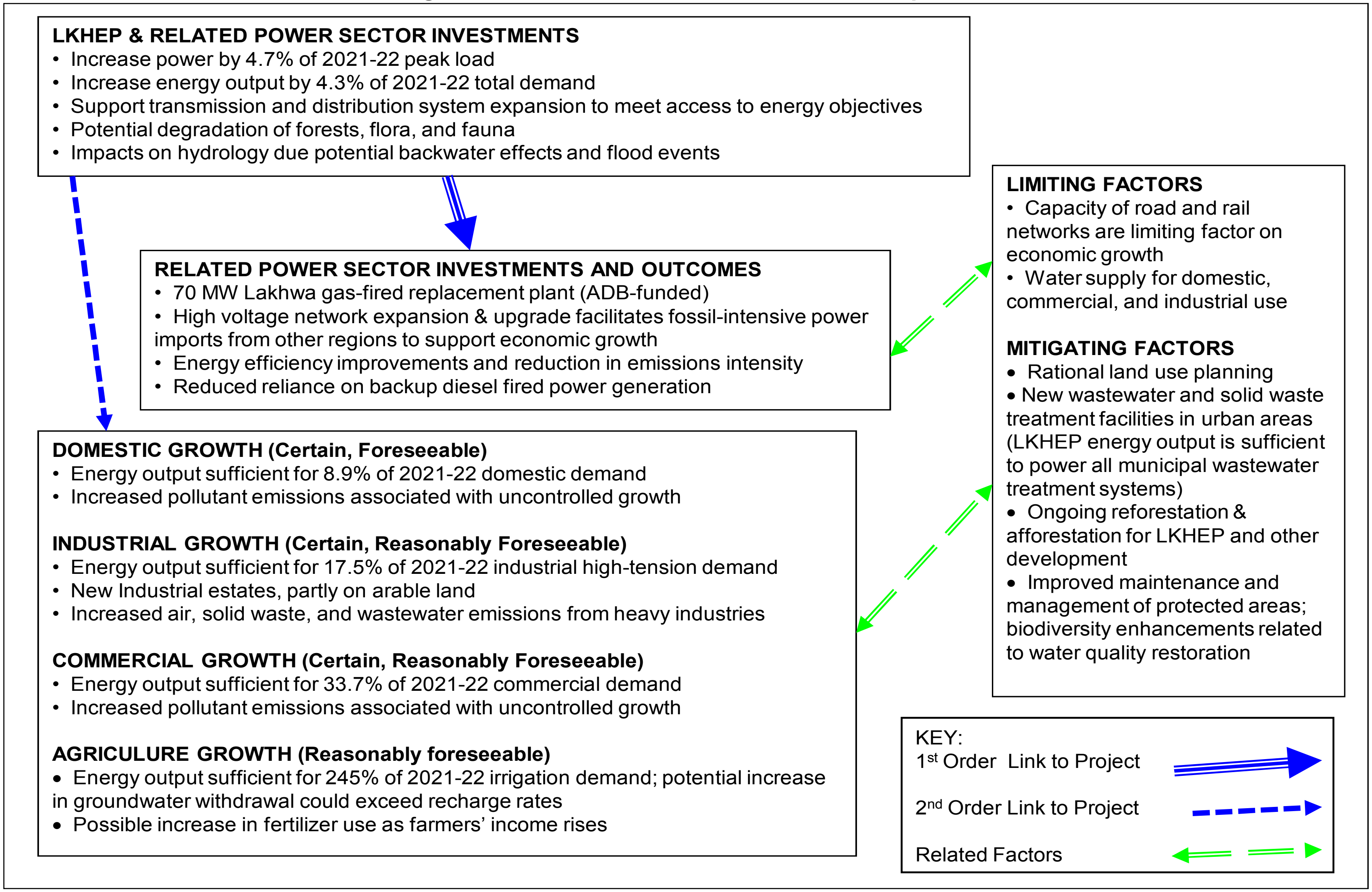


Table 112: Impact Characterization

Related Activities and Sector Growth	Impact Characteristics				Comments
	Additive	Compensatory	Synergistic	Masking	
Related power sector investments	Grid expansion will facilitate increase in electricity consumption from grid mix dominated by thermal power plants. In-state growth of thermal power is limited by availability of coal and natural gas.	Output from LKHEP, new hydropower in NE Region, and imports from Bhutan will reduce emissions intensity and partly offset thermal power growth in Assam. Power system efficiency will improve due to related investments in transmission and distribution system, reducing emissions intensity. Further efficiency improvements are expected from other end-use efficiency gains.	Additional power supplies will support industrial estates and other infrastructure. Commercial and domestic power consumption will increase, with improved efficiency.	New power generation units at Lakhwa will replace obsolete units. Future hydropower development in Assam will be mainly small run-of-river plants. An additional 1,220 MW of coal-fired capacity is slated for development	Investments in new power generation capacity and transmission system expansion are effectively induced by economic growth, rather than *vice versa*. Improved power supplies will benefit social infrastructure, especially public health facilities and schools.
Commercial and Industrial	Air emissions of PM, SO_2, and NO_x could theoretically increase by about 8% to a maximum of 18%; ambient air quality objectives are expected to be maintained.	Value-added employment opportunities create social benefits for local residents, including backward classes/indigenous peoples.	Emissions fallout may be transferred to soil and water.	Limited effects due to rational land use planning and siting. New access roads will not facilitate increased forest and tourist access.	Pollutant emissions can be minimized with advanced, cleaner process technologies. Improved grid-supplied power reduces need for diesel-fired captive and standby generation.
Agriculture	Groundwater withdrawal theoretically could increase by more than 100% to support expanded crop production.	Use of chemical fertilizers expected to be limited in favor of organic fertilizers due to relative costs. Groundwater resources could be stressed if large-scale increase in irrigation occurs.	Excessive chemical fertilizer use could contaminate surface and groundwater.	Expanded agricultural output, including possible expansion of biomass power, will support overall economic growth.	Increased farmers' income is consistent with economic growth and poverty reduction objectives.

E. Sustainability Criteria Assessment

519. The broader impacts of LKHEP may be considered using the following sustainability criteria:

(i) Twelve criteria identified by the UN Economic and Social Commission for Asia and the Pacific (ESCAP), summarized in Table 113;
(ii) Thirteen indicators identified by World Bank (2003), summarized in Table 114; and
(iii) Comparison with other large dams based on reservoir area and number of people relocated per MW of installed capacity (the smaller the flooded area relative to MW capacity and the fewer people displaced per MW of capacity, the better), presented in Table 115.

520. The UN ESCAP and World Bank criteria and aspects are consistent with ADB's SPS 2009. Table 113 shows that the project fulfills all of the ESCAP requirements and can to be defined as "sustainable infrastructure." The project also rates positively on the World Bank's "good dams" indicators shown in Table 114.

Table 113: UN ESCAP Sustainable Infrastructure Criteria

Sustainability criterion	LKHEP aspects/activities
Minimizes resource use and ecological impacts throughout the life cycle	Project is part of an integrated cascade-type development initiated in 1980; upstream hydro plants became operational in 1984; LKHEP will be the last large hydro project on the Kopili River. Environmental and social impacts have been minimized by careful site selection.
Preserves ecosystem integrity	No sensitive ecosystems identified in the area of direct influence. Opportunity to reverse water quality degradation and ecosystem damage caused by acid discharge from illegal upstream coal mining.
Does not aggravate adverse global phenomena such as climate change and ozone depletion	Offsets fossil power expansion with avoided GHG emissions estimated at 352,000 tCO_2e per year. Use of ozone depleting substances will be minimized through adoption of best management practices.
Delivers economically viable goods and services	Economically viable and will provide badly needed power supplies to consumers in an energy-starved region: annual design output is sufficient for about 450,000 people at merit consumption of 1,000 kWh/yr/person. (EIRR > 12%)
Maximizes long-run economic growth for the benefit of all	New electricity supplies will be delivered through the state grid and will enhance supply to nearby communities. The project design is consistent with least-cost power system expansion plan for Assam and Northeast Region of India.
Financially viable	Financially viable with WACC < FIRR
Is managed and operated in a sustainable way	Environmental and social safeguard frameworks will ensure sustainability in addition to technical, economic, and financial viability including impacts of acid water on life of the project (note that the upper Kopili HEP is still functional, despite low pH).
Is socially inclusive	All consumers in grid-serviced areas will benefit. Directly affected people in the project area support the project and will benefit through the project owner's Corporate Social Responsibility (CSR) program.
Contributes to reducing poverty	Yes, commercial energy services are necessary for economic development and poverty reduction in the region.
Contributes to meeting the SDGs	Yes, energy is a necessary input to meet SDGs.
Appropriate for the stage of development and context	Yes, the project is part of the state's development program for conventional large-scale power assets.
Accepted and supported by	Yes, based on need for reliable energy to support economic

general population	development.
Source: *Greening Growth in Asia and the Pacific: Follow-up to the World Summit on Sustainable Development: Taking action on the Regional Implementation Plan for Sustainable Development in Asia and the Pacific, 2006-2010* (UNESCAP, 2008). ADB uses similar terminology to describe sustainable infrastructure; see Asian Development Bank, *ADB In Focus: Sustainable Infrastructure* (Manila, 2009).	

Table 114: Indicators for "Good" and "Bad" Dams (World Bank 2003)

Indicator	LKHEP aspects
Reservoir Surface Area	552 ha/120 MW = 4.6 ha/MW. See Table 115 – compares favorably with 10 "best" of 49 dams assessed by World Bank (2003)
Water Retention Time in Reservoir	Approximately 7 days. Opportunity to reverse water quality degradation caused by illegal upstream mining.
Biomass Flooded	[Some farmland will be flooded mainly due to inundation of 553 ha of land.]
Length of River Impounded	Less than 6 km
Length of River Left Dry	Partially dewatered section of the river between dam and powerhouse is about 5.6 km and about 8.3 km further downstream during peaking power operation.
Number of Down river Tributaries	5 tributaries (within 10 km d/s sections from LKHEP) are noted in the draft EIA (WAPCOS, Section 5.2), the catchment areas are summarized above in Table 111; no flow data available but these tributaries appear to be perennial based on review of Google Earth imagery.
Likelihood of Reservoir Stratification	Froude number < 1 indicates potential for stratification which is minimized by (i) Underflow sluice/spillway design and (ii) 20% e-flow that will be harnessed by APH at toe of dam. Total GHG emissions from the project is estimated to be approximately 12,169.4 tCO_2/yr, from 552 ha. inundation of reservoir area.
Useful Reservoir Life	50 years based on dead storage volume divided by the design sedimentation rate/reservoir area
Access Roads through Forests	Site is within 1 km of Lanka-Umrangso road; 11 access roads totaling 13.10 km will be required; native forest will not be disturbed.
Persons Requiring Resettlement	18 families. Assuming 5 people per household, 0.75 people/MW of capacity will be relocated. See Table 115 – compares favorably with 9 "best" of 49 dams assessed by World Bank (2003)
Critical Natural Habitats Affected	No critical habitats identified within area of direct influence.
Fish Species Diversity and Endemism	Opportunity to reverse water quality degradation caused by acid discharge from illegal upstream coal mining, supporting rejuvenated aquatic flora and fauna. Aquaculture to be considered as part of environmental and social management plans.
Cultural Property Affected	No cultural property identified in area of direct influence.
Source: World Bank. 2003. *Good Dams and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects*. Latin America and Caribbean Region, Sustainable Development Working Paper Number 16. World Bank; Washington, D.C., November 2013.	

521. As shown in Table 115, Compared to 50 large dams assessed by the World Bank (2003), the project ranks 11th best based on flooded area per unit of generation capacity, and within the top 10 best in terms of people displaced per unit of generation capacity, both are good indicators of the overall environmental and social impacts of projects with large dams: the smaller the flooded area relative to MW capacity and the fewer people displaced per MW of capacity, the better. The generation capacity per flooded area is commonly referred to as power

density, and may be taken as an indicator of the potential for GHG emissions (estimated at 12,169.4 tCO_2/yr) arising from the reservoir.[90] In terms of similar capacity and geographic setting, the project is closer to the Nikachhu project in Bhutan than other facilities presented in Table 115.

Table 115: LKHEP Compared to 50 Large Dams (listed from smallest Flooded Area/MW)

Project (Country)	Rated Capacity (MW)	Reservoir Area (ha)	People Displaced	Flooded area (ha/MW)	People Displaced / MW
Nikachhu (Bhutan)*	118	4.9	55*	0.04	0
Arun II (Nepal)**	402	43	775	<1	2
Pehuenche (Chile)	500	400	0	<1	0
Pangue (Chile)	450	500	50	1	<1
Guavio (Colombia)	1,000	1,530	4,959	2	5
Tehri (India)	2,400	4,200	100,000	2	42
Ghazi Barotha (Pakistan)	1,450	2,640	899	2	< 1
Nam Theun-Hinboun (Laos)	210	630	0	3	0
Ertan	3,300	10,100	30,000	3	9
Fortuna (Panama)	300	1,050	446	4	1.5
Lower Kopili (India)	120	552	135	4.6	< 1
Chixoy (Guatemala)	300	1,400	3,445	5	11
Grand Coulee (United States)	6,494	33,306	10,000	5	2
Three Gorges	18,200	110,000	>1,300,000	6	>71
Tarbela (Pakistan)	3,478	24,280	96,000	7	28
Salvajina (Colombia)	270	2,030	3,272	8	12
Zimapan (Mexico)	280	2,300	2,800	8	10
Itaipu (Brazil/Paraguay)	12,600	135,000	59,000	11	5
Victoria (Sri Lanka)	210	2,270	45,000	11	214
Kararao/Belo Monte (Brazil)	8,381	116,000	n.a.	14	n.a.
Aguamilpa (Mexico)	960	13,000	1,000	14	> 1
Betania (Colombia)	510	7,370	544	14	> 1
Urra I (Colombia)	340	7,400	6,200	22	18
Mangla (Pakistan)	1,000	25,300	90,000	25	90
Bakun (Malaysia)	2,400	70,000	9,000	29	4
Ataturk (Turkey)	2,400	81,700	55,000	34	23
El Cajon (Honduras)	300	11,200	4,000	37	13
Ilha Solteira (Brazil)	3,200	125,700	6,150	39	2
Guri Complex (Venezuela)	10,300	426,000	1,500	41	<1
Salto Grande (Argentina/Uruguay)	1,890	78,300	n.a.	41	n.a.
Nam Theun II (Laos)	1,086	45,000	5,700	41	5
Arenal (Costa Rica)	157	7,000	2,500	45	16
Yacyreta (Argentina/Paraguay)	3,100	165,000	50,000	53	19
Tucurui (Brazil)	3,980	243,000	30,000	61	8
Narmada Sagar (India)	1,000	90,820	80,500	91	81
Porto Primavera (Brazil)	1,815	225,000	15,000	124	8

[90] A decision by the Clean Development Mechanism (CDM) Executive Board noted that hydro projects with power density higher than 10 W/m^2 of reservoir area did not need to consider GHG emissions from flooded biomass in order to qualify for CDM registration. The power density for the LKHEP is 21.7 W/m^2.

Project (Country)	Rated Capacity (MW)	Reservoir Area (ha)	People Displaced	Flooded area (ha/MW)	People Displaced / MW
Churchill Falls (Canada)	5,225	665,000	0	127	0
Khao Laem (Thailand)	300	38,800	10,800	129	36
Kedung Ombo (Indonesia)	29	4,600	29,000	159	1,000
Kainji (Nigeria)	760	126,000	50,000	166	66
Pak Mun (Thailand)	34	6,000	4,945	176	145
Cabora Bassa (Mozambique)	2,075	380,000	250,000	183	120
Aswan High (Egypt)	2,100	400,000	100,000	191	48
Nam Ngum (Laos)	150	37,000	3,000	247	20
Sobradinho (Brazil)	1,050	415,000	65,000	395	62
Kariba (Zambia/Zimbabwe)	1,260	510,000	57,000	405	45
Balbina (Brazil)	250	236,000	1,000	944	4
Akosombo (Ghana)	833	848,200	80,000	1,018	96
Bayano (Panama)	30	35,000	4,400	1,167	147
Kompienga (Burkina Faso)	14	20,000	1,842	1,426	132
Brokopondo (Suriname)	30	160,000	n.a.	5,333	n.a.

n.a. = Data not available.

Sources: Compiled from Goodland 1997, Goodland 1995, Mason 1995, several World Bank project reports, and data provided during the World Commission on Dams Regional Consultation (Sao Paulo, Brazil, August 1999).

Notes:

The data are approximate.

* For Nikachhu (Bhutan), the project directly impacts 11 households, but no houses require relocation.

** Arun II (Nepal) has not been constructed.

Installed capacity is the power generation potential of a project (i.e., the nameplate capacity) and not the power actually generated but is easier to calculate *ex ante*.

This table should **not** be interpreted as an endorsement *per se* of those projects with favorable ratios of hectares flooded or people displaced per megawatt. Some of the projects with favorable ratios in this table nonetheless have other, unfavorable siting characteristics in terms of the other criteria noted in World Bank (2003); some others were relatively well sited, but implementation of environmental or social mitigation measures was inadequate.

This table includes a few multipurpose projects for which hydroelectric power was less important than other objectives (e.g. irrigation water for the Aswan High Dam in Egypt).

F. Conclusions

522. LKHEP will expand power supply and improve efficiency in the Assam State electricity grid, with significant reduction in emissions intensity from the project operation. As gas supplies to the Lakhwa plant are currently limited to requirements for the existing power generation units, the air pollutant load will not increase; rather, emissions intensity will reduce. Other ambient environmental objectives are expected to be met after the power plants become operational. Based on the due diligence conducted till date, the power evacuation system will not have significant environmental impacts.

523. Cumulative and induced impacts are expected to result from domestic, commercial, agricultural, and industrial sector growth. In the case of agriculture, groundwater pumping could increase theoretically by at least 100%, which could stress available groundwater resources.

Additive impacts from industrial development could be mitigated by rational land use planning and enforcement of existing GoI and GoA environmental regulations.

524. The ADB-funded investments will have cumulative and induced impacts, which may be mitigated effectively under the GoI and GoA regulatory regime and ADB's SPS 2009. This preliminary finding is elaborated under SEIA.

Check this link for article on elephants in Assam
http://www.academia.edu/6680408/Understanding_spatial_and_temporal_patterns_of_human_elephant_conflict_in_Assam_India

Note on potential reservoir stratification; calculation of Densimetric Froude number, F:
F = 320 x (L/D) x (Q/V)
If F > 1, stratification is not expected.

Where:	*L = length of reservoir (m)*	*= 6000 m*
	D = mean depth (m)	*= 70 m*
	Q = flow (m^3/second)	*= 138 m^3/s*
	V = reservoir volume (m^3)	*= 106 million m^3*

F = 320 x (6000/70) x (138/106,000,000) = 0.0357
As F < 1, stratification can be expected.

Stratification will be avoided and/or minimized by construction of underflow sluice and e-flow through the dam to the auxiliary powerhouse at the toe of the dam.

VII. CLIMATE CHANGE IMPACTS AND RISKS

525. HEPs are likely to be affected by climate change, An initial climate risk screening and a climate risk and vulnerability assessment (CRVA) studies have been carried out for LKHEP by ADB in 2017. The summary of these assessments is presented in this section while the detailed report on CRVA is provided as Annex 8.

A. Climate Projection

526. **Temperature**: By 2050s, annual mean temperature in the project area is projected to increase by 2.48 ^{0}C under the RCP8.5 emissions scenario. The highest temperature rise is projected to occur in December (>2.75 ^{0}C) and the lowest in July (<2.19 ^{0}C).

527. **Precipitation:** Under the same scenario, annual total precipitation is projected to increase by 206 mm or 7.6% by 2050s. The increase is projected to occur overwhelmingly during the May-October monsoon season (190mm, 8.8%). Precipitation during dry season (January to April) is projected to decrease slightly.

B. Climate Impacts

528. **Reduced Reliability of Power Generation in Dry Season:** Climate change may result in serious adverse impacts on water resources by significantly increasing the intra-annual as well as seasonal variability of river flow. Changing hydrological flows due to increased and more variable precipitation will impact hydropower generation and the run-of-river type of hydropower generation is more susceptible to the impact of climate change. Power generation during the monsoon season will not be significantly affected as there will be sufficient river run-off. Variability in river run-off should be adequately accounted for by using the diurnal storage. For the dry season, reduced river flows and depleted reservoirs can significantly decrease hydropower output, in a result, power generation will be less reliable. Since the proposed project will only be used as peaking station during the dry season, the diurnal storage may help reduce the climate vulnerability.

529. **Storage Capacity and Sediment Flushing:** The projected increase in monsoon precipitation is likely to result in exacerbated soil erosion within the watershed. Increased sediment load entering the storage will not only result in reduced water storage which requires more frequent flushing of sediment, but also cause damages to turbines and exacerbated flood risks.

530. **Damages to Equipment**: The rivers in the Himalayan region often transport sand with the highest Quartz content. Quartz is very detrimental to the turbines. Increased sediment load due to increased precipitation intensity may accelerate the wearing of equipment.

531. **Effluents from Opencast Coal Mining Sites in the Upstream Areas are Highly Acidic**. Increased precipitation during the monsoon season may result in more effluents from the mining sites.[91] Acid effluents are highly erosive and corrosive, which will damage the turbines and other equipment. The wear and tear due to erosion/corrosion caused by acid mine discharge will reduce the efficiency and the lifespan of the equipment leading ultimately to economic loss.

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[91] The upper reaches of the river Kopili have been adversely affected by acid drainage from illegal mining in upstream areas and also affected operations of upstream Kopili HEP since 2006. A decision in 2014 by the National Green Tribunal (NGT) has reportedly resulted in curtailment of illegal mining upstream with concomitant improvements in water quality/acid drainage due to illegal and uncontrolled rat hole mining upstream in State of Meghalaya

C. Screening Results

532. **Natural/Climatic Hazard**: The geo-environmental setting of Assam makes the State highly susceptible to multiple hazards caused by geological, climatic and hydrological factors. The main hazards include: 1) earthquake; 2) Flood; 3) Landslide; 4) Lightning; and 5) Cyclone wind.

533. **Project Components**: 1) Soil erosion could impose a serious problem to the sediment flushing schedules due to increased precipitation and storms. A detailed study on the sediment generation and load within Kopili basin has been conducted; 2) Acid coal mine discharge is a detrimental problem within the watershed. Sustainable watershed management including the restoration of ecosystems within the watershed are proposed as part of the WQRP and IWRMP Report; 3) Cyclones may bring gusty winds to the project area, therefore the transmission lines must be able to withstand strong winds. Adequate design measures for tower footing has been included in the design.

534. Based on the climate risk screening results, the proposed project is envisaged as a High Risk for Multi-Hazard Index and Climate Impacts. Overall, the project is categorized as high for Climate Risk.

D. Required Actions/Recommendations

535. **Earthquake:** In order to prevent the uncontrolled rapid release of water from the reservoir of a storage dam during a strong earthquake, the dam must be able to withstand the strong ground shaking from even an extreme earthquake referred to as the Safety Evaluation Earthquake (SEE) or the MCE. Large storage dams are generally considered safe if they can survive an event with a return period of 10,000 years, i.e. having a one percent chance of being exceeded in 100 years. LKHEP falls in high risk category for earthquake (CRVA). The site specific earthquake study has been completed by Department of Earthquake Engineering, IIT Roorkee. The site specific design parameters for MCE and DBE conditions are recommended as 0.36g and 0.18g for horizontal and 0.24g and 0.12g for vertical ground motion, respectively.

536. **Landslide:** The project site is prone to a medium risk of landslides (however, none are observed in the project area, based on detailed analysis of 2017 GoogleEarth images). In any case, slope stabilization should be implemented to protect all physical structures (such as powerhouses, dams, access road, pylons, etc.). In the project design slope stabilization measures such as providing retaining walls, geotextile and biotechnical turfings etc. are included. Regular monitoring of the watershed is also recommended.

537. **Flash Flood:** Flood risks have been included in the project design. Spillways and flood outlets are designed to safely convey major floods to the watercourse downstream from the dam. They are selected for a specific dam and reservoir on the basis of release requirements, topography, geology, dam safety, and project economics. The design spillway capacity of LKHEP with catchment of 2,106 km^2 is 16,110 m^3. Compare this with the spillway capacity of the upstream Khandong dam on the same Kopili river with catchment area of 1,256 km^2 being 15,471.3 m^3. It is clear that the design spillway capacity of LKHEP is inadequate. Considering future risks of flash floods on dam safety, it is recommended that an allowance be added to the volume to cope with the projected increase in peak flow. This allowance should be estimated using projected climate change scenarios. A dam break analysis and disaster management plan (Annex 30) has been prepared to deal with dam failures. Design of the spillway will be reviewed by project management consultant and necessary design changes will be incorporated in the final design by EPC contractor.

538. **The overhead transmission lines must be able to withstand strong winds.** A minimum overhead clearance of transmission lines must be maintained for safety. Material to reduce thermal sag (e.g., aluminum conductor composite core – ACCC) may need to be specified at project design stage.

539. **Lightning protection must be installed for the power supply component of the project.** Lightning surges may cause serious damages to the expensive equipment in the power supply system for LKHEP. Lightning protection must be implemented.

540. **Sedimentation:** The Himalayan rivers often transport sand with a high Quartz content. Therefore, to reduce risks of such materials into the turbine flow, particular attention must be given to the design of the structural arrangements of LKHEP. The consideration of this aspect is of prime importance if the project engineers/designers intend to use de-sanding structural arrangement in LKHEP. De-sander in certain cases may not be a viable solution and the project engineers/designers should carefully evaluate the need, viability, and the cost benefit ratio before considering it as a necessary project component. For run-of-river HEPs, an efficient sediment flushing arrangements are also necessary. A detailed study on the sediment generation and load within Kopili basin has been conducted and included in the DPR (Annexure 6). Sluice spillway outlets with continuous flushing provision are proposed in LKHEP to deal with sedimentation issues.

541. Adequate measures in CRVA to prevent equipment corrosion must be implemented.

VIII. ANALYSIS OF ALTERNATIVES

A. Introduction

542. This section presents the symmetrically compared feasible alternatives to the proposed LKHEP project. Since the project is a new project, alternatives such as other sources of energy (Biomass and/or waste-to-energy, Solar, Wind, Thermal, Hydro–annual storage), tandem operation with Kopili HEP, multiple small HEPs, longer tunnel with smaller dam, proposed design etc. have been considered and analysed for its likely impacts on various environmental parameters. Additionally, an evaluation of potential environmental impacts in terms of 'with' and 'without' project situation has been considered for the justification of the project. This section also presents a discussion on how environmental parameters were assigned due importance and considered in the analysis of alternatives.

B. Assam Power Sector Context

543. The project is part of the near-to-medium term electricity generation expansion program for Assam. APGCL operates about 378 MW of generation capacity in the State. About 1,378 MW of net new capacity is at different stages of development, about half of which is from the proposed Margherita supercritical coal project in eastern Assam (see Table 111). When the construction is completed, circa 2022, it will account for less than 5% of forecast peak load of 2,534 MW.

Table 116: Assam Power Generation Capacity Under Development

Project	Capacity	Status
Bongaigon Thermal Power Station (Coal) – NTPC Ltd.	250 MW	250 MW to be commissioned in October 2015, of which 130 MW is dedicated to APGCL under power purchase agreement; additional 500 MW is expected to be sold to other states outside of Northeast Region.
Revival of Chandrapur Thermal	60 MW	JV with private sector. Environmental clearance received. Coal linkage awaited.
Margherita Supercritical mine-mouth coal	660 MW	Proposed as Joint Venture with NEEPCO (51%) and APGCL (49%). Coal linkage awaited. DPR under preparation.
TOTAL COAL	***970 MW***	No other coal-fired power plants have been identified
Namrup Replacement Plant Combined Cycle gas turbine	100 MW	65% complete; open cycle commissioning expected by year-end 2015
Lakwa Replacement Plant – internal combustion engine natural gas	70 MW	Contract award for principle equipment by year-end 2015; funded by ADB (MFF-083, Tranche 1)
40 MW Titabor Power Project	40 MW	Further development pending confirmation of gas allocation.
30 MW Cachar Power project	30 MW	APGCL awarded gas supply on open tender for ONGCL. Gas linkage confirmation awaited.
TOTAL Natural Gas	***70 MW***	Net addition of 70 MW of capacity due to lack of available gas supplies
Myntriang Stage-1 (3x3 MW); Enhancement of Stage II (1.5 MW)	10.5 MW	Approximately 57% project work is completed. Commissioning is expected by December 2016
Borpani Middle Stage II HEP	24 MW	DPR approved by APGCL Board in December 2014.
Borpani Middle Stage I HEP	21 MW	DPR under preparation

Project	Capacity	Status
Borpani Middle Stage I – barrage toe powerhouse	12 MW	DPR under preparation
Amring HEP	21 MW	n/a
Upper Karbi Longpi	60 MW	n/a
Lower Kopili HEP	120 MW	Environmental clearance received in Q4 2017.
Total Hydropower	***268.5 MW***	LKHEP represents 45% of hydro capacity under development
Namrup Solar	2 MW	Co-located with Namrup thermal plant. To be proposed under JNNSM. DPR under preparation.
Lakwa Solar	2 MW	Co-located with Lakwa thermal plant. To be proposed under JNNSM. DPR under preparation.
Amguri Solar PV	60 MW	n/a [JNNSM – not APGCL]
Suryataap Solar	5 MW	Off-take tariff set in September 2015; commissioning date unknown
Total Solar	***69 MW***	
GRAND TOTAL	**1,377.5 MW**	LKHEP represents 8.7% of total capacity under development

Notes: Projects by APGCL except as noted. Status details from APGCL Tariff Order dated 24 July 2015 (pages, 16-18) and APDCL Tariff Order dated 24 July 2015 (page 54).

544. **Power Supply from Other Sources:** Assam imports electricity from outside of the Northeast Region of India mainly through PPA executed by APDCL. Imports will continue for the foreseeable future, as the 1,378 MW capacity expansion shown in the Table 116 above would cover 54% of the peak load of 2,534 MW forecast for year 2021-22. In addition to the projects summarized above, APDCL has signed PPA to procure 118 MW power from the Nikachhu HEP in Bhutan[92] through PTCIL for a period of 25 years effective from July 2019. APDCL has also requested that the Central government of India allocate 500 MW of power from the HEPs at Punatsangchhu-I & II and Mangdechhu in Bhutan. APDCL has signed a power sales agreement with the Solar Energy Corporation of India to procure 20 MW solar power from April 2016.

545. **LKHEP Development History***:* The project was identified in the 1980s as part of a cascade-type hydropower development program including the existing upstream Kopili HEP. The cascade concept was seen as a logical complement to thermal power in part because HEPs could provide daily peaking power. In the project area, the river Kopili has not been used extensively for fisheries or irrigation. The gradient and topography in the project area are suitable for high-head HEP development. Except for the proposed Karbi Longpi upper stage 60 MW project (not in the same catchment), LKHEP is the last large hydropower project identified for development in Assam; all other hydropower concepts are less than 25 MW capacity (not in the same catchment. LKHEP is the last HEP in Kopili river catchment (see Table 111).

546. A DPR was prepared for the project in 1987 which provided analysis of alternatives and configurations for a design capacity of 150 MW. In 2006, the DPR was updated to account for a 20% e-flow, and as a result design capacity decreased to 120 MW. The project is now at an advanced stage of regulatory clearances. The project represents about 45% of hydropower capacity under development and about 8.7% of total generation capacity slated for development in Assam (see Table 116). Various alternative hydro designs, other energy resources, and technology options as well as their costs and impacts are summarized in Tables 117 and 118.

[92] The Nikkachu project is being financed with support from ADB approved in January 2015.

Table 117: Summary of Potential Environmental Impacts for Various Alternatives

Alternative	Soil & Land	Geology	Hydrology	Water Quality	Air Quality	Noise	Flora/Fauna	Employment	Socio-Culture
No project	n/a	n/a	n/a	n/a	Indirect degradation due to increased use of diesel & other fossil fuels for power generation (relative to the proposed project)			Energy shortage constrains growth of employment opportunities	
Biomass and/or waste-to-energy	May require plantation-based feedstock		Direct impacts if large-scale plantations are developed for feedstock		Requires robust emissions control systems	Localized impacts can be readily mitigated	Direct impacts if forests are cleared for plantations for feedstock	Employment in supply chain may be higher than the proposed project	
Solar	Minimal impact		Indirect impact from equipment manufacturing		n/a	Quietest option for utility-scale operations	No impact with rooftops; minimal for solar farms	Employment in supply chain may be higher than the proposed project	
Wind	Minimal	n/a	Indirect impact from equipment manufacturing		n/a	Noise and vibration may create nuisance to nearby residents	Minimal for large-scale wind farms on unused & unproductive land	Employment in supply chain may be higher than the proposed project	
Thermal	Direct impacts associated with fossil fuel extraction		Direct impacts from water use & wastewater discharge		Requires robust emissions control systems	Noise control can be readily implemented	Direct impacts from site clearing & pollutant emissions	Employment gains may be offset by public health impacts	
Hydro–annual storage	Similar to proposed project		Greater impacts due to storage effects		Deeper reservoir may have higher potential to create GHG emissions	n/a	Greater impacts due to larger reservoir	n/a	Greater indirect downstream impacts
Tandem operation with Kopili HEP	Lower impacts than proposed project as no new diversion structure and reservoir would be required. Inflow from catchment area below existing Kopili tailrace would not be disturbed				n/a	n/a	Uncertain: no new reservoir would be created, but partial dewatering of river would increase	Employment creation less than for the proposed project	
Multiple smaller HEPs	Impacts might be greater depending on site-specific cumulative footprint		Impacts may be lower depending on turbine/generator technology used		n/a	n/a	Impacts may be lower depending on turbine/generator technology used	Employment creation may be greater than for the proposed project	
Longer tunnel with smaller dam	Lower impacts than proposed project due to smaller reservoir. Dewatered stretch of river would be longer than proposed project.				n/a	n/a	Dewatered stretch of river would be longer than proposed project.	n/a	n/a
Proposed design	Soil and bedrock excavation is required, but issues of sediment mobilization can be properly managed.		Impacts mainly during low-flow season	Low pH from upstream illegal coal mining is the main issue; LKHEP will not contribute to that.	Reduced emissions relative to other options	Impacts mainly during construction	Impacts can be mitigated effectively and may be offset via constructed wetlands for water quality restoration, and compensatory afforestation (CA), as well as monitoring and habitat management in the large contiguous forest patch south of the project areas.	1,000 jobs during construction and 300 during operations	Boom cycle during construction. Disruption for 1,842 families (8,631 persons total)

Notes: n/a = not applicable

Table 118: Relative Costs for Alternatives

Alternative	Capacity Required [a]	Installed Cost ($/Watt) [b]	Total Cost ($million)	Cost of Energy ($/kilowatt-hour)	Notes
Biomass and/or waste-to-energy	90 MW	$1.5 – 3	$135 M - $270 M	>$0.12	Higher installed cost for cogeneration technology
Solar	270 MW	$1.5	$405 M	> $0.09	Cost of energy is sensitive to cost of funds
Wind	180 MW	$2	$360 M	$0.11	Cost of energy is sensitive to cost of funds
Thermal	80 MW	$1	$80 M	$0.07 – 0.09	Cost varies with fuel type
Hydro – annual storage	120 MW	> $2	> $240 M	> $0.10	Higher upfront capital cost
Tandem operation with Kopili HEP	120 MW	< $2	< $240 M	< $0.10	Smaller reservoir but longer section of partial dewatering
Multiple smaller hydro projects	~ 120 MW	$2.5 – 4	$300 M - $480 M	~ $0.10	Higher aggregate upfront capital cost
Selected Power house site, smaller dam with longer tunnel	120 MW	~ $2	~ $240 M	~ $0.10	Higher tunneling risk offset by lower dam construction risk
Proposed design	120 MW	$2	~ $240 M	$0.10	Cost of energy assumes commercial financing rates

[a] Equivalent capacities are estimated assuming energy output of 470,000 MWh/year and typical plant load factors (PLF) for different energy resources and generation technologies. Estimates are rounded off.
Biomass @ 60%: 470,000/(8,760 x 0.6) = 89.4 MW Solar @ 20%: 470,000/(8,760 x 0.2) = 268.3 MW
Wind@ 30%: 470,000/(8,760 x 0.3) = 178.8 MW Thermal@ 70%: 470,000/(8,760 x 0.7) = 76.6 MW

[b] Does not include transmission connection cost

C. Various Alternatives

547. **No project/no new generation capacity:** The “without project” alternative would continue the status quo, with energy shortages constraining access to energy and economic growth in the State. Energy supply shortfalls would be met through imports and use of back-up generators using petroleum fuels. Environmental impacts would accrue in other States and Assam due to import of electricity and from continued use of petroleum-fired generators, respectively. In the absence of new generation capacity, transmission and distribution (T&D) system and end-use efficiency improvements could deliver substantial energy savings to offset the need for new generation capacity (and/or electricity imports). For example, reducing state-wide projected T&D system losses in year 2020-21 from around 18% to 13% would yield electricity savings roughly equivalent to LKHEP total output; alternatively stated, 5% T&D loss reduction could be delivered theoretically as a “virtual power plant.”

548. **Biomass and/or waste-to-energy:** Installed costs will depend on configuration, e.g., power will be at the lower end of the range only while cogeneration will be more expensive. In turn, the cost of energy will depend on installed cost and feedstock cost. De-risking the feedstock supply chain would be required for a bankable project. Waste-to-energy plants require

an established waste collection system to ensure feedstock supply. Biomass plants are typically limited to 25–35 MW per plant due to feedstock capture radius limitations; therefore 3 or 4 plants would be required for energy output equivalent to the proposed design of the project, and 3-4 transmission connections would be required (increasing the total grid "footprint"). Sugarcane is grown in the project area, but sugarcane bagasse cogeneration could be developed only if a sugar mill were constructed in the area; this additional upfront capital cost would make the biomass project much higher than indicated in Table 118. Biomass does not appear as an attractive alternative based on the complexities associated with securing the supply and the additional upfront development costs. Biomass could complement the project development but not a viable alternative to the project.

549. **Solar:** The estimated installed costs and cost of energy reflect recent bids for utility-scale ground-mounted projects in India; installed costs for rooftop systems are higher. Utility-scale solar requires 2 to 2.5 ha/MW installed capacity; therefore, a total of 675 ha would be required to generate equivalent output to the proposed project. Solar has some load-following characteristics, with typical maximum solar output occurring in the mid-afternoon. Energy storage would be required to time-shift the peak solar output to match evening peak demand period. Additional costs for energy storage are not included. As installed system costs and levelized cost of energy decline, solar will be an increasingly attractive option, but mainly as captive and distributed generation such as the 2 MW projects proposed at the Namrup and Lakwa thermal power stations. Since LKHEP design includes diurnal storage capacity, solar is a logical complement but not a viable alternative to the project.

550. **Wind:** The estimated costs are based on project experience in India. Assam has no proven wind resources to exploit; site-specific wind monitoring for 1 year would be required to complete a bankable feasibility study. For some sites, maximum wind output might occur in the evening, coinciding roughly with evening peak demand. Additional costs for energy storage are not included. Similar to the case for solar as an alternative, wind power is a logical complement but not a viable alternative to the project.

551. **Thermal:** Coal and natural gas fired power plants generally exhibit lower installed costs than a large HEP, but the variable operating and maintenance costs tends to increase over plant lifetime and are more pronounced compared to a large HEP. Currently, gas supplies are not readily available for additional capacity development in Assam, and coal supplies are tentatively committed to the power projects at Bongaigon, Chandrapur, and Margherita (see Table 111).

552. **Hydropower with annual/multi-year storage:** An annual/multi-year storage scheme is consistent with LKHEP design providing a baseload output during high flow season and peaking power during low flow season, but the project site is not amenable to a larger reservoir than currently planned and an alternative site for a larger storage scheme has not been identified. Capital costs would be higher, which in turn would increase cost of energy. Environmental and social impacts would be higher due to greater hydrologic disruption and larger reservoir area, with modest incremental benefits.

553. **Tandem operation with Kopili HEP:** This is possibly the best alternative among hydropower options with respect to costs and environmental considerations, but requires commercial and technical agreements with NEEPCO and clearances from central and state government planning and regulatory agencies. This alternative would eliminate the project reservoir, but would require partial dewatering of the river from the existing Kopili HEP powerhouse to the proposed project powerhouse site, with greater potential impacts (on ecological aspects in upstream as well as downstream) due to dewatering, compared to the

proposed project. With this configuration, LKHEP would be a pure run-of-river operation depending solely on the outflow from the Kopili powerhouse, and the benefits of project peaking operation during low-flow season would not materialize. A preliminary feasibility assessment would be required, which if positive would be followed by preparation of a DPR.

554. **Multiple smaller hydro plants:** Installed costs shown in Table 118 are for low-head configuration with commercially-available modular generation systems. Costs for additional switchyards and transmission infrastructure are not included. Smaller low-head projects could still be developed downstream but would require new feasibility assessment. The cumulative impacts of multiple smaller plants may be greater than the proposed project design, new access roads would be required during construction, and each plant would include some basic infrastructure for operating personnel.

555. **Selected project area with longer tunnel and smaller dam:** In theory, the same energy output could be generated by harnessing the design flow through a longer tunnel to utilize higher elevation difference (higher head). This could be achieved with a smaller diversion structure and smaller reservoir area (which would reduce peak generation in the low-flow season), but the dewatered section of the river would be longer (about 10.5 km compared to present 5.6 km). If the proposed main powerhouse site were utilized, a new diversion site would need to be identified, and vice versa if the dam site were retained. It may be possible to achieve the same output as the proposed project by reducing the installed capacity and running the plant more hours per year; such a configuration would have a different annual profile of baseload versus peaking output. This alternative poses higher construction risk for the tunnel component which could be offset by reduced dam construction risk. The dam and powerhouse sites were selected as part of the cascade scheme including the upstream Kopili HEP, i.e. alternative dam and powerhouse sites have already been considered as discussed in Section D below.

556. **Proposed Design:** Costs of energy assumes purely commercial financing costs; the actual cost should be lower with ADB financing. The proposed dam and main powerhouse sites were selected in order to optimize generation output so that the plant operates at full capacity in high-flow season (baseload operation) and provides peaking power in low-flow season. With respect to the power capacity, energy output, costs, and risks, the proposed design appears to be optimum with respect to the various alternatives discussed above.

D. Various Alternatives for LKHEP Components

557. As part of project feasibility study various alternatives for project components (dam site, HRT, power house locations) have been analyzed and based on due considerations to topographical features, technical, economic, environment and social considerations, final option has been selected. Technical requirements were the main driver for the selected alternative, since environmental features within the area considered are not significantly different from one location to the other (see GoogleEarth images presented earlier).

558. **Dam Axis/Location**: Two alternatives dam axes have been studied as there was no better dam location than these two. Alternative dam axis was studied at 155m upstream of the finally selected dam axis. This site was explored by few drill holes. This location was not preferred due to: i) depth of weathering was more at this site in comparison to finally selected site, and ii) there was very small outcrop of Granite/Granite gneiss on this location than existence of many big out crops at the finally selected dam axis.

559. **Alternative study for other components:** ***Alternative study 1:*** It was proposed to construct a 71.35m high concrete gravity dam, intake structure located at 350m upstream of the dam axis, 7.5m dia horse shoe shaped HRT, 31.0, dia open to sky surge shaft, 5.8m dia circular pressure shaft, shaft type (semi underground) power house and TRT. Later on, it was observed that excavation and stabilization of 36m deep power house pit in overburden and weathered rock would cost more and space constraint to keep unit auxiliaries and their panel.

560. **Alternative study 2A:** In this study dam site was kept same. Power intake was shifted to 35m upstream of final dam axis, realignment of HRT, refixation of surge shaft location, shifting of power house location 300m d/s of alternative study 1.

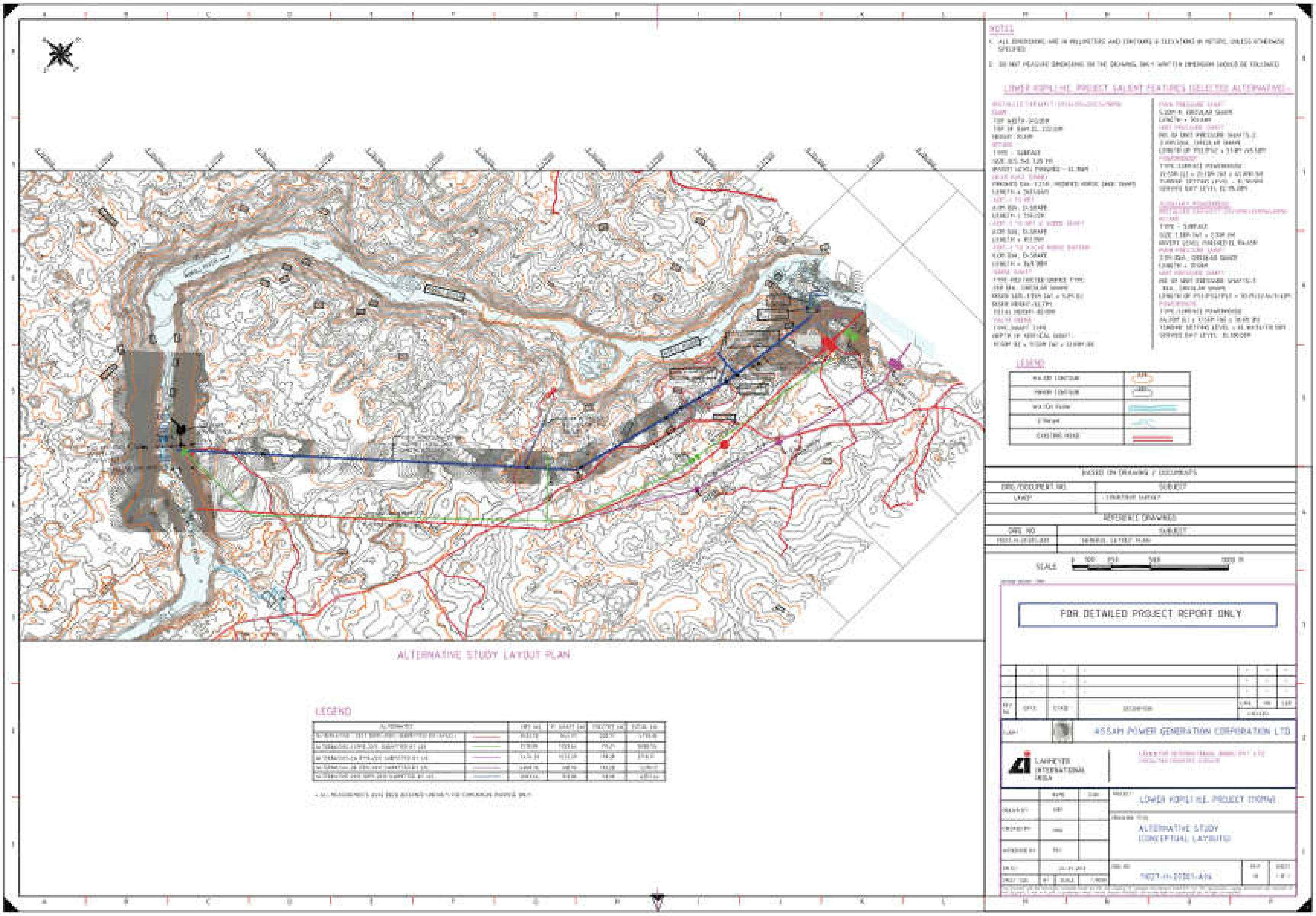
561. Two alternative surge shaft were studied i.e. 2A & 2B. A 1,277m long pressure shaft at alternative 2A was not considered as it was more than 5 times the effective head which would create operation problem in electro-mechanical equipment.

562. In study 2B, surge shaft at alternative location was considered. At this location, 70m surge shaft was to be constructed as massive chimney type structure. Due to not stability of surge shaft location and long pressure shafts, this alternative 2 was not considered.

563. Final Location: Dam axis has been kept same place as alternative 1 & 2. Power intake is kept 35m U/S of dam axis, HRT, Surge shaft, pressure shaft & power house have been shifted downstream side as shown in the attached drawing. As per this alternative, HRT having 7.25m dia horse show shaped and 3,604m long, 25m dia surge shaft, one pressure shaft of 5.20m dia and surface power house. Extension geological exploration have been carried out at these locations and found suitable.

564. The alternative studies and the finally accepted location is shown Figure 67.

Figure 67: Layout Plan of Alternatives



IX. CONSULTATION, PARTICIPATION AND INFORMATION DISCLOSURE

565. In accordance with ADB's SPS 2009 and EIA Notification of GoI (2006), public consultations were held, as part of comprehensive EIA study. The consultations were undertaken with project beneficiaries, local/government officials, community leaders, non-government organizations (NGO's), stakeholders in the PIA and people likely to be affected due to the project implementation. Specific attentions were given to women and disadvantaged groups including vulnerable communities during the consultations. Topics of discussion included various issues affecting these stakeholders and appropriate responses that would result in incorporation of beneficial environmental and social measures.

A. Objectives of Consultations

566. The process of public participation/consultations was taken up as an integral part of the project in accordance with environmental and social assessment requirements. The objectives of the stakeholder consultations are:

- To ensure the stakeholder engagement of the whole process;
- To inform and educate the general public, affected communities/persons and other stakeholders about the proposed project activities;
- To familiarize the affected communities/persons and other stakeholders with technical, environmental, social and economic issues of the project for better understanding;
- To solicit opinions of the affected communities/persons on current environmental and social issues and assess the significance of environmental and social impacts due to LKHEP;
- To secure inputs with respect to project planning, selection of mitigation measures and monitoring strategies;
- To foster co-operation among officers of the executing agency, ADC of Dima Hasao and Karbi Anglong, affected communities/persons and other stakeholders to achieve a working relationship for smooth implementation of the project;
- To solicit opinions of the affected communities/affected persons of their willingness to participate in the project via bottom up planning and decision making process and securing local acceptance of the project;
- To inculcate the sense of belongingness among the public about the project.

B. Methodology used for Public Consultations

567. Both formal and informal modes of consultation were used in the public consultation process for the project. Consultation with the stakeholders, beneficiaries, and community leaders were carried out using standard structured questionnaires as well as unstructured questionnaires. In addition, focused ground discussions (FGDs) and personal discussions with officials, on-site discussion with project affected stakeholders, and reconnaissance visits have also been made to the project area. The attempts were made to encourage participation in the consultation process of the government officials from different departments that have relevance to the project. Similarly, local people from different socio economic backgrounds in the villages as well as urban areas with the PIA, women groups, residents at upstream, downstream and catchments area of the Lower Kopili dam, local commuters, and other concerned stakeholders were also consulted.

C. Consultation and Participation Process

568. In acquiring ADC lands for a public purpose by GoA, there is a two-tier consent seeking consultation program. The first tier is the ADC's consent to transfer tribal land to a non-tribal purpose vis-a-vis issuance of a no-objection certificate (NOC). The Dima Hasao ADC and Karbi Anglong ADC issued a provisional NOC for implementing LKHEP on 29 July 2015 and 15 September 2015, respectively. The second tier of consent is the agreement among the affected households, APGCL–Executing Agency (EA), the relevant ADC, and the GoA. For the second tier of consent, a series of consultations and negotiations have been conducted between affected communities/affected persons (APs) since 2009 while the ADB project team (including environment and social safeguards consultants) joined several of these consultations since 2014.

569. Details of first tier and second tier consent seeking consultation program including methods of consultations, key issues addressed during consultations and negotiations, etc. are provided in RTDP, Section V– Consultation, Participation, and Information Disclosure while the photographs and attendance sheets of all consultations are placed in Annex 6 of this EIA. The issues raised are mostly related to land and compensations mechanism. There were no significant environmental issues raised, since there are no fish in the river, and wildlife observations that were noted apply to areas north and south of the project area. Also, there are no residential areas in the forest patch between the highway and the Kopili River, where the project works will be (residences in the flooded reservoir area are addressed with the R&R Plan).

570. Between November 2014 and November 2015, ADB project team (and environment and social consultants) have attended three public consultations at the proposed project site. APGCL officially notified all concerned stakeholders regarding the place, time, and venue of the consultations. These consultations have been attended by members of the EA and their field staff, Gaon Buras, representatives of the ADC Dima Hasao and Karbi Anglong, representatives of the left bank and right bank (of River Kopili) Lower Kopili Hydroelectric Project's Affected Persons Associations (LKHEPAPAs), affected communities/persons (APs), local area NGO called Rural Development and Upliftment of Society, Forest Department rangers, local Revenue Officers, Student Union representatives of Assam Democratic Student Union, and Karbi Anglong Student Union, etc. The number of participants during consultations varied from 17 to 40 persons (involving 15-20% female participants).

571. Key points discussed during the public consultations were as follows: i) the affected communities showed a public acceptance of the project, mainly due to anticipated provision of basic infrastructure (roads, bridges, water and electricity connection and supply, education and health services) as well as access to employment opportunities (contract, civil works, etc.); ii) compensation payments for resettlement and development of alternative livelihood options (for people in the reservoir area) such as employment in power plant, community based livelihood programs for affected communities; iii) the affected communities anticipate deriving monetary benefit from the EA's Corporate Social Responsibility (CSR)-Community Development Scheme as per GoI Circular dated 19 May 2012 and MoEF&CC ToR memo dated January 30, 2014; and iv) biodiversity in the project area is poorly documented, but consultations confirmed the presence of Asian elephants in and around the project area as well as the Chinese Pangolin[93]; v) the affected communities confirmed the importance of access to areas affected by the

[93] Elephant is considered as endangered (EN) under the IUCN conservation status while Chinese Pangolin is considered as Critical (CR); both are on Schedule I of the Indian Wildlife Protection Act (1972) which is the highest protection accorded to species.

proposed project for livelihood such as hunting, collecting firewood, obtaining water to maintain their tribal cultural practices. Alternate access roads have been proposed where access is restricted by the project. Also the water requirements of the local people are mainly obtained from small tributaries. Project will also provide access to project water resources to meet domestic needs of the local people.

572. The above key points are recurrent topics that have come up at various consultative meetings and negotiations. The consent of the affected communities/persons to handover their tribal land and other property for the proposed project are contingent upon the satisfactory implementation of the above key points and potential project sustainability. The matrix below shows (see Table 114) that the EA, ADCs, and GoA have agreed to address these key points in consultation with the affected communities and their representatives.

573. Meetings with other relevant Government agencies (Forest Department, Assam Biodiversity Board, Brahmaputra Board, etc.) were also carried out to assess the project approach and gather pertinent information related to LKHEP project.

574. In addition to above public consultations, between 4 and 7 March 2016, ADB safeguard team carried out gender (women centric) consultations in six project affected villages 94. A total of 71 women attended these consultations. Additionally, on 6 March 2016, ADB safeguard consultants carried out consultations with affected persons who will be physically displaced due to the project. A total of 8 persons from 8 such households (HHs) in Dima Lanku village were interviewed. The major issues raised are mostly related to land and compensation and outcome of consultations is presented in the RTDP, Section V- Consultation, Participation, and Information Disclosure, Table 119 and 120. Record of Consent Seeking Consultation is provided in Annex 6 of this EIA.

575. Consultations with affected communities and other relevant stakeholders will continue throughout the life of the project (through a Communication and Consultation Plan), and will be open and gender inclusive and also focused on disadvantaged people. The consultation process will be undertaken under the direction and supervision of PMU, EA.

Table 119: Consent Seeking Consultations Held by ADB/EA in the Project Area

Place and Date	Issues Discussed	Opinions & Consensus	Response and Action Taken
Lonku March 18, 2015 Total participants 17 Lonku LP	• Details about the project • Broad community support for the project • Preservation of traditional tribal livelihoods • Biodiversity of the project area • Payment of Compensation – calculation, payment	**Community Support** • The affected communities /persons showed public acceptance of the project, mainly due to anticipated rehabilitation of basic infrastructure in the area as well as access to employment opportunities for the locals. • The discussions pointed out the need for an efficient and dynamic coordination among the LKHEPAPA (right bank of the river), LKHEPAPA (left bank of the river), and the two ADCs to ensure a common understanding of the proposed project and facilitate resettlement and livelihood restoration programs. **Preservation of traditional tribal livelihoods**	• Basic infrastructure in the project area will be enhanced by project. • Consultations with ADCs and local people are ongoing and will be continued.

[94] The six affected villages are Longku, Boro Lonku, karbin langso, Krungming Langso, Digramhdisa and Toto langsho.

Place and Date	Issues Discussed	Opinions & Consensus	Response and Action Taken
School June 2, 2015 Total participants 35 Lonku LP School November 24, 2015 Total participants 44 Gender related consultation across 6 affected villages March 4 – 7, 2016 Total (women) participants 71	schedule. • Possibility of an enhanced compensation for acquired property • Employment opportunities for the affected persons (Aps) and future potential livelihood support derived from the project • Proposed Development Measures as part of project benefits • CSR-CD Activities; adequacy and distribution • Gender issues pertaining to development measures, compensation payment and relocation	• The affected communities/persons rely on forests (Reserve Forest, Proposed Reserve Forest, Unclassified Forest, and/or Community Forest) for medicinal herbs, collection of dry twigs used as fuel for cooking, native construction material for house building, and for grazing of flocks. The affected communities/persons confirmed the importance of maintaining their access to forests so that they can continue to collect firewood and water, maintain traditional hunting and jungle product collection practices. This is considered as a vital aspect of their traditional tribal livelihoods. Thus, the need for taking adequate measures to preserve the cultural identity of the local peoples while the area is going through a rapid change and development is agreed and reiterated. **Biodiversity** • The Krugming Reserve Forest (RF) in Dima Hasao and the District Council RF in Karbi Anglong is home to wild elephants among other animals. The affected communities experience frequent movement of elephants from Longku side and Panimur side–both situated on the right bank of River Kopili in Dima Hasao. Wild elephants also cross left bank to right bank from within the District Council RF in Karbi Anglong up to and across to Dima Hasao. • The movement of wild elephants is typically intensified during the rainy season when these animals move out from the Reserve Forest area in search of food to other nearby areas. Note: the forest ranger Panimur did not know of a specific elephant corridor. Additionally, the Reserve Forests also hosts animal species such as Stag (moso), Chinese Pangolin, Deer (meesai), Wild Boar, Monkeys (magusa), Jackal, Birds such as the wood pecker (daojgaima), and some reptiles. **Compensation** • Compensation payments for resettlement and development of alternative livelihood options were highlighted as one of the key issues affecting the communities and potential project sustainability. The participants at the consultation meeting suggested that the rate of compensation determined by the two ADC in 2012 needed revalidation. The EA have informed the	• Livelihood of the local people will not be affected by the project. Project will also support livelihood programs. • Biodiversity conservation program has been proposed which also include monitoring of movement of wild animals. A biodiversity management committee which also include local forestry officials has been proposed in the project. • MoUs have been signed with ADCs. Compensatio n will be paid directly in

Place and Date	Issues Discussed	Opinions & Consensus	Response and Action Taken
		stakeholders that the base rate as determined in 2012 was revised by adding a premium of Rs 50,000 per *bigha* of land. This makes the total compensation 80 percent more than the original compensation rate. The compensation should be paid as a lump sum into each affected person a joint bank account, if the affected person is married. If unmarried, the money should go to affected person's bank account payable by a crossed cheque. • Tripartite arrangement among the EA, the two ADCs, and the LKHEPAPAs (right bank and left bank) is essential and required to ensure easy and efficient payment of compensation packages to the affected persons. **Enhanced Compensation** • An agreement between the EA and ADCs regarding the provision of 5 percent of power generated by the project as free electricity or 5 percent of gross revenue were discussed. It is decided that the ADCs and EA will discuss a mutually agreeable plan and sign a Memorandum of Agreement (MoA) to finalize the plan in consultation with GoA. **Employment Opportunities** • The affected communities/persons highlighted that the project should provide employment to the local persons. It was suggested that at least 80 percent of non-technical jobs should be given to local persons. Priority should be given to the qualified local persons in recruiting employees for Grade III and IV positions. Due consideration should also be given to the local persons in filling technical positions of the project related activities. • The civil contracts between Rs 0.3 million and 0.5 million are to be given to the local persons or their associations after meeting the tender conditions and other regulations. **Proposed Development Measures** • The affected communities /persons face continuous challenges due to lack of basic infrastructure such as access to portable water, electricity, health care, education (schools), and sanitary facilities. It was suggested that it is necessary to develop a Local Area Development Plan that targets improvement of educational facilities, health care facilities, infrastructure facilities such as	bank account of affected person. • MoUs have been singed with ADCs. • MoUs been singed with ADCs has employment provisions for local people. • Project has provisions for basic infrastructure for local

Place and Date	Issues Discussed	Opinions & Consensus	Response and Action Taken
		roads, and living standards. The plan would also provide Livelihood improvement training, particularly to young adults including women. The EA was requested to prepare a plan with a budget for this activity in addition to their proposed CSR program for the area. • All stakeholders present agreed that the relocation sites should be suitable for agricultural production and other livelihood requirements. The resettlement sites should also be provided with drinking water facilities, access to forest resources and grazing lands. **CSR-CD** • The project-affected communities expect to receive monetary benefit from the APGCL's CSR agenda as per the GoI Circular dated 19 May 2012 and the MoEF&CC ToR Memo, dated January 30, 2014. • The APGCL confirmed that 2 percent of the gross revenue from the project from the first 4-5 years of operations could be set aside for its CSR activities. This will be about US$ 900,000) per year, based on the estimated average tariff of about $0.10/kWh as per the project DPR. The CSR program will provide substantial value addition and should be advertised as an extra effort of the APGCL to ensure project's sustainability. **Gender** • The discussions focused on gender related issues and identified the importance of sustainable (and long term) employment generation opportunities integrating local resources and traditional cultural practices. • Enhancement of self-help group (SHG) [95] vis one-time payment to each SHG thereby enabling group members to buy capital assets (such as sewing machines, handloom machines, pigs, goats, and cows). This will help improve their livelihoods, and engage in durable employments. • Skill-based training programs for women to help with household income generation activities; training members in book keeping, financial management as well as vocational training in manufacturing and marketing of	people. • Relocations sites will be selected in consultations with local administration with access to basic facilities. • MoU signed with ADCs has basic provisions. • Provisions are made for gender specific programs and schemes.

[95] A self-help group (SHG) is a small voluntary association of the persons often of the same socio-economic class; most often a SHG promotes small savings among its members and such savings are kept in a bank. Practically in each affected village, there are women run SHG. Each member of the group saves Rs 50 to100 per month and the savings are deposited in a common deposit account at a bank. This money is used to provide loans to the group members when they need money for children's education and emergency medical expenses.

Place and Date	Issues Discussed	Opinions & Consensus	Response and Action Taken
		bamboo and wood-based products. • Access to local resources such as bamboo and timber for making bamboo and wood-based products and local traditional garment production. • Promotion of income generating activities undertaken by women (such as animal husbandry, beekeeping, poultry, piggery, dairy farming) vis training and capital assistance. A provision of a training centre/community hall in an accessible location within the project area is necessary to locate such village development programs. • Construction of a high school in a nearby location to help students (particularly girls who drop out early due to distance and time taken to travel to current school) finish their education; establishing a scholarship program for girls who complete their basic education (with merit). • Access to piped water (portable) supply as a part of the Local Development Program since potable water is a major problem in the project area. In summer, wells dry up and as a result, women walk up to 3 to 4 km to fetch water.	

D. Stakeholder Consultations

576. As part of supplemental environmental assessment studies, a State level (involving Meghlaya and Assam States) stakeholder engagement workshop in Shillong, Meghalaya has been conducted on 7 October 2017. Attendees included representatives from the key government agencies from Assam and Meghalaya States, regional Central government agencies, educational institutes, ADB, NGOs, and individual among others. The findings of WQRM and IWRMP have been discussed during the workshop. The participants recognized the need of an institution to manage the water resources of the basin in an integrated way. However, the decision on the form of the institution-a formal RBO with a full mandate or a coordinating institution, would only be decided by high level representatives of key agencies of both Assam and Meghalaya. Detailed minutes of the meeting are provided in WQRM Report.

577. Another stakeholder meeting has been organized on 6 February 2018 at Assam Water Resource Management Institute (AWRMI) in Guwahati. The objective of meeting was to discuss recommendations of the IWRM and WQRM findings including proposed Hydromet Monitoring & Flood Management System for Kopili River Basin. The meeting was attended by officials from WRD, Assam; AWRMI, FREMA, APGCL, ADB consultants, NERWALM and PMC. All the particpants were on the view that a coordinated efforts from all concern agencies is required to implement any measures in the river basin.

Welcome remarks by ADB	Welcome address by APGCL

Key note by MOEF&CC, Shillong Office Representative

Presentation on IWRM Component

Stakeholder Meeting in Guwahati, IWRMI

Stakeholder Meeting in Guwahati, IWRMI

578. The consultation process will continue during next phases of the project. As per ADB's SPS 2009 requirements a consultation will be organized once the EIA is completed. ADB has previously participated in the consultations and it will also participate in next consultations.

E. Public Hearing

579. In order to fulfill GoI EIA requirements for Category A projects, a formal public hearing has been conducted by the Assam State Pollution Control Board (ASPCB) on 10 January 2017 at the project site. The advertisement for the public hearing was issued in the local daily newspaper “The Assam Tribune” on 6th December 2016 publication. Representatives from both the affected districts attended the public hearing meeting. APGCL has coordinated with ASPCB and local district administrations of Dima Hasao and Karbi Anglong for conducting the public hearing. The public hearing was attended by over 200 people representing ADC members, local communities, APs, civil society and non-government organization (Dima Hasao Rural Development Society). ASPCB has submitted the official report on the public hearing proceedings to EAC of MoEF&CC. EAC has considered the recommendations of the public hearing while issuing the environmental clearance (EC) to the project.

580. The issues raised by the public and their replies by the government officials, APGCL, EIA/DPR Consultants are presented in Table 120.

Table 120: Issues raised and Response given during Public Hearing

S.No	Name & Address	Issue Raised	Remarks on the Issues Raised
1.	Mr. Prabin Hojai, Secretary, LKHE Project Affected Peoples Association	The sand is presently available and extracted from Kopili river. What will be the effect on river Kopili after the project is operational.	The sand quarries are identified in specific locations where deposition of sand going on for many years. There will be no effect on the identified sand quarries during project operation phase.
2.	Mr. Pratingttajai, Secretary, LKHE Project Affected Peoples Association	He welcomed the project Submitted a memorandum for their demand points in the proposed project area people and explain the details of memorandum	Response to demanding points are enclosed in Public Hearing Report.
3.	Mr. Dorsing Engis, on behalf of local people of Longren area	What’s the Rehabilitation and socio-economic development Plan of the Lower Kopili HEP	Right to Fair Compensation and Transparency in land Acquisition Rehabilitation and Resettlement Act, 2013.
4.	Mr. KamediInghi, Karbi, Anglang District of Assam	He requested the project proponent for reassessment of the affected area for the project	joint assessment comprising representatives of respected District Councils, APGCL were carried out in 2012. APGCL has accordingly submitted the assessment proposal to Govt. of Assam, and based on the same, Govt. has allotted the necessary funds to APGCL. Thus, reassessment at this stage will be difficult. Both the councils were agreed to the fact 2012 be the cut off year.
5.	Mr. Saysing Durang, Asstt. Secretary, DimaHarao Rural Development Society, an NGO	He suggested to fix a date for fulfillment the demand of local people by APGCL	Date may be fixed up by the Rural Development Society. APGCL, authorized representatives of District councils and administrations. APGCL is free to discuss any constructive

S.No	Name & Address	Issue Raised	Remarks on the Issues Raised
			issues at any time.
6.	Mr. Martin Tarang, Local people	He asked that whether the picnic spot in the downstream of Kopili river will be safe from the project. He also suggested to plant with local fruit species.	Efforts will be made to protect the picnic spot during construction as well as during operation of the project. There is a provision for plantation as well as Green Belt Development Plan in the project area. About 1600 trees/ha including fruit bearing trees will be planted.

Source: Public Hearing Report (Feb 2017) submitted by ASPCB to the MoEF&CC

581. During the time of public hearing three nos. of Memorandum from local people were received by ASPCB. The Memorandums and reply by ASPCB and APGCL are included in the public hearing report. Figure 68 show the images of public hearing.

Figure 68: Photographs of Public Hearing Proceedings

Public Hearing Notice displayed at several locations


Gethering at Public Hearing Venue


Presentation of Project and EIA by Project Proponent and Consultant


Interaction from Participants

F. Interaction with Local/National and International NGOs

582. In order to get independent views on the likely impacts of LKHEP, NGOs at local as well as international level were consulted during the EIA process. This includes Indian Bird Conservation Network (IBCN); World Wide Fund for Nature-India (WWF-India) Assam Office;

student associations and local self-help groups. Representations given by the South Asia Network on Dams, Rivers and People (SANDRP) to MoEF&CC were also incorporated in the project design. The IBCN is active in protected areas of Assam whereas the WWF do not have direct activities in the project area. Local NGOs consulted also included Dima Hasao Rural Development Society, Rural Development and Upliftment of Society, and other local civil societies.

583. Aspects such as conservation activities, presence of flora and fauna, likely project impacts and possible mitigation measures were discussed and views and suggestions from these NGOs (mostly related to catchment area treatment, health and safety of workers and livelihood of local people) were incorporated in the EMP. Consultation will continue with these NGOs during project construction, implementation and operation phases.

G. Information Disclosure

584. APGCL will be responsible for disclosing EIA in compliance to ADB's Communication Policy 2011 and ADB's SPS 2009. The draft EIA will be disclosed in the English language in the office of APGCL. Summary of the EIA report will also be published in Hindi and Asamese language. The report and translated summaries will also be made available to interested parties on request from the office of the APGCL (Guwahati; and also in the nearest local Government office). Since this is Category A project, the draft EIA report will be disclosed to the public through ADB website, 120 days before the approval of the tranche 3 for ADB financing. The draft EIA report will also be made available to all stakeholders as part of the consultation process required under the ADB's SPS 2009. The final report will also be disclosed on ADB website.

585. The consultation and information disclosure will be continued during implementation phase as well. The proposed consultations and information disclosure plan during project planning and implementation are presented in Table 121.

Table 121: Format for Public Consultation and Information Disclosure Plan

Project Activity	Approach	Issues to Discuss	Schedule	Responsible Agencies[96]
Detailed Survey (Walk over)	• Informal /formal briefing of project to households situated in and around the project area via public consultations including gender (women-centric) Focused Group Discussion (FGD) and consultations with physically displaced persons/HHs. • Informal briefing of project to villages/HHs situated along the RoW for	• Discuss with affected communities /persons and other stakeholders on anticipated environmental impacts, safety issues, mitigation measures, current tribal cultural practices, and biodiversity in and around the project area and proposed ROU • Discuss with the affected	Pre-Construction Stage	PMU/SESC/NGOs/ LKHEPAPA

[96] PMU – Project Management Unit; SESC - Social and Environmental safeguards Cell; NGO – Non-governmental organization; LKHEPAPA – Lower Kopili Hydroelectric Project Affected Persons' Association; EA – Executing Agency (APGCL); ADB – Asian Development Bank

Project Activity	Approach	Issues to Discuss	Schedule	Responsible Agencies[96]
	proposed power evacuation viz 220 kV DC and 33 kV SC transmission lines • Consultative meetings on resettlement and rehabilitation of 18 households	communities/persons/HHs their entitlements, compensation and Jirat rates, payment, time line for delivery, and the grievance redress mechanism (GRM). • Discuss entitlements and plan for agreement, time frame and sequencing of rehabilitation, allotment of houses, etc.		
Pre-construction Works	• Formal briefing of project via Notice to ADC and relevant representative bodies one month prior to any civil works • Publicize key project information (kit) including summary of EIA, EMP, RTDP, GRM (e.g. complaint form format, ADB accountability mechanism, etc.) among all affected communities/persons/HHs/other relevant stakeholders • Full disclosure of EIA, RTDP to affected communities/persons/HHs/other stakeholders	• Distribute leaflets/flyers or booklets in local language	Project Planning, Design and Pre-Construction Stages	PMU/SESC/NGOs
	• Web disclosure of EIA and RTDP	• Draft and final copies of the EIA and RTDP will be posted on ADB and EA websites	Pre-Construction Stage	EA/ADB
Construction Works	• Project information dissemination in local language on: - EMP (Safety issues related to construction work e.g. trenching, blasting, excavation hazards, movement of vehicles, occupational health and safety, etc.) - GRM - Compensation and Entitlements • Village level or local informal meetings as needed	• Distribution of project information leaflets to all affected communities/persons, HHs, and relevant representative bodies • Publish a list of affected lands/sites in local newspapers • Publish project commencement details and its progress	Intermittently during Construction Stage	PMU/SESC/NGOs/ LKHEPAPA

Project Activity	Approach	Issues to Discuss	Schedule	Responsible Agencies[96]
	• Public Notification			
	• Publicize key project information (kit) including summary of EIA, EMP, RTDP, GRM among all affected communities/persons/HHs/other relevant stakeholders • Full disclosure of EIA, RTDP to affected communities/persons/HHs/other relevant stakeholders	• Distribute leaflets or booklets in local language	To be determined	PMU/SESC/NGO
	• Web disclosure of EIA and RTDP	• Draft and final copies of the EIA and RTDP will be posted on ADB and EA websites	To be determined	EA/ADB
Operation and Maintenance Works	• Project information dissemination in local language on: - Safety issues related to significance of warning signs, maintenance of ROU, etc.) - GRM - Compensation and Entitlements • Conduct Emergency drills involving local community on annual basis • Conduct semi-annual information drive or ADC level meetings on safety measures • Relevant press releases, as and when needed • Response to public inquiries in timely manner	• Distribute leaflets or booklets in local language	Operation Stage	

X. GRIEVANCE REDRESS MECHANISM

A. Introduction

586. APGCL will formally institute a transparent and time-bound grievance redress mechanism (GRM) to receive and resolve APs' grievances and complaints, if any, due to project impacts and on the delivery of their entitlements.

587. The GRM is an accessible and trusted platform for all the APs to seek solutions and relief for their project-related problems and grievances, without resorting to lengthy and costly judicial process. The success and legitimacy of GRM will depend on the APs' capacity for consultations and desire to resolve grievances through discussion and negotiation (They have already well demonstrated their capabilities on both grounds). APGCL will ensure that the APs and the line agencies that participate in project activities understand the role and functions of the GRM LKHEP in resolving problems and grievances pertaining to environmental impacts, land acquisition, compensation, relocation, income and livelihood restoration and improvement. Before project activities commence, a program of publicity to the GRM will be given by APGCL. The sample complaint form format is included in the RTDP.

B. Grievance Redress Process

588. A three-tier GRM will be established. The first tier is the grass-roots level mechanism. Grievances of the APs will be first dealt with by Gaon Buras and field level project officers, in consultation with the project contractors and other project related agencies. Complaints that cannot be addressed at the level of Gaon Buras will be forwarded to the project-level grievance redress committee (GRC) which is the second tier of the GRM. The third tier is the appellate GRC at the State level. APGCL will deal with the complaints and grievances as the appellate GRC. The presence of the GRM or seeking relief from the GRM is not a bar to take grievances and complaints to National courts for arbitration.

1. First-tier GRC

589. Grievances and complaints that need immediate attention can be directed to the Gaon Buras and field level project officers who are in the area. These on-site personnel will be first level accessible contacts for aggrieved communities/APs to obtain a quick resolution to a grievance or a complaint. Contact phone numbers, addresses, and names of the Gaon Buras, field level project officers, and project contractors will be displayed at all project related construction site offices and relevant public places. Registers for recording complaints and grievance (for both verbal and written complaints) will be available with Gaon Buras and field level project officers. The latter will be informed by the Social and Environmental Safeguards Cell (SESC) at the PMU on how to record the grievances and complaints, matters of arbitration, solutions and relief provided. Gaon Buras and field level project officers can resolve grievances on-site in consultation with project contractors and other project related agencies. They are required to do so within 7 days from the receipt of a complaint or grievance at the field. If issue is unresolved, APs can approach Second-tier GRC. Records of grievances received at field level will be sent (immediately on receipt and on dealing with grievance) to the SESC at the PMU enabling to track the progress in GRM.

2. Second-tier GRC

590. The GRC at the project level will address the aggrieved communities/APs' complaints and grievances promptly, using a transparent process that is gender responsive, culturally

appropriate, and readily accessible, at no costs and without retribution. It will be chaired by the Project Director of PMU or his/her representative. The safeguard officers of the SESC, an administrative officer, concerned engineers, project contractors, representative from the LKHEPAPAs of Dima Hasao and Karbi Anglong districts, at least one women representative, and district officials will also take part in the GRC meetings. The GRC will have a secretary. It could call upon land surveyors, Gaon Buras of the project area, and other project related agencies to participate in GRC meetings.

591. The Secretary, GRC will receive complaints and grievances. A record of each complaint or grievance (for both verbal and written complaints) will be kept at the project office. At this level, each grievance or complaint will be resolved within 15 days from the date of its registration at the project office. The decisions of the GRC will be conveyed in writing to aggrieved communities/APs who sought relief for their grievances and resolution for problems through Gaon Buras and field level project officers. If issue is unresolved, APs can approach the third-tier GRC.

3. Third-tier GRC

592. If the GRC at the project level considers the grievance/complaint beyond its jurisdiction or it cannot resolve the issue, the PMU will refer it to APGCL, the third tier GRC in Guwahati, for resolution or relief. APGCL will attempt to resolve grievances within total 30 days from the date of its registration at the project office. The Appellate GRC at APGCL in Guwahati will be chaired by the Deputy General Manager (Hydro). The other members of the GRC are the representatives of the revenue department, ADCs, land survey department, relevant LKHEPAPAs, and the Gaon Buras. The GRC will hear the complaint or the grievance and provides its decision to the aggrieved communities/APs in 30 days from the registration of the complaint at the project office. The decision of the GRC will be communicated in writing to aggrieved communities/APs through Gaon Buras and field level project officers. If issue is unresolved, APs can approach other mechanisms i.e. Court, ADB’s India Resident Mission, ADB’s Accountability Mechanism.

C. Other Avenues to Redress Grievances

593. There are three other avenues open for aggrieved communities/APs to resolve their problems, complaints and grievances with regard to the project and its implementation.

1. ADB India Resident Mission in New Delhi

594. An aggrieved party/APs can directly contact the ADB’s resident mission in New Delhi regarding a grievance or problem that the GRM has failed to resolve to its satisfaction. Aggrieved communities/APs will inform the resident mission in writing and initiate a good faith negotiation to solve the issue/problem by working with the concerned Resident Mission’s specialists and, if necessary, with ADB’s South Asia Regional Department in Manila. Aggrieved communities/APs may use English or any local language to send the complaint to the resident mission or to the regional department, and the hearing of the case can be done in the preferred language of the aggrieved communities/APs.

2. ADB Accountability Mechanism

595. The aggrieved communities/APs also can use the ADB’s Accountability Mechanism through writing to the Complaint Receiving Officer at the ADB Headquarters in Manila. The Accountability Mechanism has two arms: the first is the Office of the Special Project Facilitator.

The Facilitator deals with the complaints with the help the project personnel and the aggrieved party through a consultative process; the second arm of the Accountability Mechanism deals with the complaints against ADB regarding its failure to abide by its own safeguard policy requirements. Information on the ADB Accountability Mechanism will be included in the key project information kit to be distributed among the aggrieved communities/APs as a part of publicizing the GRM.

3. India's Courts System

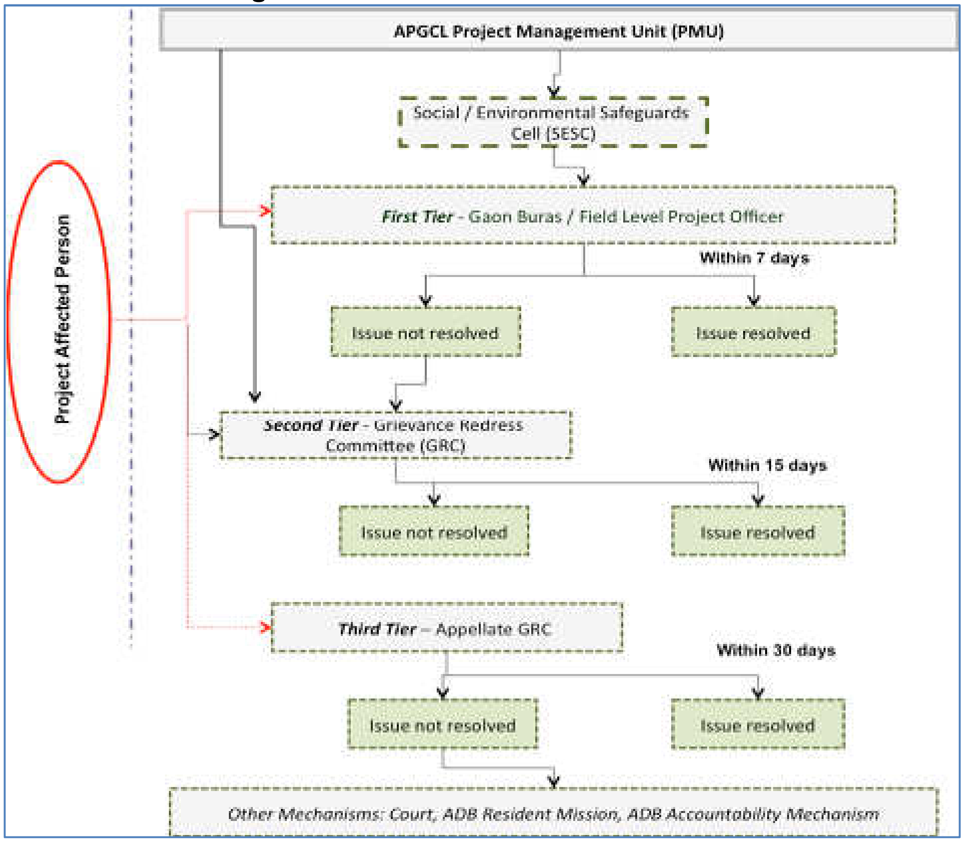
596. If the GRM of the project cannot resolve a grievance or the aggrieved communities/APs feel that they have not received a fair hearing or award, they can access the country's court system for relief at any stage of the deliberations in GRCs. In such an event, the GRC immediately terminates its hearing.

D. GRC Record-Keeping

597. Records of all grievances received, including contact details of the complainants, dates of the complaints received, nature of grievances, agreed corrective actions, the dates of key decisions, implementation of such decisions and final outcome are recorded and kept in the project office. The number of grievances recorded and resolved and the outcomes will be displayed/disclosed at the project office, at APGCL in Guwahati, and on APGCL's website. A summary of this information will be included in the monthly progress report of NGOs and semi-annual safeguard monitoring reports to be submitted to ADB. All GRC meeting deliberations and decisions will be recorded and will be available for public reference. If ADB is involved in a grievance resolution, it will maintain records of its proceedings and disclose to all parties engaged in the hearings.

598. Figure 69 show the Grievance Redress Progress proposed for LKHEP.

Figure 69: Grievance Redress Process



E. Periodic Review and Documentation of Lessons Learned

599. The safeguard officers of SESC with the support of PMU and NGOs will review the functioning of GRM and record information on the effectiveness of the mechanism and improvements required on biannual basis.

F. GRM Costs

600. All costs incurred in GRC meetings, consultations, communication and reporting/information dissemination will be borne by the PMU. Cost estimates for grievance redress are included in resettlement cost estimates (refer to RTDP). ADB will bear the cost of its own involvement in grievance resolution. The complainants are not charged any fee for the service. It is a good practice to provide aggrieved communities/APs with transport facilities to the project offices, or offer cash payment for travel related expenses by the project, if feasible.

G. Meetings of GRC

601. The GRCs will meet according to a published timetable in response to a complaint. This information will be disseminated among all APs, ADCs, and their LHEPAPAs. Each session/meeting will be held at a place which is convenient for Aggrieved communities/APs to attend. The GRC procedures will be communicated through public notices and at the community meetings. The APs will be made aware of the presence of the GRM, its powers, and benefits during consultations and group discussions. At such gatherings, the APs will be encouraged to discuss their views on the structure and functions of the GRM.

XI. ENVIRONMENTAL MANAGEMENT PLAN

A. Introduction

602. The EMP for LKHEP is the synthesis of all proposed mitigation and monitoring actions as well as institutional measures, set to a time-frame with duly assigned responsibility and defined follow-up actions for APGCL, the contractor and the regulatory agencies to implement in order to avoid, minimize and mitigate adverse environmental impacts and enhance positive impacts. The major components of EMP are:

- Mitigation of potentially adverse environmental impacts;
- Monitoring of mitigation measures, plans and actions during pre-construction, construction, and operation phases; and
- Institutional arrangements for implementation and monitoring of EMP.

B. Objectives of Environmental Management Plan

603. The main objectives of EMP are as follows:

- Ensure compliance with ADB's SPS 2009, IFC EHS, and regulatory requirements of GoA and GoI;
- Avoid, mitigate and compensate anticipated adverse environmental impacts via measures, actions, and plans during pre-construction, construction, and operation phases;
- Stipulate monitoring actions, supervision, and institutional measures for safeguards compliance; and
- Ensure that environmentally sound, sustainable and good practices are adopted such that the project development is environmentally sustainable.

C. Impacts and Mitigation Measures

604. Anticipated potential adverse environmental impacts and suggested mitigation measures specific to the project are summarised in following paragraphs and presented in a matrix format in Table 123.

1. Impacts

605. Following are anticipated potential adverse environmental impacts:

- Impacts due to acquisition of about 1,577 ha of land for the project;
- Impacts on biodiversity (flora and fauna) and surrounding area due to clearing of forests and tree cutting, particularly Reserved forest areas;
- Impacts due to land diversion i.e. 523 ha of forest land for non-forest purpose;
- Temporary impacts on land and air environments due to construction camps;
- Temporary impacts on land, air and water environments due to construction and operation of Batching Plants, and DG sets, etc.;
- Impacts on biophysical environment due to quarrying;
- Impacts on air and water quality, and local residents due to construction activities;
- Impacts on land and water environment due to waste disposal;
- Impacts on hydrology changes, sediment movements and erosion;

- Impacts on ecosystem services changes;
- Impacts on upstream and downstream water uses;
- Impacts on occupational health and safety due to all onsite and offsite construction works;
- Cumulative impacts from HEPs; and
- Impacts on safety during LKHEP operation.

2. Mitigation Measures

a. Compensatory Afforestation

606. To mitigate impacts due to forest (tree) cover loss measures such compensatory afforestation (CA) plan, cutting only trees marked by the State Forest Department, ensuring that the area is cleared as per directives/delineation of Forestry staff etc. will be implemented. The CA plan has been proposed by EA (refer to Biodiversity Conservation and Management Plan) and the same will be finalized in consultation with State Forest Department. The CA plan indicates tree plantation to be undertaken in ratio of 1:2 (two trees planted for one cut down). Since the reserve forest land to be acquired for LKHEP is 523 ha, a total of (523 x 2) 1,046 ha of degraded forest land will be afforested (and trees will be planted in at least the 1:2 ratio noted above). The works under the CA plan will be undertaken by the State Forest Department with support of APGCL. Efforts will be made to execute CA plan on lands that are contiguous to the project, if possible. Native tree species of the area shall be required for plantation under the CA plan.

607. The cost of the CA plan on degraded forest land is RS. 1,558.09 lakh including maintenance cost for seven years. Additionally, APGCL will pay for the Net Present Value (NPV) as estimated by the State Forest Department. In addition to the CA plan, APGCL will also undertake a Green Belt Development plan (Annex 21 for tree planting and planting of vegetative cover) around the perimeter of various project appurtenances, selected stretches along reservoir periphery, etc. The greenbelt development will cover about 20 ha of land and about 1,600 trees/ha. The plantation and maintenance will be undertaken by APGCL while native species will be selected in consultation with the State Forest Department. The treated wastewater and the compost (from composting of solid waste generated in labor camps/workers' colonies) will be used during the greenbelt development.

b. Biodiversity Conservation

608. To minimize the likely impacts on flora and fauna in and around the project, the following measures have been incorporated in the project design and proposed for implementation during construction and operation of the project.

- Creation of a greenbelt around the perimeter of various project appurtenances, selected stretches along reservoir periphery, access roads to compensate for the loss of habitat (Annex 21).
- Implementation of Biodiversity Conservation and Management Plan (Annex 9).
- Establishment of a biodiversity conservation committee.
- Compliance with guidelines issued by the National Wildlife Board of India for linear intrusion in natural area pertaining to roads and power lines (Annex 2).
- Compliance with guidelines issued by CEA for laying transmission lines in areas critical from the point of view of saving wildlife (Annex 2).

- Habitat improvement proposals are included in the Biodiversity Conservation and Management Plan (Annex 9).
- Noise generating equipment like DG sets, compressors shall have acoustic enclosures, and shall be installed at a distance of least 1 km from the forest areas.
- Noise generating activities shall not be permitted during 6 PM to 7 AM.
- Construction equipment's operators and heavy machinery/transport drivers shall be instructed to move slowly in the wildlife movement areas and restrain from honking.
- If any wild animal(s) such as small mammals come within the vicinity of 100 m from the construction site, construction works shall stop immediately and only resume after the animal have moved away to a safe distance. Environmental expert with PMSC and contractor's environmental officer (who will be called in) will ensure this by direct observations.
- Provisions of signage as a precautionary measure to provide awareness about wildlife's movement shall be made to avoid accidents.
- Project staff and work crews shall not be allowed to have fire-arms and animal traps etc. Strict penalties shall be evoked for anyone engaging in tree clearance or poaching of animals.
- Construction facilities such as workers camp, construction camp, hot mix plant, batching plant shall be located at a distance of at least 1 km from the forest areas.
- Employment agreements shall specify heavy penalties for illegal hunting, trapping and wildlife trading–all other ancillary workers shall also agree in writing not to participate in such activities.
- Strict anti-poaching surveillance measures such as awareness raising programs, heavy penalties, increase in patrolling by local forest rangers, community watch program etc. shall be implemented, especially during construction phase.
- Other measures proposed are i) provision of wild fruit plantation for wildlife; ii) planting local fruit bearing species in gaps; iii) anti-grazing drive in drawdown area to protect any bird nesting areas (such as in grass and shrub areas) during breeding (winter) season; and iv) construction of check posts/watch towers in key locations–in collaboration with forest department (for intermittent monitoring).
- Conservation actions as proposed by IUCN (during construction and during the initial project operation) such as conducting a comprehensive survey and monitoring in and around the project area to establish range, distribution and population status of vulnerable and critical habitats in the project area for assessing its habitat requirements and identifying threats are proposed.

c. Muck Disposal

609. The total quantity of muck generation has been estimated to be about 1.005 million m^3. Considering, 40% swell factor, the total muck expected to be handled is 1.407 million m^3. About 35% material of muck shall be used as construction material. Thus, 0.985 million m^3 of muck is planned for disposal at the pre-designated disposal sites. The holding capacity of disposal sites is estimated as 1.032 million m^3.

610. The disposed muck shall be piled at an angle of repose at the disposal sites with due engineering considerations and phyto-remedial measures for materials stabilization such as design (plan and cross sections), re-vegetation through by using grass and turfing of slopes,

and afforestation with local native plant species. The cost for remediation of muck disposal sites include slope turfing, ground preparation, manure application, providing 5 cm of soil cover, building a retaining wall, transportation and carriage, fencing, maintenance, and irrigation. The Muck Disposal Plan including cost estimates are presented in Annex 13.

d. Waste Management

611. Waste generation is expected from residential colonies, labor camps, office buildings and hazardous wastes (i.e. bio-medical wastes) are anticipated from worksite first aid stations. A Solid Waste Management system shall be implemented for waste management that will function on four basic principles viz. segregation and primary storage at the source, collection, transportation, treatment, and disposal.

612. The waste will be segregated at source into two categories (recyclable and non-recyclable) and collected via door to door collection system (from the staff/labor colonies and labor sheds). A public awareness program on waste segregation shall be implemented targeting workers/labors, contractors, project officers, and local communities living nearby. The waste will be segregated into two categories and segregated wastes will be stored in two different containers at designated areas (in a fenced area with an impermeable concrete floor and a berm with capacity for 110% of waste volume). The collected waste shall be transported by licensed transporter to approved (licensed and engineered) waste disposal sites/landfill (to be identified by contractor in consultation with local District administration) and records of all waste movements should be kept as per the requirements of the Municipal Solid Waste (Solid Waste Management & Handling) Rules 2000. The landfill shall be restricted to non-biodegradable, inert and other waste that are not suitable either for recycling or for biological processing. Land filling shall be done following proper norms and the landfill sites shall meet the specifications as given in these rules.

613. The recycled waste will be handed over to the licensed waste recycling agencies. All hazardous wastes will be collected and stored in designated areas (in bounded area with impermeable concrete floor and berm with 110% volume). The hazardous material will be handed over to licensed hazardous waste handling and collection agencies for further disposal at an approved location.

614. The detailed solid waste management plan including Hazardous Waste Management Plan is prepared and presented in Annex 22 and 23.

e. Hydrological Balance

615. The following mitigation measures shall be implemented to minimize the impacts on hydrology:

- The construction works shall be conducted during low flow (dry) season such that there is no interruption in the flow. A minimum downstream e-flow rate released from the re-regulation dam shall be 5.345 m^3/s, and the minimum downstream water depth will be maintained at 0.5 m. These are derived as 20% of the average flow of four consecutive leanest months in a 90 % dependable year.
- Safety plans for the project shall include provisions to handle emergencies due to flash floods at construction sites, if any during high flow (rainy) season (with evacuation of workers if the risk is high).
- An emergency response and disaster management plan, which outlines communication and evaluation mechanisms in case of dam failure/floods, has been

prepared. Community DMCs are proposed and community based flood risk management plans will also be prepared in flood prone villages (note that there are no riverside villages for 19.5 km downstream of the dam site, and riverside farm plots start at 12 km downstream from the dam site) .

- Emergency response training shall be conducted for the local stakeholders living downstream of dam site.
- Construction materials for both the diversion channel and the dam structure shall be carefully stored during the high flow season.
- Water levels at major locations/communities, especially downstream from proposed dam site shall be monitored on a continuous basis as per environmental monitoring plan, and this data shall be analyzed for electricity production.
- During construction works, regular stakeholder consultations with upstream and downstream local residents shall be conducted to aspire local persons of the construction schedule and manage expectations.
- Watershed management planning shall be required for managing upstream activities such as to ensure that the reservoir water quality is maintained. Details of the watershed management measures including water quality restoration measures are presented in IWRMP and WQRP.
- River discharge and e-flow shall be monitored continuously at downstream locations as per the e-flow management plan both during construction and operation phases.
- An Dam Break Analysis and Disaster Management Plan is presented in Annex 30.

f. Water Pollution

616. To maintain the water quality of the river, following measures shall be implemented.

- Sewage from labor camps/worker colonies shall be treated in a Sewage Treatment Plant (STP) comprising of aerated lagoon and secondary settling tank, prior to discharge meeting water quality discharge standards (Annex 2).
- Effluents from crushers shall be treated in a settling tank of an adequate size prior to discharge meeting water quality discharge standards (Annex 2).
- Effluents from tunneling works like drilling, shotcreting, etc.; batching plants, fabrication units and workshops shall be treated in settling tanks of adequate size prior to discharge meeting water quality discharge standards (Annex 2).

617. The detailed Water Pollution Control Measures are presented in Annex 26.

g. Air Emission and Dust Control

618. The contractor shall implement an Air Pollution Control Plan for dust suppression resulting from quarrying activities, crushing and batching plants, road construction, embankment and channel construction, haulage of materials and construction of work camps. The Air Pollution Control Plan shall include the following measures:

- Machinery and dust causing activities shall be located at least 1 km away from sensitive receptors as per the provisions and design of site layout.
- Stockpiles shall be placed at an appropriate locations (at least a km away from receptors and downwind side) taking into consideration the wind direction.
- Blasting activities shall take place during daytime only (between 7 AM to 6 PM).
- All vehicles shall switch off engines when halted, and shall not leave vehicle engines

idling.

- All vehicles shall be washed or cleaned before leaving the project site.
- Loads entering and exiting project site shall be covered by tarps if expected to contribute to dust emissions.
- Construction equipments and engines shall be inspected for emission levels on a regular basis and adjusted as required.
- Cutting equipments shall use water as suppressant or other practical ventilation systems.
- In an event that combustion engines are used underground, adequate ventilation system shall be provided to avoid exposure of workers to toxic gases.
- Unpaved roads shall be sprinkled with water in and around the affected villages at least 2 times a day in the dry season; this frequency shall be increased or decreased depending on inspector's observations/monitoring.
- Other areas shall be sprinkled with water as needed to suppress dust dispersion by winds.
- The contractor shall securely cover skips and minimize drop heights.

619. The detailed Air Pollution Control Measures are presented in Annex 24.

h. Noise and Vibration Control

620. Since there are no residential communities currently in the immediate vicinity of the project site, the primary noise impact would be on onsite workers, resettled communities by the riverside, and wildlife if any spotted in the immediate vicinity of the project site. The noise impacts shall be mitigated as follows:

- Appropriate Personal Protective Equipment (PPE) for noise protection shall be provided to all workers.
- Noise monitoring shall be conducted at select locations as indicated in the environmental monitoring plan.
- All noise generating construction equipments shall have sound control devices (e.g., exhaust mufflers, acoustic enclosures), equipments shall be serviced as per the manufacturer's maintenance schedule.
- There should be no noise exceedance from construction activities. In case noise monitoring result found higher noise level (Annex 2) that activity shall be stopped. Also all noisy construction activities in sensitive areas shall be limited to only day time (7 AM – 6 PM).
- A blasting report shall contain complete details of the blasting schedule and procedures. People shall be Warnings shall be issued in advance to workers/communities and trespassing to the blasting area shall be strictly prohibited.
- In case any wild animals are spotted close to the project area, all construction activities shall cease until wildlife moves away (or is captured and taken away) to a considerable safe distance of 1 km. Supervision consultant expert will ensure safe distance.
- Transport vehicles shall have exhaust mufflers and serviced as per the manufacturer's maintenance schedule.
- It is not expected that noise barriers will be required given the distance between work sites and residential areas (mostly along the highway). However, if needed, noise barriers can be installed. Lump sum budgetary provisions have been made in the EMP.

- Site Specific EMP (SEMP) shall be prepared prior to construction phase to reduce noise impact from project activities. The SEMP shall provide the map of project transportation route, worker camps, nearby villages and noise monitoring stations.

621. **Impacts of Vibration:** To control vibrations due to blasting activities, EPC contractors shall be required to retain a qualified blasting specialist to develop a site-specific blasting program that will assess, control, and monitor air blasts and ground vibrations from blasting operations. This program shall include, at a minimum, the following measures:

- The contractor shall use current state-of-the-art technology to assure that blast-related vibrations at offsite residential, other occupied structures, and adjoining forested areas (outside the periphery of the acquired total forest land) are as low as possible, consistent with blasting safety procedures. Under no circumstance shall the blast vibration as measured at selected / earmarked locations (e.g. on the ground adjacent to a residential structure), be allowed to exceed the frequency-dependent limits specified in the Alternative Blasting Level Criteria contained in USBM Report of Investigations 8507 (Annex 36 – Blasting Vibrations Limits).
- The contractor shall monitor and record air blast and vibration within 330 m (1000 feet) of worker camps, other occupied structures, and adjoining forested areas (outside the periphery of the acquired total forest land) to verify that measured levels are within the recommended limits at those locations. If blasts and vibrations are found to exceed recommended limits, alternative blasting or excavation methods shall be employed to comply with the limits.
- Air blast and vibration monitoring shall also be made at the nearest offsite residential or other occupied structure. If vibration levels are expected to be lower than those triggering the seismograph at that location, or if permission cannot be obtained to record at that location, recording shall be accomplished at some closer offsite location in line with the structure. Specific locations and distances where air blast and vibration are measured shall be documented in detail along with measured air blast and vibration amplitudes.

622. The detailed Noise Control Measures are presented in Annex 25.

i. Restoration and Re-development of Quarries and Borrow Areas

623. The project shall require about 1,245,000 m^3 (831,000 m^3 coarse and 414,000 m^3 fine) aggregates for construction works. These material will be sourced from three existing quarries identified within 10 km radius of the project site. Appropriate slope stabilization measures shall be implemented to prevent possibilities of soil erosion and landslides. Quarry slopes shall be maintained at a slope 1:1, and covered with topsoil of at least 30 cm, followed by afforestation with locally native species of high economic and ecological value as well as planting locally native grass, herbs and shrubs. The construction of retaining walls shall also be undertaken, if required. The quarries will be restored through engineering and biological measures such as phyto-remediation.

624. The budget earmarked for phyto-remediation of quarry sites is RS. 1.15 million. The cost breakup includes i) plantation – 0.3 million; ii) turfing – 0.1 million; iii) retaining wall – 0.5 million; iv) training and labor cost – 0.15 million; and v) fencing – 0.1 million.

625. Quarry Areas Restoration Plan is presented in Annex 14.

626. For re-development of borrow area, items such as preservation of top soil and re-application of stored top soil has been considered in the EMP cost. The Contractor will re-develop the borrow areas before closing of same.

j. Road Construction

627. Following measures will be implemented to control impacts due to road construction such as the construction of 13.10 km of access roads (rehabilitation of 48 km long road from Lanka to the project site will be covered by PWD).

- Area for clearing shall be kept minimum to the formation width (which is 5 m in general. Since the clearing area shall be properly demarcated to save desirable trees and shrubs and to keep tree cutting to the minimum. At present about 611 trees are likely to be cut due to access road improvement work. Compensatory afforestation will be done at 1:2 ratio.
- Where erosion is likely to be an issue, clearing operations shall be scheduled and performed such that the grading and permanent erosion control operations may follow immediately thereafter, if the project conditions permit; otherwise temporary erosion control measures shall be provided between successive construction stages. However, under no circumstances should very large surface area of erodible earth material be exposed at any one time by clearing.
- The method of balanced cut and fill formation shall be adopted to avoid large difference in cut and fill quantities.
- The cut slopes shall be suitably protected by breast walls, provision of flat stable slopes, construction of catch water and intercepting drains, treatment of slopes and unstable areas above and underneath the road, etc.
- Landslide prone areas shall be treated with location specific engineering protection measures.
- Where rock blasting is involved, controlled blasting techniques shall be adopted to avoid over-shattering of hill faces.
- Excavated material shall not be thrown haphazardly but dumped duly dressed up in a suitable form at designated muck disposal area where it cannot get easily washed away by rain, wind, etc. and such spoil deposits may be duly trapped or provided with some vegetative cover (much of the excavated material can be used to bolster and level the road shoulders).
- Drainage of the water from hill slopes and road surface is very important. All artificial drains shall be linked with the existing natural drainage system.
- Surface drains shall have gentle slopes. Where falls in levels are to be negotiated, check dams with silting basins shall be constructed such that soil is not eroded and carried away by high velocity flows.
- Location and alignment of culverts shall be chosen such as to avoid severe erosion at outlets and siltation at inlets.
- Tree felling for road construction/works shall be kept bare minimum and strict control must be exercised in consultation with the State Forest Department. New local tree species shall be planted at a ratio 1 cut : 2 planted as an integral part of the project within the available land and if necessary, separate additional land may be acquired for this purpose.
- Depending on the availability of land and other resources, afforestation of roadside areas shall be carried out for a sufficient distance on either side of the road.

628. A separate EMP has been developed for the road component and presented in Annex 35.

k. Workers' Health and Occupational Safety

629. All components of the workers' camps, including accommodations, sanitation facilities, water supply and other infrastructure, recreation facilities, kitchens and dining areas, and medical facilities, shall adhere to and be maintained at internationally accepted health and safety standards including IFC EHS Guidelines.

630. The workers and other project personnel shall be provided training in prevention of diseases such as mosquito-borne diseases, intestinal diseases, HIV/AIDS and other venereal diseases. They shall also be provided training in proper use of sanitary facilities, access and use of portable water, and waste disposal.

631. Workers and other project personnel shall be trained in work safety measures and practices. First aid teams trained in emergency response shall be assigned at each of the construction sites and medical facilities (first aid kit, medicines, ambulance etc.) capable to deal with emergency incidences shall be provided at each project sites. A doctor shall be available within reasonable distance (within 10 km) from the construction site if an accident occurs or in case of serious illness.

632. Water and drainage facilities shall be maintained to avoid breeding of mosquitoes. Use of pesticides will be avoided and may be used only if deemed necessary, and must follow the following conditions: the pesticides shall have negligible adverse impact on humans, they shall be effective against target species, they shall have minimal effect on non-target species and the natural environment, and they shall be safe for the personnel who apply them. The handling, storage, application, and disposal of pesticides shall be done in accordance with international best practices such as the Food and Agricultural Organization's International Code of Conduct on the Distribution and Use of Pesticides[97].

633. Following measures are proposed for health and safety of workers.

- The location, layout and basic facility provision of each labor camp will be submitted to supervision consultant prior to their construction. The construction shall commence only after approval of supervision consultant.
- The contractor will maintain necessary living accommodation and ancillary facilities in functional and hygienic manner as approved by the EA.
- Adequate water and sanitary latrines with septic tanks attached to soak pits shall be provided.
- Preventive medical care to be provided to workers including a First-Aid kit that must be available in the camp.
- Waste disposal facilities such as dust bins must be provided in the camps and regular disposal of waste must be carried out.
- The Contractor will take all precautions to protect the workers from insect and pest to reduce the risk to health. This includes the use of insecticides hitch should comply with local regulations.
- No alcoholic liquor or prohibited drugs will be imported to, sell, give, and barter to the workers of host community.

[97] http://www.fao.org/docrep/018/a0220e/a0220e00.pdf

- Awareness raising to immigrant workers/local community on communicable and sexually transmitted diseases.

634. Detailed mitigation measures of workers' health and safety recommended for all the construction of work camps are presented in Annex 12: Public Health Delivery Plan, Annex 18: Project Personnel Health Program, Annex 16: Plan for Environmental Training to Workers, and Annex 29: Safety Practices During Construction Phase.

l. Protection of Sensitive Receptors

635. Sensitive receptors in the project areas (both near dam as well as along the access roads) shall be protected by implementing a time schedule (7 AM – 6 PM) for construction activities, provision of sign boards, and appropriate noise barriers such as planting trees and/or raised boundary walls (if needed). Site specific plans shall be prepared for the construction phase. Costs are included in the EMP budget. Note, however, that almost all receptors (residences and farmers' fields) are located along the highway. There are none along the proposed access roads within project area (see Figure 43).

m. Potential Environmental Enhancement/Protection Measures

636. Annex 9 to Annex 30 of this EIA presents good environmental management practices, plans and guidelines/documents for the following aspects of project construction. These plans and guidelines are an integral part of the EMP and may need revisions by the Project Management and Supervision Consultant (PMSC) and contractor based on actual site conditions during the project implementation.

- Biodiversity Conservation and Management Plan (Annex 9)
- Catchment Area Treatment Plan (Annex 10)
- Fish Management Plan (Annex 11)
- Public Health Delivery System (Annex 12)
- Muck Disposal Plan (Annex 13)
- Restoration Plan for Quarry Areas (Annex 14)
- Guidelines for Quarry Area Management (Annex 15)
- Plan for Environmental Training to Workers (Annex 16)
- Plan for Construction Camp Management (Annex 17)
- Project Personnel Health Program (Annex 18)
- Landscaping and Restoration of Construction Areas (Annex 19)
- Environmental Management in Road Construction (Annex 20)
- Green Belt Development Plan (Annex 21)
- Solid Waste Management Plan (Annex 22)
- Emergency Plan for Hazardous Materials (Annex 23)
- Measures for Air Pollution Control (Annex 24)
- Measures for Noise Pollution Control (Annex 25)
- Measures for Water Pollution Control (Annex 26)
- Energy Conservation Measures (Annex 27)
- Fire Protection in Labor Camp and Staff Colonies (Annex 28)
- Safety Practices During Construction Phase (Annex 29)
- Dam Break Analysis and Disaster Management Plan (Annex 30)

D. Environmental Monitoring and Reporting Program

637. Environmental monitoring is an essential tool for environmental management as it provides the basic information for rational management decisions. To ensure the effective implementation of mitigation measures and EMP during construction and operation phases of the project, it is essential that an effective Environmental Monitoring Plan (EmoP) be designed and followed.

638. EMoP has the underlying objective to ensure that the intended environmental mitigations are realized and these results in desired benefits to the target population causing minimal deterioration to the environmental parameters. Such plan targets proper implementation of the EMP. The broad objectives are:

- To evaluate the performance of mitigation measures proposed in the EMP.
- To evaluate the adequacy of environmental assessment.
- To suggest ongoing improvements in management plan based on the monitoring and to devise fresh monitoring on the basis of the improved EMP.
- To enhance environmental quality through proper implementation of suggested mitigation measures.
- To meet the requirements of the existing environmental regulatory framework and community obligations.

1. Performance Indicators

639. The significant environmental (physical and biological) and social parameters that shall be affected at critical locations due to the project shall serve as wide/overall Performance Indicators. However, environmental parameters can be quantitatively measured and compared over a given time period have been selected as specific Performance Indicators (PIs) for monitoring due to their regulatory importance, availability of standardized procedures, and presence of relevant expertise (Standards are given in Annex 2).

- Water Quality – pH, BOD, temperature, electrical conductivity, total suspended solids, turbidity, total dissolved solids, calcium, magnesium, total hardness, chlorides, sulphates, phosphates, nitrates, DO, COD, BOD, Iron, Zinc and Manganese, heavy metals, Faecal coliforms, before and after treatment from settling tank of the constructed STPs, as well as Kopili river and reservoir.
- Air Quality – Particulate Matter ($PM_{2.5}$, PM_{10}), CO, NO_X and SO_2 at selected locations (at work sites and near the highway).
- Noise levels at sensitive receptors (schools, primary health centers, nearby hospitals if any, community/religious places, surrounding forested area at least distance 2 km radius from project appurtenances), individual receptors within 1 km distance, camps and work places.
- Ecological surveys of forests, wildlife, qualitative and quantitative assessment of flora and fauna, monitoring of restoration of muck disposal sites; aquatic ecology parameters such as phytoplankton, zooplankton, benthic animals and fish composition (but only if pH changes), status of afforestation program, presence and migration pattern (if any) of larger wildlife (such as elephants).
- Survival rates (minimum 70%) of trees planted as part of CA for lost forests and trees along existing and new roads.
- Water flow in downstream locations and tributaries.
- Incidences of water related diseases, such as malaria.

- Accidents during construction and operation (public and employees) – near miss, minor injury, major injury, fatal.
- Changes in land use in immediate adjacent areas.

2. Water Quality Monitoring

640. **Construction Phase**: The effluent shall be monitored before and after treatment from an settling tank. The frequency of monitoring shall be once per month. It is assumed that 3 Sewage Treatment Plant (STPs) shall be constructed to treat sewage generated from five labor camps. A total of (3 STPs * 12 months* 4 samples, i.e. before and after treatment) 144 samples/year shall be analysed. The following parameters shall be monitored: pH, BOD, total suspended solids, total dissolved solids, and faecal coliforms. The cost of analysis of one sample (including transportation) is estimated as RS. 2,000. Thus, total cost for analysis of 144 samples is estimated as RS. 0.288 million per year. The analysis may be conducted at a laboratory recognized by the State Pollution Control Board of Assam.

641. **Operation phase**: The surface water quality of Kopili river and reservoir shall be monitored three times per year. The following parameters shall be monitored: pH, temperature, electrical conductivity, total suspended solids, turbidity, total dissolved solids, calcium, magnesium, total hardness, chlorides, sulphates, nitrates, DO, COD, BOD, Iron, Zinc and Manganese, and Faecal coliforms. The sampling sites shall be:

- 1 km upstream of the reservoir site.
- Reservoir water.
- 1, 5 and 8 km downstream of the dam site (i.e., about 2 km downstream from tailrace)

642. The total cost of analysis is estimated as RS 0.075 million per year and shall be conducted through the entire life of the project. The analysis may be conducted at a reputed external agency recognized by State Pollution Control Board of Assam.

643. During project operation phase, one STP shall be constructed to treat effluent from the project colony. The effluent shall be monitored after treatment from an oxidation ditch. The frequency of monitoring shall be once per week. The following parameters shall be monitored: pH, BOD, COD, total suspended solids, total dissolved solids and faecal coliforms. The cost of analysis of one sample is estimated as RS. 2,000 (including transportation). Based on the frequency, total cost for analysis of 104 samples is estimated as RS. 0.208 million/year.

644. Thus, total cost for analysis for the project operation is estimated as RS. (0.075 + 0.208) RS. 0.283 million/year.

3. Air Quality Monitoring

645. **Project Construction Phase**: The ambient air quality monitoring during construction phase shall be carried out by an external agency, recognized/approved by State Pollution Control Board of Assam at four stations close to construction sites and near sensitive receptors (those along the highway). The monitoring shall be conducted for the following three seasons:

- Pre-monsoon season
- Monsoon season
- Post-Monsoon season

646. The frequency of monitoring shall be twice a week for four consecutive weeks at each station for each season. The following parameters shall be monitored: Particulate Matter ($PM_{2.5}$ and PM_{10}), Sulphur dioxide (SO_2) and Nitrogen dioxide (NO_2).

647. Ambient air quality shall be monitored every year for (5 stations * 2 days/week * 4 weeks x 3 seasons) 120 days. A total cost of monitoring is estimated as RS. 0.72 million/year @ Rs. 6,000 per day.

648. A meteorological laboratory shall be set up at one of the ambient air quality monitoring stations. Automatic recorders for temperature, humidity, wind speed & direction, rainfall shall be commissioned at the site. An amount of RS. 1 million shall be earmarked for this purpose.

649.

4. Noise Quality Monitoring

650. Noise emissions from vehicular movement, operation of various construction equipments may be monitored during construction phase at major construction sites including sites for employees and at the nearest sensitive receptors (along the highway). The frequency of monitoring shall be once every month. For monitoring of noise generators an Integrating Sound Level Meter shall be required. An amount of RS. 0.1 million has been earmarked for the purpose.

5. Ecology

651. **Project Construction Phase**: A detailed ecological survey covering forests, fish, and wildlife shall be undertaken during the pre-construction and construction phases (to set baselines and determine possible subsequent changes). The survey shall be conducted once in each season for three seasons (pre-monsoon, monsoon, and post monsoon) every year for the entire construction period. The following aspects shall be covered:

- Qualitative and Quantitative assessment of flora and fauna.
- Monitoring of restoration of muck disposal area.

652. Monitoring of aquatic ecology will be essential to achieve sustainable yield of fish. The following parameters shall be monitored: phytoplanktons, zooplanktons, benthic life and fish composition (if they are there; possibly not given the low pH). The monitoring can be conducted by a reputed external agency once in a year for construction period. The sum of RS. 1.2 million per year has been earmarked for this purpose.

653. **Project Operation Phase**: Status of afforestation programmes and survival rate of trees (70% minimum), migration patterns (if any) of fauna shall be studied by ecological assessments, use of camera traps, and satellite imagery. The study shall be conducted once in each season for three seasons (pre-monsoon, monsoon, and post monsoon) per year for initial 2 years of operation and can be continued further, if found necessary. The sum of RS.1.2 million/year has been earmarked for this purpose. The monitoring shall be conducted by a reputed and recognized external agency.

6. Incidence of Water-Related Diseases

654. **Project 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

shall be closely monitored three times a year (pre-monsoon, monsoon, and post monsoon) with the help of data maintained in the government dispensaries/hospitals and local health centres.

- Implementation : Public Health Department, and Dispensary constructed for labor camps
- Cost per annum : RS. 0.3 million.

655. **Project Operation Phase**: Increased prevalence of various vector borne diseases and adequacy of local vector control and curative measures shall be monitored. The monitoring shall be done three times in a year (pre-monsoon, monsoon and post-monsoon).

- Implementation: Nearby Dispensary/Public Health Centres
- Cost per annum : RS. 0.3 million.

7. Land use Pattern

656. **Project Operation Phase**: During project operation phase, the land use pattern shall be monitored once per year. An amount of RS. 0.5 million has been earmarked for this purpose.

E. Environmental Reporting System

657. **Environmental Monitoring Cell**: An Environmental Monitoring Cell (EMC) shall be formed in order to assess and review the progress of the various mitigation measures suggested in the EMP. The EMC will have representatives of the MoEF&CC, experts from the concerned State Government Departments, representatives of project affected families/villages, local NGOs and EA. The EMC shall sit at least semi-annually for verifying progress and reporting the same. The EA shall depute a Senior Officer to coordinate with the EMC.

658. **Monitoring Mechanism**: APGCL shall engage an independent supervising agency/organization for project management and construction supervision that will also manage environmental components (see discussion below). APGCL shall depute a full time Senior Officer to PMU to co-ordinate the progress of the environmental management activities. The independent supervising agency (PMSC) will work closely with the EMC and delegate necessary laboratory analysis to reputed labs, data collection and information on work progress. The PMSC shall prepare a progress report every two months, and present it to the EMC committee through its environmental cell. For any major comments or obstacles, the independent agency may call a meeting where representatives from independent agency, EA and EMC shall be present and any issue may be discussed in the meeting.

659. EMoP covering various performance indicators, frequency and institutional arrangements of the project in the construction and operation stages, along with the estimated cost, is summarized in Table 124.

660. The reporting system will operate linearly with the contractor who is at the lowest rank of the implementation system reporting to the PMSC, who in turn shall report to the PMU. All reporting by the contractor and PMSC shall be on a monthly basis, with a rolling-up of daily and weekly observations from work sites. The PMU shall be responsible for preparing targets for each of the identified EMP activities.

661. The compliance monitoring and the progress reports on environmental components may be clubbed together and submitted to the PMU quarterly during the implementation period. The

operation stage monitoring reports may be annual provided the Project Environmental Completion Report shows that the implementation was satisfactory. Otherwise, the operation stage monitoring reports will have to be prepared as specified in the said Project Environmental Completion Report.

662. Responsibilities for overseeing will rest with the PMSC's staff reporting to the PIU. Capacity to quantitatively monitor relevant ecological parameters would be an advantage but monitoring will primarily involve ensuring that actions taken are in accordance with contract and specification clauses, and specified mitigation measures as per EMP. An external monitor will support the PIU in monitoring activities.

663. During the implementation period, a compliance report may include description of the items of EMP, which were not complied with by any of the responsible agencies. It would also report to the management about actions taken to enforce compliance and identify corrective actions and the implementation and success of those corrective actions. It may however, be noted that certain items of EMP might not be possibly complied with for a variety of reasons. A corrective action plan will be identified in case of non-compliance. The intention of the compliance report is not to suppress these issues but to bring out the circumstances and reasons for which compliance was not possible (such as jurisdictional issues). This would help in reinforcing the implementation of EMP.

664. Photographic records will also be established to provide useful environmental monitoring tools. A full record will be kept as part of normal contract monitoring. Reporting and Monitoring Systems for various stages of construction and related activities have been proposed to ensure timely and effective implementation of EMP.

665. The reporting system has been prepared for each of the phase of road construction namely:

- Pre-construction
- Construction
- Operation

666. This reporting shall be done through:

- Reporting by the Contractor to the PMSC
- Reporting by PMSC to PIU and PIU.

667. The stage-wise reporting system presented in Table 122.

Table 122: Stage-wise Reporting System of PIU

Format* No.	Item	Contractor	Project Management and Supervision Consultant (PMSC)		Project Implementation Unit (PIU)	
		Implementation and Reporting to PMSC	Supervision	Reporting to PIU	Oversee / Field Compliance Monitoring	Reporting to Environment Officer of PIU
C1	Monitoring of construction site and construction camp	Before start of work	Daily	Monthly	Daily	Quarterly
C2	Target sheet for Pollution Monitoring	As required	As required	After Monitoring	As required	After Monitoring
C3	Target sheet for	-	Monthly	Monthly	Monthly	Quarterly

Format* No.	Item	Contractor	Project Management and Supervision Consultant (PMSC)		Project Implementation Unit (PIU)	
		Implementation and Reporting to PMSC	Supervision	Reporting to PIU	Oversee / Field Compliance Monitoring	Reporting to Environment Officer of PIU
	tree plantation					
C4	Target sheet for monitoring of cleaning water bodies	-	Monthly	Monthly	Monthly	Quarterly
O1	Target sheet for Pollution Monitoring	-	-	-	As per monitoring plan	After Monitoring
O2	Target sheet for survival reporting of plantation	-	-	-	Monthly	After Monitoring
O3	Target sheet for monitoring of cleaning water bodies	-	-	-	Monthly	After Monitoring

- Formats will be developed and provided by supervision consultant to the contractor.
- Blank box shows no action required from that agency

Table 123: Environmental Management Plan

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
DESIGN AND PRE-CONSTRUCTION PHASE							
1.	Impact on air, water, noise, soil	Location and design of power house, office, substation and colony	• Siting of colony away from construction areas including plantation all around colony. • Drainage system with de-silting chamber, will be provided all around power house, office, substation and colony. • Solid waste storage bin system will be provided at required location. • All buildings are designed and will be constructed as per seismic zone provision. • The site-specific earthquake study has been completed by Department of Earthquake Engineering, IIT Roorkee. The site-specific design parameters recommended by IIT for MCE and DBE conditions are recommended as 0.36g and 0.18g for horizontal and 0.24g and 0.12g for vertical ground motion, respectively have been considered. The design has been reviewed by independent experienced dam expert appointed by ADB and found to be adequate. • Dam safety surveillance and monitoring aspects are included. Personnel Safety equipments will be provided at required location.	Design Check	Document Review	DPR Consultant, PMSC	PMU
	Exposure to safety related risks			Design Check	Document Review	DPR Consultant, PMSC	PMU
2.	Release of chemicals ashes in receptors (air, water, land)	Equipment specifications and design parameters.	• CFC not used in substation transformers or other project facilities or equipment by concerned agencies. • Processes, equipment, and systems will not to use chlorofluorocarbons (CFCs), including halon, and their use.	Technical specifications	Document Review	DPR Consultant, PMSC	PMU
3.	Exposure to noise	Power Plant /Substation location	• Design of plant enclosures to comply with IFC EHS noise regulations (85 dB(A) at work sites for heavy industry.	Design Check	Document Review	DPR Consultant, PMSC	PMU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
4.	Acquisition of private land	Location of powerhouse, head works.	• Acquisition of agricultural and cultivable land minimized.	Land area requirements	Document Review	PMU	PMU
5.	Social inequities	Involuntary resettlement or land acquisition.	• Compensation will be paid for temporary / permanent loss of productive land as per Govt. rules and regulation. • A list of all the affected persons by type of losses and extent of damages has been prepared through and the same will be compensated as per RTDP prepared as per GoI and ADB's SPS 2009 requirements.	No. of affected people and entitlement provisions	Document Review, Compensation process	PMU	Revenue Department
6.	Loss of precious Ecological values/impacts on precious species due to acquisition of 523 ha of forest land	Encroachment into precious ecological areas.	• Minimize acquisition of forest areas. • Avoid encroachment by careful site and alignment selection of access roads, and transmission lines. • Afforestation of 1,046 ha (1:2 tree planting ratio) of degraded forest land • A compensatory afforestation and biodiversity conservation and management plan has been prepared (Annex 9). • Cut only trees marked by the Forest Department • Ensure that the area is cleared as per directives/delineation of Forestry staff	Compensatory afforestation process, land take, no. of trees to be cut	Document Review, Clearance papers	PIU, Forest Department	PMU, Forest Department
7.	Nuisance to neighbouring properties	Noise related	• Substations, powerhouse, head works designed to ensure noise will not be a nuisance. Noise will be controlled within IFC EHS noise standards. In any case, there is no proximity of residences to these features.	Technical specifications	Document Review	DPR Consultant, PMSC	PMU
8.	Flooding hazards/ loss of agricultural production	Interference with drainage patterns/ Irrigation channels	• The alignment of river channel and siting of project facilities are done to avoid any flooding hazard. Detailed hydrological assessments have been carried out as part of detailed design. Additional IWRM management plan has been prepared. • Dam Break Analysis and disaster management	Design Check	Document Review	DPR Consultant, PMSC	PMU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			plan has been prepared (Annex 30).				
9.	Environmental pollution	Escape of polluting materials	• Transformers designed with oil spill containment systems, and purpose-built oil, lubricant and fuel storage system, complete with spill cleanup equipment • Construct 110% fenced and bermed area with impermeable concrete floor. • Powerhouses/substations to include drainage and sewage disposal systems (septic tanks, sewage treatment plant) to avoid offsite land and water pollution.	Design Check, technical specifications	Document Review	DPR Consultant, PMSC	PMU
10.	Contamination of receptors (land, water)	Equipment submerged under flood	• Powerhouses/substations constructed above the high flood level (HFL) i.e. 185.34 m, by raising the foundation pad. This level also includes any possible effects from future climate change.	Design Check	Document Review	DPR Consultant, PMSC	PMU
11.	Natural disaster frequently observed	Ground subsidence/ landslide	• Civil design and sitting of project facilities has been done with due considerations to earthquake and landslide so as to avoid any hazard.	Design Check	Document Review	DPR Consultant, PMSC	PMU
12.	Fire hazards	Explosions/fire	• Design of Powerhouses/substations has included modern fire control systems/firewalls in accordance with the norms of National Fire Protection Association (NFPA) and Tariff Advisory Committee (TAC). • Provision of fire fighting equipment to be located within 20 m of transformers, power generation equipment. • Fire protection and Safety practice have been prepared (Annex 28, 29).	Design Check	Document Review	DPR Consultant, PMSC	PMU
13.	Tree cutting	Cutting of trees during site clearance	• Restricting tree cutting within construction limit. • Avoiding tree cutting at ancillary sites. • Providing and maintaining compensatory tree plantation i.e. three times of cutting. • Compensatory afforestation plan prepared.	No. of trees to be cut	Observations	Forest Dept./PIU	PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
14.	Removal of vegetative covers (dust, pollution)	Work site clearance	• Use of controlled clearing activities • Use of dust controlled measures • Collection and disposal of debris and muck.	Vegetation to be cleared	Observations	PIU	Forest Dept./PIU
15.	Removal of utilities	Work site clearance	• Necessary planning and coordination with concerned authority and local body. • Prior notice to and consultation with concerned authority, local body and public to be affected so as to ensure that work does not get affected and impact on public is minimum.	Utility shifting plan	Observations	Concerned utility agencies / PIU	CSC/PIU
16.	Religious places	Work site	• Suitable mitigation measures have been incorporated in social impact assessment report.	RTDP	Observations	PIU	CSC/PIU
17.	Camp site and contractor facilities	Establishment of contractors' facilities	• Obtain permits and NOCs from ASPBC and other statutory agencies. • Contractor to submit a camp and site office plan defining all facilities to be created. These include human waste disposal facilities and solid waste management facilities. The basic plans provided in Annex 17) to be updated and finalized by contractor.	NOCs and permits	Document check.	PMU/PIU/ Contractor	ASPCB, PMU
18.	Project facilities and commencement of construction	Clearances and permits	• Obtain environmental clearance from MoEF&CC • Obtain forest clearance from forest departments • Include EMP in the contract documents.	Clearance letters	Document check.	PMU/PIU/ Contractor	MoEF&CC, Forest Dept., PMU
CONSTRUCTION PHASE							
1.	Impact and air, water, noise, soil	Civil construction work for power house, tunnel, office, substation, access roads, colony etc.	**Air Pollution**: • All the vehicles must have valid PUC certificates at all the time during construction phase of the project. • Water sprinkling shall be done to suppress the dust emissions from the site. • All the DG sets used for construction shall have valid consents from Assam State Pollution Control Board and shall have built-in stacks to reduce the air emission impacts. • Refer to Annex 24: Measures for Air Pollution	PM10, Dust pollution, Complaints from local residents Equipment/ vehicle maintenance record	Measurement Observations, public discussions	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			Control **Noise Pollution:** • Construction materials shall be properly maintained and noise barriers, if needed, shall be provided around worksites, to reduce the noise levels. Design of such barriers will be finalized by CSC environment specialist. • All the workers will be provided with personal protective equipment including ear plugs and other necessary provisions by the contractor. • Refer to Annex 25: Measures for Noise Pollution Control	Noise level, complaints from local residents, vehicle maintenance record, awareness programs implemented	Noise level measurement, field observations, discuss with local residents	Contractor	PMSC/PIU
			Water Quality: • Quality of water (river and wastewater discharged from the construction site) shall be analyzed monthly during construction, for its compliance to the disposal standards of pollution control authority. • Refer to Annex 26: Measures for Water Pollution Control **Others**: • Proper plantation all around colony. Refer to Annex 21: Green Belt Development Plan	Drainage systems, Total solids and turbidity level	Review records, site visit and observations, turbidity level and other water quality parameters to be checked	Contractor	PMSC/PIU
	Exposure to safety related risks		• Drainage with De silting chamber, will be provide all around power house, office, substation and colony. • Solid waste storage bean system will be provided at required location. Refer to Annex 22: Solid Waste Management Plan • All buildings designed constructed as per seismic zone provision. • Safety system will be provided at required location. Refer to Annex 18, Annex 28, Annex 29 for Occupational, Health and Safety Plans.	Planning for waste management	Review of planning and practices for waste management, site visit, observations	Contractor	PMSC/PIU
2.	Infrastructure provisions at labor camps	Health and hygiene at workers camps	• Contractor during the progress of work will provide, erect and maintain necessary living accommodation and ancillary facilities for labor	Planning for health and safety,	Review of planning and practices for	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			as per the requirements of applicable labor regulations of Government of India. • All the work sites and camp sites shall also be provided with basic sanitation and infrastructure as per the requirements of Building and other Construction Workers (regulation of Employment and Conditions of Service) Act, 1996. • Refer to Annex 12: Public Health Delivery System • Refer to Annex 18: Project Personnel Health Plan • Refer to Annex 28: Fire Protection in Labor Camps and Staff Colonies • Refer to Annex 29: Safety Practices during Construction	practices being implemented	seepage and spoil disposal, control, site visits		
		Fire Protection in Labor Camp and Staff Colonies	• Safety Practices During Construction Phase • Refer to Annex 28: Fire Protection in Labor Camps and Staff Colonies	Planning for health and safety	Check record, observations, discussion with workers	Contractor	PMSC/PIU
3.	Solid Waste Management	Construction camps	• Collection and disposal of human waste as per waste management plan. • Refer to Annex 22: Solid Waste Management Plan	Quantity of SW collected and disposed	Record check, observations	Contractor	PMSC/PIU
4.	Muck disposal	Tunneling and excavation activities	• Muck generated from various tunnelling and excavation activities would be dumped suitably to designated sites • Refer to Annex 13: Muck Disposal Plan	Quantity of muck generated and disposed	Record check, observations	Contractor	PMSC/PIU
5.	Construction sites	Restoration of sites	• Restoration of construction sites. • Refer Annex 19: Construction Site Restoration Plan.	Physical inspection of sites	Record check, observations	Contractor	PMSC/PIU
6.	Noise and vibrations	Equipment layout and installation	• Construction techniques and machinery selection seeking to minimize ground disturbance. • Refer to Annex 25: Measures for Noise Pollution Control	Noise and vibration levels	Noise and vibration monitoring record	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
7.	Disturbed farming activity	Physical construction	• Construction activities on cropping land time to avoid disturbance of field crops (within 1 month of harvest wherever possible).	Crops damaged	Observations	Contractor	PMSC/PIU
8.	Noise vibration and operator safety, efficient operation, equipment wear and tear	Mechanized construction	• Construction Mechanized maintenance and turning of plant. • Proper maintenance and turning of plant • Implement environmental mitigation and good-construction as integral component of each civil activity and as day-to-day activity	Planning for health and safety	Record check, observations	Contractor	PMSC/PIU
9.	Increase in airborne dust particles	Construction of access roads	• Existing roads and tracks used for construction and maintenance access to the site wherever possible. • Refer to Annex 24: Measures for Air Pollution Control	Dust levels	Record check, observations	Contractor	PMSC/PIU
10.	Increased land requirement for temporary accessibility	Construction of access roads	• New access ways restricted to a single /intermediate carriageway width. • Refer to Annex 20: Road Construction Management Plan	Planning for access roads	Observations	Contractor	PMSC/PIU
11.	Temporary blockage of utilities	Construction work	• Temporary placement of fill in drains/canals not permitted	Water blockage	Observations	Contractor	PMSC/PIU
12.	Loss of vegetative cover	Site clearance	• Marking of vegetation to be removed prior to clearance, and strict control on clearing activities to ensure minimal clearance.	No. of trees to be cut	Review clearance papers, field observations	Contractor/Forest Dept.	PMSC/PIU
13.	Fire hazards	Trimming/cutting of trees	• Trees allowed growing up to a specified height within the work areas by maintaining adequate clearance between the top of tree and the conductor as per the regulations.	No. of trees to be cut	Observations	Contractor	PMSC/PIU
14.	Loss of vegetation and deforestation		• Trees that can survive pruning to comply should be pruned instead of cleared. • Felled trees and other cleared or pruned vegetation to be disposed of as authorized by the statutory bodies.	No. of trees to be cut	Review clearance papers, field observations	Contractor	PMSC/PIU
	Loss of vegetation and deforestation	Reservoir clearing	• Removal of maximum commercially viable timber. • All remaining timber, after commercial and salvage logging operations have been completed, will be cut as necessary and burnt.	Area to be cleared	Review clearance papers, field observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			• Avoid removing stumps, as disturbed soil may release far more nutrients in water.				
15.	Loss of vegetation and deforestation	Wood/vegetation harvesting	• Construction workers prohibited from harvesting wood in the project area during their employment, (apart from locally employed staff continuing current legal activities). • Contractor should arrange LPG gas for cooking of food for their workers. • Refer to Annex 17: Plan for Construction Camp Management	Fuel supply to workers	Review clearance papers, field observations	Contractor	PMSC/PIU
16	Loss of Biodiversity, Disturbance/accidents/injury, to wildlife and avian fauna	Construction and clearing of forest areas	• Implementation of Compensatory afforestation plan. • Creation of a greenbelt around the perimeter of various project appurtenances, selected stretches along reservoir periphery, access roads to compensate for the loss of habitat • Provisions of adequate signages and speed limit on road sections within forest areas to avoid accidental roadkills . • Poaching activities should be monitored in workers areas and well as community areas (as per Annex 9). • Implementation of Biodiversity Conservation and Management Plan (Annex 9) • Compliance with guidelines issued by the National Wildlife Board of India for linear intrusion in natural area pertaining to roads and power lines. • Compliance with guidelines issued by the CEA for laying transmission lines in areas critical from the point of view of saving wildlife. • Provision of wild fruit plantation for wildlife • Annual bird count of migratory birds by involving locals and bird experts • Rehabilitation with local fruit bearing species in gaps • Anti-grazing drive in drawdown area to protect the bird breeding areas in proximity to reservoir during breeding season – only in	Incidences of wildlife loss	Review clearance papers, field observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			winter season. Grazing by local people will be allowed during dry season. • Construction of check posts/watch towers in key locations • Conservation actions as proposed by IUCN (during construction and during the initial project operation) such as conducting a comprehensive survey and monitoring in and around the project area to establish range, distribution and population status of vulnerable and critical habitats in the project area for assessing its habitat requirements and identifying threats are proposed. • Establishment of biodiversity conservation committee. • Refer to Annex 9: Biodiversity Conservation and management Plan • Refer to Annex 21: Green Belt Development Plan				
17.	Runoff to cause water pollution, solid waste disposal	Surplus earth work/soil	• Excess fill from excavations disposed of next to roads or on barren land or personal in agreement with the local community or land owner. • Soil excavated from power houses will be disposed as safe & scientific manner by placement on barren land or along back fill trench weir etc.	Vehicle maintenance record, review plans for waste management and oil handling practices	Review of planning and practices for seepage and spoil disposal, control, site visits	Contractor	PMSC/PIU
18.	Loss of soil and water pollution	Substation construction	• Fill for the substation foundation obtained by creating or improving local water supply ponds or drains, with the agreement of local communities. • Construction activities involving significant ground disturbance (i.e., substation land forming) not undertaken during the monsoon season.	Planning for soil conservation	Record check, observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
19.	Contamination of receptors (land, water, air)	Storage of chemicals and materials	• Fuel and other hazardous materials securely stored above high flood level with safety measures. • Refer to Annex 18: Project Personnel Health Plan	Vehicle maintenance record, review plans for waste management and oil handling practices	Record check, observations	Contractor	PMSC/PIU
20.	Noise nuisance	Construction schedules	• During work near settlements construction activities only undertaken during the day and local communities will be informed of the construction schedule.	Noise level monitoring	Record check, observations	Contractor	PMSC/PIU
21.	Contamination of receptors (land, water, air)	Provision of facilities for construction workers	• Construction workforce will be provided for certain facilities it includes proper sanitation, water supply and waste disposal facilities. • Refer to Annex 17: Construction Camp Management Plan	Planning for health and safety	Review of planning and practices for seepage and spoil disposal, control, site visits	Contractor	PMSC/PIU
22.	Loss of agricultural productivity	Encroachment into agricultural land	• Use of existing roads wherever possible. • Ensure existing irrigation facilities are maintained in working condition. • Protect/Preserve topsoil and reinstate after construction completed. • Repair/reinstate damaged bunds, etc. after construction completed	loss of agricultural products	Record check, observations	Contractor	PMSC/PIU
23.	Social inequities	Encroachment into agricultural land	• Compensation for temporary loss in agricultural production as per provisions of Resettlement and Tribal Development Plan	RTDP	Record check, observations	Contractor	PMSC/PIU
24.	Soil loss, downstream siltation; etc.	Uncontrolled erosion/silt runoff	• Need for access tracks minimised, use of existing roads. • Limit site clearing to work areas regeneration of vegetation to stabilize works areas on completion (where applicable). • Avoidance of excavation in wet seasons. • Water courses protected from siltation through use of bunds and sediment ponds. • Refer to Annex 26: Water Pollution Control Measures	Soil erosion planning and cases	Record check, observations	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
25.	Losses to neighbouring land uses/values	Nuisance to nearby properties.	• Contract clauses specifying careful construction practices on every stage. • Maximum existing access ways will be used. • Productive land will be reinstated following completion of construction.	Construction planning	Record check, observations	Contractor	PMSC/PIU
26.	Social inequities	Nuisance to nearby properties.	• Compensation will be paid for loss of production, if any as per provisions of Resettlement and Tribal Development Plan	RTDP	Record check, complaints, observations	Contractor	PMSC/PIU
27.	Flooding and loss of soils, contamination of receptors (land, water)	Flooding hazards due to construction impediments of natural drainage.	• Avoid natural drainage pattern/facilities being disturbed/ blocked/ diverted by ongoing construction activities. • Refer to Annex 30: Dam Break Analysis And Disaster Management Plan	Construction planning	Record check, observations	Contractor	PMSC/PIU
28.	Contamination of receptors (land, water)	Equipment submerged under flood	• Equipment stored at secure place above the high flood level (HFL) i.e. 185.34 m.	Construction planning	Record check, observations	Contractor	PMSC/PIU
29.	Loss of land values	Inadequate siting of borrow areas	• Existing sites (if available) will be used, therefore, no need to develop new sources of aggregates.	Construction planning	Record check, observations	Contractor	PMSC/PIU
30.	Injury and sickness of workers and members of the public.	Environment, Health and safety	• Arrangement of Environment awareness programme. • Contract provisions specifying minimum requirements for construction camps. • Preparation and implementation of health and safety plan. • Arrangement of primary health centre with medicine and instrument with a knowledgeable health staff. • Arrangement for health and safety training sessions. • Refer to Annex 12: Public Health Delivery System • Annex 16: Plan for Environmental Training of Workers • Refer to Annex 17: Plan for Construction Camp	Training and awareness programs, Health and safety plans	Review of planning and practices for seepage and spoil disposal, control, site visits	Contractor	PMSC/PIU

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
			Management • Refer to Annex 18: Project Personnel Health Program • Refer to Annex 22: Solid Waste Management Plan • Refer to Annex 23: Emergency Plans for Hazardous Materials • Refer to Annex 24: Measures to Control Air Pollution • Refer to Annex 25: Measures to Control Noise Pollution • Refer to Annex 26: Measures to Control Water Pollution • Refer to Annex 27: Energy Conservation Measures • Refer to Annex 28: Fire Protection In Labor Camp And Staff Colonies • Refer to Annex 29: Safety Practices During Construction Phase • Refer to Annex 30: Dam Break Analysis and Disaster Management Plan				
31.	Likely to maximize damages	Inadequate construction stages monitoring.	• Training to personal of implementing agency for environmental monitoring work. • Implementation of effective environmental monitoring and reporting system using checklist of all contractual environmental requirement. • Appropriate contact clauses to ensure satisfactory • implementation of contractual environmental mitigation measures.	Training and awareness programs, Environment monitoring plans	Record check, observations	Contractor	PMSC/PIU
OPERATION PHASE							
1.	Loss of vegetation and deforestation	Wood/vegetation harvesting	• Staff working at site prohibited from harvesting wood in the project area during their employment, (apart from locally employed staff continuing current legal activities). APGCL/Contractor should arrange LPG gas for cooking of food for their workers.	Loss of forests	Record, observations	Forest Dept./PIU	APGCL
2.	Tree plantation	-	• Compensatory afforestation plan.	Survival rate of trees (70%	Field observations	Forest Dept./PIU	APGCL

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
				minimum)			
3.	Wildlife and Biodiversity	Loss of wildlife / biodiversity	• Implementation and monitoring of biodiversity conservation plan activities.	Change in habitats	Field observations	Forest Dept./PIU	APGCL
4.	Contamination of receptors (land, water)	Equipment may submerged under flood	• Equipment will be installed above the high flood level (i.e. 185.34 m) by raising the foundation pad. This level also includes climate change factors.	Pollution levels	Record, observations	APGCL	APGCL
5.	Soil Erosion	-	• Implementation and monitoring of Catchment Area Treatment Plan (Annex 10) prepared.	Catchment Area Treatment	Record, observations	APGCL	APGCL
6.	Dam Break and Disaster management	Dam Break and Disaster management	• Installation of alert system in control room • Setting up of communication system in various villages • Flood Forecasting Arrangements • Follow Disaster Management Plan (Refer to Annex 30)	Disaster Management Plan	Record, observations	APGCL	APGCL
7.	Water Quality	Water quality change	• Monitoring once in every season at various locations • Monitoring of water quality restoration plan	Water quality parameters	Record, observations	APGCL	APGCL
8.	Ecology	-	• Monitoring of Ecology of the project area shall be done once in each season	Biodiversity Conservation Plan	Record, observations	APGCL	APGCL
9.	Land use Pattern	-	• Monitoring of Land use pattern once in a year	Land use pattern	Record, observations	APGCL	APGCL
10.	Injury and sickness of staff/workers	Inadequate provision of staff/workers health and safety during operations	• Careful design using appropriate technologies to minimize hazards. • Safety awareness raising for staff. • Preparation of emergency plan and training given to staff, for their implementation. • Adequate sanitation and water supply facilities will be provided.	Training and awareness plan, safety plans	Record, observations	APGCL	APGCL

Sl.	Environmental Issue	Activity/Location	Mitigation Measures	Monitoring Indicators	Monitoring Methods	Implementing Agency	Supervising & Monitoring Agency
11.	Injury/mortality to staff and public	Electric shock Hazards	• Careful design using appropriate technologies to minimize hazards. • Security fences around substations/ powerhouse/ head works. • Barriers to prevent climbing on/dismantling of transmission towers. • Appropriate warning sign on facilities. • Electric safety awareness rising in project areas. • Fire hydrant point and fire extinguisher may be placed at appropriate places.	No. of incidences	Record, observations	APGCL	APGCL
12.	Unnecessary environmental losses of various types	Operation and maintenance staff skills less than acceptable	• Adequate training in O&M to all relevant staff of substations and transmission line maintenance crews. • Preparation and training in the use of O&M manuals and standard operating practices.	Training plans	Record, observations	APGCL	APGCL
13.	Diminished ecological and social values.	Inadequate periodic environmental monitoring.	• Proper environmental monitoring of project operations and maintenance activities.	Environment parameters	Monitoring Records, observations	APGCL	APGCL
14.	Release of chemicals and gases in receptors (air, water, land)	Equipment periodic environmental monitoring	• Processes, equipment and systems using chlorofluorocarbons (CFCs), including halon, should not be used in any stage of equipment.	Environment parameters	Record, complaints, observations	APGCL	APGCL
15.	Nuisance to neighbouring properties.	Noise related	• Powerhouses/substations sited and designed to ensure noise will not be a nuisance	Equipments performance	Record, complaints	APGCL	APGCL
16.	Operational performance	All environmental aspects	• APGCL shall monitor the operational performance of the various mitigation measures implemented in the project.	Environment and ecological parameters	Record, complaints, observations	APGCL	APGCL

APGCL = Assam Power Generation Corporation Ltd., PMU = Project Management Unit, PIU = Project Implementation Unit, PMSC = Project Management and Supervision Consultant

Table 124: Environmental Monitoring Plan

Environmental Features / Stage	Parameters and Standards	Location	Frequency	Duration	Action Plan in case criteria exceeds the standards	Responsible party	
						Implementation	Supervision
Soil and Sediments							
Pre-construction Stage	pH, Electrical Conductivity, Nitrogen, Phosphates, Potassium, Organic matter, water content, silt content, average grain size, heavy metals, Al, Fe, Cu, Mn, As, Zn, Ni, Pb, Cr, C, Cd (Standards by CPCB as given in Annex 2)	At identified locations • 1 km upstream of submergence site • Submergence area • 1 and 3 km downstream of dam site	Once prior to start of construction	-	Contamination of sediments	PMSC/External monitor	PMSC, PIU
Air Quality and Noise Levels							
Pre-construction Stage	• $PM_{2.5}$, PM_{10}, SO_2, NOx, CO, HC (Standards given in Annex 2) • Leq - Noise levels day time and noise time on dB (A) scale (GoI and IFC Standards given in Annex 2)	• Wherever the contractor decides to locate the Hot mix plant • At major construction sites as suggested by CSC for regular monitoring • At hot mix plant and equipments yards • At sensitive receptor locations	Once prior to start of construction	Continuous 24 hours/or for 1 full working day – twice in a week.	Review adequacy of measures proposed in EMP.	PMSC/External monitor	PMSC, PIU
Construction Stage	• $PM_{2.5}$, PM_{10}, SO_2, NOx, CO, HC (Standards given in Annex 2) • Leq - Noise levels on dB (A) scale (GoI and IFC Standards given in Annex 2)	• Wherever the contractor decides to locate the Hot mix plant • At major construction sites as suggested by CSC for regular monitoring • At hot mix plant and equipments yards • At sensitive receptor locations (along the highway)	Once in a season excluding monsoon for entire duration of construction	Continuous 24 hours/or for 1 full working day – twice in a week.	Check and modify control devices like bag filter/cyclones of hot mix plant Provide additional noise barriers	Contractor Through approved monitoring agency	PMSC, PIU

Environmental Features / Stage	Parameters and Standards	Location	Frequency	Duration	Action Plan in case criteria exceeds the standards	Responsible party	
						Implementation	Supervision
Operations Stage	• $PM_{2.5}$, PM_{10}, SO_2, NOx, CO, HC (Standards given in Annex 2) • Leq - Noise levels on dB (A) scale (GoI and IFC Standards given in Annex 2)	• At selected locations in the project site (dam site, powerhouse, permanent colony) • At sensitive receptor locations (along the highway)	Quarterly for 2 years	Continuous 24 hours/ or for 1 full working day - Once in a week	Check and provide suitable measures	PIU Through approved monitoring agency	PMU
Water Quality							
Pre-construction Stage	pH, Temperature, DO, Oil & Grease, Conductivity, TSS, TDS, Alkalinity, Total Hardness, Calcium, Magnesium Chloride, Phosphate, Sulphate, Nitrate, heavy metals, COD, BOD, Iron, Total Coliform, Faecal Coliform, Salinity (Surface Quality Standards by CPCB as given in Annex 2)	At identified water bodies locations • 1 km upstream of submergence site • Submergence area • 1, 3 and 8 km downstream of dam site • At identified water bodies locations (wells and other ground water sources in project area)	Once prior to start of construction	-	Check and modify petrol interceptors, Silt fencing devices.	PMSC/External monitor	PMSC, PIU
Construction Stage	pH, Temperature, DO, Oil & Grease, Conductivity, TSS, TDS, Alkalinity, Total Hardness, Calcium, Magnesium Chloride, Phosphate, Sulphate, Nitrate, heavy metals, COD, BOD, Iron, Total Coliform, Faecal Coliform, Salinity (Surface Quality Standards by CPCB as given in Annex 2)	At identified water bodies locations • 1 km upstream of submergence site • Submergence area • 1, 3 and 8 km downstream of dam site	Once in a season Excluding monsoon for 2 years	-	Check and modify petrol interceptors, Silt fencing devices.	Contractor Through approved monitoring agency	PMSC, PIU
	pH, Temperature, Conductivity, TSS, TDS, Alkalinity, Total, Hardness, Calcium, Magnesium Chloride, Phosphate, Sulphate, Nitrate, Iron, heavy metals, (Ground Quality Standards by CPSB as given in Annex 2)	• At identified water bodies locations (wells and other ground water sources in project area)	Once in a season Excluding monsoon for 2 years	-	Check and modify petrol interceptors, Silt fencing devices.	Contractor Through approved monitoring agency	PMSC, PIU

Environmental Features / Stage	Parameters and Standards	Location	Frequency	Duration	Action Plan in case criteria exceeds the standards	Responsible party	
						Implementation	Supervision
	pH, BOD, COD, TSS, TDS (Effluent Quality Standards by CPSB as given in Annex 2)	AT STP locations (Before and after treatment from each STP)	Monthly		Check and modify petrol interceptors, Silt fencing devices; adjust STP mechanisms.	Contractor Through approved monitoring agency	PMSC, PIU
Operation Stage	pH, Temperature, DO, Oil & Grease, Conductivity, TSS, TDS, Alkalinity, Total Hardness, Calcium, Magnesium Chloride, Phosphate, Sulphate, Nitrate, COD, BOD, Iron, Total Coliform, Faecal Coliform, Salinity (Surface Quality Standards by CPSB as given in Annex 2)	• 1 km upstream of submergence site • Submergence area • 1, 3 and 8 km downstream of dam site	Once in a season Excluding monsoon for 2 years	-	Check and modify petrol interceptors, Silt fencing devices. Check and repair STW if required.	PIU Through approved monitoring agency	PMU
	pH, Temperature, Conductivity, TSS, TDS, Alkalinity, Total, Hardness, Calcium, Magnesium Chloride, Phosphate, Sulphate, Nitrate, Iron. (Ground Quality Standards by CPSB as given in Annex 2)	• At identified locations(wells and other ground water sources in project area, staff colonies)	Once in a season Excluding monsoon for 2 years	-	Check and modify petrol interceptors, Silt fencing devices.	PIU Through approved monitoring agency	PMU
	pH, BOD, COD, TSS, TDS (Effluent Quality Standards by CPSB as given in Annex 2)	AT STP locations (Before and after treatment from each STP)	weekly	-	Check and modify petrol interceptors, Silt fencing devices; adjust STP mechanisms.	PIU Through approved monitoring agency	PMU
Water-related diseases							
Construction	Identification of water related diseases, adequacy of local vector control and curative measure, etc.	Labor camps and colonies	Three times a year	-	Check hygiene conditions in camp and colonies	Contractor through approved monitoring agency	PMSC, PIU
Operation	Identification of water related diseases, adequacy of local vector control and curative measure, etc.	Villages adjacent to project sites	Once in a year	-	Check hygiene conditions in worker colonies	PIU through approved agency	PMU
Terrestrial Ecology							

Environmental Features / Stage	Parameters and Standards	Location	Frequency	Duration	Action Plan in case criteria exceeds the standards	Responsible party	
						Implementation	Supervision
Pre-construction	Terrestrial Flora and fauna (using camera traps, incidental observations)	At selected locations in the project area, near proposed worksites, along the transmission line route, along access roads, and in the forest south of the project area, for determination of baseline	Once prior to start of construction	-	Check baseline record Check status of flora and fauna and provide additional monitoring, if required.	PMSC/External monitor	PMSC, PIU
Construction	Status of afforestation programme of green belt development, Terrestrial Flora and fauna (using camera traps, incidental observations)	At selected locations in the project area, near worksites, along the transmission line route, along access roads, and in the forest south of the project area	Once every season	-	Check baseline record Check status of flora and fauna and provide additional protective measures, if required.	Contractor Through external agency	PMSC, PIU, Forest Department
Operation	Status of afforestation programmes of green belt development, Terrestrial Flora and fauna (using camera traps, incidental observations, and satellite image analysis)	At selected locations in the project area, near the dam and powerhouse, along the transmission line route, along access roads, and in the forest south of the project area	Once every season	-	Check baseline record Check status of flora and fauna and provide additional protective measures, if required. Survival rate of trees (70% min.)	PIU	PMU, Forest Department
Aquatic Ecology							
Pre-construction	Phytoplankton, zooplankton, benthic animals, fish composition	• 1 km upstream of reservoir site • downstream of dam site	Once prior to start of construction	-	Check baseline record	PMSC/External monitor	PMSC, PIU
Construction	Phytoplankton, zooplankton, benthic animals, fish composition	• 1 km upstream of reservoir site • downstream of dam site	Once every season	-	Check baseline record, determine change-cause factors and	PIU Through approved monitoring agency	PMSC, PIU

Environmental Features / Stage	Parameters and Standards	Location	Frequency	Duration	Action Plan in case criteria exceeds the standards	Responsible party Implementation	Supervision
					adjust		
Operation	Phytoplankton, zooplankton, benthic animals, fish composition, river discharge (e-flow and tributaries)	• 1 km upstream of reservoir site • Submergence area • 1, 3 and 8 km downstream of dam site	Once every season	-	Check baseline record, determine change-cause factors and adjust	PIU	PMU
Hydrology							
Construction	Discharge (m^3/s)	• Above dam, below dam, at TRT and confluence point of Mynriang with Kopili river.	Monthly	-	Check baseline record	PIU Through approved monitoring agency	PMSC, PIU
	e-flow	• E-flow at the dam will be monitored constantly (in situ gauge) as per the e-flow management plan	Constantly	-	Check baseline record with designed minimum e-flow figures	PIU	PMU
Operation	Discharge (m^3/s)	• Above dam, below dam, at TRT and confluence point of Mynriang with Kopili river.	Monthly for first 2 years	-	Check baseline record	PIU Through approved monitoring agency	PMSC, PIU
	e-flow	• E-flow at the dam will be monitored constantly (in situ gauge) as e-flow management plan	Constantly	-	Check baseline record with designed minimum e-flow figures	PIU	PMU
Land use							
Operation	Land use pattern using satellite data	Project area	Once in a year	-	Check status with satellite images (passive monitoring; only intervene if there is illegal forest clearing)	Contractor Through external agency	PMU
Health and Safety							

Environmental Features / Stage	Parameters and Standards	Location	Frequency	Duration	Action Plan in case criteria exceeds the standards	Responsible party	
						Implementation	Supervision
Construction	Monitor and report health and safety incidents	All construction sites	Continuous	-	Follow EMP provisions and take actions as per IFC EHS Guidelines	Contractor	PMSC / PIU
Operation	Monitor and report health and safety incidents	All project facilities	Continuous	-	Follow and take actions as per IFC EHS Guidelines.	PIU	PMU
Meteorology Parameters							
Operation	Wind direction & velocity temperature humidity, rain	At one of the ambient air quality sampling sites	Continuous	-	Data check	Contractor Through external agency	PMU

PMU = Project Management Unit , PIU = Project Implementation Unit, PMSC = Project Management and Supervision Consultant.

F. Institutional Requirements

668. APGCL will be the Executing Agency (EA) and the Implementing Agency (IA) for LKHEP (Tranche 3). A fully functional Project Management Unit (PMU)[98] headed by a Project Director which report to the Chairman of APGCL with appropriate staffing has been established. APGCL will establish a Project Implementation Unit (PIU) comprising of dedicated senior staff who would be responsible to deal with (a) project preparatory activities including providing information and overseeing the development of bid documents; (b) financial matters including agreeing with ADB on financial covenants; (c) supervision and implementation of the environmental and social safeguards requirements, as well as any Corporate Social Responsibility (CSR) plans.

669. APGCL through the PMU, will be responsible for the monitoring of environmental management during construction and operation. APGCL staff expertise will be complemented by a network of qualified consultancies that will be utilized to assist in safeguard assessments, EMP, EMoP, and reports. Most of the required technical and human resources to design and construct the sub-projects will be hired through Engineering, Procurement and Construction Contractor (EPC) contracts and monitored by AGPCL staff.

670. Since this is a Category A project, an external monitoring agency will be required to monitor and report the implementation of environmental safeguards aspects of the project. The external environment monitor will have a team comprises of an environmental safeguard implementation expert, ecological/biodiversity expert and health and safety expert. Indicative ToR for the external environment monitor is presented Annex 37. A biodiversity conservation committee will also be established as part of Biodiversity Conservation and Management Plan.

671. APGCL, a new EA for ADB loans, is under the process of developing strong in-house capacity to identify, appraise, supervise installation, monitor operation and report on projects. Appropriate capacity development interventions such as training on all aspects such as appraisal, supervision, installation, project monitoring operation, environment and social assessment and monitoring shall be developed through the ADB funded project. For environmental safeguards a training program with training modules has been proposed (Annex 16) and associated budget has been allocated in the EMP budget. Capacity development activities will be implemented through participation in relevant courses and seminars, provision of hand-holding through consultants and technical backstopping by PMU.

672. This will ensure that APGCL will follow well-established procedures for project design, and environmental and social impact assessments, including procedures for implementation. It should be ensured that staff are recruited and trained by both agencies so that the environmental and social safeguards management is carried out in full compliance with the ADB's SPS 2009 and applicable regulations of the state and central governments.

673. The project will be implemented by PMU of APGCL based on Guwahati. The Project Director of PMU will be overall responsible for EMP implementation. Figure 70 show the structure of the project implementation arrangement. The following key players are involved in EMP implementation during construction stage:

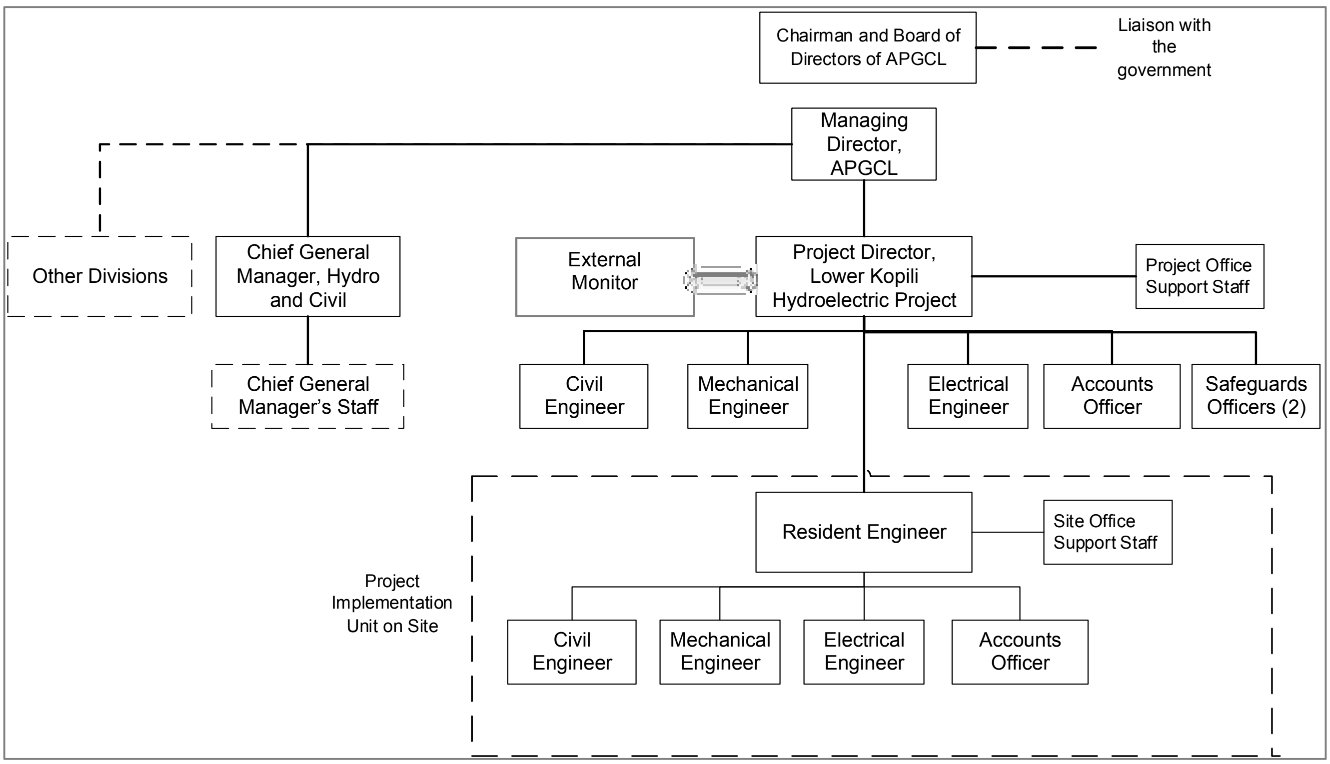
- EA (thought PMU)
- PIU
- External Monitor

[98] PMU provides Institutional support for financial management and institutional capacity development to all EAs.

- Project Management and Supervision Consultants (PMSC); and
- Contractors.

674. The PMU will have a dedicated Social and Environmental Safeguards Cell (SESC) with a qualified full time environment specialist and a full time qualified social safeguard specialist assisted by a team of environmental and social field assistants. Their office will be located at the project office in the project area. The SESC will keep close contacts with the head office of the APGCL in Guwahati regarding safeguard application and its progress. SESC will be headed by the Project Director but coordinating and supervising implementation of safeguard measures will be undertaken by the designated Environmental and Social Officers. There is a need for capacity building of environmental unit through various trainings. Proposed training modules are presented in Annex 16 and associated budget has been allocated in the EMP budget.

Figure 70: Structure of the Project Management Unit



675. The Project Director of PMU with the assistance of designated safeguards (environment specialist, social development specialist) officials from SESC will be overall responsible for ensuring compliance of safeguard measures and will be reporting to the regulatory bodies and ADB certifying that relevant environmental safeguard measures have been complied with during project implementation. At the field level, the Environment Specialist, Ecology Officer and H&S Officer will supervise implementation of safeguard measures for this project and submit monthly reports to PMU.

676. PMU may engage independent agencies for carrying out pollution monitoring activities. The Supervision Consultant shall be interacting with these agencies and facilitate them in carrying out such activities.

677. The Project Management and Supervision Consultant (PMSC) will have an Environmental Safeguards Specialist in its team and it will liaise with PMU environment unit to ensure that Contractor complies with the requirements of various environmental safeguard measures through supervision, monitoring and reporting on the same. Efforts must be made by PMSC to ensure that environmental mitigation and good-construction-practices are not only considered but actually implemented as integral component of each civil activity. It should be considered as day-to-day activity. Implementation of environmental safeguard measures needs team effort and as such the Team Leader of PMSC will delegate the responsibilities to each member of the supervision team with respect to their core responsibilities. The project should have a provision of Environmental Specialist within PMSC to supervise implementation of safeguard measures. This person's role would be more on advisory, assisting the Team Leader of PMSC on the following:

- Advise PMU on preparing reports to ADB and other statutory bodies;
- Preparing procedures for implementing EMP;
- review Contractor's EMP, traffic management plan and safety plan and recommend for its approval/improvements, to the Team Leader;
- provide training to PMU and PIU, PMSC and Contractors' staff on implementing environmental safeguard measures;
- advise on obtaining various statutory environmental clearances on time;
- conduct weekly field visits to examine environmental compliances and suggest corrective actions; and
- any other issues as will be required to ensure environmental compliance.

678. Besides, the Team Leader of PMSC will nominate a senior environmental specialist from the site office for being directly responsible for day-to-day supervision of implementation of stipulated safeguard measures, to ensure accountability. This person will provide guidance to the field staff of PMSC and Contractor for implementing each of the activities as per the EMP, and will be responsible for record keeping, providing instructions through the Engineer for corrective actions, ensuring compliance of various statutory and legislative requirements and assist Engineer for submitting reports to PIU. This person will maintain a close co-ordination with the Contractor and PIU for successful implementation of the environmental safeguard measures.

679. Responsibilities of various agencies involved in the project implementation are described in following paragraphs.

1. Executing Agency Responsibilities

680. The EA's responsibilities will mainly be focused on addressing national or state level environment safeguard issues and decisions concerning the projects. Specific responsibilities on environment safeguards at the EA level are:

- Ensure that all environment safeguard requirements as given in ADB's SPS 2009, and applicable laws and rules under MoEF&CC are being complied with during all stages of respective projects under the loan.
- Reviewing and approving all environment safeguards related documents such as EIA, EMP monitoring reports etc. prepared for projects under the investment program.
- Timely endorsement and signing of key documents and forwarding to the respective agency such as those required for processing of environmental clearance, forestry clearance etc. and disclosure on ADB website.

- Taking proactive and timely measures to address any environment safeguards related challenges at the national or state level such as delays in processing of clearances (during pre-construction), significant grievances (during construction)
- Recruiting an external monitor to conduct third party environmental monitoring for category A project.

2. Implementing Agency Responsibilities

681. The IA's responsibilities will mainly be focused on implementing environment safeguard requirements in accordance with the EIA and EMP at the project and site level. Specific responsibilities on environment safeguards at the IA level are:

- Review the budgetary needs for complying with the Government's and ADB's requirements on environment safeguards and ensure the proposed budget is in line with project requirements.
- Prepare forms, reports and all documents etc. for processing of environmental, forestry and related clearances in a timely manner and submit them for further review and signing to the authorized officer in the respective EA office.
- If any problems or long delays are encountered when processing the clearance documents, immediately alert the authorized officer at the EA level and seek ways resolve the problem at the soonest.
- Provide necessary support to the consultants preparing the environmental assessment reports to facilitate smooth and efficient preparation of documents, conduction of meetings, conduction of public hearings etc. required by ADB, MoEF&CC, SPCB, Forestry Department, etc.
- Review EIA reports including EMP and EMoP prepared by the consultant and provide comments if necessary.
- After receipt of satisfactory EIA report including EMP and EMoP forward the respective reports to the respective EA for further endorsement and forwarding to ADB for disclosure on the ADB website.
- Ensure that all necessary regulatory clearances are obtained prior to commencing any civil work of the respective contract package.
- Ensure EPC contractors to update EMP and EMoP based on detailed design and implementation of EMP is included under the contractor's responsibilities.
- Ensure that EMP and EMoP which includes required mitigation measures and monitoring requirements with defined Bill of Quantity (BOQ), forms part of bidding document for the case of item rate based contracts.
- Ensure that contractors have access to EIA report including EMP and EMoP of the project.
- Ensure that contractors understand their responsibilities to mitigate environmental problems associated with their construction activities.
- Ensure and Monitor that all required permits, no objection certificates etc. are obtained by the contractor for establishment and operation of equipments and facilities as detailed in EIA.
- With the support of the environmental focal person of the contractors and PMSC ensure that the contractor implements EMP including EMoP as given in the respective EIA report.
- In case of unanticipated environmental impacts during project implementation stage, with the support of PMSC prepare and implement an updated EIA and EMP to account

for such impacts after seeking concurrence from ADB. The updating shall be carried out after due consultation with the stake holders and concerned government agencies.

- In case during project implementation a project needs to be redesigned, review the environmental classification and revise accordingly, and identify whether supplementary EIA study is required. If it is required, prepare the ToR for undertaking SEIA and hire an environment consultant to carry out the study.
- Ensure that construction workers work under safe and healthy working environment.
- Ensure effective implementation of GRM to address APs' concern and complaints.
- Ensure regular consultations are taking place with affected communities and key stakeholders during construction as well as operation phases of the project.
- Submit quarterly monitoring reports for category A project on the implementation of all environment safeguard requirements including EMP and EMoP under the respective project to ADB and make these reports available for public disclosure.

3. External Monitor's Responsibilities

682. External monitor is responsible for the following:

- Independent monitoring of implementation of EMP and Biodiversity Conservation and Wildlife Protection Plans.
- Pre-construction baseline surveys on environment and biodiversity (flora, fauna and critical habitats).
- Training and awareness programs.
- Advise EA on environment and biodiversity issues during construction and initial years of operation, and
- Assisting EA with independent monitoring reports.

4. ADB's Responsibilities

683. ADB is responsible for the following:

- Review REA checklist and endorse or modify the tranche classification proposed by APGCL.
- Review EIA report and disclose the draft and final reports on the ADB website as required;
- Issue project's approval based on EIA report;
- Monitor implementation of EMP through due diligence missions;
- Provide assistance to EA and IA of project, if required, in carrying out its responsibilities and for building capacity for safeguard compliance; and
- Provide further guidance to EA and IA on the format, content, and scope of EIA report and quarterly environmental monitoring reports for submission to ADB.

684. For ensuring that EMP is properly implemented, Contractor shall appoint a full time qualified and experienced Senior Environmental and Safety Officer (ESO) for the overall project, as well as an Environmental Officer and a Health & Safety Officer for every construction site (from the commencement to completion of the project). The qualification and responsibilities of ESO as stipulated below should be considered. The qualification of ESO will be as given below:

- Diploma or Graduate in environmental management, with post graduate specialization in Environmental Engineering or Environmental Science or equivalent;

- 5 to 10 years of total professional experience; and
- About 3 to 5 years of experience in similar projects i.e. management of environmental issues in design and construction of hydropower and civil infrastructure development projects.

685. The responsibilities of ESO, EO and HSO of Contractor will include the following:

- Directly reporting to the Project Manager of the Contractor;
- Discussing various environmental issues and environmental mitigation, enhancement and monitoring actions with all concerned directly or indirectly;
- Prepare Contractor's EMP, e-flow and sediment management plan, traffic management plan and safety plan as part of their Work Program;
- Ensure contractor's compliance with EMP stipulations and conditions of statutory bodies;
- Assisting project manager to ensure environmentally sound and safe construction practices;
- Assisting project manager to ensure the timely procurement of materials that are included in the Bill of Quantities relating to environmental mitigation and enhancement measures;
- Conducting periodic environmental and safety training for contractor's engineers, supervisors and workers;
- Preparing a registers for material sources, labor, pollution monitoring results, public complaint and as may be directed by the Engineer;
- Assisting the PIU on various environmental monitoring and control activities including pollution monitoring;
- Preparing and submitting monthly reports to PMSC on status of implementation safeguard measures; and
- Ensure effective implementation of GRM to address APs' concern and complaints.

686. As mentioned above, there will need for capacity building of PMU and PIU on various environmental and social aspects of the project through various environmental trainings and awareness programs. Considering the complex legal framework there is a need for PMU and PIU staff to updating the information and keeping abreast with the changing legal and administrative requirement. The requirements of various statutory permits and clearances are mentioned in Table 4 of Chapter 2. For successful implementation of EMP, it is essential to orient engineers of PMU, PIU, PMSC and Contractor who would be mobilized for this project. A one-day environmental orientation workshop will be conducted at Guwahati by an ADB-supported consultant, once contractor staff are mobilized and before activities begin at work sites. The training program is included in Annex 16.

G. Environmental Management and Monitoring Budget

687. A budget of Rs. 826.038m[99] (US$ 12.90m) has been estimated for implementation of EMP. The details of environmental management budget are given in Table 125.

688. The cost required for implementation of EMoP is of the order of Rs.10.992 million @ Rs. 2.508 million/year. A 10% annual price increase may be considered for every year. The construction period for estimation of cost for implementation of Environmental Monitoring programme during construction phase has been taken as 4 years. The details are given in Table 126. The cost required for implementation of the Environmental Monitoring Programme in

[99] Cost of Resettlement and Rehabilitation Plan (RS 1166.6 million) is excluded from EMP budget.

operation phase is of the order of Rs. 2.283 million/year. It is proposed to continue environmental monitor program for initial three years of operation phase. Total cost of operational phase environmental monitoring for three years is of the order of 6.849 million (@2.283million/year). The details are given in Table 127.

Table 125: Cost Estimate Cost for Implementing Environmental Management Plan*

S. No.	Item	Cost (Rs. Million)
1.	Compensatory Afforestation, and Bio-diversity conservation	191.035
2.	Catchment Area Treatment	122.37
3.	Public health delivery system	42.36
4.	Muck management	34.0
5.	Stabilization of quarry sites	11.5
6.	Restoration and Landscaping of construction sites	10.0
7.	Environmental management in road construction	16.952
8.	Greenbelt development	2.0
9.	Solid Waste Management	23.484
10.	Water pollution control	18.5
11	Energy Conservation measures	10.0
12.	Disaster Management Plan	37.0
13.	Local Area Development Plan	58.1
14	Plan to preserve cultural identity of the locals	12.286
15.	Environmental Monitoring during construction phase	10.992
16.	Monitoring and Evaluation Aspects	6.0
17.	Purchase of meteorological instruments	1.0
18.	Purchase of noise meter	0.1
19.	Water Quality Restoration Plan	65.0
20.	Training and Awareness Building	2.0
21.	External Monitor	94.51
22.	Pre-construction baseline monitoring	50.0
23.	Environmental Monitoring during operation phase (for initial three years)	6.849
	Total	**826.038**

Table 126: Cost Estimate for Environmental Monitoring Plan (Construction Phase)

S. No	Item	Cost (Rs. Million /year)	Total cost for construction period of 4 years with 10% escalation per year (Rs. million)
1	Water quality 144 samples	0.288	1.152
2	Ambient Air quality 120 samples	0.72	2.88
3	Ecology	1.2	5.568
4.	Incidence of water related diseases	0.3	1.392
	Total	**2.508**	**10.992**

Table 127: Cost Estimate for Environmental Monitoring Plan (Operation Phase)

S. No	Item	Cost (Rs. million/year)
1	Water quality	0.283
2	Ecology	1.2
3	Incidence of water related diseases	0.3

4.	Land use pattern	0.5
	Total	**2.283**

XII. CONCLUSIONS AND RECOMMENDATIONS

689. As per the ADB's SPS 2009 EIA categorization process, the proposed project (hydropower development) is classified as environment Category A and as per GoI policies the project also falls under category A; listed for environment clearance by MoEF&CC as the capacity of the project is 120 MW. The categorization is based on the typical magnitude and extent of likely impacts from hydropower projects. The EIA for the proposed project has been carried out as part of project preparation and in compliance with ADB's SPS 2009 and GoI requirements.

690. The diversion of water for hydropower generation will result in change in the hydrological regime of the area, however minimum e-flow (20% of average lean season flow at the dam, and increasing continuously downstream) will be maintained for maintaining ecological habitat. Note: A water quality restoration plan is also being developed to enhance the aquatic ecosystem and downstream water quality in the river.

691. There are no environmentally sensitive areas (protected areas) within the PIA, however based on stakeholder consultations, the biodiversity of the area is complex. However, the impact assessment process has indicated that there are no significant negative environmental and socio-economic impacts associated with the proposed project that cannot be mitigated to negligible or acceptable levels. All significant issues were screened out during the consideration of alternative locations.

692. The project footprint in 523 ha. of Reserve forest land does not contain discrete management unit (DMU) for unique or critically vulnerable flora and fauna. Experience with similar projects in North East region indicate that the temporary negative impacts due to pre-construction preparation and construction works can be managed with "Best Practices" and measures to address issues such as: minimize sediment mobilization, reduce noise and air quality issues, and contain waste (management and disposal). Diversion of 523 ha. of Reserve forest land will be compensated via Compensatory Afforestation (CA) scheme in coordination with the Assam State Forest Department. The impacts on wildlife will be managed via Biodiversity Conservation and Monument Plan. Aquatic ecology in the river is negligible due to acidic nature of water. Nevertheless, minimum e-flow (20% of average lean season flow at the dam, and increasing continuously downstream) will be maintained for ensuring an adequate aquatic habitat in the downstream river sections. These are the main factors in maintaining environmental impacts at an acceptable and manageable levels.

693. There is full local community acceptance of the project. Affected families will be compensated as per provisions of the Resettlement and Tribal Development Plan developed for LKHEP. The project will help bring significant power service reliability to State and local and national economic benefits while resulting in GHG emission reductions. All required mitigation measures and respective monitoring of their performance are documented in the EMP. The environmental mitigation measures will be incorporated into the contractor's contract documents. This EMP will become the *modus operandi* for the project, ensuring that predicted impacts are well-managed, and that accountability for mitigation performance is in place. Before the start of civil works for the any component of the project, APGCL must obtain necessary clearances/permits from statutory authorities.

694. Given the observations and conclusions from the impact assessment processes documented above, the project appears to be acceptable for implementation, as designed, according to GoI and ADB standards and policy requirements.

ANNEXURES

(Included separately in Volume 2)