Environmental Impact Assessment

October 2018

India: Assam Power Sector Investment Program Tranche 3

Supplementary EIA Volume 2

Prepared by Assam Power Generation Corporation Limited (APGCL), Government of Assam for the Asian Development Bank. This is an updated version of the draft originally posted in April 2018 available on https://www.adb.org/projects/documents/ind-47101-004-eia

LOAN 3327 IND

ASSAM POWER SECTOR INVESTMENT PROGRAM – TRANCHE 2

Consulting Services for Supplemental Environmental Assessment for Lower Kopili Hydropower Project

Final Report
(Volume 2 - Cumulative Impact Assessment Report)

Submitted to:

Assam Power Generation Corporation Limited
INDIA

November 2017

TABLE OF CONTENTS

Page

LIST OF FIGURES

ABBREVIATIONS

ADB	–	Asian Development Bank
ALD	–	anoxic limestone drainage
AMD	–	acid mine drainage
AoC	–	area of concern (refer to Project's area of influence)
APSIP	–	Assam power sector investment program
ARD	–	acid rock drainage
APGCL	–	Assam Power Generation Company Limited
APDCL	–	Assam Power Distribution Company Limited
AQI	–	air quality index
BC	–	black carbon
BOD	–	biological oxygen demand
CIA	–	cumulative impact assessment
COD	–	chemical oxygen demand
CSMRS	–	Central Soil And Material Research Station
DPR	–	detailed project report
EA	–	executing agency
EIA	–	environmental impact assessment
EMP	–	environmental management plan
FGD	–	focus group discussion
FRL	–	full reservoir level
GoA	–	Government of Assam
GoI	–	Government of India
GHG	–	green house gases
IEE	–	initial environmental examination
IFC	–	International Finance Corporation
IR	–	inception report
IWRMP	–	integrated water resources management plan
KHP	–	Kopili Hydroelectric Project
LKHEP	–	Lower Kopili Hydroelectric Project
MDDL	–	minimum draw down level
MFF	–	multitranche financing facility
MoEF&CC	–	Ministry of Environment, Forest and Climate Change
MW	–	megawatt
NEEPCO	–	North Eastern Electric Power Corporation Limited
NEHU	–	North Eastern Hill University
PCBA	–	Pollution Control Board Assam
PIU	–	project implementation unit
PMU	–	project management unit
RBO	–	River Basin Organization
RFP	–	request for proposal
RIZ	–	resource impact zones
RP	–	resettlement plan
RORPs	–	run-of-river plants
RRP	–	report and recommendations of the president
RSPM	–	respirable suspended particulate matter
QMS	–	quality management system
SEA	–	supplemental environmental assessment
SHP	–	small hydropower project
SIA	–	social impact assessment

SPS	–	safeguard policy statement
SPM	–	suspended particulate matter
TA	–	technical assistance
TDS	–	total dissolved solids
TOR	–	terms of reference
VEC	–	valued ecosystem components
WQR	–	water quality restoration

1. INTRODUCTION

1.1 Project Background

1. On 3 July 2014 ADB Board approved a multi-tranche Financing Facility (MFF) to the Government of Assam (through Government of India) for the Assam Power Sector Investment Program (APSIP). The APSIP aimed to finance a portion of the power sector investment plan for generation and distribution of the Government of Assam (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.

2. The investment program is estimated to cost US$430 million. On Government request, ADB provided MFF in an amount up to US$300 million from ADB's ordinary capital resources to help finance a part of the investment program. The MFF comprise three tranches. Tranche 1 for US$ 50 million (Loan 3140-IND) was approved on 11 July 2014 and became effective on 12 May 2015; it 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 for US$ 48 million (Loan 3327-IND) was approved on 23 November 2015 and the loan was signed on 07 November 2016; it includes expansion and upgrading of the power distribution system in the state of Assam, and strengthening institutional capacity of Assam Power Distribution Company Limited (APDCL). The Government is planning to submit PFR 3 for Tranche 3; it includes financing for the 120 megawatt (MW) Lower Kopili Hydroelectric Project (LKHEP).

3. The detailed project report (DPR) for the Lower Kopili HEP has been prepared by APGCL including an EIA as per Government of India (GOI) requirements. The draft EIA report has been reviewed by ADB and existing issues were identified which require action by APGCL before the project can be funded under the Investment Program. These issues include:

- Low pH in Kopili River, Khandong and Umrong Reservoirs is contributing to degradation of the existing Kopili HEP through corrosion of the metallic components of the facilities. Source of low pH is presumed to be from illegal coal mining waste discharging acid mine drainage into tributaries to the Kopili River. Some of these illegal coal mine sites have been preliminarily identified but additional investigation and site characterization is needed to design a remedial strategy.
- Draft EIA prepared by WAPCOS (October 2016) requires three additional components in order to be finalized: a Cumulative Impacts Assessment (CIA), an Integrative Water Resources Management Plan (IWRMP) and a Water Quality Restoration Plan including a mitigation strategy.
- Cumulative Impacts Assessment - Need to update Lower Kopili (LK) site characterization including surface drainages, volumes and existing wetlands.
- Further identification of illegal mine sites and pyritic rock exposures contributing to low-pH drainage.
- Further identification of surface drainages and impacts.
- Mitigation and remediation plan needed, including pilot study for anoxic limestone drains as a treatment option.
- Comprehensive surface water treatment system needs to be designed and implemented based on above investigations and impact assessment.

4. An additional Terms of Reference (TOR) was issued by the Ministry of Environment, Forest and Climate Change (MoEF&CC) of India for the EIA, which included cumulative impact of operation of the LKHEP and existing HEP development. The EIA is also required to comply with ADB's Safeguard Policy Statement (SPS). Following review of WAPCOS EIA, ADB and APDCL/APGCL identified additional studies required to complete the EIA to meet GOI and ADB requirements. APDCL invited consulting services proposals for Supplemental Environmental Assessment (SEA). Subsequently, ES Safeguards Compliance Services Private Limited, India was retained by APDCL/APGCL as Consultant to undertake 'Consulting Services for Supplemental Environmental Assessment for Lower Kopili Hydropower Project'. The consultant worked work with APGCL and other assisting consultants and conducted the Supplemental Environmental Assessment as detailed in the consultant's TOR. The supplemental environmental assessment consulting services are being financed under Tranche 2 of the MFF. Lower Kopili Hydropower Project is proposed for financing under Tranche 3 of the Assam Power Sector Investment Program.

1.2 Objectives and Definitions

5. The objectives, scope and methodology of the LKHEP Cumulative Impact Assessment (CIA) are described in the following subsections.

6. The purpose of the CIA is to assess the reasonably foreseeable cumulative impacts, including both direct and indirect (or induced) impacts, attributable to the ADB- funded LKHEP investment and its associated facilities. More specifically, as per the TOR, the CIA aims:

- To determine if the combined impacts of LKHEP, the operations of Kopili HEP, and the activities further upstream such as coal mining operations will impair the valued ecosystem components (VECs), broadly defined here to include water resources, biodiversity, agricultural and forest lands, and social infrastructure and welfare
- To identify management measures needed to avoid or minimize any unacceptable condition of the VECs

7. Although there is no current official ADB guidance on how to conduct a CIA, ADB does define cumulative impacts in relevant guidance documents, as described below.

8. Environment Safeguards: A Good Practice Sourcebook (2012)

- Glossary. "Cumulative Impacts. The combination of multiple impacts from existing projects, the proposed project, and anticipated future projects that may result in significant adverse and/or beneficial impacts that cannot be expected in the case of a stand-alone project."
- Page 15. "Areas and communities potentially affected by cumulative impacts from further planned development of the project, other sources of similar impacts in the geographical area, any existing project or condition, and other project-related developments that are realistically defined at the time the assessment is undertaken. The combination of multiple impacts from existing, the proposed, and anticipated future projects may result in significant cumulative impacts (positive or negative), which cannot be expected in the case of stand-alone projects. Examples are incremental contribution of pollution emission by a new thermal power plant in an airshed, reduction of water flow in a watershed due to multiple withdrawals, and increased pressure on the survival of wildlife species in a given ecosystem."

9. Currently, ADB defers to IFC's Good Practice Handbook: Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets (downloaded from the internet January 2017). IFC defines CIA similarly: During the process of identifying environmental and social impacts and risks, developers or project sponsors:

- Recognize that their actions, activities, and projects – their development – may contribute to cumulative impacts on valued environmental and social components (VECs) on which other existing or future developments may also have detrimental effects.
- Avoid and/or minimize these impacts to the greatest extent possible. Furthermore, their developments may be at risk because of an increase in cumulative effects over ecosystem services they may depend on.

10. A key conclusion of these definitions of CIA is that the other projects to be evaluated in the CIA – past, ongoing and future – do not need to be physically or economically linked, actually or potentially, to the subject ADB investment, nor do they need to be projects in the same sector as the proposed project – hydropower, power or water sectors. This contrasts with the scopes of the two LKHEP Preliminary CIAs already conducted:

- WAPCOS EIA. The scope of the CIA prepared as part of the WAPCOS EIA is more limited than the scope of the present CIA in that it calls for collective assessment of the operation of the three Kopili River Basin reservoirs: Khandong dam, Longku dam and Lower Kopili HEP.
- ADB Preliminary CIA. ADB prepared the Assam Lower Kopili Hydroelectric Power Project Preliminary Cumulative and Induced Impacts Assessment (v0 December 2015, an unpublished report funded under TA-8351 IND: Advanced Project Preparedness for Poverty Reduction - Preparing the Second Power Sector Investment Project for Assam). The scope of the ADB Preliminary CIA is broader than the scope of this CIA in that it addresses induced impacts and associated facilities impacts, in addition to cumulative impacts. Induced impacts and associated facilities impacts are addressed in the ADB LKHEP EIA and not in this CIA. These additional types of impacts are defined by ADB's Environment Safeguards: A Good Practice Sourcebook Draft Working Document (December 2012), as follows:
    - Induced impacts are diverse and/or beneficial impacts on areas and communities from unintended but predictable developments caused by a project, which may occur later or at a different location.
    - Associated facilities impacts are impacts of facilities that are not funded as part of a project but whose viability and existence depend exclusively on the project, or whose goods or services are essential for successful operation of the project.

1.3 Scope and Methodology

11. The methodology used in this CIA complies with:

- ADB's 2009 Safeguard Policy Statement
- ADB's 2012 Environment Safeguards: A Good Practice Sourcebook

12. In addition, in order to be consistent with best international practices in conducting CIA, the methodology has also been informed by:

- Good Practice Handbook: Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets, International Finance Corporation (IFC), downloaded from www.ifc.org, January 2017
- Hydropower Sustainability Assessment Protocol. International Hydropower Association's (IHA), November 2010
- The IFC Good Practice Note on Environmental, Health and Safety Approaches for Hydropower Project 2018.

13. Based on the consultant's terms of reference, the CIA scope of work (SOW) includes the following subtasks under task 2:

Task 2.1: Scoping

- Task 2.1.1: Define the project activities
- Task 2.1.2: Identify the area of concern (AoC) and temporal extent (i.e., set spatial and temporal boundaries)
- Task 2.1.3: Identify and select the VECs to be included in the assessment
- Task 2.1.4: Identify other previous, existing, and future or planned projects and human activities that affect or may affect the VECs to be included in the assessment, such as upstream hydropower and industrial activities, and nearby transport links

Task 2.2: Establish/Describe the Existing Condition of Selected VECs

- Task 2.2.1: Complete the collection of available data and information on the effects of other existing activities and/or projects on the condition of the VECs within the AoC
- Task 2.2.2: Collect data on trends in the condition of VECs and regional thresholds

Task 2.3: Assess the Cumulative Impacts on VECs

- Task 2.3.1: Determine the indicators to describe the VEC condition
- Task 2.3.2: Assess impacts of LKHEP on the VECs
- Task 2.3.3: Estimate or predict the future condition of the VECs as affected by Kopili HEP, upstream activities along Kopili River, and planned activities (if any) or developments downstream of LKHEP within the AoC
- Task 2.3.4: Estimate the combined impacts of LKHEP, Kopili HEP, upstream activities along Kopili River, and planned activities on the VECs

Task 2.4: Assess the Significance of Anticipated Cumulative Impacts

- Task 2.4.1: Compare results against thresholds and evaluate the significance of anticipated cumulative impacts on the VEC
- Task 2.4.2: In the absence of thresholds or limits of acceptable change, recommend/suggest an appropriate threshold
- Task 2.4.3: Consult with various stakeholders, government agencies, and technical experts on the appropriate threshold

Task 2.5: Design and Plan Implementation of Management Measures

- Task 2.5.1: Identify measures (other than those identified in the EIA of LKHEP) to reduce the estimated unacceptable cumulative impact on a VEC to an acceptable level following the mitigation hierarchy
- Task 2.5.2: Identify the need for additional mitigation of other existing and/or planned projects
- Task 2.5.3: Identify the potential for regional strategies that could keep the acceptable condition of the VECs
- Task 2.5.4: Identify efforts/initiatives on how to engage stakeholders in implementing

the management measures that may be beyond capacity of APGCL as well as NEEPCO

14. The detailed methodology – as adapted and further elaborated from the Consultant's Terms of Reference – is presented in Appendix A. It is noted that actual implementation of the methodology was constrained by data availability and an accelerated reporting timeframe. The limitations, and the assumptions made to address those limitations, are noted at relevant points in the ensuing sections of the report. The CIA report was due by early May 2017 which was before the completion of the other two components of the Supplemental Environmental Assessment (Water Quality Restoration Report and Integrated Water Resources Management Plan) and the overall revision of the WAPCOS EIA being undertaken through a separate contract.

1.4 Organization of Report

15. The remainder of this report includes:

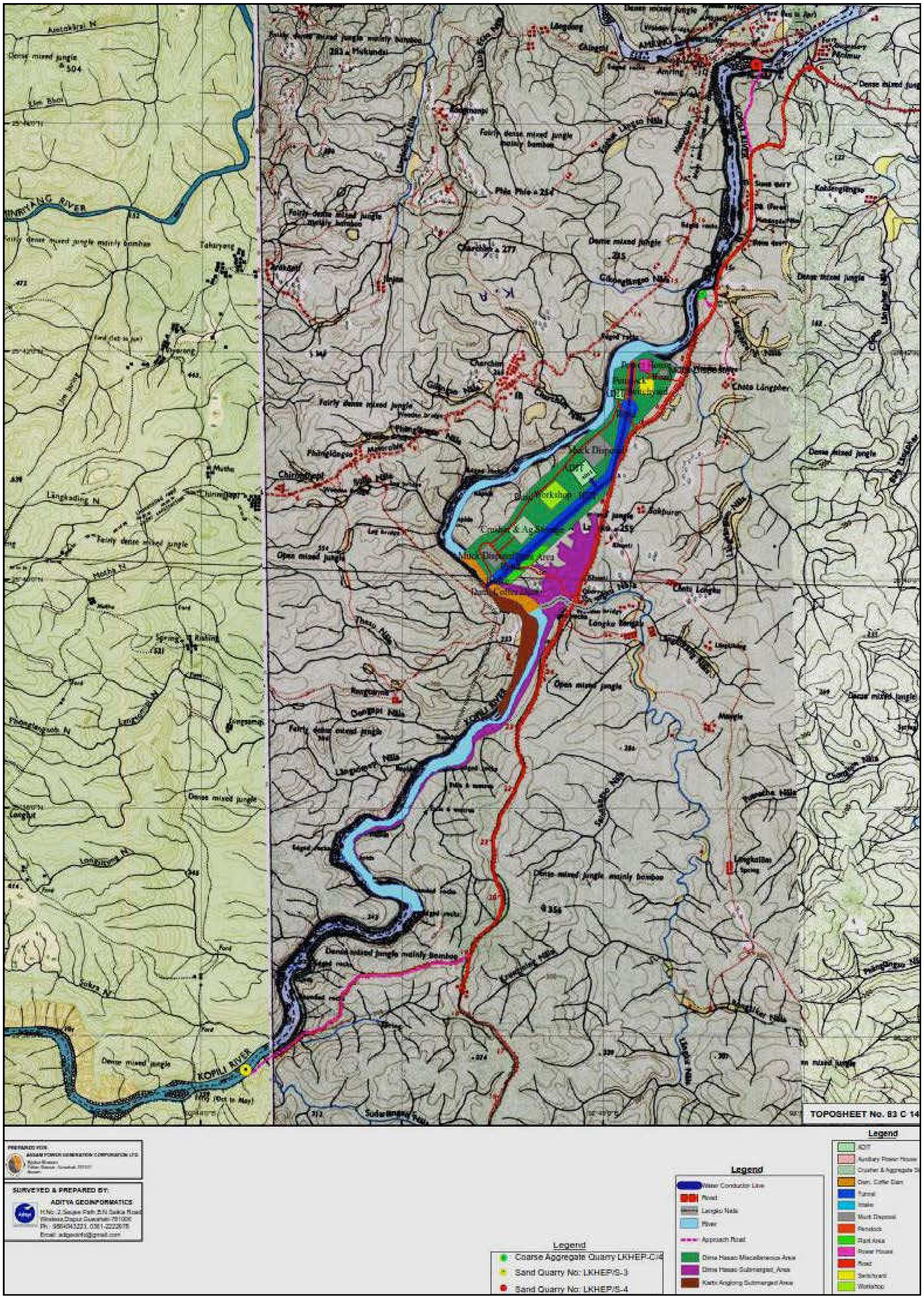
- Physical description of the project (Section 2),
- Delineation of the project's spatial and temporal area of influence (Section 3),
- Outline of other major projects and overall development context and their projected impacts on the project area of influence (Section 4),
- Definition of the project's Valuable Ecosystem Components (VECs), evaluation of their current and projected condition with and without the proposed LKHEP, and identification of measures to mitigate the cumulative impacts of the project (Section 5), and
- Conclusions and recommended action plan (Section 6).

2. PROJECT DESCRIPTION

16. The proposed LKHEP will receive water from (i) tail race outlet from the existing Kopili power plant, (ii) incremental flow from the river catchment area between Khandong dam and the proposed LKHEP dam near Longku, and (iii) any reservoir releases ("spill") from Khandong and Umrong reservoirs. LKHEP is designed as a hybrid run-of-river and storage design. During high flow season it will operate on a run-of-river basis, but in low flow season it will store water during the day and then release flow and generate power during the evening peak demand period. This design and variations thereof are common in India, and are generally referred to there as run-of-river with daily storage.

17. LKHEP is designed to have a total capacity of 120 MW in two power plants: the main power plant is rated at 110 MW and the auxiliary power plant is rated at 10 MW. The main power plant will receive water diverted at the dam, while the auxiliary power plant is located at the toe of the dam harnessing the environmental flow. The main power plant is expected to operate at full capacity (base load) during the high-flow season, and operate in peaking mode during the low-flow season. The auxiliary power plant will operate throughout the day, when water is released from the bottom of the dam to maintain the environmental flow. (E-flow will be released throughout the year. E-flow release timing relative to downstream cumulative impacts is addressed in detail in Section 5.2.) Power output will be evacuated to the existing Sankardevnagar substation. See Figure 2.1 below for a location drawing of the LKHEP and other hydropower facilities in the basin. Figure 3.1 in Section 3 below shows the overall project area.

Figure 2.1: LKHEP Facilities



3. PROJECT AREA OF INFLUENCE

18. Based on review of the draft EIA and DPR, it is noted that there is no direct discussion of an AoC and that the descriptions of most areas of concern, whether of proposed project facilities or zones of potential impact. Areas of concern were geographically vague and not always accompanied by user-friendly maps and there is no comprehensive map consolidating the important features in one view. Thus, as a first step in defining and refining the project area of influence, for CIA purposes, it was necessary for the consultant team to obtain more precise geographic information for features important to the CIA and to prepare maps displaying those features. Such maps can be used not only for presenting findings and recommendations in the CIA report, but also for communicating with project stakeholders. For the CIA, the temporal and spatial boundaries, respectively, set for the CIA are described below.

19. Temporal Boundaries. Taking into account recent trends and the existing condition of the basin, the potential impacts of LKHEP construction, including construction of related infrastructure, will be evaluated for the 4-year construction period of 2018-2022 which is consistent with other relevant project documents. The startup and operation phase impacts will be evaluated for the 20-year horizon of 2022- 2042. A 20-year period corresponds well with the planning horizons of most government sectoral and regional plans and studies. Longer-term, qualitative projections based on anticipated trends may be possible depending on data availability and uncertainty.

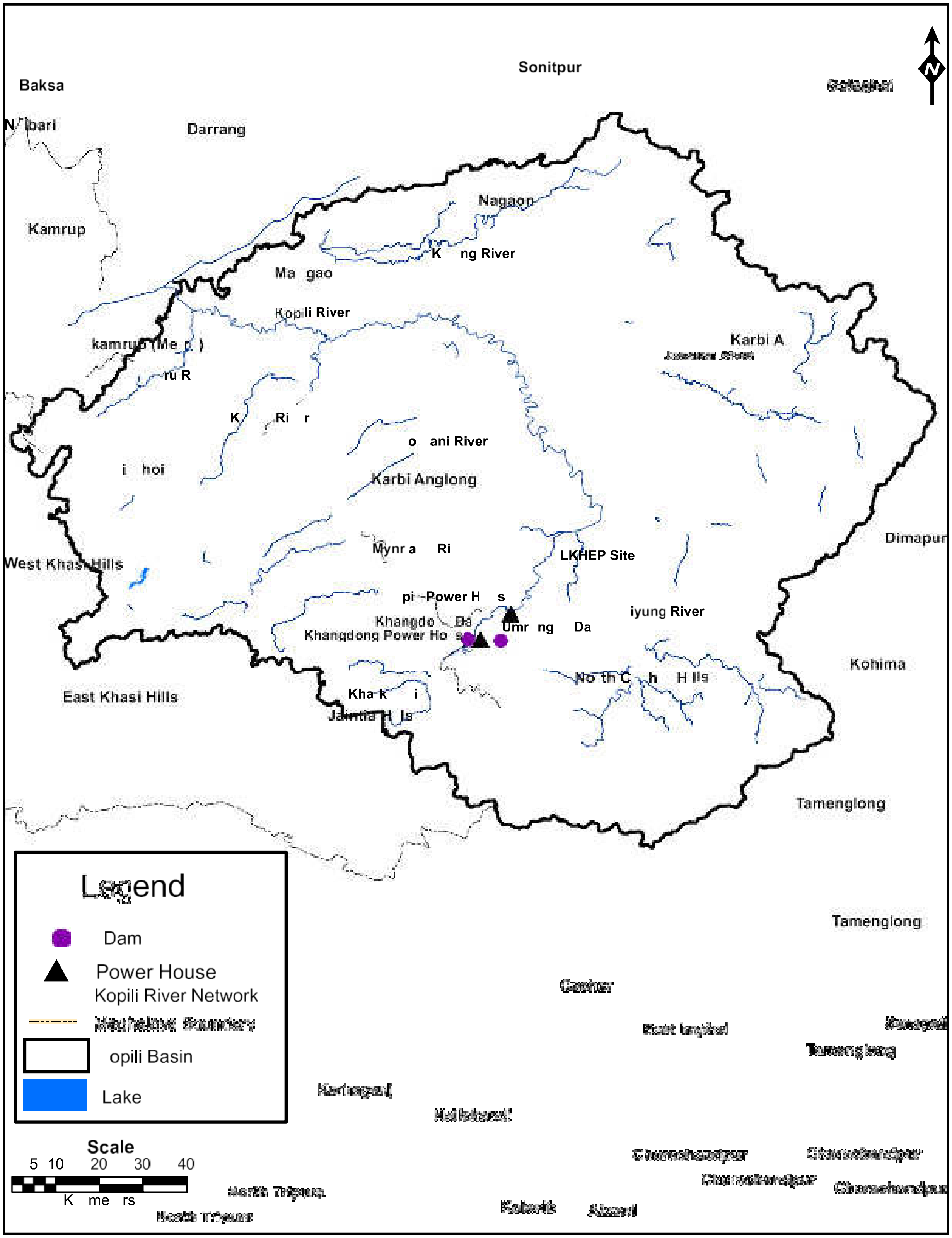
20. Spatial Boundaries. The spatial boundaries of the CIA are defined to facilitate evaluation of different types of potential cumulative impacts. External influences that create significant direct impacts in the basin are accounted for in the assessment (e.g., inter-basin water transfer, acid mine drainage), while any external areas identified as having a significant impact on basin values are also addressed. To address the project’s potential influences on river water quality and quantity, the main basin values that will be affected by the project, the AoC should cover the entire catchment of the upper and lower Kopili basin (upstream and downstream of the proposed LKHEP), including the Kharkar-Kopili confluence. In addition, to address the facility itself as well as associated facilities and infrastructure, the AoC should encompass the areas within a 25 km radius of the proposed LKHEP, 5 km radius along the alignments of proposed associated facilities/infrastructure, including 60 km along the road from Land to Garampani, and 40 km along the 220 kV transmission line from LKHEP to Lanka (Sankerdevnagar substation). From the social perspective, the AoC should embrace the geopolitical boundaries encompassing the two autonomous districts, Dima Hasao and Karbi Aglong, in which the Kopili River Basin resides and in which social, economic, resettlement and development impacts, both positive and negative, will focus. Moreover, the portion of Assam and Meghalaya States which illegal coal mining is occurring that creates acid drainage which flows via the KharKar River into the Kopili River is considered as a part of the AoC for the purpose of CIA.[1] Figure 3.1 presents a map of the AoC.

21. Note that the AoC defined above may vary somewhat for the individual VECs; in addition, more specific geographic subsets called Resource Impact Zones (RIZs) have been delineated for some of the VECs. These variations are described in the definitions of the respective VECs in Section 5 below.

---

[1] According to the para 6 of Safeguard Requirements 1, ADB safeguard policy statement (2009), the area of influence does not include potential impacts that might occur without the project or independently of the project. The illegal coal mining has been undertaken independently of the project, and the related impacts (i.e high acidity of the river) have occurred due to the mining. As per the definition, this area is not required to be included in the project’s area of influence, however, with regard to the CIA, it was considered as an AoC,

Figure 3.1: Map showing AoC of LKHEP project



4. OTHER DEVELOPMENTS AND PROJECTS

22. The DPR and other power sector planning documents provide an adequate overview of other HEP and conventional power projects being planned for the LKHEP AoC. However, it is important to note that the CIA must also consider the past, ongoing and projected impacts of other projects, regardless of whether they are part of, or physically or economically linked to, the ADB LKHEP investments, or are hydropower or water resource sector developments in general. Therefore, aside from the recent three years of power demand trends, and that portion of demand that the LKHEP has capacity to supply, there are other factors that influence or can be used as indicators to project development and growth in the AoC. These include projections of economic growth, government subsidies to industry, government provision of infrastructure, government planning documents, building permits, land conversion approvals, etc. In this regard, the Consultant reached out to the planning department and other relevant departments of the GoA and the two Autonomous District Councils of Karbi Anglong and Dima Hasao Districts in an attempt to obtain relevant data, studies, etc. regarding those development and growth trends and projections and confirm or supplement the power demand growth scenarios. Data collection difficulties and resulting data limitations are noted where relevant in the ensuing sections.

23. Section 4 is organized into three subsections presented in rough order of most to least geographic proximity to the LKHEP project, involvement of LKHEP or other ADB financing, and data availability/uncertainty. Section 4.1 describes other power development in the Kopili River Basin and Assam State, financed by ADB or otherwise. Section 4.2 addresses overall and sector-specific development projections based on electricity demand alone taken from ADB's Preliminary CIA. Section 4.3 addresses the larger context of development in the LKHEP AoC, both overall and by sector, based on economic, demographic and government planning indicators of development and growth in the LKHEP AoC. Section 5 provides a more detailed discussion of the current and projected environmental and social condition of each of the respective VECs as a result of the larger development context, both with and without consideration of the impacts of the LKHEP project.

24. Note that information relevant to the broader development planning analysis is not provided in the WAPCOS EIA or DPR and that only very limited data were provided in response to the Consultant's contacts and requests of various district and state agencies to get general development planning information; available data /information provided to the Consultant has been incorporated in this CIA. See Section 4.3 for more discussion of these data limitations.

4.1 Other Power Sector Development

25. The power sector discussion covers projects being financed by ADB in the same loan, and in the same general geographic area as the LKHEP project, i.e. the Kopili or Brahmaputra river basins in Assam State, as well as those being financed separately by ADB, GoI, GoA and others.

26. Other ADB Financed Power Projects in Assam State. Power sector investments related to the LKHEP project funded by ADB include:

- Transmission system to evacuate LKHEP power to state grid (future ADB loan still to be put into ADB program)
- Distribution system expansion and upgrades (MFF-083 Tranche 2; not directly related to Tranches 1 and 3)

- Access roads associated with the LKHEP project (MFF-083 Tranche 3)
- 70 MW replacement power plant at Lakwa (MFF-083 Tranche 1)

27. These projects are discussed in more detail below.

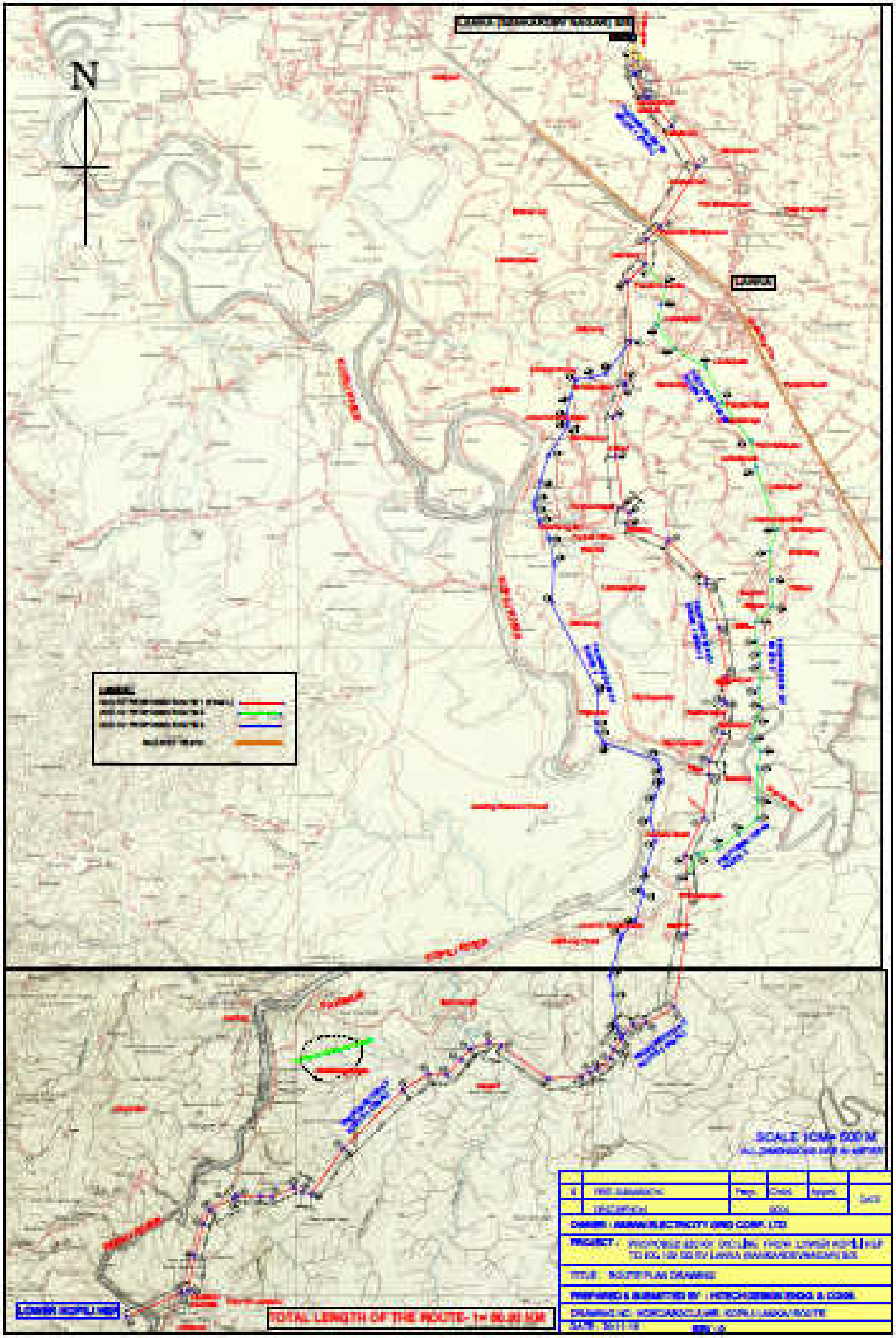
28. LKHEP Transmission and Distribution Lines. The transmission system associated with LKHEP will be constructed and operated by the Assam Electricity Grid Company Ltd. (AEGCL, the Assam state transmission utility). ADB, GoI and GoA are engaged in preliminary discussion regarding the inclusion of this transmission system in a future ADB- funded project.

29. Power generated at the 110 MW LKHEP main power plant will be transferred to the Lanka Substation located at Sankerdevnagar through a new 220 kV double circuit transmission line. This transmission line is estimated to be about 40 km long and would use a new right of way from LKHEP to Lanka. The existing substation at Lanka is presently rated at 132 kV, and this substation will be upgraded and expanded to 220 kV to receive power from the LKHEP.

30. Power received at Lanka from LKHEP will be partly distributed to serve customers and regions presently served by the Lanka substation, with the balance of power transferred to the upstream network through the Lanka-Misa transmission lines. Power generated at the 10 MW auxiliary power house will be transferred to the switchyard at the main powerhouse.

31. AEGCL commissioned a preliminary route survey to identify a suitable corridor for the 220 kV lines, with three routes considered. The corridor runs from the main powerhouse area to the Lanka Substation mainly on the right bank of the Kopili River, avoiding the Panimur Reserve Forest and more densely populated areas. The terrain and land use are similar for all three routing options. The preferred route was selected to minimize the number of river, road, and rail crossings. Cultivation along the route is mostly paddy fields (rice) and sugar cane. Figure 4.1 shows route alignment of transmission line.

Figure 4.1: Showing alignment routes of proposed transmission line and land use



32. ADB has conducted preliminary site reconnaissance and due diligence on the proposed transmission route, with special attention to potential biodiversity impacts. The preliminary conclusion is that any potential environmental impacts are minimal and acceptable (detailed discussion of biodiversity is presented in new Appendix II to the WAPCOS EIA). The transmission lines are not subject to environmental assessment requirements under the GOI regulatory framework. If the proposed lines are included in a future ADB project (as has been discussed informally), an environmental assessment will be conducted in accordance with ADB's SPS 2009.

33. LKHEP Access Roads. Ten (10) access roads will be constructed specifically for the project, ranging in length from 0.03 km to 5.52 km, with aggregate length of 13.1 km. This road network will be concentrated in the area between the dam, main powerhouse, the river, and the Lanka-Umrangso road. This area will be impacted during construction by clearing, construction of temporary and permanent buildings, and for disposal of construction spoils (soil and rock waste which cannot be used by the project facilities). Most of the project-specific road network will have restricted access, and will not facilitate expanded access to reserved forests or environmentally sensitive areas. In addition, improvements to 60 km of the main road from Lanka to Umrangso are underway, which will facilitate improved traffic flow and shorter travel times. These road improvements, although initiated independently of the LKHEP project, are certainly poised to facilitate the transport of equipment and material to the project site(s).

34. Lakwa Power Plant and other Power Plants not financed under ADB LKHEP Project Loan. The 70 MW Lakwa power plant is an inside-the-fence supply-side efficiency improvement project which will replace 60 MW of obsolete generating capacity. 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 Lakwa 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 (as of year-end 2015).

35. The LKHEP project is part of the near- to medium-term generation expansion program for Assam. The Assam Power Generation Corporation Ltd. (APGCL, the LKHEP project owner) operates about 378 MW of generation capacity in the state. About 1628 megawatts (MW) of net new capacity is at different stages of development, of which about 40% is from the proposed supercritical coal project at Margherita in eastern Assam. Table 4.1 lists the developing power projects by fuel type. Figure 4.2 shows power generation projects in Kopili river basin on map.

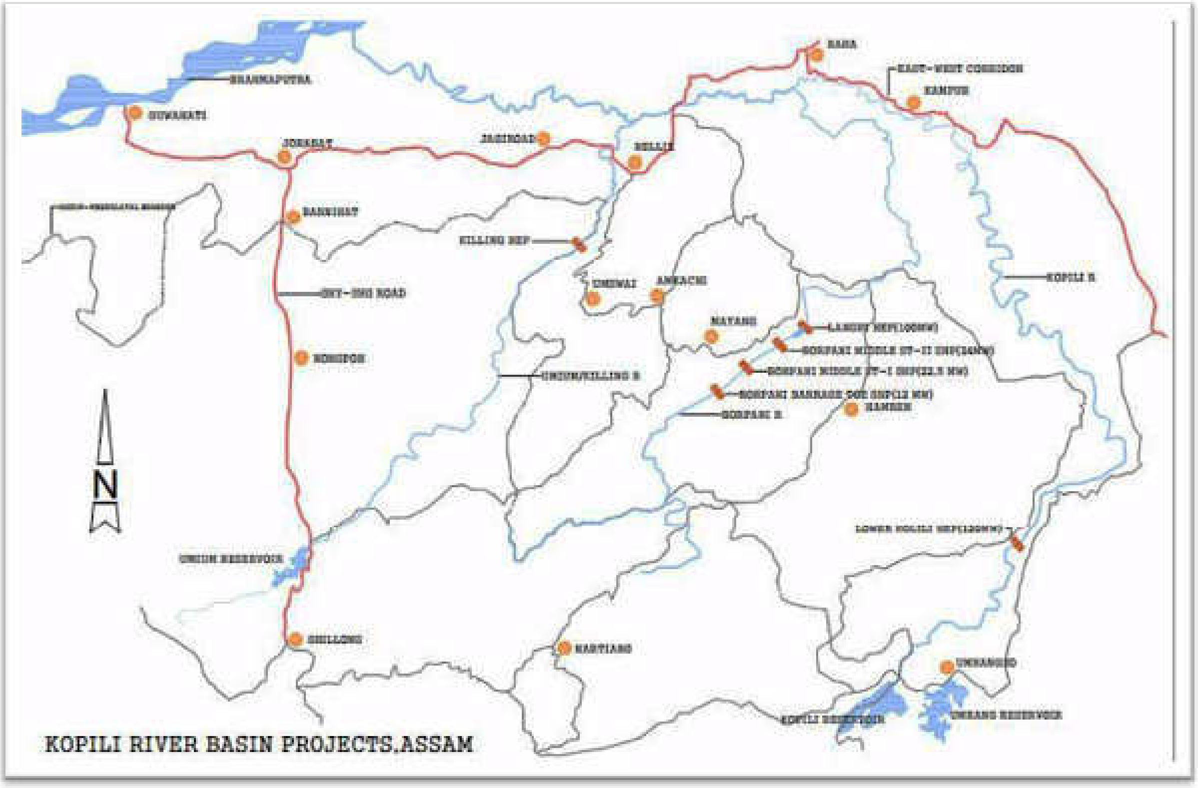
36. It is beyond the scope of this CIA to research and evaluate the environmental and social impacts of a long list of power projects in Assam. Qualitatively, even considering only these planned future power plants in combination with the proposed LKHEP, it is clear that there is a significant potential cumulative impact of developments in the power sector, with a wide variety of environmental and social impacts, positive as well as negative. However, these projects are dispersed widely within the state of Assam and its constituent river basins and airsheds and, aside from Lakwa and LKHEP projects, they are not financed by ADB. Moreover, when LKHEP is completed, circa 2021, it will account for less than 5% of the forecast peak load of 2,534 MW and the other power plants will theoretically benefit – independently – from the grid expansion and efficiency improvements support by ADB.

Table 4.1: 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	***1220 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 (Amring) HEP	21 MW	DPR under preparation
Borpani Middle Stage I –	12 MW	DPR under preparation
barrage toe powerhouse		
Upper Karbi Longpi	60 MW	n/a
Lower Kopili HEP	120 MW	Environmental clearance expected in Q2 2016.
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	1627.5 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).

Figure 4.2: Map showing power generation projects in Kopili River Basin, Assam



37. Assam also imports electricity from outside of the Northeast Region of India mainly through power purchase agreements executed by Assam Power Distribution Company Ltd. (APDCL). Imports will continue for the foreseeable future, as the 1628 MW capacity expansion shown above would cover 65% of the peak load of 2534 MW forecast for year 2021-22. In addition to the projects summarized above, APDCL has signed power purchase agreements (PPA) to procure 118 MW power from the Nikachhu hydropower station in Bhutan through Power Trading Corporation of India, Ltd. (PTCIL) for a period of 25 years with effect from July 2019. APDCL has also requested that the central government allocate 500 MW of power from the hydroelectric projects at Punatsangchhu-I and 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.

4.2 Other Development Based on Projections of Electricity Demand

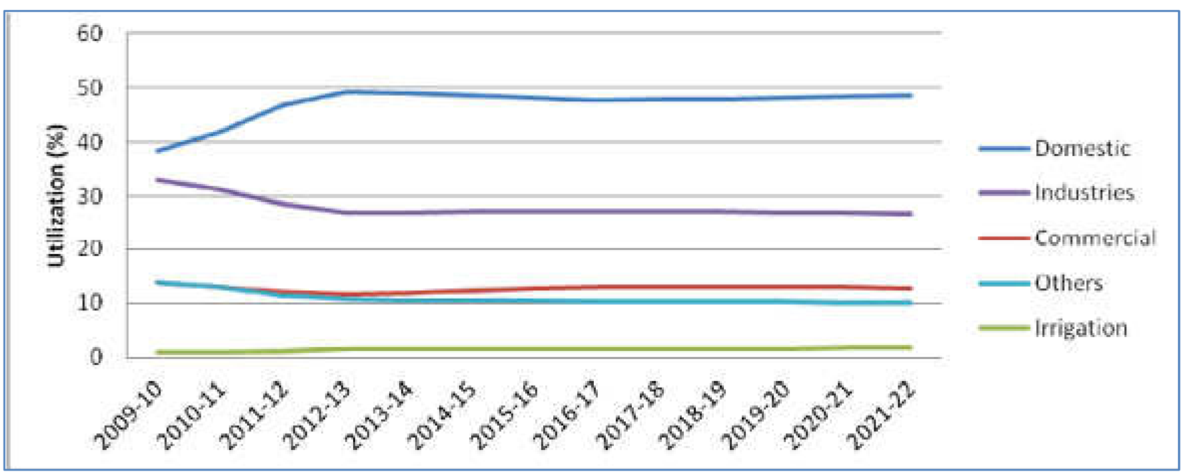
38. This section, drawn from the ADB Preliminary CIA, addresses other development in the LKHEP AoC, both overall and by sector, based on electricity demand. In addition to descriptions of sectoral electricity demand, these discussions briefly address the types of environmental and social impacts anticipated in each sector. Section 5 below aggregates impacts from multiple sectors according to the respective VECs, e.g. the Water Quality VEC, and elaborates on them in the context of recommended applicable mitigation measures.

39. The following discussions are taken from the ADB Preliminary CIA. Some caveats are appropriate to note:

- The sectoral projections discussed below are based on electricity demand alone and should be considered in conjunction with the projections of development and growth based on other indicators, as discussed in Section 4.1 above, and should be updated if and when additional data may become available.
- The discussions below focus on that portion of projected electricity demand – overall and by sector – which the LKHEP project capacity could supply as a way of estimating project-specific second-order impacts. However, the entirety of electricity demand – overall and by sector – should be evaluated from the perspective of cumulative impacts, assuming such total demand will ultimately be supplied by other power generation projects.
- Most of the ADB-funded projects in the Indian power sector address under-served areas with suppressed energy demand. In Assam, generation, transmission and distribution projects are being induced by unmet demand resulting from economic growth, not the reverse. As discussed in more detail below (and in the Analysis of Alternatives section of the WAPCOS EIA), the LKHEP project will supply less than 5% of Assam's projected peak load at the time the plant is commissioned.

40. Overview of Sectoral Development Growth. Figure 4.3 shows 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 (latest fiscal year) 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%.

Figure 4.3: Utilization by Consumer Category (%). Source: APDCL

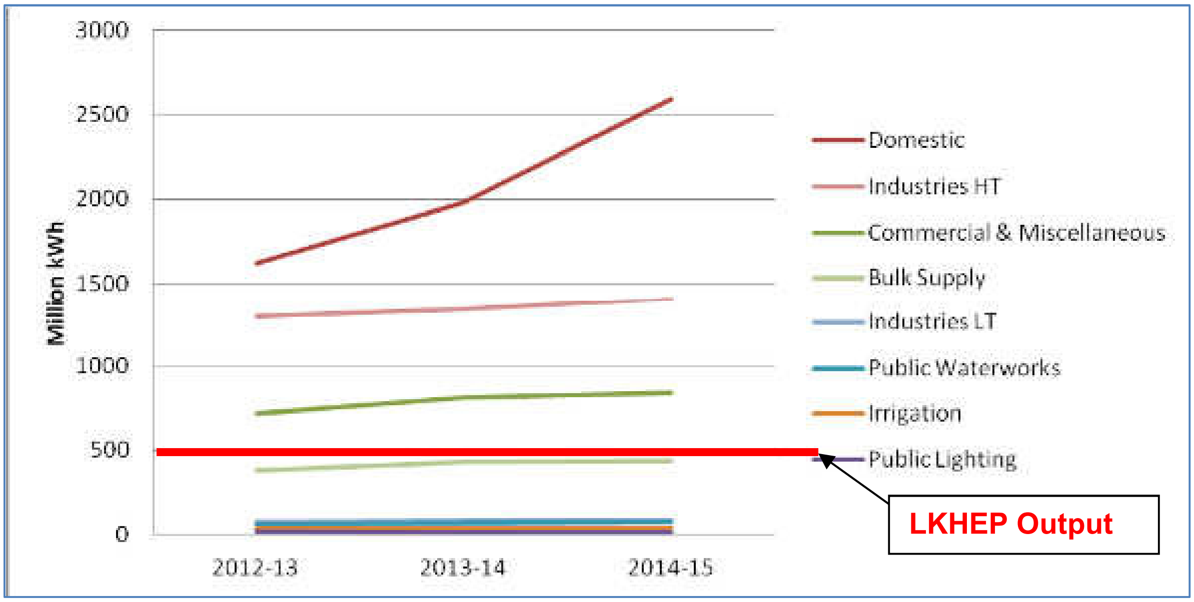


41. Table 4.2 and Figure 4.3 present consumption forecasts from 2009-10 through 2021-22, showing overall growth of 221%. From 2014-15 (latest fiscal year) going forward, domestic growth is projected at 71%, commercial at 46%, industry at 24%, and agriculture at 45%. Water works and street lighting are projected to grow 20% and 21% respectively. Table 4.3 and Figure 4.3 present sales data from APDCL for the most recent three years (2012-13 through 2014-15), which show consistent trends when compared with the projections shown in Table 4.2 and Figure 4.4.

Table 4.2: Electricity Forecast (18th EPS, 2011) [Million kWh (MU) except as noted]

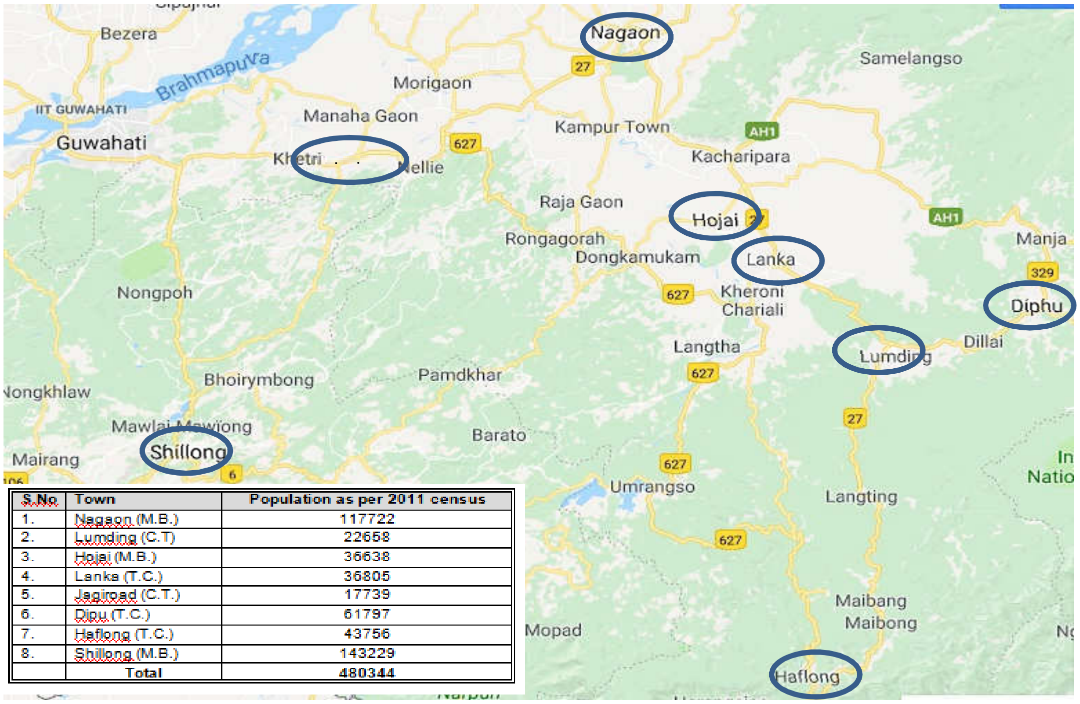
Consumption Categories	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Domestic	1251	1582	2136	2581	2805	3003	3216	3443	3722	4024	4351	4704	5086
Commercial (& misc.)	450	494	549	611	680	757	842	937	1014	1088	1166	1251	1341
Public Lighting	6	9	12	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
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 4.4: Energy Consumption Forecast 2009 – 2022.
Source: APDCL



42. Domestic and Commercial Growth. Domestic and commercial consumption is mainly for lighting, refrigeration, air conditioning, and other appliances. The total output of the LKHEP would be sufficient to cover 8.9% of domestic demand in 2021-22, and 33.7% of commercial demand in 2021-22. As shown in Table 4.2, domestic growth was 22% from year 2012-13 to 2013-14, and 31% from 2013-14 to 2014-15. Domestic growth is expected to continue to increase as shown in Figures 4.3 and 4.4. 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 shown in Figure 4.4. Growth in these 2 categories is due in part to new urbanization and redevelopment of existing urban areas, see Figure 4.5. The long-term environmental impacts will be determined mainly by rational land use planning, zoning enforcement, traffic management, and expansion of water, sanitation, and solid waste management services.

Figure 4.5: Map showing existing urban areas near the project location

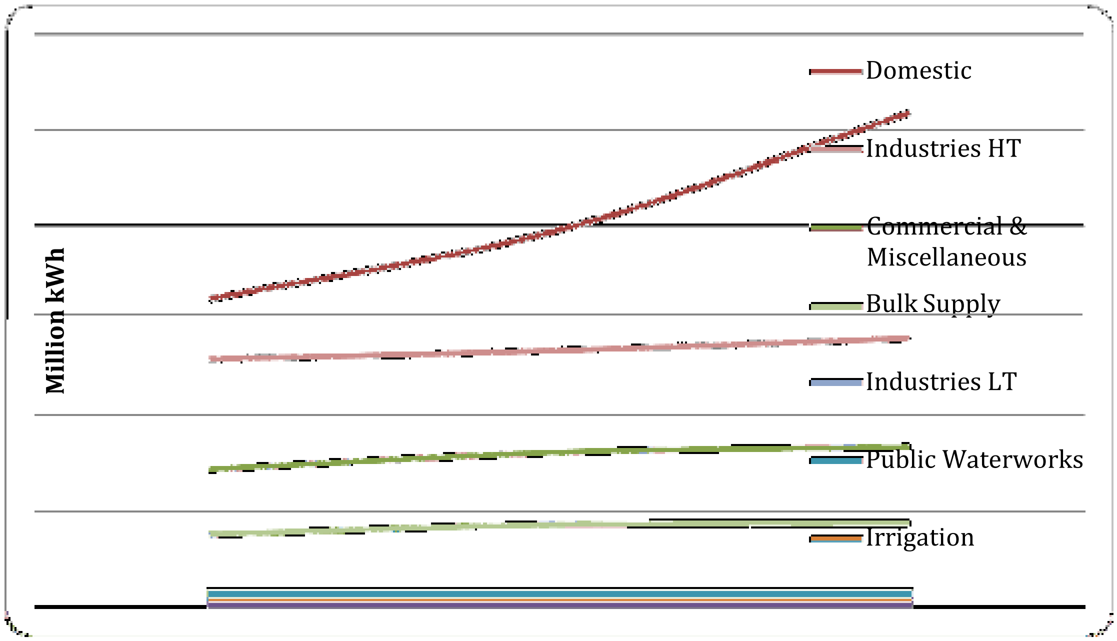


43. Industrial Growth. Future industrial growth appears to be a certainty based on the Government of Assam's economic development plans, but growth in electricity consumption has been comparable to commercial consumers. As shown in Table 4.3, industrial high tension growth was 3.5% from year 2012-13 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, which are mostly diesel-fired except for some facilities in Upper Assam which use natural gas. The total output of the LKHEP 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 proposed transmission evacuation plan, this cement plant will not receive power from LKHEP, but industrial plants connected to the Sankardevenagar substation will benefit. It is not known how much of the diesel-fired power will be displaced by HEPs in the future.

Table 4.3: 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%**	

Figure 4.6: Electricity Sales by Category. Source: APDCL



44. Environmental impacts of industrial growth are mainly due to primary pollutants of air, wastewater, and solid wastes, as well as potentially hazardous pollutants 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 and environmental management regulations. If industrial growth is at all constrained by lack of power, providing power will help stimulate industrial growth, which will not necessarily manage its pollution, despite Government regulations. This is a risk and potential negative cumulative impact.

45. Agricultural Development. Agricultural productivity increases are reasonably foreseeable. As shown in Table 4.3, 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 available power supplies, and most farmers can only produce one crop per year. Based on the projection shown in Table 4.3, the total output of the LKHEP would be sufficient to increase electricity for irrigation by a factor of 2.7 in year 2021-22. This potential magnitude of increased groundwater withdrawals is theoretically possible, but such an increase is inherently limited by the total area of cultivated land. The LKHEP energy output could facilitate double-cropping with a 100% increase in groundwater withdrawals. However, comparison of Tables 4.2 and 4.3 shows that 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.

46. 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 LKHEP output went to irrigation, total groundwater use could still be sustainable assuming that other sectors were not expanding groundwater use at similar rates. Major environmental impacts (synergistic effects) could result from increase in chemical fertilizer applications, but the incremental expense to farmers is a

limiting factor. Increased cropping should improve farmers' incomes, which is consistent with economic development objectives.

4.3 Other Development Based on Demographic, Economic, and Planning Data

47. The original intent of this section is to address the larger context of development and growth in the LKHEP project area of influence, i.e. development beyond LKHEP, both overall and by sector, to supplement and check reliance on sectoral projections of electricity demand, as detailed in Section 4.2 above. To do this, the Consultant searched for growth projections based on economic, demographic and government planning indicators of development in the LKHEP area. The Consultants met with relevant local stakeholders and obtained publicly available documents, with an emphasis on the planning departments of the GOA and the two autonomous districts.

48. The Consultant Team met with several officials of the Assam State Planning Department and were advised that the Department could not share information because of the autonomous status of the two affected districts. The Planning Department referred us to officials of the respective district councils and district administrations for more information. The team then met with officials of the Dima Hasao Autonomous District Council and communicated remotely with officials of the Karbi Anglong Autonomous District Council. We were able to obtain some documentation from each, as follows:

- Draft Working Plan, Dima Hasao Forest Division (West), Haflong (01/10/2014 to 01/10/2019)
- Working Plan of Hamren Forests Division, Karbi Anglong District Council, 2005/6 – 2010/11
- A series of departmental reports on how the respective departments plan to achieve the Sustainable Development Goals (SDGs) Karbi Anglong Planning & Development Department, 2016
- Annual Plan Under Hill Area Development Plan (HADP) for the Year 2012-13, Karbi Anglong Autonomous Council
- Annual Plan 2012-13 & Proposed Five Year Plan (2012-17) Allocations, Northeast Council
- An Approach to 12th Five Year Plan (2012-2017), Assam Planning and Development Department

49. According to the Assam Planning Department's Approach to the 12th Five Year Plan, in general, Assam has been growing at a slower rate than the rest of the country (6.1% during the first 3 years of the 11th Plan period). The hill area of Assam had an even slower rate of growth. According to the North Eastern Councils' (NEC's) Annual Plan 2012-13, the region's basic economic strengths and weaknesses are quoted in italics below.

50. ***Strengths****: The region's basic economic strengths are:*

- *Large natural resources and potential for growth in the agro-forestry and horticultural sectors including expansive and extensive bamboo plantation, exotic flora*
- *Large mineral deposits (particularly in Assam and Meghalaya)*
- *A vast bio-diversity hot spot*
- *Vast water resources including tremendous hydel power potential*
- *Great promise for tourism development*

- *Proximity to one of world's fastest – growing economies, those of the Southeast Asia*
- *A highly literate population*
- *Rich heritage of handicrafts/handloom/tribal artefacts*
- *Strong community spirit and traditional democratic system of local self-governance.*

51. ***Weaknesses:*** *The region's economic weaknesses are:*

- *Inadequate development of basic infrastructure*
- *Geographical isolation and difficult terrain that reduces mobility: high rainfall and recurring flood in the Brahmaputra valley*
- *Lack of capital formation and proper enterprise-climate*
- *Slow spread of technology*
- *Absence of a supporting market structure and adequate institutional finance structure*
- *Low level of private sector investment*
- *Lack of local agricultural surplus*
- *Insurgency problems*
- *Late start in the development process*

52. None of the documents obtained contained data on trends, or provided projections of development and growth, either by sector or overall, in their respective districts. In general, these documents had the following limitations: (1) they were plans and budgets that were aspirational in nature; (2) they addressed activities that largely do not have environmental aspects; (3) they are somewhat dated in some cases; and (4) there has been no apparent follow-up reporting on the extent to which they were implemented or effective.

However, several of the district plans reviewed, including especially the water resources, forestry and agriculture plans, are useful from the perspective of mitigation measures – relating to both project-specific and cumulative impacts – that should be integrated into the overall LKHEP environmental and social management plan.

5. VALUABLE ECOSYSTEM COMPONENTS

53. VECs have been identified based on review of the WAPCOS EIA, DPR and Inception Mission and Interim Mission meetings and tours, in rough order of significance, as follows:

- Water Quality VEC
- Water Quantity VEC
- Air Quality VEC
- Land, Forestry and Ecology VEC.

54. Each VEC discussion addresses the following topics:

- Definition, including VEC-specific AoC and Resource Impact Zones
- VEC conditions, excluding the proposed LKHEP project
- Cumulative impacts assessment, considering both LKHEP and other development
- Significance of cumulative impacts
- Mitigation measures addressing cumulative impacts.

5.1 Water Quality VEC

5.1.1 Definition

55. Upstream illegal coal mining areas are generating acid mine drainage (AMD) which has significantly deteriorated water quality and aquatic ecology in the Kopili River. The AMD pollution from upstream illegal coal mining should be considered a cumulative impact when considered in conjunction with the water quality impacts anticipated to be generated directly by the proposed LKHEP. The LKHEP water quality impacts are described in detail in the WAPCOS EIA and the ADB EIA for the LKHEP project.

56. While the direct LKHEP impacts are expected to be relatively easy to mitigate, and acidity is not expected to increase as a direct result of the proposed project, the direct LKHEP impacts need to be considered in the context of existing water quality being relatively good except for the acidity. Taken collectively, the increases in the other water pollutants resulting directly from the LKHEP project, along with the existing acidity from the upstream illegal coal mining areas, will threaten water quality, and thus aquatic ecosystems and ecosystem services, and nullify opportunities to restore these attributes.

57. Therefore, to address this issue in this CIA, a VEC addressing water quality has been designated. This “Water Quality VEC” covers the entire Kopili River Basin, but within that broad area there are two sets of areas critical to improving water quality, called Resource Impact Zones:

- The areas where water quality impacts on aquatic ecosystems and ecosystem services are of greatest significance and concern, namely the stretches of the Kopili River upstream and downstream of the Upper Kopili Hydropower (KHP) project and LKHEP project, as well as their respective reservoirs.
- The areas which offer opportunities for directly preventing or reducing the acid mine drainage, including the upstream illegal coal mining areas extending into Meghalaya State where there are source control (mine closure and AMD-impacted surface water treatment) opportunities, the area immediately upstream of the KHP project, including the Kharkhar River, where passive treatment using constructed limestone drainage systems would be feasible and effective, and the area immediately upstream of the LKHEP project where more active wastewater treatment could be attempted, at a considerably higher cost.

5.1.2 VEC Conditions without LKHEP

58. Illegal coal mining upstream of the KHP project in Assam and especially Meghalaya State does not appear to be abating and, while there is a legal battle ongoing over the cessation of illegal coal mining in the state (see Mitigation Measures below), no remedial efforts are currently underway or planned to manage and mitigate illegal mining in Meghalaya. Therefore, the safe assumption is that AMD pollution will continue to occur and possibly increase. While it may be logical to believe that relief could be possible from dilution during the annual monsoon season, however this has not been the case in the Umrong and Khandong Reservoirs where pH remains consistently low through monsoon season. In addition,there is insufficient neutral pH surface water input to significantly raise pH in the Kopili River between the Reservoirs and the LKHEP site. Dilution of acidity has so far been shown only to occur downstream of the proposed LKHEP site, where acid-neutral tributaries enter the Kopili River.

59. The following summary of Kopili River Basin surface water quality, monitored by the Consultant team that is preparing the Water Quality Restoration Plan, addresses existing AMD/pH and general water quality (conventional water pollutants) in the Kopili River Basin. The domestic wastewater generated from the proposed LKHEP project colony will be treated in a wastewater treatment plant and reused for green development. Therefore, there will not be any cumulative impacts on river water quality due to wastewater generation/discharge from the project colony. Aside from the impacts of the proposed LKHEP Project, which are discussed under Cumulative Impacts Assessment below, there are no trends or hard data suggesting that the existing water quality conditions in the basin will change significantly in the next 10 years. On the other hand, as mentioned above, the rathole coal mining is illegal and apparently not monitored or controlled, so it would not be unreasonable to conclude that such mining could increase along with its AMD impacts

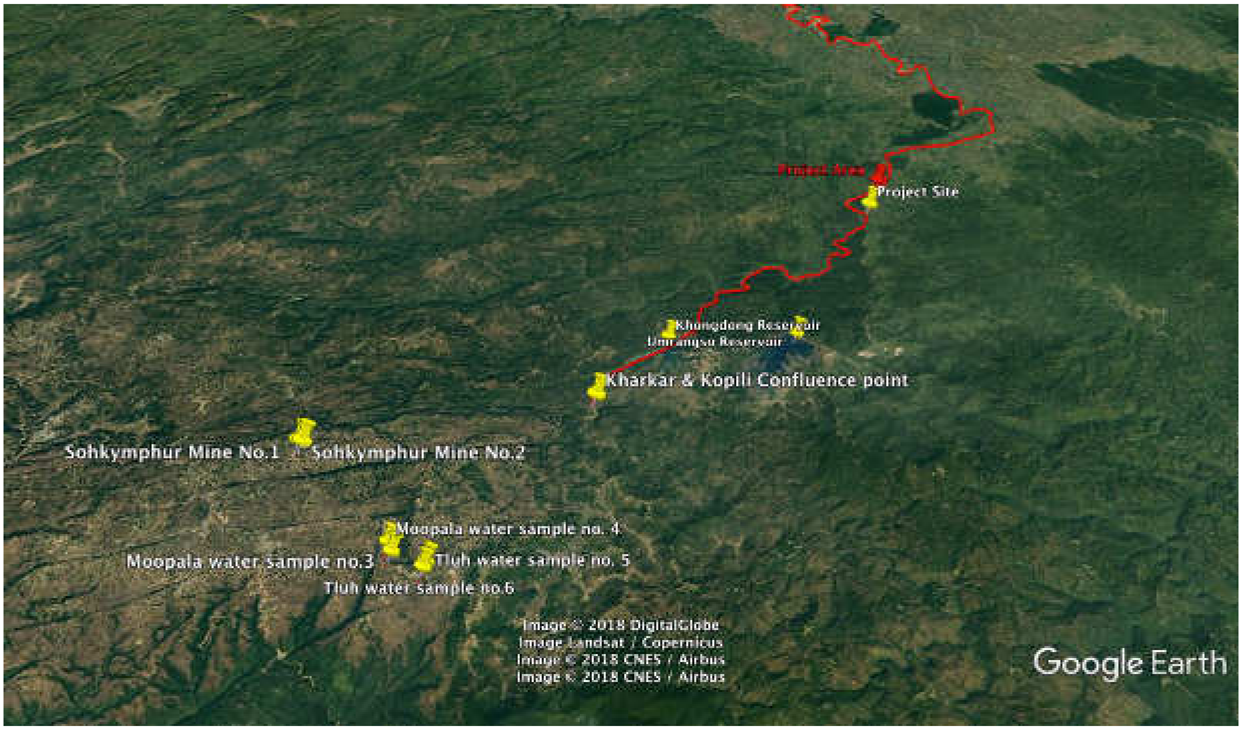
60. Water quality data in the lower Kopili River has been assembled and evaluated using two sources: The WAPCOS EIA (2016) and the APGCL Design Project Report (2015). Additionally, pH data was obtained from NEEPCO for the Khandong and Umrong Reservoirs.

61. Acid Mine Drainage Contamination - Water quality in the lower Kopili River is influenced predominately by low-pH surface water draining from illegal mining areas in west Assam and Meghalaya, refer Figure 5.1. The acid mine drainage (AMD) flows into the Kharkar River. The mineral pyrite (FeS_2) contained in the coal deposits produces sulfuric acid upon exposure to air and water. A study conducted by the Central Soil and Materials Research Station (CSMRS), New Delhi (2010) reported pH levels at 2.8 to 3.3 in the Kharkar River. This was confirmed that samples collected by Consultant team during a site visit in January 2017, where pH in the Kharkar was measured at 3.3 and 3.8 below the confluence with the Kharkar River, as shown in Table 5.1.

Table 5.1: Water Quality Sample Locations and Field Parameters, January 2017

Tributary	Field pH	Field Electrical Conductivity (µs/cm)
Umrongso East Bank	4.2	120
Lower Kopili Damsite	4.1	140
Longku Nala	7.4	60
Kharkar River upstream	3.3	480
Kopili River upstream	7.4	40
Kopili River downstream	3.8	440

Figure 5.1: Map showing existing reservoirs and water sampling locations upstream of proposed Lower Kopili HEP



62. The pH measurements obtained from NEEPCO for the Khandong and Umrong Reservoirs for the period 2007-2015 indicate that pH ranges between 3 and 5 with little to no seasonal variation and no definitive trends upward or downward. Water quality in the lower Kopili does vary seasonally, due to influx of precipitation during monsoon rains. The pH in the Lower Kopili Project Area varies between from 3.2 to 5.2. There are inadequate data to evaluate seasonal variations in Upper Kopili and Kharkar Rivers, or whether pH levels are trending down due to increasing illegal mining activity.

63. General Water Quality – Other than low pH, there are no major sources of pollution loading in the basin. The catchment has low population density and little agricultural activity. Other than illegal mining there are no other industrial sources of contaminant discharge into the Kopili drainage.

64. Water quality sampling in the Lower Kopili is reported in the WAPCOS EIA and has been divided into three seasons: winter, summer and monsoon. Sampling results are tabulated in Table 5.2. The pH level in the project area of Lower Kopili hydroelectric project ranged from 3.2 to 5.2, and does not meet the permissible limit for drinking water standards. The TDS (total dissolved solids) level in monsoon season ranged from 40 to 47 mg/l. The TDS level ranged from 59 to 66 mg/l in winter season and 61 to 66 mg/l in winter season. The TDS levels were well below the drinking water limit of 500 mg/l. The hardness levels are below the permissible limit of 200 mg/l specified for drinking water. Hardness is caused by divalent metallic cations. The principal hardness causing cations are calcium, magnesium, strontium and ferrous and ferriciron. The low levels of calcium and magnesium are mainly responsible for the soft nature of the water. Chlorides and sulfates are also below the permissible drinking water limit of 200 mg/l. The concentration of cations, including sodium, potassium, calcium and magnesium were observed to be quite low which is also reflected by the low TDS level. Iron and other metals

are also well below the permissible drinking water limits. Concentration of phenolic compounds and oil and grease are also low.

65. The BOD values are well within the permissible limits, indicating the absence of organic contaminants. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. Dissolved oxygen ranged from 4.2 to 4.9 mg/l at various sampling locations monitored for three seasons as a part of the study. Due to low pH, water quality of river Kopili is unfit for domestic, irrigation, bathing or industrial use. Additional water quality data are needed to properly interpret these water quality parameters further.

Figure 5.2: General Water Quality Seasonal Trends Lower Kopili

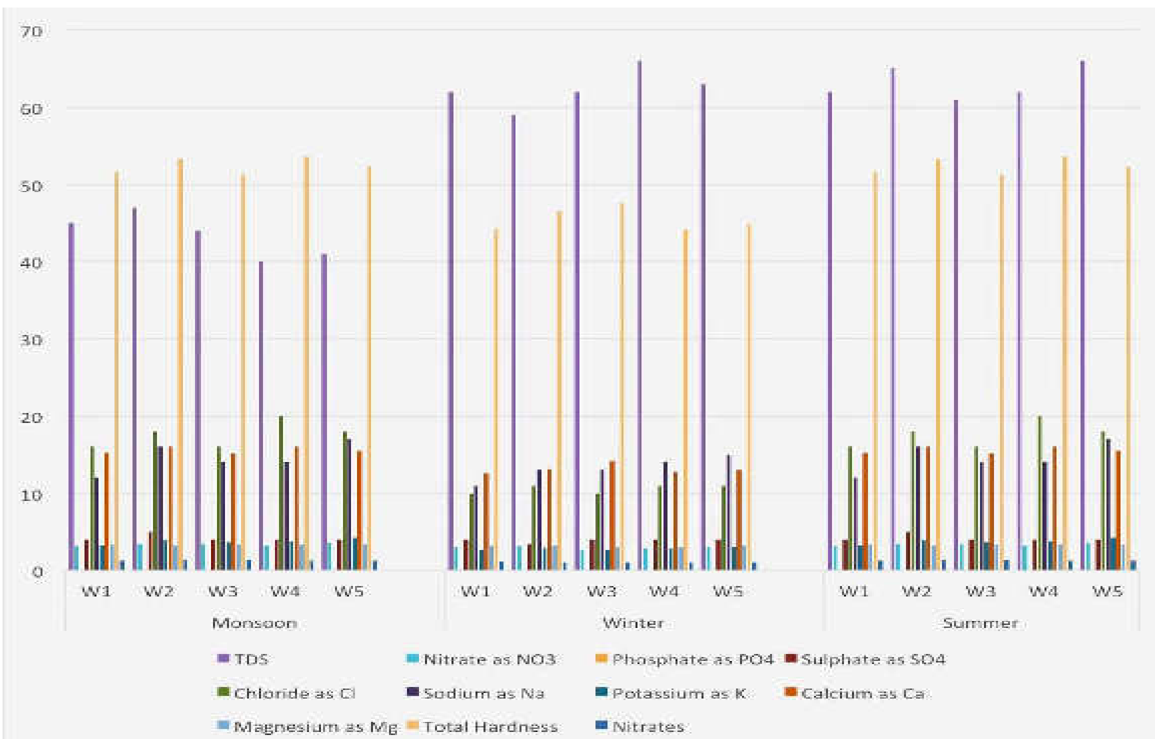


Table 5.2: Water samples and sampling details

Sample Code	Details
W1	Upstream of Dam Site
W2	Dam Site
W3	Downstream of Dam Site
W4	Power House site
W5	Downstream of Power House Site
Season	**Months**
Monsoon	August-14
Winter	December 2014-January 2015
Summer	April 2015

66. January 2017 Surface Water Sampling - Six (five surface and one ground water) samples for laboratory analysis were collected at the sites listed in Table 5.2 as discussed above. The team also took field readings of pH and conductivity, also included in Table 5.3 and listed below. Samples were sent for analysis to the Civil Engineering Department laboratory, Assam Engineering College, Guwahati. The analytical results are shown in Table 5.3 below:

Figure 5.3: Map showing water Samples location with respect to project location

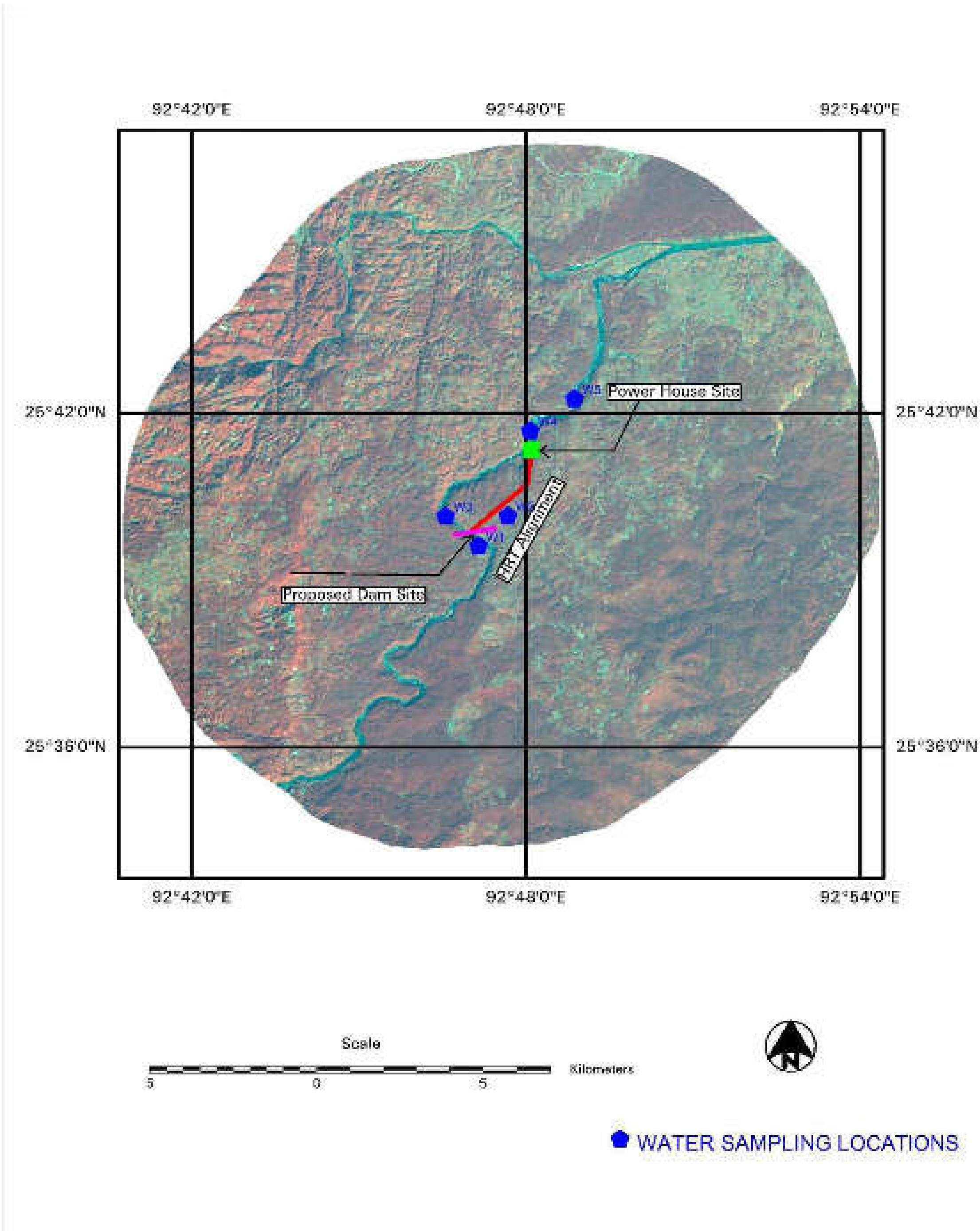


Table 5.3: Analytical Results (Water Samples Collected in January 2017)

Parameter	Specifications	Sampling locations					
		Kopili river before confluence with Kharkar	Kopili river after confluence with Kharkar	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
Amount of 0.1N NaOH to neutralize 200 ml (Phenolphth alein Indicator)	Not more than 2 ml	0.8	1.5	3.1	0.8	0.6	1.6
Amount of 0.1N HCl to neutralize 200 ml	Not more than 10 ml	1.2	0.4	0.4	2.8	1.6	1.2

Parameter	Specifications	Sampling locations					
		Kopili river before confluence	Kopili river after confluence	Kharkar River	Longku Nala	LKHEP Dam axis	Well
(Methyl Orange Indicator)							
Organic Content (mg/L)	200	0.07	0.16	1.52	0.15	0.64	BDL
Inorganic Content (mg/L)	3000	59.5	116.3	187.5	55	41.5	66

67. 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 anoxic limestone drainage (ALD) and other passive treatment technologies (less than 25 mg/L) which are AMD treatment alternatives discussed in the WQRP. 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.

5.1.3 Cumulative Impacts Assessment

68. The direct LKHEP impacts stem from several aspects of both the construction and operation of the proposed LKHEP project and, if uncontrolled, include potential increases in several different water quality parameters. The discussion below – taken verbatim from Section 5.1.1, Water Quality, of the WAPCOS EIA Executive Summary – summarizes the projected wastewater discharges directly attributable to the proposed LKHEP. The projected LKHEP water quality impacts are described in more detail in Section 9.2, Impacts on the Water Environment, of the WAPCOS EIA.

i. Construction Phase

69. Sewage from labor camps/colonies. The project construction is likely to last for a period of 4 years. The peak labor strength likely to be employed during project construction phase is about 800 workers and 200 technical staff. The increase in the population as a result of migration of labor population during construction phase is expected to be of the order of 2,800. 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.

70. Effluent from crushers. During construction phase, at least one crusher will be commissioned at the quarry site by the contractor involved in construction activities. It is proposed only crushed material would be brought to construction sites. A total quantity of 50 m3/hr of effluent is expected to be generated from various crushers.

71. Pollution due to muck disposal. The major impact on the water quality arises when the muck is disposed along the river bank. The project authorities have identified suitable muck disposal sites which are located near the river channel. The muck will essentially come from

the road-building activity, tunneling and other excavation works. The unsorted waste going into the river channel will greatly contribute 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 and as a result, the biological productivity will be greatly reduced. Therefore, prolonged turbid conditions would have negative impact on the aquatic life.

72. Effluent from tunneling sites. During tunneling work the ground water flows into the tunnel along with construction water, which is used for various works like drilling, shotcreting, etc. The effluent thus generated in the tunnel contains high suspended solids.

73. Effluent from batching plants. During construction phase, batching plants will be commissioned for production of concrete. Effluent containing high suspended solids shall be generated during operation and cleaning of batching plants. However, no major adverse impacts are anticipated due to small quantity of effluent and large volume water available for dilution in river Kopili.

74. Effluent from fabrication units and workshops. The fabrication units and workshops which shall be functional during construction phase will generate effluents with high suspended solids and oil and grease level.

ii. Operation Phase

75. Effluent from project colony. During project operation phase, due to absence of any large-scale construction activity, the cause and source of water pollution will be much different. Since, only a small number of O&M staff will reside in the area in a well- designed colony with sewage treatment plant and other infrastructure facilities, the problems of water pollution due to disposal of sewage are not anticipated. In the operation phase, about 50 families (total population of 200) will be residing in the project colony. About 0.03 mld of sewage will be generated. The total BOD loading will be order of 9 kg/day.

76. Impacts on reservoir water quality. The flooding of previously forested 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 will be offset long-term by the acidity of the water, so the impact is anticipated to be short-term if the AMD is not remediated

77. Eutrophication risks. Another significant impact observed in the reservoir is the problem of eutrophication, which occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. However, in the present case, fertilizer use in the project area is negligible, hence, the runoff at present does not contain significant amount of nutrients. Even in the post-project phase, use of fertilizers in the project catchment area is not expected to rise significantly. Thus, in project operation phase, problems of eutrophication, which is primarily caused by enrichment of nutrients in water, are not anticipated.

5.1.4 Cumulative Impacts Significance

78. As described under Cumulative Impacts Assessment above, the LKHEP project will discharge conventional water pollutants from several construction and operation sources. The impacts from these discharges will be readily mitigated (see Cumulative Impacts Mitigation Measures below). However, since the existing basin concentrations of conventional water

pollutants are quite low, any concentrations will degrade existing water quality if only by small increments.

79. More significantly, illegal coal mining areas are generating AMD which has significantly deteriorated water quality and aquatic ecology in the Kopili River. When considered in conjunction with the water quality impacts directly attributable to the LKHEP project, overall impacts on the WQ VEC represent the most significant cumulative impacts of the LKHEP project. Improved water quality will be crucial to support existing and restore past riverine aquatic ecology upstream and downstream of the reservoir and dam, as well as to support new lacustrine aquatic ecology in the reservoir. These ecological improvements in turn are needed to provide local stakeholders the ecosystem services and other project benefits dependent on water quality – such as fisheries, agriculture, water supply and recreation – that typically justify hydropower projects such as the proposed project.

5.1.5 Cumulative Impacts Mitigation Measures

80. The Water Quality Restoration Plan in the Supplemental EIA identifies and evaluates several mitigation options addressing the AMD issue. Appendix C to this CIA summarizes these options using the site data available. Since submittal of the ES Safeguards Interim Report in April 2017, it has been determined that only “at-source” mitigation measures will be developed further due to cost constraints, site availability limitations and mitigation effectiveness as listed in Appendix C. These include but are not limited to: oxic and anoxic alkaline limestone drains, stormwater diversion measures, pit backfilling, waste rock capping, and pit wall shotcreting. In addition to the AMD mitigation measures, the direct LKHEP water quality mitigation measures, as presented in the WAPCOS EIA, (recommended by MoEF&CC and as detailed in the technical design report), should be implemented.

81. From the social side, the local community can be called upon to help, specifically by creating a “community conservation corps” of Kopili River Basin residents, in both Assam and Megalya, who would be paid by the GoA to implement AMD mitigation measures in the shorter term and in the longer term help realize the ecological and economic benefits that improved water quality in the Kopili River and LKHEP reservoir will offer. These activities include:

- Constructing anoxic limestone drainage (ALD) passive treatment facilities (as detailed in the Water Quality Restoration Plan, for AMD reduction in the upper reaches of the Kopili River Basin – on NEEPCO property in Assam or on the Kharkhar River in Meghalaya State – and backfilling the illegal coal mining pits, both in Assam and Meghalaya, to reduce AMD generation.
- Helping to implement and/ or monitor the implementation and effectiveness of the LKHEP water quality mitigation measures recommended in the WAPCOS EIA.
- Creating and maintaining fishery, drinking water, irrigation, agricultural, recreational and tourist facilities and businesses that will be able to take advantage of the improved water quality in just 1-2 years.

82. The issue of small illegal coal mining in Meghalaya State has reached a critical juncture. Environmental groups are pressuring the state to enforce a National Green Tribunal (NGT) decision that all coal mining be ceased in the state, but claim that the state allows the mining to go on. In Meghalaya, the community owns the natural resources, not the state, so the state believes it cannot enforce the NGT’s decision. In addition, the National Coal Company that would presumably operate in a more environmentally sound manner, cannot mine coal in Meghalaya because their charter allows it to contract only with state government, not with the community. Although this situation is complex, and not easily resolved, it is recommended that

APGCL and ADB look for ways to engage appropriate parties toward a resolution that will allow the LKHEP AMD problem to be remediated. Some possibilities include:

APGCL should partner with Meghalaya State, NEC/Coal India and State environmental regulatory agencies to discuss the potential impacts of continued illegal coal mining. The environmental implications associated with the chemical/physical properties of the coal – high sulfur, and high-ash when inefficiently mined to include dirt bands (which is certain to be the case with rathole-produced coal) – should be a topic of stakeholder discussion. Promoting discontinuation of rathole mining in favor of technically-controlled modern extraction methods would increase production and efficiency, radically improve worker safety and environmental best management and pollution controls, both in the mining area and in coal-fired operations.

- Working with the state governments and the national coal and power companies to create a market for private coal development in Meghalaya and Assam that would involve auctioning off coal mining tracts and permits to legitimate and capable coal mining companies with eligibility and selection criteria that include willingness and capacity to: (1) remediate past artisanal coal mining sites on their respective tracts using local community labor resources; and (2) follow best international practice in ongoing environmental management.
- Planning a conference on AMD site remediation and water quality restoration in the IWRM planning context. Promote the conference to the respective states' representatives to the Brahmaputra Board, inviting the Meghalaya Electricity Board, the national coal company and NEEPCO, as well as APGCL and ADB, to participate. Include the conference, or a series of related meetings, in the Kopili River Basin IWRM Plan component of the SEA. Dr. O.P. Singh should be invited to participate and to share the results of his research work on AMD from illegal coal mining in Meghalaya State, and its effect on Kharkar River water quality.
- Engage Dr. O. P. Singh of North Eastern Hill University (NEHU) to conduct the pilot plant study for AMD remediation; he has stated that his department or NEHU is ready to provide advisory and technical support for pilot plant implementation once approved by the affected local communities and state government.
- Creating awareness and best practices guidelines for pit hole mining operations (excavation, handing and storage, transportation) by miners.
- ADB should continue to promote alternative sources of energy for local residents, for example:
    - Broadening and accelerating the GOI's distribution of gas cylinder stoves
    - Installing pico-solar equipment in homes to power lights and mobile phones
    - Installing photovoltaic solar energy in both on-grid and off-grid village configurations
    - Ensuring access to hydropower via distribution from KHP and LKHEP projects

83. According to the WAPCOS EMP, wastewater effluents should be treated as follows:

- Domestic sewage – Sewage from community toilets can be treated in an aerated lagoon followed by a secondary settling tank. The treated effluent can be used for meeting irrigation requirements of areas being afforested under greenbelt development and canal bank plantation.

- Crushers – treated in settling tanks
- Tunneling sites, batching plants, fabrication units and workshops, and muck disposal – treated prior to disposal.
- The above recommended treatment methods should be confirmed and further elaborated in the ADB Supplemental EIA.

84. The WAPCOS EMP also provides a Catchment Area Treatment Plan that focuses on control of runoff, erosion and siltation of the river system. Suites of physical and biological control methods are recommended. The motivation for implementation of these mitigation measures is additionally justified from the cumulative impacts perspective.

5.2 Water Quantity VEC

5.2.1 Definition

85. Environmental flows describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and wellbeing that depend on these ecosystems. However, while the application of environmental flow requirements is a necessary and effective mitigation measure for hydroelectric power projects, the imposition of the LKHEP dam and reservoir still significantly alter the hydrography and hydrology of the river system and thus adversely affect and change the aquatic ecosystem. More specifically, in the case of the LKHEP Project or any HPP in the Kopili River Basin, the dams and reservoirs limit the potential to restore the past lotic ecosystem, even if water quality issues are resolved. When considering that there are already two dams and reservoirs upstream supporting the KHP, and that there have been several other small hydropower projects (SHPs) proposed for elsewhere in the basin or in the two autonomous districts in the basin, it is valid to identify a Water Quantity VEC that is subject to cumulative impacts. (Note that, for the purposes of this report, SHPs are all envisaged to be run-of-river plants (RORPs) as defined by the GOI, and are heretofore referred to as SHP/RORPs.

86. The relevant Resource Impact Zones for the Water Quantity VEC are, from the water flow perspective, the river stretches in which the existing, proposed and potential future SHP/RORPs affect the flow immediately upstream and downstream of their respective dams and, from the aquatic ecology perspective, potentially the entire Kopili River Basin.

5.2.2 VEC Conditions without LKHEP

87. Figures 5.4 and 5.5 present maps of the Kopili River Basin, and its land use and land cover, respectively. Figure 5.5 is a schematic of the Kopili River Basin showing the areas in square kilometers and locations in km from the Kopili headwaters of tributary catchments and dams. pH profile of the river basin is shown in Figure 5.7. Based on review of all the past data, Table 5.4 provides the sub- catchment areas and cumulative catchment area of the Kopili River Basin.

Figure 5.4: Map of Kopili River Basin

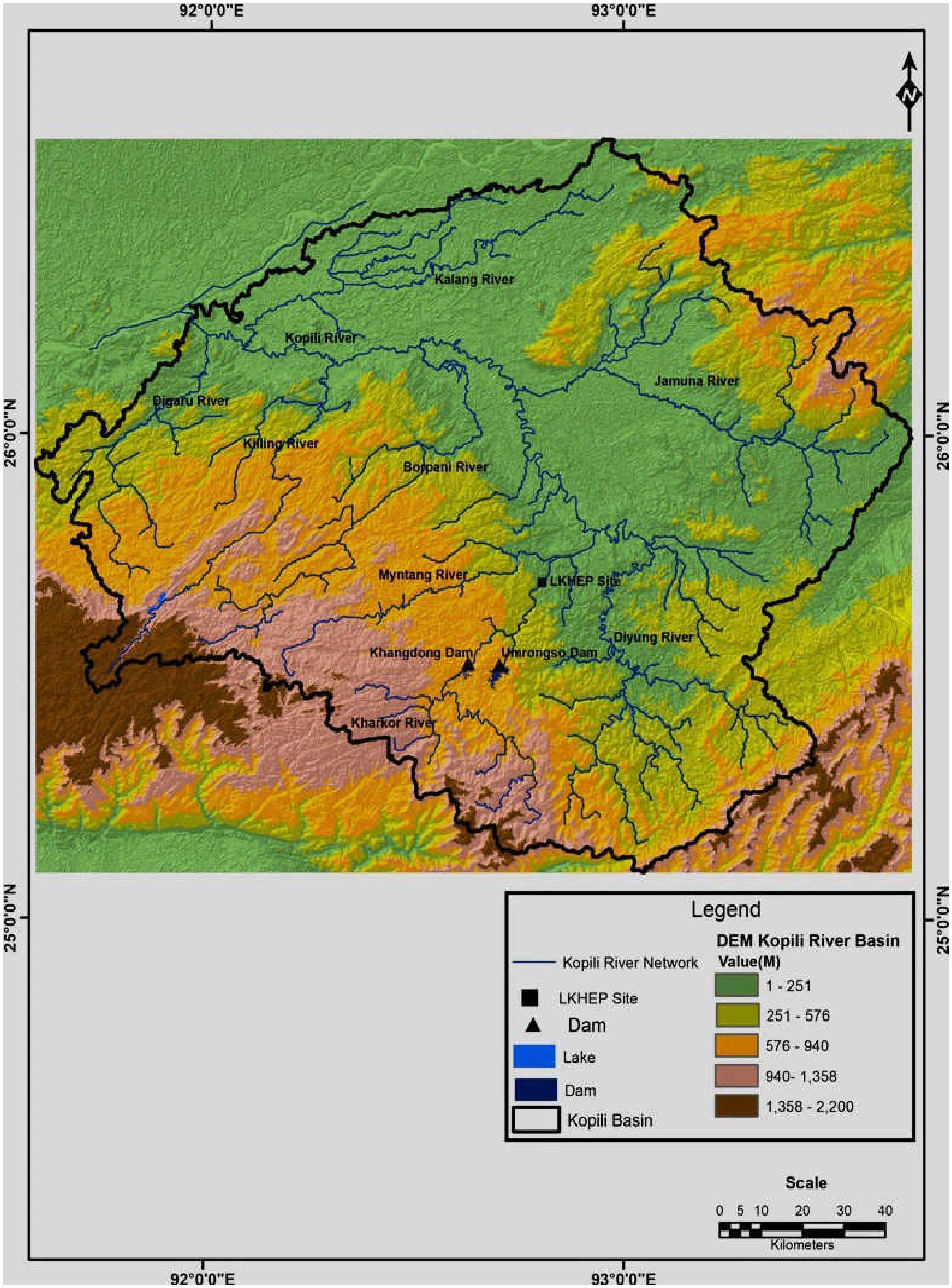


Figure 5.5: Land Use and Land Cover

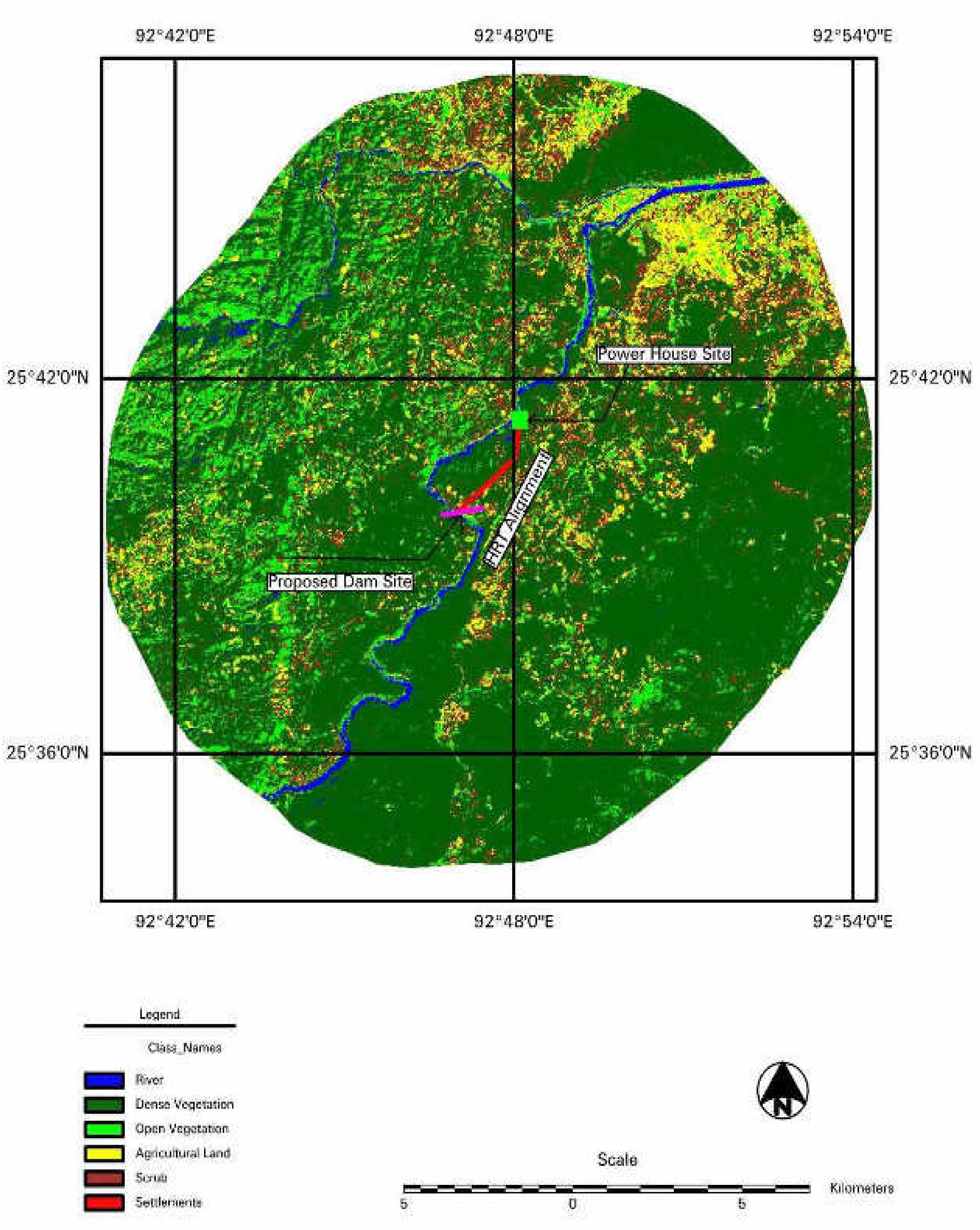


Figure 5.6: Schematic of Kopili River Basin
(Note that the Kopili River flows from south to north.)

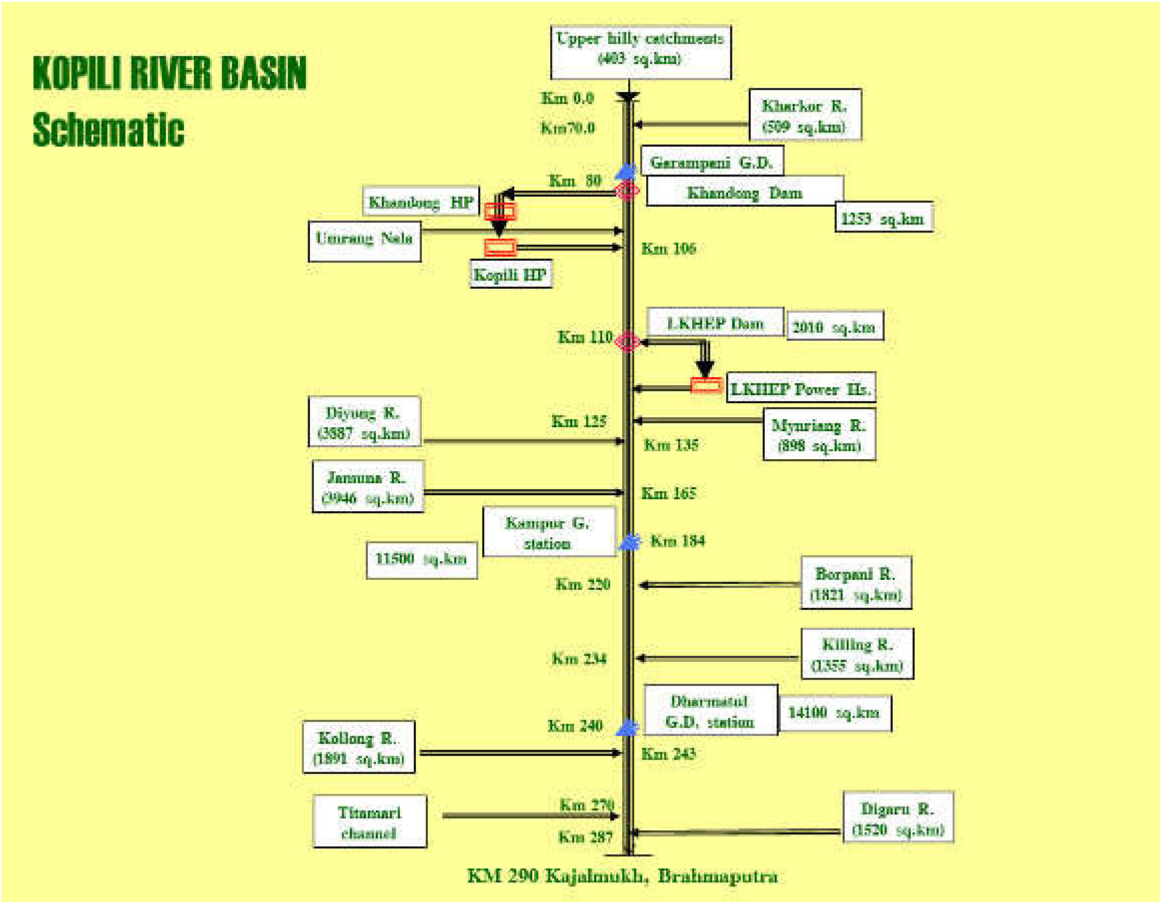


Figure 5.7: pH profile of Kopili River Basin

Table 5.4: Kopili River Basin Sub-Catchment and Cumulative Catchment Areas

No	Sub-catchment	km from origin	Area (sq. km)	Cumulative (sq.km) catchment area
1	Head water catchment	0	403	403
2	Kharkar River	70	509	912
3	Local nalas and catchment up to Khandong dam	0- 80	341	1,253
4	LKHEP dam site	90	757	2,010
5	Myntang River	115	898	2,908
6	Diyung River	135	3,887	6,795
7	Jamuna River	165	3,946	10,741
8	Borpani River	220	1,821	12,562
9	Killing River	234	1,355	13,917
10	Kalong River	243	1,891	15,808
11	Digaru, Titamari channel & lower floodplain	243-287	1,709	17,517
12	Kopili River channel	290	3,480	20,997
	TOTAL		**20,997**	**20,997**

Catchment area of Dharmatul G.D. station = 14,100 sq km
Catchment area of Kampur G station = 11,500 sq km

88. Assessment of Kopili Basin Water Quantities and Flows. The following summary of existing water flows in the Kopili River Basin, provided by the Consultant team preparing the IWRMP, addresses existing quantity and timing of water flows in the Kopili River Basin as evaluated from existing data. The reader is referred to the IWRMP Report for more in- depth analysis and supporting tables and figures in Section 9, Water Resources Systems Analysis.

89. The NEEPCO owned Kopili hydropower system was commissioned in 1984 (first unit) and 1997 (second unit). The proposed LKHEP will receive water from (i) the tail race outlet from the existing Kopili power plant, (ii) incremental flow from the river catchment area between Khandong dam and the proposed LKHEP dam near Longku, and (iii) any spills from Khandong and Umrong reservoirs. Flow computations have been carried out using the data from 1959 to 2016 (with several years' gap in data). The computed flows at the LKHEP site have three characteristics due to the impact of the upstream Kopili HEP:

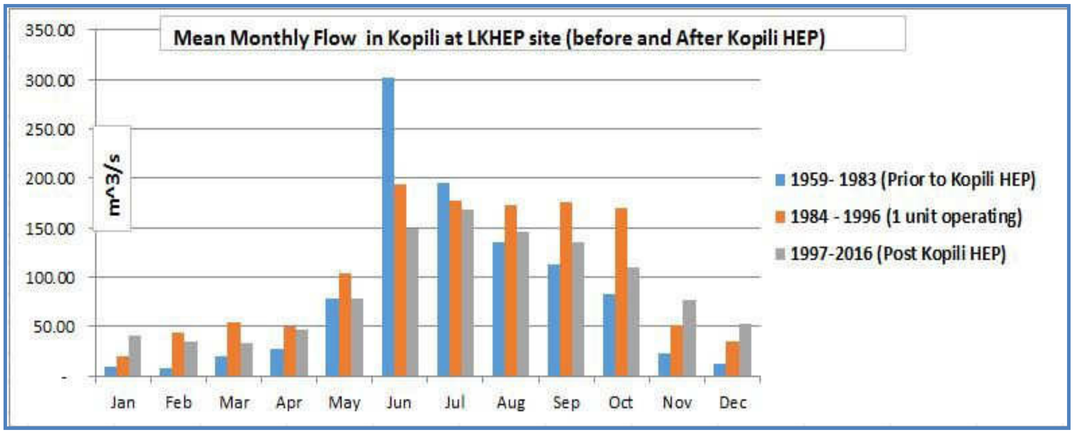
(i) Pre-Kopili HEP Period: 1959 – 1983 – Natural flow
(ii) Transition Period: 1984-1996 – Flows affected by the operation of the first unit of KHEP
(iii) Post-Kopili HEP Period: 1997-present – Flows affected by the full operation of KHEP

90. The computed daily data are presented in the IWRMP report. A summary of the mean monthly flows during the three periods is given in Table 5.5. The different flow characteristics during the three periods are also depicted Figure 5.8. As expected, the impact of operation of the Kopili hydropower system, by releasing regulated flow 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 flows during the monsoon season are reduced. Further analysis of water resources in the Kopili basin are guided by the above findings. While analysis of natural catchment flows will be based the natural flows before 1984, analysis for future planning will be based on the flow data from the post-LKHEP period after 1997.

Table 5.5: Summary of Mean Monthly Flows at LKHEP during the Three Periods

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
1959-1983 (Prior to Kopili HEP)	8.95	8.33	18.96	26.54	77.60	301.87	194.48	135.29	112.57	83.11	22.27	12.35	83.82
1984-1996 (1 Unit Operating)	20.35	43.59	54.56	49.03	103.13	192.95	177.34	172.73	176.37	169.94	51.84	34.31	103.85
1997-2016 (Post Kopili HEP)	40.14	35.06	32.81	46.73	77.78	148.90	168.84	145.39	135.53	109.39	76.00	52.04	89.05

Figure 5.8: Flow Characteristics during the Three Periods



91. Design Discharge Used in LKHEP. LKHEP is designed as a hybrid run-of-river and storage design. During high flow season it will operate on a run-of-river basis, but in low flow season it will store water during the day and then release flow and generate power during the evening peak demand period. This design and variations thereof are common in India, and are generally referred to there as run-of-river with daily storage. In the Detailed Project Report of LKHEP, annual flow volumes for the period 1998 to 2010 have been considered to arrive at the 90% and 50% dependable hydrologic years. The summary results of dependable flow analysis for 90% and 50% dependable years are shown in Table 5.6.

Table 5.6: Dependable Year Flow Volumes

Dependability	Dependable Water Year (June – May)	Annual Flow Volume (MCM)
90%	2004-05	2184.4
50%	1998-99	2483.6

92. Flow Duration Curves for 90% and 50% dependable years have been portrayed in Figures 5.9 and 5.10, respectively.

Figure 5.9: Flow Duration Curve for 90% Dependable Year: 2004-05

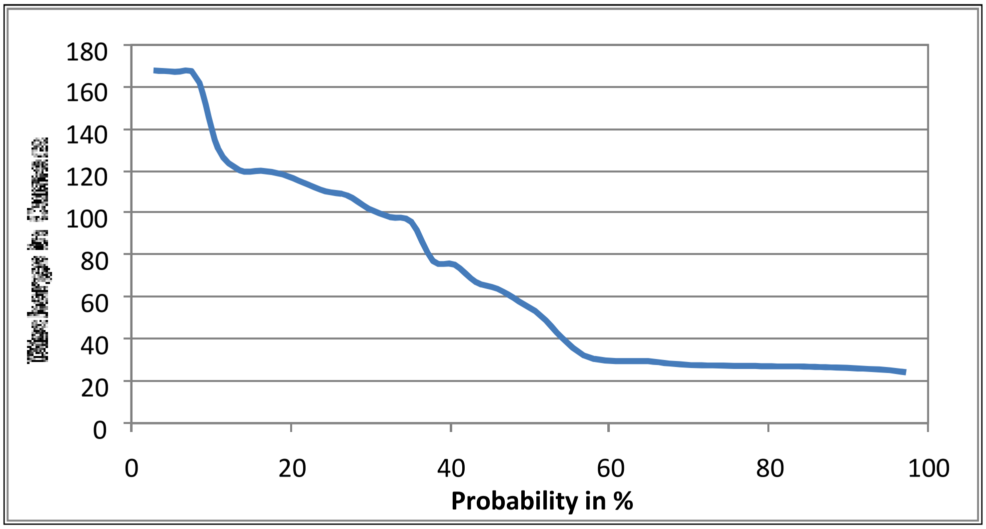
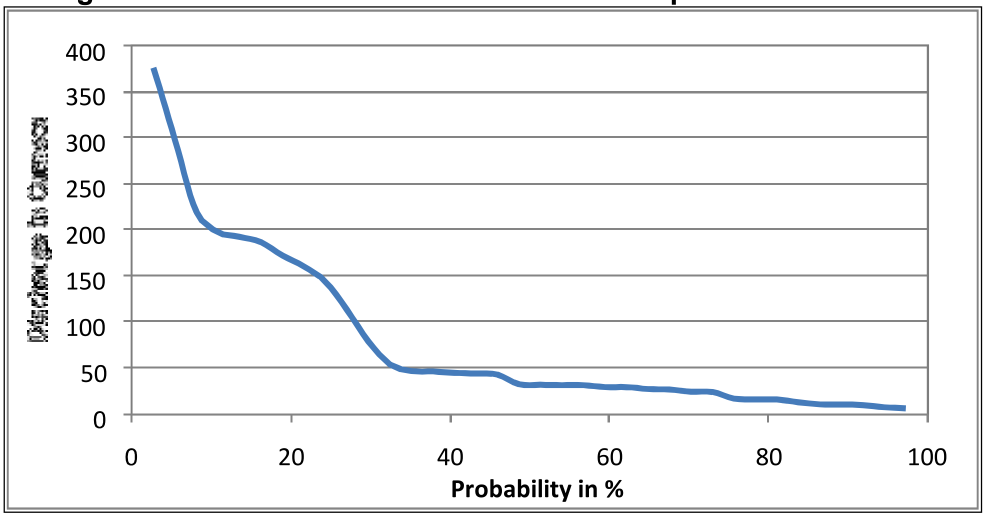


Figure 5.10: Flow Duration Curve for 50% Dependable Year: 1998-99



93. Monthly and Annual Variations in Discharge Values. Based on the daily discharge data received from APGCL, monthly and annual mean, maximum and minimum discharge values were calculated. In last 19 years (1998-2016), annual mean discharge varied between 48.14 m^3/s (2012) to 128.77 m^3/s (2000) with annual average of 89.0 m^3/s. It is also noted that more than 66% of total discharge of Kopili River was received during monsoon months (June-October). Variations in discharge values of Kopili River at Longku from 1999-2016 are depicted in Figure 5.11 while monthly mean, maximum and minimum discharge observations calculated from last 18 years' data is summarized in Figure 5.12. Monthly variation of discharge in the before-dam and after-dam eras are depicted in the IWRMP Report.

Figure 5.11: Variation of Discharge Values of Kopili River at Longku From 1999-2016

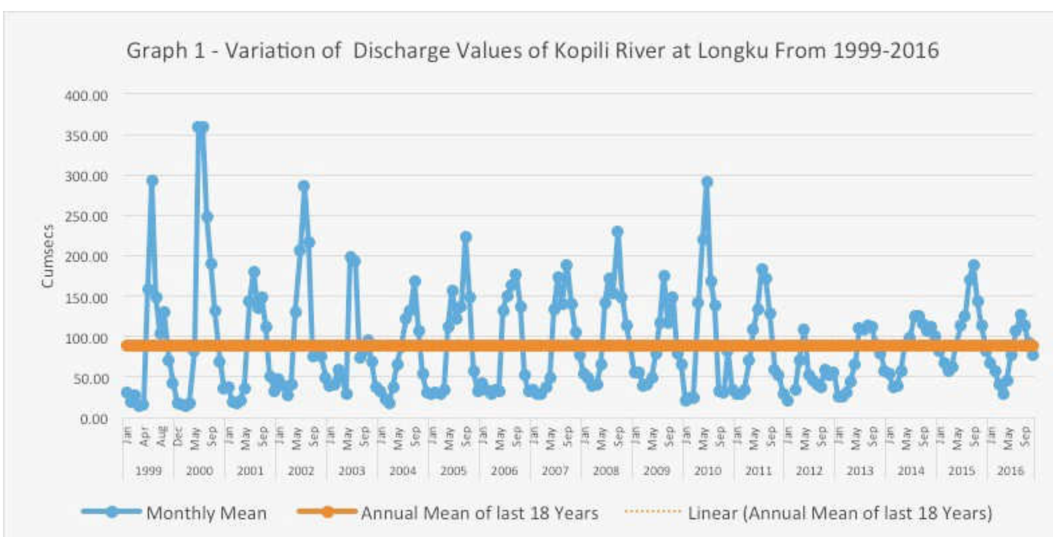


Figure 5.12: Monthly Variation of Discharge of Kopili River

94. Environmental Flow Release. As per the Terms of Reference of the EIA issued by MOEF&CC, 20% of the average flow of the four consecutive leanest months in a 90% dependable year should be maintained as environmental flow during the lean season. 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.

95. The annual flow volume estimates for the period 1979-1980 to 2009-2010 have been considered to arrive at the 90%, 75% and 50% dependable hydrologic years. The long-term river flow series was established in the form of 10-day discharge values; computed from the available daily discharge data. The 50% and 90% dependable years were worked out as 1998-1999 and 2004-2005 with annual flow volume as 1,801.2 MCM and 1,715.2 MCM, respectively. The design discharge for power generation is 112.71 m^3/s. The 10-daily discharge for the 90% dependable year is provided in the IWRMP Report.

96. 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 m3/s, so even during the lean season there will be daily environmental release although only during night-time. 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 as113.2 m^3/s.

97. 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 m³/s, 97.6 m³/s, 95.1 m³/s and 47.1 m³/s respectively. The average discharge during the period is 67.3 m³/s. The environmental release for this period has been considered at the rate of 25% of the average discharge, i.e. 16.835 m³/s.

98. The minimum environmental flow release during the lean months (December to March) was adopted in the DPR is 5.345 m³/s. The main power station of LKPH is proposed to comprise two units of 55 MW each, which are designed to be operated as a peaking plant for at least 3 hours a day. In the auxiliary power house below the dam, two units each of 2.5 MW and 1 unit of 5 MW will be operated to utilize the mandatory environmental flows.

99. Computation of Environmental 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).

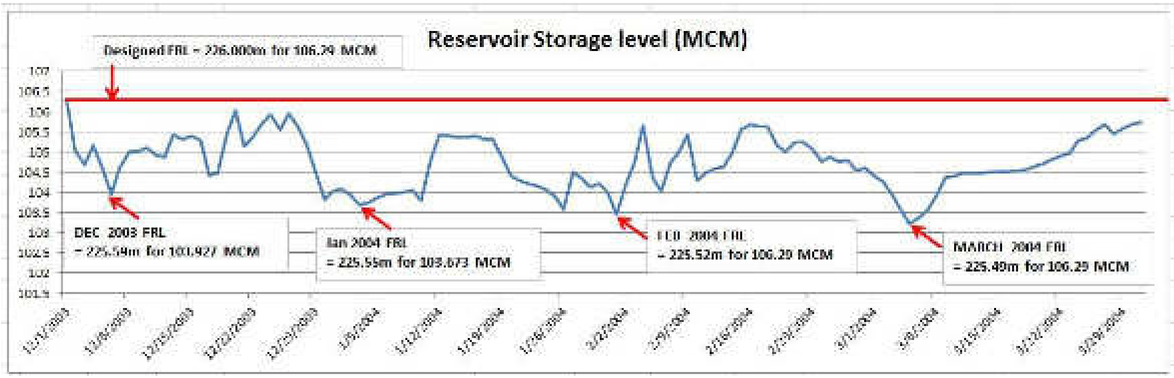
100. Design Basis for Reservoir Operation. The basis for simulating the operation of the reservoir is its configuration the main power house is set up with a plant capacity of 110 MW comprised of two units with capacity of 55 MW each. During the non-monsoon season, the plant is to be operated as a peaking plant generating at full plant capacity for at least 3 hours a day. It has been proposed to utilize the environmental release for generating hydropower by passing it through turbines of a dam toe power house named as Auxiliary Power House. This auxiliary power house will have two units of 2.5 MW each and one unit of 5 MW. This will act as a base load plant generating power.

101. In order to generate power to meet diurnal peak load, the main power house is proposed to be operated in the mode of diurnal peaking. As per the design, LKHEP can be operated at full plant capacity for most of the monsoon months while diurnal peaking operation can be supported in the non-monsoon months. The operation as a peaking plant can be supported for at least 3 hours a day. For a few 10-daily periods during the lean flow season, the plant will have to operate with one machine running to maintain generation for a minimum of 3 hours. Alternatively, hours of peaking can be reduced for these periods with extreme low flows. It has been envisaged to operate the reservoir at Full Reservoir Level (FRL) throughout the year, to gain maximum advantage of the head available. The live storage is just sufficient to support all the units operating at full load for about 7.94 days. Therefore, it has been planned to release all the water during the last 10-daily period of the month of May, taking the reservoir water level to Minimum Draw Down Level (MDDL). It is expected to get filled up to FRL during the next two 10-daily periods. However, generation in one 10-daily period has to be sacrificed; which can be made use for regular maintenance operations.

102. The design discharges adopted for the various turbines are 56.35 m^3/s for each of the 55 MW units, 6.23 m^3/s for each of the 2.5MW units, and 12.46 m^3/s for the 5 MW unit. The total design discharge of the main power house is 112.71 m^3/s with an average net head of 108 m while the design discharge for the auxiliary power house is 24.94 m^3/s with a net head of 47.30 m, all at FRL.

103. Based on the simulation of the reservoir with daily inflow from upstream during the four lean months from December 2003 to March 2004, the IWRMP Report provides tables showing reservoir operation results in terms of inflows and releases during the four months. Figure 5.13 shows the reservoir operation result from 2003 December 1 to 2004 March 31.

Figure 5.13: Reservoir Operation Simulation during 1 Dec 2003 - 31 March 2004



104. The conditions used in the reservoir simulation are:

- The storage is at Full Reservoir Level (FRL) at the end of November 2003.
- The reservoir is kept at FRL as much as possible in order to utilize the design head of 108 m for the two main power units (2X 55MW).
- The two power units are operated for peaking purpose and one must be operated for at least 3 hours.
- A design discharge of 56.35 m^3/s is released to one unit.

105. Table 5.7 summarizes the operation results for the four months. It is noted that it is possible to release the minimum environmental 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 environmental flow. The number of days during which the units can operate for 3, 6 and 9 hours can also be counted from the tables provided in the IWRMP Report.

Table 5.7: 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

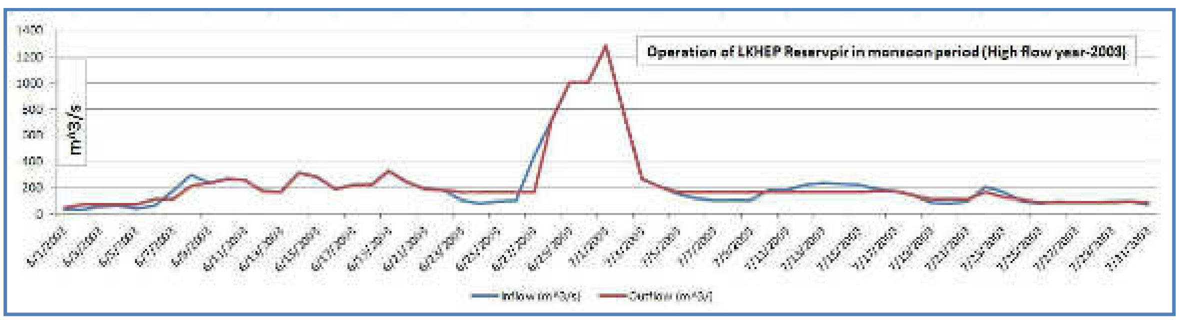
106. <u>Reservoir Operation during Floods</u>. A simulation of reservoir operation was carried out during the monsoon period to assess its impact on flood flows. The monsoon period of the year 2003 was found to be a high flow year. The simulation results show that the operation of the LKHEP reservoir 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 5.8 shows the summary of power plant operation hours.

Table 5.8: Summary of Daily Reservoir Operation during June-July 2003

	Main Power Plant Operation		Aux Power Plant Operation		
	Unit-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		

107. Figure 5.14 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 can also be seen as the result of combined operation of the Kopili HEP (Khandong dam) and the proposed LKHEP.

Figure 5.14: Daily Reservoir Operation in Monsoon Period (High Flow Year 2003)



5.2.3 Cumulative Impacts Assessment

108. According to the ADB Preliminary CIA, the major direct water flow impacts of the LKHEP will occur in the reservoir area and the partially de-watered section of the river between the dam and main powerhouse. 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 (particularly in the dry season). The flow diversion will also partly dewater 5-6 km of the river below the LKHEP dam. Normal flow will be restored below the main powerhouse and tailrace outlet... The LKHEP site was selected in part because the hydrologic disruption caused by the existing Kopili HEP was expected to be negligible upstream of the LKHEP dam site near the village of Longku. However, the LKHEP will extend the hydrologic disturbance caused by the Kopili HEP further downstream by at least 10 kilometers.

109. According to hydrological data and analysis presented in the IWRMP Report, summarized above, the key findings are:

- Cumulative impacts are: fluctuation in the reservoir level above LKHEP dam; a dewatered section between the dam and the powerhouse tailrace, where 5.3 m3/s will flow, apparently all the time; and, 3 hours per day when the reservoir is being filled, and there is no power generation, which means only 5.3 m3/s plus downstream tributary discharge below the powerhouse during the storage time.
- The impact of operation of the Kopili hydropower system, by releasing regulated flow 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 flows during the monsoon season are reduced.
- 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 2004-2005, 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.
- The operation as a peaking plant can be supported for at least 3 hours a day. For a few 10-daily periods during the lean flow season, the plant will have to operate with one machine running to maintain generation for a minimum of 3 hours. Alternatively, hours of peaking can be reduced for these periods with extreme low flows. It has been envisaged to operate the reservoir at Full Reservoir Level (FRL) throughout the year, to gain maximum advantage of the head available. The live storage is just sufficient to support all the units operating at full load for about 7.94 days. Therefore, it has been planned to release all the water during the last 10- daily period of the month of May, taking the reservoir water level to Minimum Draw Down Level (MDDL). It is expected to get filled up to FRL during the next two 10- daily periods. However, generation in one 10-daily period has to be sacrificed; which can be made use for regular maintenance operations.

5.2.4 Cumulative Impacts Significance

110. According to the IWRMP Report, the impacts of the existing and future "dams" are not significant as far as 10-daily/monthly river flows are concerned, however daily flows might be affected in the dry season. According to the ADB Preliminary CIA, the impacts will be masked by inflows from the catchment area downstream of the main powerhouse, including perennial tributaries to the Kopili River. Based on the relative size of catchment areas (see Table 5.4 above), the downstream hydrologic disruption should be greatly diminished at the confluence with the Jamuna River. Impacts from the Kopili HEP and LKHEP are not expected to be observable at the confluence of the Kopili and Brahmaputra. (See the IWRMP Report for data on discharges from downstream tributaries.)

111. Despite the application of environmental flow requirements, the imposition of the LKHEP dam and reservoir significantly alter the hydrography and hydrology of the river system on a localized basis. However, those localized physical impacts can adversely affect and alter the aquatic ecosystem and thus complicates the effort to restore fisheries for the longer stretches of the river. More specifically, in the case of the LKHEP Project or any HPP in the Kopili River Basin, the dams and reservoirs limit the potential to restore the past lotic ecosystem, even if water quality issues are resolved. When considering that there are already two dams and reservoirs upstream supporting the KHP, and that there have been several other

SHP/RORPs proposed for elsewhere in the basin or elsewhere in the two autonomous districts in the basin, it is valid to conclude that there are cumulative hydrologic and hydrographic impacts that, although individually localized, will affect fishery restoration potential in the overall basin. The success of reintroducing lotic fish and other fish and aquatic species in the overall river basin will be threatened if their habitat is intermittent and discontinuous.

5.2.5 Cumulative Impacts Mitigation Measures

112. The LKHEP project is a “run-of-river” HPP, as defined by the GOI. As such, during the dry season, it will store water during the dayand discharge it during the night at the base of the dam as “environmental flow”. According to the EIA, to mitigate the adverse impacts of the LKHEP dam and reservoir on Kopili River water quality and aquatic and riparian ecology, an environmental flow requirement has been set, asfollows:

- Monsoon Season - May to September - the cumulative flow releases including spillage during monsoon period should be about 30% of the average flows during the 90% dependable year
- Non-monsoon / Non-lean Season - October and April - 25% of the average flows during the 90% dependable year
- Lean Season - November to March - 20% of the average flows during the 90% dependable year

113. The environmental flow requirements are based on release data provided by the DPR and approved by the Expert Environmental Appraisal Committee of the MoEF&CC, as well as the Central Electricity Authority and Central Water Commission of India. Although 5-6 km of river stretch between the dam and power house/ tail race will be partly dewatered, APGCL is committed to maintaining the environmental flow rate so that the river will never completely dry up below the dam. It is critical that these flow rate mitigation measures be implemented and monitored at LKHEP and at any future SHP/RORPs planned for the Kopili River Basin to address cumulative impacts as well as LKHEP- specific impacts.

114. Theoretically, the environmental flow rate has been calculated to support historically indigenous lotic (fast water) fish species. However, as mentioned above, the ultimate success of reintroducing the indigenous lotic fish species may depend on there being a more continuous and integrated river system than one interrupted by multiple dams and reservoirs. Therefore, lotic fish species should be selected that are likely to be the most robust and tolerant regarding variations in river flow rate and/or length of fast flow stretches. In addition to reintroducing lotic fish species, the creation of slow moving reservoirs presents the opportunity to introduce lentic (slow water) fish species to provide an additional ecosystem service and livelihood to local residents.

115. Design and implement a comprehensive fisheries reintroduction plan, including specifications of lotic and lentic species, and timing and locations of reintroduction, as well as implementation budget and responsibilities. The plan should provide for long-term regular monitoring and evaluation of plan implementation and effectiveness with contingencies for restocking to maintain population levels and to achieve a balanced gene pool through transfers from other stream stretches, as necessary. In addition, the implementation and effectiveness of the environmental flow rates should be monitored and evaluated on a regular basis during project start-up and operation as part of implementing the ESMP.

5.3 Air Quality VEC

5.3.1 Definition

116. As a primary or direct impact, the proposed LKHEP project will potentially emit methane (CH_4), a potent greenhouse gas that is shown to contribute to global climate change, from decomposing vegetation remaining in the reservoir bottom after filling. However, if the vegetation is removed before the reservoir is filled but then burned, then GHG emissions will be generated in the form of carbon dioxide (CO_2). In addition, as a secondary or indirect impact, the project will supply up to 5% of the latent electricity demand in Assam, which will support a proportionate extent of development in all sectors in the AoC – domestic, industrial, transport, etc. – all of which in turn generate air pollution, particularly particulate matter.

117. Separate from and not caused by the proposed project, there are existing point and non-point sources of air pollution in the vicinity of the project. These include the existing cement plant point source which emits particulate matter and other air pollutants which, although apparently controlled to levels below applicable standards, still contributes to the current poor regional ambient air quality. In addition, there are numerous existing area-wide sources of air pollution, especially of particulate matter, including vehicular emissions and road dust in the transport sector; fuelwood, charcoal and coal burning in the domestic sector; and slash and burn (jhoom) cultivation and dust generation in the agriculture sector.

118. While these various project and non-project sources generate different air pollutants in different concentrations, and most of these impacts are more or less readily mitigated, they nonetheless collectively threaten human and environmental health in the same airshed. Thus, the project and non-project PM pollution in the region combined with the threat that LKHEP greenhouse gas (GHG) emissions pose to global climate warming amount to a cumulative impact on the Air Quality VEC.

119. The Resource Impact Zone relevant to the Air Quality VEC is the airshed(s) of the Kopili River Basin.

5.3.2 VEC Conditions without LKHEP

120. The Pollution Control Board Assam (PCBA) has been monitoring Guwahati's ambient air quality under the National Air Quality Monitoring Programme (NAMP) and has observed respirable suspended particulate matter (RSPM) and suspended particulate matter (SPM) well above prescribed limits – with annual averages high or in critical condition in almost all city monitoring locations since 2008. In December 2016, the Air Quality Index (AQI) for Guwahati was 113, up from 92 in December 2015. An AQI of 101- 200 is considered "Moderate", i.e. "Breathing discomfort to the people with lung disease, heart disease, children and older adults." Moreover, Guwahati has one of the highest Black Carbon (BC) pollution levels in the world. The poor existing ambient air quality in the city is due to vehicular emissions and dust from rapid urbanization and inadequate transport infrastructure that results in people travelling in their private vehicles and causing severe traffic congestion and increased emissions from idling vehicles.

121. According to the PCBA, the Nagaon air pollution monitoring station is the closest one to the LKHEP AoC. As can be seen in Table 5.9 below, the Nagaon AQI was 139 in the January-June 2016 period, i.e. even higher than for Guwahati's December 2015 and 2016 averages. The AQI score is largely a function of Nagaon's PM10 score (Respirable Suspended Particulate Matter, or RSPM) while its SO_2 (sulfur dioxide) and NO_X (nitrogen oxides) scores were somewhat lower.

122. According to the PCBA's report, State of Environment, Assam Ambient Air and Water Quality, 2014, from 2009-2014 Nagaon had Low SO_2 and NO_X levels, but SPM (Suspended Particulate Matter) and RSPM levels were High or Critical every year. With even slow growth in the Hill Country, the trends in the LKHEP AoC are toward worsening particulate matter (PM10 and PM2.5) and black carbon (BC) pollution.

Table 5.9: Air quality Index of project area *(At Nagaon station average AQI during January to June 2015)*

S.No.	Pollutants	Conc. in ug/m^3	AQI
1	PM10	158.06	139
2	SO2	8.27	
3	NOx	14.57	

Source: *Air Quality Index during January to June 2015, Pollution Control Board, Assam*

5.3.3 Cumulative Impacts Assessment

123. Regarding conventional air pollutants – PM10 or RSPM, SO_2 and NO_X – there is a significant existing issue, which is trending upward, with PM10 in the LKHEP AoC, without the LKHEP project, that the LKHEP project may worsen due to direct impacts during the construction phase (raising dust and emitting exhaust from the operation of construction vehicles) and indirect or induced impacts during the operation phase of the project (raising dust and vehicle exhaust from increased traffic resulting from population and economic growth). The proposed LKHEP construction sites, including auxiliary roads, and the existing local roads accessing the site, are in close proximity to each other.

124. Regarding GHG emissions to the atmosphere – the LKHEP 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 (tCO2e/MWh), GHG emissions reduction is estimated to be 370,640 tCO2e per year. Primary pollutant emissions will be reduced as follows: 103 t/year particulate matter (PM2.5), 945 t/y nitrogen oxides, and 3230 t/year sulfur oxides.

125. Construction of LKHEP will require cement, electricity, and petroleum fuels which present an embedded emissions "debt" at the front end of the project which is estimated to be 385,630 CO_2, not including emissions due to permanent forest cover loss. Reservoir methane emissions are considered to be insignificant as the proposed design will minimize or prevent reservoir stratification, and the power density is greater than 10 Watts per square meter of reservoir area. The estimated annual emissions reduction is 370,640 t CO_2 e; 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 5.10 below.

Table 5.10: Greenhouse Gas Emissions Balance

GHG Emissions Sources and Sinks	Amount (t/y)
SOURCE: Construction Activities Embedded emissions from cement 718,000 m3 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 = 8995 tCO_2e/y Electricity consumption during construction 2.705 MW (WAPCOS EIA Volume 1, Table 2.5) running @ 8760 h/y for 5 years Grid emissions factor at 0.82 tCO_2e/MWh Emissions = 2.705 x 8760 x 5 x 0.82 = 97,153 tCO_2e 97,153 tCO_2e / 25 years = 3886 tCO_2e/y Petroleum fuels Fuel consumption during construction: 3 MW of diesel gensets running 4000 hours/year = 12,000 MWh/y; emissions factor of 1.06 tCO2e/MWh; 5 year construction period: Emissions = 12,000 x 1.06 x 5 = 63,600 tCO_2e; 63,600 tCO_2e 63,600 tCO_2e / 25 years = 2544 tCO_2e/y	15,425
SOURCE: Permanent Forest Cover Loss Forest loss: calculated coefficient from Nam Ngiep 1 in Lao PDR: 5.13 tCO2e per year per hectare of lost forest x 600 hectares	3,078
SINK: Power generation 452,000 MWh/y x 0.82 tCO_2e/MWh	1. 370,640
TOTAL NET ANNNUAL GHG REDUCTION	**2. 352,137**

5.3.4 Cumulative Impacts Significance

126. Reservoir methane emissions are considered to be insignificant as the proposed design will minimize or prevent reservoir stratification, and the power density is greater than 10 Watts per square meter of reservoir area. More recent scientific evidence indicates that this contribution is probably less than 1 percent2. Overall, LKHEP will add generation to the future Assam grid mix that will replace an equivalent generation of the current mix of fuel types with a higher proportion of essentially zero GHG-emitting hydropower. This will result in a future reduction of 370,640 tCO_2e from the overall Assam grid with LKHEP included versus continuing the current Assam grid mix without LKHEP. Likewise, the project and non-project emissions of PM in the vicinity of the LKHEP are likely to be incremental over existing emissions and readily mitigated.

5.3.5 Cumulative Impacts Mitigation Measures

127. To mitigate possible emissions of greenhouse gas (methane) directly attributable to the LKHEP project, the following measure should be taken:

- Remove all vegetation from the base of the proposed reservoir before it is filled so that it will not be available to decompose under water which would generate methane gas that would escape to the atmosphere, but ensure that as much as possible of the wood

[2] World Bank 2013. IFC Good Practice Note on Environmental, Health and Safety Approaches for Hydropower Projects (2018)

harvested is utilized without burning it, e.g. in construction or manufacturing.

128. To mitigate the indirect project, and non-project, impacts of the LKHEP project on other parameters of air quality in the airshed, especially PM, the following measures should be considered:

- Municipal – Utilize rational land use planning, enforce zoning requirements, manage traffic, and expand water, sanitation, and solid waste management services to reduce the long-term air quality impacts of growth in all sectors.
- Energy – Reduce the use of coal, charcoal and wood for fuel, e.g. through intensified support to alternative energy sources for local residents, for example:
    - Broaden and accelerate the GOI's distribution of gas cylinder stoves
    - Install pico-solar equipment in homes to power lights and mobile phones
    - Install photovoltaic solar energy in both on-grid and off-grid village configurations
    - Employ distributed generation systems for power supply (which could have compensatory effects if natural gas or renewable energy technologies are employed).

129. This will not only reduce air emissions directly from their combustion, but also reduce soil erosion and associated dust generation from the extraction, production or collection of these fuels from the landscape.

- Agriculture – Broaden and accelerate district agriculture department programs to convert jhoom (slash and burn) agriculture to reduce soil erosion and dust generation.
- Transport -- Pave or repave local roads to control dust generation.
- Industry – Upgrade to cleaner production technology, install air pollution control and monitoring technology applicable to the respective industrial sectors, land use planning (industrial estates), and enforcement of existing EIA and environmental management regulations.

5.4 Land, Forestry and Ecology VEC

5.4.1 Definition

130. As a primary or direct impact, the proposed LKHEP project will result in the loss, through clearing or degradation, of approximately 524 ha of forest land, including reserve forests on both sides of the river, map showing forest area is given in Figure 5.15. The Kopili River flows through a steep-sided valley from the existing Kopili HEP area down to the Panimur Forest guesthouse, below which the topography is less steep. The dewatered section is in this steep-sided valley, which is not inhabited and not used for agriculture. At full level, the reservoir will rise above the 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 dewatered section will be permanently altered by construction of the dam, powerhouse, and other facilities as well as seasonal rise and fall of the reservoir level. Outside of the main river channel, the reservoir area will expand and contract with seasonal flow and storage behind the dam.

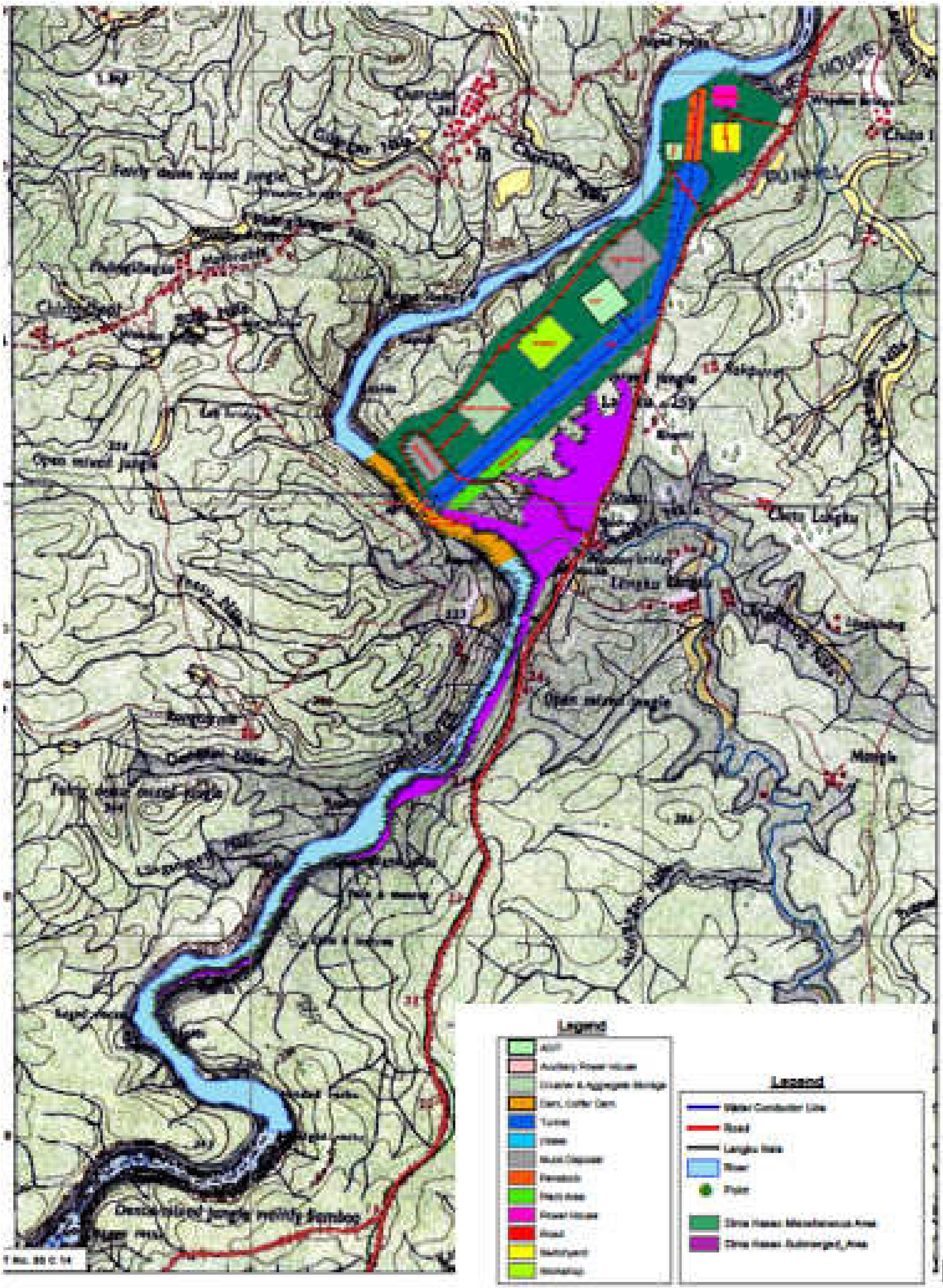
131. In addition, as a secondary or indirect impact, the project will supply up to 5% of the latent electricity demand in Assam which will support a proportionate extent of development in all sectors in the AoC – domestic, commercial industrial, transport, agriculture, etc. – all of which in turn may result in conversion of land from forest, with its attendant biodiversity and soil stabilizing attributes, into land with little or no biodiversity and with development implemented

often with little or no runoff or erosion control.

132. While these various project and non-project causes of land conversion result in different types and levels of biodiversity and soil loss, and most of these impacts are more or less mitigatable, they nonetheless collectively threaten ecosystem health and reduce the provision of ecosystem services to people in the AoC, and thus represent a Land Quality VEC subject to cumulative impacts.

133. The Resource Impact Zones relevant to the Land, Forestry and Ecology VEC include: (1) the area that will be cleared to accommodate the dam, reservoir and other LKHEP facilities and infrastructure; and (2) the entire Kopili River Basin from the perspective of project-induced and non-project growth and development impacts on surface water runoff and soil erosion and consequent impacts of land, forestry and ecology degradation.

Figure 5.15: Toposheet map showing forest land under project LKHEP



5.4.2 VEC Conditions without LKHEP

134. Separate from and not caused by the proposed project, there is an existing and continuing trend in land conversion in the AoC, including for fuel wood collection, charcoal production and artisanal coal mining in the energy sector; slash and burn (jhoom) cultivation and other agriculture; and informal settlements and ribbon development along roads in the built environment sector. These activities are already affecting the Land, Forestry and Ecology VEC, without considering potential direct impacts of the LKHEP on land and biodiversity. Unfortunately, no data describing trends in land conversion or degradation, or projecting development or growth, in the basin were discovered, so these findings are based largely on observations made during the field visits to the Kopili River Basin.

5.4.3 Cumulative Impacts Assessment

135. Agricultural and forest lands and biodiversity will be significantly impacted by the reservoir and the dewatered section of the river. Aerial imagery and site reconnaissance indicates that the greatest physical impacts occur due to reservoir operations, with relatively lesser impacts due to partial dewatering between the dam and powerhouse. The Kopili River flows through a steep-sided valley from the existing KHP project area down to the Panimur Forest guesthouse, below which the topography is less steep. The dewatered section is in this steep-sided valley, which is not inhabited and not used for agriculture. At full level, the reservoir will rise above the valley walls and extend onto the right bank of the river. As stated above, this extended reservoir area and the right bank of the river adjacent to the dewatered section will be permanently altered by construction of the dam, powerhouse, and other facilities as well as seasonal rise and fall of the reservoir level.

136. The project area is not considered to be a biodiversity "hot spot," although there are sensitive species and reserved forest areas to be protected. 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 afforestation at a one-to-one ratio in other areas under the direction of the Assam 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.

137. In addition, as a secondary or indirect impact, the project will supply up to 5% of the latent electricity demand in Assam which will support a proportionate extent of development in all sectors in the AoC – domestic, industrial, transport, agriculture, etc. – all of which in turn may result in conversion of land from forest, with its attendant biodiversity and soil stabilizing attributes, into land with little or no biodiversity and with development implemented with little or no runoff or erosion control.

5.4.4 Cumulative Impacts Significance

138. The projected land impacts directly attributable to the LKHEP project, when considered in combination with the ongoing land conversion and development impacts in the Kopili river basin, can be considered cumulative impacts. With the limited data and plans available regarding land development, it is difficult to estimate the significance of cumulative land impacts. However, from a qualitative perspective, they are potentially significant and justify attention to the applicable mitigation measures outlined below.

5.4.5 Cumulative Impacts Mitigation Measures

139. The following mitigation measures should be considered to address the cumulative impacts of the LKHEP project on the Land Quality VEC:

- Agriculture – Work with the two autonomous district agriculture departments to broaden and accelerate their programs to eliminate jhoom (slash and burn) agriculture to reduce surface water runoff and soil erosion.
- Energy – Reduce the use of coal, charcoal and wood for fuel, e.g. through intensified support to alternative sources of energy for local residents, thus reducing soil erosion from the extraction, production or collection of these fuels from the landscape, e.g.:
  - Broaden and accelerate the GOI's distribution of gas cylinder stoves
  - Install pico-solar equipment in homes to power lights and mobile phones
  - Install photovoltaic solar energy in both on-grid and off-grid village configurations
  - Ensure local access to power distributed from the KHP and LKHEP projects
- Forestry and Ecology – Work with the two autonomous forest departments to intensify their afforestation and reforestation programs, including afforestation at a ratio of 1:1 in areas such as the reservoir that will be deforested. Clear the reservoir bottom in a way that minimizes surface water runoff and soil erosion and find ways to utilize the wood cleared with a minimum of burning. Offset biodiversity via fisheries and constructed wetlands in the reservoir area.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

140. The cumulative environmental and social impacts of the proposed LKHEP project have been evaluated in the context of four Valuable Ecosystem Components – water quality, water quantity, air quality, and land quality – using IFC's guidance for cumulative effects analysis. Some of the major benefits of a proposed hydropower project that would accrue to local affected parties is the provision of clean water to use for drinking, irrigation, and recreation, as well as water quality and environmental flow that will support healthy lotic and lentic aquatic ecosystems and associated fisheries and community livelihoods. However, due to AMD resulting from rat-hole coal mining in the Kopili River Basin, and the possibility of multiple hydropower projects on the Kopili River, achieving these usual benefits in the case of the LKHEP project will involve the implementation of significant mitigation measures. In addition, there are cumulative impacts on the air quality and land quality VECs that, while less significant than those impinging on the water quality and water quantity VECs, still need to be addressed.

6.2 Recommendations

141. Recommendations are presented below in three categories: General Recommendations, combined Water Quality and Water Quality VECs (higher significance) and combined Air Quality and Land Quality VECs (lower significance).

142. General Recommendations

- The recommendations of this CIA should be integrated into the LKHEP environmental and social mitigation and monitoring programs.
- The LKHEP environmental and social mitigation and monitoring programs should be closely linked to the many relevant plans of the two autonomous districts relating to environmental and natural resources protection, e.g. those for forestry, wildlife, fisheries, agriculture, municipal infrastructure, energy and planning.
- APGCL's implementation and oversight of the LKHEP ESMP should be done in close coordination with the two autonomous districts for their technical contributions and from a stakeholder participation perspective.
- The River Basin Organization (RBO) outlined in the Kopili River Basin IWRMP should include representatives of APGCL and the two autonomous districts, as well as other stakeholders such as relevant departments of Assam and Meghalaya State, NEEPCO and Coal India Limited who can address the coal mining AMD issue.
- The RBO should take the lead in implementing the more regional or basin-wide recommendations of this CIA and play a continuing coordination role relative to identifying, evaluating, mitigating and monitoring cumulative impacts from future major projects, energy related or otherwise, in the Kopili River Basin.

143. Mitigation Measures Addressing Combined Water Quality and Water Quantity VECs:

VECs for water quality and water quantity have been defined separately in Sections 5.1 and 5.2, respectively, because independently they pose significant and challenging cumulative impacts to mitigate and will thus benefit from individual management and monitoring. Ultimately, though, they are both intended to restore and sustain the same valued ecosystem, i.e. Kopili River aquatic ecology and its associated fishery and ecosystem services which will in turn provide a significant LKHEP environmental and social benefit to local affected parties. Such a benefit would normally accrue to the affected parties in a typical proposed hydropower project and would very much improve the benefits to risks ratio of the LKHEP project.

144. Summarizing the mitigation measures presented in Sections 5.1 and 5.2, the key actions toward this goal, short-term and long-term, are:

145. Short-Term

- Engage NEHU or other qualified local university team or local NGOs to collect Kharkar River data for evaluation of passive treatment alternatives, and possibly implement a pilot project, to be recommended in the WQRP, and as approved by the affected local communities and state government, to evaluate, select and design AMD control measures. Select the most robust and cost-effective control measures and proceed to implement the selected measures.
- ADB help organize and fund a conference on AMD site remediation and water quality restoration in the IWRM planning context. Invite representatives to the Brahmaputra Board, APGCL and Meghalaya Power Department, relevant departments of Assam and Meghalaya States, District Councils of Dima Hasao and Karbi Anglong Autonomous Districts, CIL and NEEPCO, and NEHU. This group could then form the nucleus of a permanent Kopili RBO which would be the most functional organization.
- Implement the environmental flow requirements and reservoir bottom drainage design, monitor their implementation and effectiveness during project startup and operation, and adjust the flow requirements as needed to achieve aquatic ecology goals.

146. Long-Term

- Implement the Water Quality Restoration Plan (WQRP) included in the Supplemental EIA to address rat-hole coal mining in Meghalaya and Assam states that is generating AMD and lowering the pH of the Kopili River.
- Implement the Integrated Water Resources Management Plan (IWRMP) included in the Supplemental EIA to provide a comprehensive, multi-sectoral plan and adaptive management system for coordinating all water and land uses in the Kopili River Basin.
- Design and implement a comprehensive fisheries reintroduction plan, including specifications of lotic and lentic species, and timing and locations of reintroduction, as well as implementation budget and responsibilities. The plan should provide for long-term regular monitoring and evaluation of plan implementation and effectiveness with contingencies for restocking to maintain population levels and to achieve a balanced gene pool through transfers from other stream stretches, as necessary. In addition, the implementation and effectiveness of the environmental flow rates should be monitored and evaluated on a regular basis during project start-up and operation as part of implementing the environmental and social management plans.

147. Mitigation Measures for Air Quality and Land Quality VECs (Lower Significance):

148. The VECs for air quality and land quality have been defined separately in Sections 5.3 and 5.4, respectively. However, the two VECs can be addressed by many of the same

mitigation measures, since many of the measures that control air emissions of PM also help control surface water runoff and consequent soil erosion and land degradation.

149. The following mitigation measures should be considered to address the cumulative impacts of the LKHEP project on the Land Quality VEC:

- Municipal – Utilize rational land use planning, enforce zoning requirements, manage traffic, pave the roads, and expand water, sanitation, and solid waste management services to reduce the long-term, growth-induced air pollution and land degradation in all sectors.
- Agriculture – Work with the two autonomous district agriculture departments to broaden and accelerate their programs to eliminate jhoom (slash and burn) agriculture to reduce surface water runoff and soil erosion, as well as air emissions of PM from dust generation.
- Forestry – Work with the two autonomous forest departments to intensify their afforestation and reforestation programs, including afforestation at a ratio of 1:1 in areas such as the reservoir that will be deforested. Clear the reservoir bottom in a way that minimizes surface water runoff and soil erosion and find ways to utilize the wood cleared with a minimum of burning.
- Energy – Reduce the use of coal, charcoal and wood for fuel, e.g. through intensified support to alternative energy sources for local residents, for example:
  - Broaden and accelerate the GOI's distribution of gas cylinder stoves
  - Install pico-solar equipment in homes to power lights and mobile phones
  - Install photovoltaic solar energy in both on-grid and off-grid village configurations
  - Employ distributed generation systems for power supply (which could have compensatory effects if natural gas or renewable energy technologies are employed).

150. This will not only reduce air emissions directly from their combustion, but also reduce soil erosion and associated dust generation from the extraction, production or collection of these fuels from the landscape.

- Industry – Upgrade to cleaner production technology, install air pollution control and monitoring technology applicable to the respective industrial sectors, conduct rational land use planning in industrial estates, and enforce existing EIA and environmental management regulations.

7. REFERENCES

Annual Plan 2012-13 & Proposed Five Year Plan (2012-17) Allocations, Northeast Council

An Approach to 12th Five Year Plan (2012-2017), Assam Planning and Development Department

Annual Plan Under Hill Area Development Plan (HADP) for the Year 2012-13, Karbi Anglong Autonomous Council

Environmental Impact Assessment, Project Number: 41924, Nam Ngiep 1 Hydropower Project (Lao People's Democratic Republic), Appendix D: Environmental Flow Assessment Report, Nam Ngiep Power Company Ltd. with assistance from ERM-Siam Co., Ltd and Environmental Research Institute, Chulalongkorn University for the Asian Development Bank, July 2014

120 Mw Lower Kopili Hydro Electric Project, Assam, Detailed Project Report, Volume IA: Main Report (Part 1 of 2), by Lahmeyer India, for Assam Power Generation Corporation Ltd., September 2015

Acid mine discharge – Challenges met in a hydro power project, by Pankaj Sharma, Sameer Vyas, Sharma S. N., Mahure N. V., Anil Rustagi, Sivakumar N., and Murari Ratnam, Central Soil and Materials Research Station, New Delhi, in International Journal of Environmental Sciences, Volume 1, No 6, 2011

Assam Lower Kopili Hydroelectric Power Project Preliminary Cumulative and Induced Impacts Assessment (v0 December 2015, an unpublished report funded under TA-8351 IND: Advanced Project Preparedness for Poverty Reduction - Preparing the Second Power Sector Investment Project for Assam)

Assam State Disaster Management Plan, by Assam State Disaster Management Authority, Government of Assam, Undated

CEIA Study for Lower Kopili H.E. Project in Karbi Anglong and Dima Hasad Districts of Assam, Volume - I EIA Report, by WAPCOS, for Government of India, October 2016

Climate Risk Screening Report, Draft, Proposed MFF, India: Lower Kopili Hydroelectric Project, by C. Y. Ji, December 23, 2015

Comments on Revised WAPCOS EIA Report, Annex 4: LKHEP Draft EIA Preliminary Review and Gap Analysis, October 25, 2016

Comments on the Response from APGCL for the Proposed Lower Kopili HEP on Kopili River in Assam, Issues for Expert Appraisal Committee, South Asia Network on Dams, Rivers and People, November 2013

Cumulative Impact and Carrying Capacity Study of Siang Sub-Basin Including Downstream Impacts, Volume-I, Prepared for: Central Water Commission EIA Directorate, Sewa Bhawan, RK Puram, New Delhi; Prepared by: R. S. Envirolink Technologies Pvt. Ltd., Gurgaon, December 2013

Departmental reports on how the respective departments plan to achieve the Sustainable Development Goals (SDGs) Karbi Anglong Planning & Development Department, 2016

Draft National Water Framework Bill, Draft of 16 May 2016

Draft Working Plan, Dima Hasao Forest Division (West), Haflong (01/10/2014 to 01/10/2019)

Effect of Climate Change on the Hydrology and Sediment Loadings of the Lower Kopili Hydroelectric Power Project, submitted to Asian Development Bank and Assam State Electricity Board, Undated

Environment Safeguards: A Good Practice Sourcebook. Asian Development Bank, 2012.

Environmental Assessment Guidelines. Asian Development Bank, 2003.

Environmental Impact Assessment, Project Number: 41924, Nam Ngiep 1 Hydropower Project

Flow: The essentials of environmental flows, Water & Nature Initiative, The World Conservation Union (IUCN), Edited by Megan Dyson, Ger Bergkamp and John Scanlon, 2003

Good Practice Handbook: Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. International Finance Corporation, downloaded from www.ifc.org, January 2017

Government of Assam Policy for Small Hydropower Development, Assam State Electricity Board, March 2007

Hydro Power Policies and Guidelines, IIT Roorkee, Water for Welfare Secretariat, February 2008

Hydroelectric Power: A Guide for Developers and Investors. International Finance Corporation, 2015

Hydropower Sustainability Assessment Protocol. International Hydropower Association, November 2010

Integrated River Basin Planning, Developing a Roadmap for the Pamba River, EU-India Action Plan Support Facility – Environment, DHI and Mott MacDonald, November 2010

Lower Kopili HEP: Outstanding issues that must be resolved before EAC can consider the project, SANDRP, September 21, 2013

National Water Policy, Government of India, Ministry of Water Resources, 2012

National Working Plan Code – 2014 (For Sustainable Management of Forests and Biodiversity in India), Ministry of Environment and Forests, Government of India, New Delhi, March 2014

Physical Assessment of the Brahmaputra River Ecosystems for Life: A Bangladesh-India Initiative, IUCN, International Union for Conservation of Nature, December 2014

Policy on Hydro Power Development, Government of India, Ministry of Power, August 1998

Resettlement and Tribal Development Plan (Draft), IND: Assam Power Sector Investment Program – Tranche 3 – Lower Kopili Hydroelectric Project, Assam Power Generation Company Limited, June 2016

Safeguard Policy Statement. Asian Development Bank, 2009

Siyota Hydro Power Pvt. Ltd., Tato 1 Hydro Electric Project, 1. Executive Summary, 2. E.I.A., 3. E.M.P., Velcan Energy, June 2012

State of Environment, Assam Ambient Air and Water Quality, 2014, and Air Quality Monitoring Reports for January-June, 2014, December 2015, and December 2016, Assam Pollution Control Board, 2014.

Working Plan of Hamren Forests Division, Karbi Anglong District Council, 2005/6 – 2010/11

APPENDIX A: METHODOLOGY FOR LKHEP CUMULATIVE IMPACT ASSESSMENT

Source: Adapted and elaborated from Consultant's Terms of Reference

Task 2.1: Scoping - Preliminary assessments and findings from the Inception Mission related to the initial task of the CIA, i.e. Task 2.1, CIA Scoping, are provided below by subtask. The wording of the subtask methodology is shown in italics while the preliminary assessments and findings are provided immediately below each subtask. The output will be a definition of project activities, spatial and temporal scope of CIA, VECs, and projects potentially impacting VECs.

Task 2.1.1: Define the project activities. Work with APGCL and WAPCOS to review and, if necessary, update and improve the EIA Project Description, including ancillary facilities and associated HEPPs in the cascade, for the purposes of the CIA. (See Section 1.1.)

Task 2.1.2: Identify the area of concern (AoC) and temporal extent (i.e., set spatial and temporal boundaries). Critically evaluate the EIA project's area of influence in light of CIA needs and, if necessary, update and improve it. The AoC spatial component will encompass resources, ecosystems and communities likely to be impacted. Working with the IWRM Planning Specialists, an attempt will be made to delineate resource impact zones. In general, both spatial and temporal boundaries should be practical and able to lead to meaningful results.

Task 2.1.3: Identify and select the VECs to be included in the assessment. Key cumulative basin impact issues associated with the project will be identified. The main impacts of major existing or proposed developments (not limited to hydropower) in the basin will be identified from: environmental monitoring data and studies, EIAs and environment management plans, incident reports, basin management plans, discussions with Government agencies, project owners and affected people, and other information sources. Per the TOR, basin water quality will be identified as a primary VEC due to acid mine drainage.

Task 2.1.4: Identify other previous, existing, and future or planned projects and human activities that affect or may affect the VECs to be included in the assessment, such as upstream hydropower and industrial activities, and nearby transport links. The other projects that the CIA will focus mainly on are the other HPPs in the same cascade. However, the consultant will also consider plans and likely developments in other sectors, including irrigation and water supply, agriculture, fisheries, forestry, mining, industry, transport, social and urban development, and conservation. The consultant will examine the key issues and cumulative impacts of LKHEP in two development scenarios and a range of growth possibilities in each scenario: (a) the "business as usual" development pattern, based on the aggregate of all proposed developments including LKHEP; and (b) the "without LKHEP" scenario. The consultant will refine this scope if required as the CIA progresses.

Task 2.2: Establish/Describe the Existing Condition of Selected VECs
The objectives of this task are to: (a) define the existing condition of the VECs selected in Task 1 above; (b) understand the potential reaction of each selected VEC to stress, as well as its resilience and recovery time; and (c) assess trends in these parameters for the selected VECs. The output will be a description of existing conditions of selected VECs.

Task 2.2.1: Complete the collection of available data and information on the effects of other existing activities and/or projects on the condition of the VECs within the AoC. Data needs will have been carefully considered in the selection of VECs under Task 1 above. The Environment Specialists will work closely with WAPCO in reviewing and utilizing that LKHEP EIA baseline information which is relevant to the selected VECs, and with AGPCL et al. relative to the impacts of other existing and planned HEPPs in the same cascade and river basin. In addition, the Environment Specialists will coordinate with the IWRM Planning Specialists and the Water Quality Specialists in collecting and analyzing data on VECs related to their scopes of work. Additional new data collection will focus on data at the lesser level of detail appropriate to the basin/regional level of the CIA. Particular emphasis will be placed on collecting water quality VEC data, especially the impact of acid mine drainage from upstream coal mines.

Task 2.2.2: Collect data on trends in the condition of VECs and regional thresholds. To the extent that it is available, data will be collected on long-term, historical trends to determine if VEC thresholds are threatened by cumulative impacts with or without the proposed project. As for 2(i) above, various sources of information will be utilized—reports from governments, NGOs, and MDBs; prior ESIAs; knowledge from resident communities; biodiversity databases such as GBIF26 or IBAT; information from areas with VECs in common that are exposed to differing levels of impact, or scientific literature. Relative to water quality, the Environmental Specialists will work with the Water Quality Specialists to understand plans for upstream mine closure and remediation as a means for stopping contamination from reaching the river and what improvement in Kopili River water quality is projected and in what timeframe.

Task 2.3: Assess the Cumulative Impacts on VECs
The objectives of Task 3 are: (a) to identify potential environmental and social impacts and risks; assess expected impacts as the potential change in condition of the VEC (i.e., viability, sustainability); and (c) identify any potential additive, countervailing, masking, and/or synergistic effects. The output will be an assessment of cumulative impacts on selected VECs.

Task 2.3.1: Determine the indicators to describe the VEC condition. Paraphrasing IFC's RCIA method, analysis of cumulative impacts on VECs involves estimating the future state, response, or significant changes in condition, of the VECs that may result from the impacts or stresses they experience from various past, present, and predictable future development, and not in terms of the intensity of the stress added by a given development. In addition to the stresses imposed by developments, the assessment should encompass the potential range of environmental variation that may influence VEC condition and not be based solely on expected average conditions (e.g., change in climate patterns and/or predictability).

Task 2.3.2: Assess impacts of LKHEP on the VECs. Once VECs and their respective data availabilities have been established in Tasks 1 and 2 above, the general methods and specific tools used for analysis will be evaluated and selected. As indicated by IFC's RCIA method, impact assessment methods and tools are specific to the characteristics of the VEC, i.e. different methods are appropriate for analysis of impacts on physical, environmental, biotic, and social VECs, and their resilience, and can include impact models, numerical models, spatial analysis using GIS, and indicator-based approaches. Consider direct (primary) and indirect (secondary and induced) impacts. Distinguish additive from synergistic cumulative impacts. Indicate the duration of impacts relative to the life of the project and evaluate life cycle effects. Rather than focus solely on other projects, the analysis should also assess the impacts on the resource impact zones and life cycle effects.

Task 2.3.3: Estimate or predict the future condition of the VECs as affected by Kopili HEP, upstream activities along Kopili River, and planned activities (if any) or developments downstream of LKHEP within the AoC. Paraphrasing IFC's RCIA method, the impact of the project is not assessed as the difference between the expected future condition of VECs and that of a past baseline condition; rather, it is assessed as the difference between the estimated future condition of VECs in the context of the stresses imposed by all other sources (projects and natural environmental drivers) and the estimated VEC condition in the context of the future baseline plus the development under evaluation.

Task 2.3.4: Estimate the combined impacts of LKHEP, Kopili HEP, upstream activities along Kopili River, and planned activities on the VECs. If feasible, considering data availability, the consultant will develop and utilize a simple conceptual model such as the IFC's Rapid Cumulative Impact Assessment (RCIA) methodology, and/or utilize a rating system such as the International Hydropower Association's Hydropower Sustainability Assessment Protocol, to assess the cumulative impacts of the identified development scenarios. The Environmental Specialists will evaluate, select and utilize impact assessment methods and tools that are specific to each VEC and its resilience. Candidate methods include impact models, numerical models, spatial analysis using GIS, and indicator-based approaches; IFC's RCIA document lists candidate tools relating to each of these methods.

Task 2.4: Assess the Significance of Anticipated Cumulative Impacts
The objectives of Task 4 are: (a) define appropriate "thresholds" and indicators; (b) determine impact and risk magnitude and significance in the context of past, present, and future actions; and (c) identify tradeoffs. The output will be the determination of the significance of cumulative impacts.

Task 2.4.1: Compare results against thresholds and evaluate the significance of anticipated cumulative impacts on the VEC. Paraphrasing IFC's RCIA method, in addition to estimation of LKHEP's impact, the future condition of VECs in the context of all stresses
– the cumulative impact – will be evaluated in reference to established threshold levels of acceptable conditions for each VEC, if known, or in reference to a past baseline for the respective VECs. Determination of impact significance will follow the assessment of cumulative impacts in Task 3 above and, ideally, be conducted in parallel with, or iteratively with, with consideration of mitigation measures in Task 5 below. Compare results against thresholds and evaluate the significance of anticipated cumulative impacts on each VEC. In estimating significance, evaluate effects on VECs in the context of the identified resource impact zone or zones in which each VEC occurs. Determine the capacity of each VEC and its associated resource impact zone(s) to accommodate additional impacts. Give particular emphasis to irreversible impacts and their associated thresholds.

Task 2.4.2: In the absence of thresholds or limits of acceptable change, recommend/suggest an appropriate threshold. In the absence of published or otherwise already established thresholds for particular VECs, the Environmental Specialists will work closely with other members of the E&S project team, APGCL, ADB to identify a short list of candidate thresholds for each VEC lacking same.

Task 2.4.3: Consult with various stakeholders, government agencies, and technical experts on the appropriate threshold. Once a short list of candidate thresholds have been identified under Task 4(ii) above, the Environmental Specialists will reach out to a broader set of stakeholders – ideally through a panel of experts and other key stakeholders established for this purpose –

to reach a consensus on appropriate thresholds. Output: Cumulative Impacts Identified

Task 2.5: Design and Plan Implementation of Management Measures
The objectives of Task 2.5 are: (a) use the mitigation hierarchy; (b) design management strategies to address significant cumulative impacts on selected VECs; (c) engage other parties needed for effective collaboration or coordination; (d) propose mitigation and monitoring programs; and (e) manage uncertainties with informed adaptive management. The output will be a mitigation plan for cumulative impacts.

Task 2.5.1: Identify measures (other than those identified in the EIA of LKHEP) to reduce the estimated unacceptable cumulative impact on a VEC to an acceptable level following the mitigation hierarchy. This task has separate components for mitigation and monitoring, as follows:

Mitigation Program. According to IFC's RCIA method, "The estimate of the cumulative project impact, together with ESIA results, indicates the need for project-specific mitigation. By contrast, the estimated overall cumulative impact indicates the need for mitigation to be implemented by the various project owners or proponent parties to ensure that their respective contributions to the overall condition of the VECs is coherent and/or compatible with what is mandated or required by government- le or government-agreed regional cumulative impact management initiatives, or as a minimum compliant with ambient quality standards for the desired use. A key part of the assessment step is estimation of the implementation and effectiveness of project mitigation and other cumulative impact management measures to reduce impacts, and this is done iteratively among Steps 3, 4 and 5."

Monitoring and Evaluation Program. The Environmental Consultant will coordinate with the IWRM Planning Specialists, Water Quality Specialists and EIA consultants to outline a CIA monitoring program. At a minimum, the monitoring plan will address river flows, water quality, and fish species at selected sites and will take into account: the location of existing and likely developments, the type of impacts and risks that different developments pose, and the monitoring requirements imposed on different sector developments. The program will include an incident reporting system to ensure that a correlation can be made between incidents and recorded data. The program will identify who will implement each action.

Task 2.5.2: Identify the need for additional mitigation of other existing and/or planned projects. The mitigation and monitoring programs will be implemented in coordination with the mitigation and monitoring programs of the various individual project or development sponsors, and incorporate current government programs and institutional arrangements, as appropriate, to standardize methods and avoid repetition.

Task 2.5.3: Identify the potential for regional strategies that could keep the acceptable condition of the VECs. The Environment Specialists will consult the IWRM Planning Specialists, Water Quality Specialists and EIA consultants to gain an overview of the institutional setup and capacity – including government policy, legislation, sector plans and development programs – to facilitate implementation of the CIA mitigation program developed by the Environment Specialists. The analysis will address the feasibility of, and progress in, establishing a River Basin Organization (RBO), or similar basin-wide or regional coordination body, to implement the mitigation and monitoring measures. The consultant will then recommend capacity building measures addressing the management of cumulative impacts at the individual project, VEC and resource impact zone levels, as well as at the overall river basin and regional levels.

Task 2.5.4: Identify efforts/initiatives on how to engage stakeholders in implementing the management measures that may be beyond capacity of APGCL as well as NEEPCO. Per the IFC RCIA method, a “best efforts” approach to CIA would involve stakeholder engagement: “Use best efforts to engage all relevant stakeholders to agree on VECs, and on each and all parties responsibilities in the (a) management of the expected impacts on VECS, and (b) monitoring and supervision of the overall condition of the VECs and the appropriate implementation of agreed mitigation measures.” The Environmental Specialist will consult with the EIA preparers, APGCL and NEEPCO to review the existing EIA stakeholder engagement program and determine what, if any, additional measures may be necessary to implement the CIA mitigation and monitoring program. This analysis may also require additional, limited outreach during the conduct of the CIA targeting selected stakeholders who may have more of a basin/regional focus. The outreach could utilize questionnaires, interviews and panels.

APPENDIX B: LIST OF PEOPLE AND ORGANIZATIONS CONSULTED

A. Inception Stage

Sl. No.	Name	Designation	Organization
1.	Mr. Prasanta Khaund	CGM (Hydro) Civil	APGCL
2.	Ms. Antara Baruah	GM (Hydro)	APGCL
3.	Mr. Utpal Dutta	OSO	APGCL
4.	Mr. Alarka Kumar Das	Director-PMU	APGCL/ PMU
5	Mr. Sankar Talukdhar	DGM-PMU	APGCL/ PMU
6.	Mr. Rakhal Talukdar	AGM (Civil)	APGCL
7.	Mr. Manash Kumar Bharatdaz	Asst. Manager	APGCL
8.	Mr. Biraj Hazarika	Jr. Manager	APGCL
9.	Mr. Nolit Deori	Jr. Manager	APGCL
10.	Mr. Kevin Jeanes	Climate Change Specialist	ADB Consultant
11.	Ms. Depati Das	Director –Geology & Mining	Directorate of Geology and Mining, Guwahati, Assam
12.	Mr. Dhiraj Pratim Sarma	Asst. Mining Engineer	Directorate of Geology and Mining, Guwahati, Assam
13.	Mr. B.K. Das	Sr. Geologist	Directorate of Geology and Mining, Guwahati, Assam
14.	Mr. Naren Deva	Deputy Chief Chemist	Directorate of Geology and Mining, Guwahati, Assam
15.	Mr. Sidhartha Baruah	GIS-Officer	Dept. of Forest, Govt. of Assam, Guwahati
16.	Mr. Ahmed	Director (Designing)	Water Resources Department, Guwahati
17.	Mr. Prasanta Dutta	Addl. Chief Engineer	Assam Water Research and Management Institute, Bsistha, Guwahati
18.	Mr. Hasan Abdullah	Director	Central Soil and Material Research Station (CSMRS), Delhi
19.	Mr. N.V. Mahure	Scientist “D”	Central Soil and Material Research Station (CSMRS), Delhi

Sl. No.	Name	Designation	Organization
20.	Dr. R.P. Pathak	Scientist 'C' and US (GS)	Central Soil and Material Research Station (CSMRS), Delhi
21.	Mr. Pankaj Sharma	Retired Senior Research Officer	Central Soil and Material Research Station (CSMRS), Delhi

B. Interim Stage

S.N.	Name of Officer	Designation	Department/Authority
1.	Mr. Prasanta Khaund	CGM (Hydro)	APGCL, Guwahati
2.	Mr. U. Dutta	OSO	APGCL, Guwahati
3.	Ms. Antara Baruah	GM (Hydro)	APGCL, Guwahati
4.	Mr. Sankar Talukdhar	DGM-PMU	PMU (APDCL)
5.	Mr. S. Mazumdar	Project Director	PMU (APGCL)
6.	Mrs. Depati Das	Director –Geology & Mining	Directorate of Geology and Mining, Guwahati, Assam
7.	Mr. Dhiraj Pratim Sarma	Astt. Mining Engineer	Directorate of Geology and Mining, Guwahati, Assam
8.	Mr. B.K. Das	Sr. Geologist	Directorate of Geology and Mining, Guwahati, Assam
9.	Mr. Naren Deva	Deputy Chief chemist	Directorate of Geology and Mining, Guwahati, Assam
10.	Dr. Alka Bhargava	Addl. Principal Chief Conservator of Forest (RF & WF), Guwahati	Dept. of Forest, Govt. of Assam, Guwahati
11.	Mr. Sidhartha Baruah	GIS-Officer	Dept. of Forest, Govt. of Assam, Guwahati
12.	Mr. Rajendra Prasad Das	Chief Engineer	Water Resources Department, Govt. of Assam, Guwahati
13.	Mr. S.U. Ahmed	Director (Designing)	Water Resources Department, Govt. of Assam, Guwahati
14.	Mr. Prasanta Dutta	Addl. Chief Engineer	Assam Water Research and Management Institute, Bsistha
15.	Ms. Mira Sarma	Design Engineer-Civil	APGCL
16.	Mr. Khanindr Barman	Assistant Executive Engineer	Assam Water Research and Management Institute, Bsistha

17.	Mr. Utpal Bora	Chief Conservator of Forest (Head Quarter)	Dept. of Forest, Govt. of Assam, Guwahati
18.	Mr. P.K. Hazarika	Conservator of Forest (Development)- RE & WP	Dept. of Forest, Govt. of Assam, Guwahati
19.	Mr. Dhiren Barman	Director- Planning	Irrigation Department
20.	Mr. Narendra Adhikari	Senior Research Officer	Irrigation Department
21.	Mr. Ananta Pathak	Associate Consultant - NABCONS	NABARD
22.	Mr. Amit Pandey		Rural Infrastructure Development Fund-NABARD
23.	Mr. D. Bhattacharjee	Head of Plant-Upper Kopili HEP	NEEPCO
24.	Mr. Mohan Chandra Dhingia	Deputy General Manager (Civil)	NEEPCO
25.	Mr. Pranab Joyati Bruah	Engineer (Civil)	NEEPCO
26.	Mr. Thaosen	Principal Secretary	NCHAC, Haflandg
27.	Dr. Runu Dutta	Director- Plan Co-ordination	Planning & Development Division-Assam State
28.	Mr. Dulal Chandar Das	Joint Secretary	Hill Area Development
29.	Mr. Kulendra Doley	Secretary- Irrigation Department	Irrigation Department
30.	Mr. Majumdar,	Executive Engineer	Brahamaputra Board

APPENDIX C: PRELIMINARY LIST OF AMD REMEDIAL OPTIONS

Alternative Number	Site Accessibility Access Constraints	Source Treatment Options	Technical Approach	Data Needs	Maintenance	Materials	Cost	Effectiveness
A1	**Full Source - Mine Site Access length of Kharkar mine sites minor tributaries cooperation of Meghalaya**	1.AMD 2.ALD 3.Pit backfilling 4.spot-treatment of minor on-site AMD 5. Wetlands polishing Alternatives based on flow model chemistry inputs	ALD/OLD based on data and decision-making flowcharts. Pit backfilling with overburden based on cooperation with miners/landowners Acquire land to install and operate ALD/OLD and wetlands sites in optimal areas prior to discharge back to Kharkar	As in Work Plan: 1-site topo map 2-tributary characterization 3-Kharkar hydrographs 4-seasonal surface water quality data in affected tributaries to Kharkar	Need to build road to site. ALD –minimal Periodic monitoring OLD – moderate maintenance and monitoring	Fairly pure limestone-CaCO3 -content >85% Backhoe Trencher Bulldozer (assume earthwork equipment can be further used in LKHEP construction) French drains and pipework – quantity TBD Hay or other organic amenity	TBD	**Maximum effectiveness** AMD Source completely addressed based on: 1-most inactive pits backfilled to minimize AMD production 2-Affected tributaries to Kharkar identified and ALD installed 3-wetlands polishing is achieved
A2	Limited AMD source access **Kharkar only- Up-and downstream (no minesite access) cooperation of Meghalaya**	Series of OLD channels in-stream with settling ponds in point-bar areas Alternatives	Hydrograph analysis of up and downstream Kharkar including point loading pH source tributaries. Design in-stream limestone channels to incorporate low flow, and monsoon	Detailed topo of Kharkar river channel. Kharkar water chemistry Kharkar hydrographs	Need to build road to site. Moderate maintenance based on limestone base quality and degree of armoring in channels. ALD channels may	Fairly pure limestone-CaCO3 -content >85% Backhoe Trencher Bulldozer (assume earthwork	TBD	**Considerable effectiveness** AMD source not addressed but transport mechanism is well-managed. based on: 1-baseline chemistry and

Alternative Number	Site Accessibility Access Constraints	Source Treatment Options	Technical Approach	Data Needs	Maintenance	Materials	Cost	Effectiveness
		based on flow model chemistry inputs	with flocculent settling areas		need renewed limestone base periodically. Precipitation and flocculation can clog channels and reduce alkalinization process	equipment can be further used in LKHEP construction) French drains and pipework – quantity TBD Hay or other organic amenity		limestone amenities.
A3	Limited AMD source access **Entire Kharkar River upstream of Confluence with Kopili** **cooperation of Meghalaya**	Series of in-stream limestone porous dams to promote alkalinization.	Number of dams based on chemistry and alkalinization to be achieved and flow-through. Dam design based on balance between porosity and flow-through and degree of armoring during flow. Will need dual-design to incorporate monsoon flows.	Detailed topo of Kharkar river channel. Kharkar water chemistry Kharkar hydrographs	Need to build road to site. Dams may need periodic maintenance and limestone replacement due to armoring or reduction in porosity/flow and corresponding plugging of dams with organic material and flocculent/sediment accumulation.	Fairly pure limestone- $CaCO_3$ - content >85% Backhoe Trencher Bulldozer (assume earthwork equipment can be further used in LKHEP construction) French drains and pipework – quantity TBD	TBD	**Fair to good** **Source not controlled** but access to Meghalaya land not needed. Dams can be managed along river channels. Will need to be in place as long as illegal mining is occurring.
A4	Limited AMD source access **Downstream**	Minor stream diversion to ALD/OLD	Divert Kharkar River Channel to point bar area with	Detailed topo of Kharkar river channel.	Need to build road to site.	Bulldozer (assume earthwork	TBD	**Fair to minimal effectiveness** Source not

Alternative Number	Site Accessibility Access Constraints	Source Treatment Options	Technical Approach	Data Needs	Maintenance	Materials	Cost	Effectiveness
	Kharkar Only before confluence **cooperation of Meghalaya**	based on low-flow/non-monsoon	low elevation. ALD/OLD sytems designed as above.	Kharkar water chemistry Kharkar hydrographs	Need to find area on east side of Kopili that would support OLD channel and flocculent settlement option. OLD requires periodic replacement of limestone due to armoring.	equipment can be further used in LKHEP construction) French drains and pipework – quantity TBD Hay or other organic amenity		addressed. Water to be treated may be increased due to inflow of uncontaminated water prior to ALD/OLD system.
A5	No Access to Kharkar **Downstream of Kharkar-Kopili Confluence on Kopili (Assam) side**	Major stream diversion to ALD/OLD based on low-flow/non-monsoon	Considered minimally feasible to infeasible based on: 1-amount of water to be treated doubles due to mixing of Kopili (normal pH) at confluence and 2-access to stream channel is difficult 3-may need pumps and electric source to pump water from river channel to ALD/wetlands.	Detailed topo of Upper Kopili river channel. Upper Kopili water chemistry Upper Kopili hydrographs	Need to build road to site Need to find area on east side of Kopili that would support OLD channel and flocculent settlement option. OLD requires periodic replacement of limestone due to armoring.	Bulldozer (assume earthwork equipment can be further used in LKHEP construction) French drains and pipework – quantity TBD Hay or other organic amenity	TBD	Minimally effective and cost Minimally Effective to INEFFECTIVE due to treatment of mixed water along with AMD source water. May be very difficult to control water flow into OLD system during monsoon season.

Alternative Number	Site Accessibility Access Constraints	Source Treatment Options	Technical Approach	Data Needs	Maintenance	Materials	Cost	Effectiveness
A6	No Access to Kharkar **At Kopili outfall into Khandong Reservoir**	Minor stream diversion to ALD/OLD based on low-flow/non-monsoon	Construct ALD and OLD channels in accessible areas upstream or at the reservoir bank. Water diversion will depend on flow and grade of river channel and access to reservoir bank for series of short/small ALDs and OLDs for monsoon flow.	Detailed topo of Kopili river channel and outfall into Khandong Reservoir. Upper Kopili water chemistry Upper Kopili hydrographs	Need to build road to site. A two-tiered system may need to be designed to accommodate low-reservoir levels during winter and maximum bank levels during monsoon.	Bulldozer (assume earthwork equipment can be further used in LKHEP construction) French drains and pipework – quantity TBD Hay or other organic amenity		**Minimally effective** and cost Minimally Effective to INEFFECTIVE due to treatment of mixed water along with AMD source water.
A7	No Access to NEEPCO or Assam Land **Upstream of LK HEP damsite/reservoir**	Active water treatment plant	WTP design based on best engineering treatment models and standard WTP construction and operation criteria	Detailed topo of Kopili River channel between Umrong Reservoir and dam site. Kopili water chemistry Kopili hydrographs	Need to build road to site. Cost to build road may be minimal at Dam Site.	Tanks, chemicals, pipework, pumps, mixing tanks, de-sludging centrifuge, power source, electrical, housing. Trained manpower.	Construction costs plus operation costs (per m^3 water treated)	**Good AMD Treatment but Very expensive and does not address upstream pH issues or source control.**