# Environmental Impact Assessment

Project Number: 50165-002
May 2017

# Bhutan: Amochhu Land Development and Township Project

Draft Report (Main)

Prepared by Construction Development Corporation Limited, Royal Government of Bhutan for the Asian Development Bank.

# Environmental Impact Assessment (EIA) Report

# For

# Amochhu Land Development and Township Project (ALDTP), Phuentsholing, Bhutan

MAY 2017

**CONSTRUCTION DEVELOPMENT CORPORATION LIMITED, BHUTAN**

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## ABBREVIATIONS

| | | |
|---|---|---|
| ADB | : | Asian Development Bank |
| ADB-SPS | : | ADB Safeguards & Policy Statements (2009) |
| ALDTP | : | Amochhu Land Development and Township Project |
| ASP | : | Activated Sludge Process |
| BMBMS | : | Biodiversity Monitoring and Bench Marking Study |
| BDL | : | Below Detection Level |
| CA | : | Competent Authority |
| CDM | : | Clean Development Mechanism |
| CEC | : | Cation Exchange Capacity |
| CEMP | : | Contractor Environmental Management Plan |
| CEO | : | Chief Executive Officer |
| CVAR | : | Climate Vulnerable Assessment Risk |
| CITES | : | Convention on International Trade in Endangered Species |
| CO | : | Carbon Monoxide |
| dB | : | Decibel |
| DGM | : | Department of Geology and Mines |
| DG Set | : | Diesel Generating Set |
| DoFPS | : | Department of Forest and Parks Services |
| DoL | : | Department of Livestock |
| DoR | : | Department of Roads |
| DSC | : | Design Supervision Consultants |
| DWC | : | Double Walled Corrugated |
| EA | : | Environmental Assessment, Executing Agency |
| EC | : | Environmental Clearance |
| EC (soil) | : | Electrical Conductivity |
| EEE | : | External Environmental Expert |
| EFP | : | Environmental Focal Person |
| EIA | : | Environmental Impact Assessment |
| EMP | : | Environment Management Plan |
| ESIA | : | Environmental and Social Impact Assessment |
| ESP | : | Exchangeable Sodium Percentage |
| ESR | : | Elevated Service Reservoir |
| ETP | : | Effluent Treatment Plant |

| | | |
|---|---|---|
| FNCA | : | Forest and Nature Conservation Act |
| FNCR | : | Forest and Nature Conservation Rule |
| GDP | : | Gross Domestic Product |
| GRC | : | Grievance Redressal Committee |
| GRM | : | Grievance Redressal Mechanism |
| GSR | : | Ground Service Reservoir |
| HDPE | : | High Density Polyethylene |
| HSC | : | High Stability Carbon |
| HSFP | : | Health and Safety Focal Person |
| IEE | : | Initial Environmental Examination |
| IRC | : | Indian Road Congress |
| IUCN | : | International Union for Conservation of Nature |
| JMA | : | Jaigaon Merchants Association |
| KLD | : | Kilo Litres per day |
| LAP | : | Local Area Plan |
| LPCD | : | Litres per Capita per Day |
| MoAF | : | Ministry of Agriculture and Forest |
| MBR | : | Membrane Bio Reactor |
| MLD | : | Million Litres per Day |
| MBBR | : | Moving Bed Bio Reactor |
| MT | : | Metric Tons |
| NBC | : | National Biodiversity Centre |
| NEC | : | National Environment Commission |
| O&M | : | Operation and Maintenance |
| OHS | : | Occupational Health and Safety |
| OHSMP | : | Occupational Health and Safety Management Plan |
| PA | : | Protected Area |
| PHCB | : | Population and Housing Census of Bhutan |
| PIC | : | Project Implementation Consultant |
| PIU | : | Project Implementation Unit |
| PM | : | Particulate Matter |
| PMU | : | Project Management Unit |
| PPE | : | Personal Protective Equipment |
| REA | : | Rapid Environmental Assessment |
| RCC | : | Reinforced Cement Concrete |
| RGoB | : | Royal Government of Bhutan |
| RoW | : | Right of Way |

| | | |
|---|---|---|
| SAR | : | Sodium adsorption ratio |
| SASEC | : | South Asia Sub regional Economic Cooperation |
| SBR | : | Sequential Batch Reactor |
| SC | : | Soil Conservation |
| SCADA | : | Supervisory Control and Data Acquisition |
| SFD | : | Social Forestry Division |
| SIA | : | Social Impact Assessment |
| SPS | : | Safeguard Policy Statement |
| STD | : | Sexually Transmitted Disease |
| STP | : | Sewage Treatment Plant |
| ToR | : | Terms of Reference |
| UASB | : | Up flow Anaerobic Sludge Blanket |
| UN | : | United Nations |
| UNCCD | : | United Nations Convention to Combat Desertification |
| UNESCO | : | United Nations Educational Scientific and Cultural Organization |
| VS | : | Vetiver System |
| WHC | : | Water Holding Capacity |
| WHO | : | World Health Organization |

**LIST OF PERSONS AND INSTITUTIONS MET**

| SN | Name/Institution | Organisation |
|---|---|---|
| 1. | Mr. Phuntsho Gyeltshen | Construction Development Corporation Ltd., Bhutan |
| 2. | Mr. Dorji Namgay | DHI-INFRA Ltd, Bhutan |
| 3. | Mr. Reezang Wangdi | Construction Development Corporation Ltd., Bhutan |
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| 6. | Ms. Kamala Thapa | Construction Development Corporation Ltd., Bhutan |
| 7. | Ms. Kritika Neopanay | Construction Development Corporation Ltd., Bhutan |
| 8. | Mr. Pushpa Raj Pradhan | Construction Development Corporation Ltd., Bhutan |
| 9. | Mr. Tenzin Khorlo | National Environmental Commission, Bhutan |
| 10. | Ms. Tshering Choden | National Environmental Commission, Bhutan |
| 11. | Mr. Lance Gore | Asian Development Bank |
| 12. | Ms. Dewi N Utami, | Asian Development Bank |
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| 14. | Ms. Shinjini Mehta | Asian Development Bank |
| 15. | Ms. Vivian Castro Wooldridge | Asian Development Bank |
| 16. | Mr. Micheal Green | PPTA, Asian Development Bank |
| 17. | Mr. Douglas Royalston Martin | PPTA, Asian Development Bank |
| 18. | Dasho Uttar Kumar | Phuentsholing Thromde |
| 19. | Mr. Wangchuk Thayey | Phuentsholing Thromde |
| 20. | Mr. D.C. Dhimal | Phuentsholing Thromde, Bhutan |
| 21. | Mr. M.N. Basnet | Forest Range Office, Phuentsholing, Bhutan |
| 22. | Mr. B.P. Sharma | Phuentsholing Range Officer, Bhutan |

# Executive Summary

1. The City of Phuentsholing is located adjacent to the Amochhu River on Bhutan's southwestern border with India. It is the country's economic capital and main trading gateway with India. The government's vision is to grow Phuentsholing into an economically vibrant, ecologically sustainable, and energy efficient center that will support economic diversification, employment creation, and income generation. However, due to increasing population and limited area, the city is facing an acute shortage of land for development and expansion. As well, the western limit of the existing city is threatened by flooding, erosion, sedimentation and loss of valuable land due to uncontrolled flow of Amochhu River. The flow has eroded vast areas of land, restricting the scope for growth and sustainability of the economy of the city.

2. A Master Plan has been prepared for the Amochhu Land Development and Township Project (ALDTP). The project is expected to fulfill the following objectives : (i) Protection from flooding, (ii) expansion of Phuentsholing city, (iii) improvement of the built environment and cultural fabric of Phuentsholing, (iv) economic growth and employment for residents of Phuentsholing and (v) Promote the importance of the City to the region and country. The Plan proposes development of additional riparian land on both sides of the river near Phuentsholing to provide protection from floods and erosion to the existing township area, and construct smart urban infrastructure to allow phased urban expansion. After the proposed works involving river training and land reclamation are completed, there would be 464 hectares of reclaimed land area available for development. The proposed land development areas were divided into five zones for the Master Plan and include Zone A which will have 66 Ha, Zone B with 94 Ha, Zone C with 277 Ha, and Zone E with 27 making up the total of 464 Ha or 1146 Acres. The schedule for the Master Plan was for completion within fifteen years. Currently, works proposed for Zone A, are being considered for funding by the ADB.

3. Project implementation of ALDTP will be undertaken in three stages for each zone, (i) Pre-construction, (ii) Construction and (iii) Operation & Maintenance. The pre-construction activities include (i) Site Access and Traffic Management (ii) Equipment Delivery and Assembly, and (iii) Material Storage, Preparation of work areas and housing for workers.

4. For the construction stage, the activities that are common to all zones for development are as follows :

- Temporary river training to maintain design bed levels at selected locations
- Back fill to raise building platform levels for development land
- Cross drainage channels / alluvial fan outfalls additional cross drainage systems built into the embankments to accommodate the discharges from the alluvial fans which enter the river channel at regular intervals along its course
- common urban infrastructure (roads, bridges, water drawl and supply, sewerage system, storm water collection, conveyance and disposal, solid waste management, power supply and distribution system, telecommunication system, firefighting systems, a flood warning system), and
- Landscape strategy for each zone.

5. **Temporary River Training:** The actual construction work in each zone will commence with river training works involving bed levelling in selected locations particularly along curving channels. The hydraulic parameters such as velocity, maximum flood level, scour depth, etc. within the trained river channel have been considered for 100 years Probable Maximum Flood (PMF). The width of trained river was optimized at 300 m which would allow the 464 Ha of land available for development.

6. **Embankment Construction:** A reinforced concrete (RCC) diaphragm wall will be used for riverbed protection which will extend below the normal river scour depth and will be supported using "dead man anchors" and "anchor slab" techniques. A combination of structures with both sloped and vertical embankments will be used based on the location, velocity, impact points and curvature of the river. For

protection of the diaphragm wall, boulder rip-rap will be placed to dissipate the high velocity flows on the embankment structure.

7. **Back Fill / Land Reclamation:** Backfilling is then required to create the reclaimed land and will be carried out using selected fill materials that will be spread in layers not exceeding 300mm. The compaction shall be done with 10-ton vibratory rollers for achieving 95% of maximum dry density.

8. **Alluvial Fan Discharge Cross Drainage:** The hill slopes that align the river channel vary in their stability and erodibility. Seasonal flows discharge large quantities of water and material forming alluvial fans at each junction with the channel riverbed. Without proper measures to stabilize the slopes and channelize the outfalls, there would be higher risks to the integrity of the embankment. On the eastern side of the river, the slopes are more fragile due to a combination of geology, type and size of material and urban development pressure. Adjoining the Zone A site, there are a number of alluvial fans below unstable hill slopes along the proposed Samtse-Phuentsholing Highway. Hill slope stability works will be carried out as part of the Highway project. Drainage channels to accommodate the outflow from the alluvial fans have been integrated into the design of all of the embankment structures. Zones on the western side of the river have slopes with better stability due to geology, less erodibility and extensive vegetation cover down to the river channel. Wetland retention basins will be used to store water for landscaping with overflow discharge to the river system as required.

9. **Common urban infrastructure (CUI):** CUI completes the construction sequence within the scope of the common activities for each zone**.** CUI refers to the essential infrastructure to be provided and built into the project after land reclamation is done as an essential base for sustainable and quality habitation before building construction. CUI consists of the construction of roads, bridges, water drawl and supply, sewerage system, storm water collection, conveyance and disposal, solid waste system, power supply and distribution system, telecommunication system, firefighting system and flood warning system. Roads, bridges and water supply are discussed in little more detail and the other elements are discussed in the main text and appendices.

10. ***Approach Roads*****:** A network of streets providing efficient routes will be constructed based on the master plan. The roads within the ALDTP consist of river front roads, major arterials, minor arterials, pedestrian walkways and bicycle tracks/lanes. It is important to note that the road network has been integrated with the upcoming Samtse-Phuentsholing Highway and Local Area Plan (LAP) and the Northern By-Pass Route.

11. ***Bridges*****:** There is a primary bridge – from Zone A to Zone C with a connection to the existing city through an existing round-about and road along the river and a second bridge is located further upstream connecting Zone E with Zone B, and from there to the Phuentsholing Samtse Highway. The timing of these bridges is presently unclear but would be required in order to proceed to development of Zone C. It is not proposed to build the primary bridge as part of the Phase 1 works. Temporary bridges will be constructed and used for transfer of construction and fill materials from identified sources to different locations within the Project Site during construction.

12. ***Water drawl and supply*****:** During the construction stage, the water demand is estimated to meet the demands for construction activities like concreting, curing, dust suppression etc. and also for domestic purpose at the construction labor camps and site offices. It is estimated that 100 KLD (70 lpcd[1]) of water will be required for the 1300 (both skilled and unskilled) workers that will be deployed at site during the construction phase.The water supply system for the operation phase will be constructed based on the projected population. Based on the Master Plan, total water demand estimated is 17000 KLD (<0.3 KL per second). This amounts to less 1% of the lean season flow of the River (i.e. ~37 KL per second),

[1] Litres per capita per day

13. An Environmental Impact Assessment (EIA) has been prepared in accordance with the overall framework for environmental and related regulations in the form of Policies, Acts, Rules, Notifications and Standards existing within RGoB. The applicability of relevant international statutes and guidelines that regulate the infrastructure sector development project has also been considered. On the basis of ADB's safeguard policy objective and considering ADB's principle for use of the precautionary approach with a project located nearby a legally protected area (i.e. the Jaldapara National Park, in India), the ALDTP has been categorized as an "A" project.

14. For the necessary baseline studies, the study area was divided in two zones, namely, 'Core Zone' and 'Buffer Zone'. The Core Zone is the ALDTP Master Plan area where the development activities are planned. The Buffer Zone is an area of 1.0 km around the edge of the ALDTP project area which was specified in the ToR issued by the National Environment Commission (NEC). The environmental baseline study was carried out for two seasons (also an NEC requirement) on the physical environment with the various components including land use, ambient air quality, meteorological conditions, ambient noise quality, water resources, soils, hydrology and geology. A study was also carried out for the biological environment which included terrestrial & aquatic ecology and a socio-economic study included demography, a social profile, infrastructure and a social impact assessment.

15. Existing land use in the Core zone is an important element for understanding the impact of the project. Zone A and Zone B are on the eastern side of the river and the areas immediately adjacent have been heavily modified with urban and semi urban rural environments. In contrast on the western side of the river, Zone C and Zone E are far less accessible and are essentially undeveloped with little evidence of human intervention. A large portion of the Core Zone is the river channel itself which has been continually disturbed by nature due to the changes in the location of the main river channel each dry season and also by diversions for mining and processing of rock and aggregate for both local construction and export to India.

16. The most significant issues associated with the Project are closely related to this current land use pattern and relate to the development of different zones. Zone A is the closest Zone to the existing Town of Phuentsholing and Jaigaon (Indian Portion) on the eastern side of the river within the river bed floodplain and the areas adjacent have been heavily modified with urban land use and consequently there are moderate to high risks for both workers and residents for air quality and moderate risks associated with noise during construction.

17. The moderate to high risk of air quality impacts of the development of Zone A will be mitigated by a range of strict controls implemented through a sub plan of each Contractors Environmental Management Plan (CEMP) enforceable through the Contract and include:

- Strategic location of in-situ crushing equipment to increase distance from residential areas.
- Installation of air pollution control equipment (such as venturi cyclones / bag filters) to reduce particulate air emissions to <100 mg/nm$^3$.
- Construction of paved apron for the entire batch mix plants. Ensure that sand and aggregates are wet during transfer and storage.
- Ensure trucks used for transportation of materials are covered with HDPE sheets; trucks should be well maintained (as per manufacturer's instructions with equivalent national Standard; tires should be cleaned before entering public roads through suitable washing / scraping equipment
- Worker protection including Personal Protective Equipment (PPE) with protective uniform, safety glasses and goggles. Masks & random use of personal samplers to check dust levels at the work site.
- Agreed restrictions on operations above critical wind velocities and directions.
- Community awareness programs on the hazards associated with airborne dust during the dry season and how to reduce risks

18. A second significant issue will occur with the development of Zones C and E. In contrast to Zone A these zones are on the western side of the river and possess characteristics of natural habitat with little evidence of prior human use and grassland and riparian vegetation which may still support large terrestrial

fauna such as the Indian elephant. Consequently the biological impacts of development are considered to have moderate to high risks.

19. As Zone C will be developed at least 5 years after the development of Zone A and Zone B. A more thorough Biodiversity Monitoring and Bench Marking Study (BMBMS) on the *Elephas Maximus* (elephant) movement and social behavior and other fauna (reptiles, amphibians and avifauna), will be carried out for a period of 3 years during development of Zone A. The result of this assessment will provide recommendations for the subsequent planning and development of Zone C and Zone E.

20. A third issue is the need for the Amochhu river to be constrained from its present width of channel and floodplain of an average of 600 to 800 meters to a design width for river training to 300 meters and its impact on aquatic ecology. During the baseline aquatic survey one vulnerable (as per IUCN classification) species of *Cyprinion semiplotum* (Chepti) and one Near Threatened (as per IUCN classification) species of *Neolissochilus hexagonolepis* (Katli) were observed. In the literature survey, one source reported (i.e. IEE for the SASEC project) the presence of an endangered species of *Tor putitora* (Golden Mahseer). Other species were of Least Concern as per the IUCN red list.

21. The proposed river training works will not have any impact on river discharge or volume. The river training works do not include abstraction or facilities to store water, so impact on discharge during construction or after development were considered minimal. There are also minimal risks of impacts expected on water level and velocity during floods. During post development, water level during floods may be slightly higher or lower than under existing conditions. The difference depends on location, but is expected to be within 300mm of existing flood levels.

22. From a geo-morphological perspective, the project has been designed to minimize post development impacts. It is anticipated that the braided river will re-form within the 300m width during each dry season and be further modified during each wet season. There will be some very small changes in water depth and velocity distribution within each braid during the dry season, but the changes are not readily calculated, or meaningful in such a dynamic alluvial environment.

23. This project has been designed to minimize impacts to the river system by undertaking the above construction works only during the dry season, and maintaining the natural flow of river. Use of the riverbed for both illegal and legal mining and quarrying activities has been occurring for many years and has involved bunding activities at the start of each dry season to move the main channel away from areas being used for mining and quarrying activities. Consequently, the risk to the smaller aquatic organisms and fish using the main channel is considered moderate to low.

24. In order to further mitigate any risk to vulnerable and endangered species, a Biodiversity Monitoring and Bench Marking Study (BMBMS) will be carried out jointly with the terrestrial survey of Zone C for a period of 3 years, to further monitor the potential impact of the project on aquatic fauna. If the monitoring indicates that there is any reduction in the population of aquatic fauna, a joint program will be developed with the National Research Centre for Riverine and Lake Fisheries, Haa (Department of Livestock) to replenish any estimated loss of the species

25. An extensive analysis of alternatives was carried out and aimed to examine a number of options (location and technological) and establishing the most environmentally favorable alternative or which would cause minimum environmental loss to the natural and social environment. The alternatives analysis was focused on the two main group of project components: (i) a riverbank protection component including embankment options, and (ii) a land/ township development with its urban infrastructure. A without project alternative was always used in the evaluation of location and technological options.

26. A detailed Environmental Management Plan (EMP) was prepared to provide clear directions to the implementation of the environmental safeguards component of the ALDTP Project. It first outlines the basic regulatory management principles that are required under both National legislation and ADB SPS (2009)

policies. It then lays out the roles of each of the major stakeholders particularly during the construction stages of the project. Following this section there is a summary of the proposed mitigation and monitoring matrix showing how the contractor or relevant operating body should mitigate the identified impact and reduce risk. Project Impact Monitoring and Environmental Quality (Ambient) and reporting requirements are included for further implementation of environmental management during the construction stage and subsequent operations.

27. It should be emphasized that the EMP provides advice to all of the Contractors during the Construction stage when each package is required to prepare a site-specific Contractor's Environmental Management Plan (CEMP) which will be implemented in accordance with National legislation and regulations and the relevant provisions of the Contract. The CEMP contains a number of sub-plans which address the issues of concern for each construction package.

28. The project is required to have a grievance redress mechanism (GRM) for people who are affected by the project to submit their grievances and a mechanism for the project to resolve a grievance received from affected people. A two tier mechanism will be adopted by the project. The first tier will be at the field Project Implementation Unit (PIU) level. A Secretariat of GRM will be established in the PIU office, with Project Implementation Consultant (PIC) health and safety or social consultant acting as the secretary. At the first level GRM, the team called the Grievance Redress Committee (GRC) will be established at the PIU level and consist of the PIU head and members from PIC, Contractors & Community. The second level GRM will be led by the Project Management Unit (PMU) head with a member from PIU and relevant PMU staff, and relevant Departments at the central government level, as well as a reputable community based organization. There would still be the right of the complainant to appeal to the Court System if the issue is not resolved to their satisfaction.

# 1 INTRODUCTION AND BACKGROUND

## 1.1 BACKGROUND

29. The Amochhu Land Development and Township Project will develop 460 hectares of riparian land near Phuentsholing, provide protection from floods and erosion, and construct smart urban infrastructure to allow phased urban expansion. The City of Phuentsholing is located adjacent to the Amochhu River on Bhutan's southwestern border with India. It is the country's economic capital and main trading gateway with India. The government's vision is to grow Phuentsholing into an economically vibrant, ecologically sustainable, and energy efficient center that will support economic diversification, employment creation, and income generation.

30. The Royal Government of Bhutan (RGoB)'s Eleventh Five Year Plan cites that the major challenge for Phuentsholing city is capacity and resources to provide basic planned urban facilities and services to the rapidly growing urban population. The Project is therefore consistent with the Eleventh Five Year Plan's strategies to address these issues. The project is also in line with the objectives of ADB's country partnership strategy, 2013–2017 for Bhutan and complements other ADB-supported developments in Phuentsholing.

31. Bhutan is a mountainous country with limited suitable land for urban growth. This particularly applies for Phuentsholing which has reached its limits for expansion, being constrained by the Amochhu River and surrounding steep terrain and conservation areas. Phuentsholing is located between two South Asia Sub regional Economic Cooperation (SASEC) trading corridors, and is the country's largest commercial and industrial hub.

32. The project aims to protect the existing and new towns from floods and riverbank erosion which currently threatens lives and livelihoods and disrupts connectivity with nearby communities. The project will train the river along both banks of Amochhu and the area reclaimed after river training will be used for the development of township. The project will be undertaken in phases which is anticipated to be completed within 15 years in accordance with the ALDTP Master Plan.

33. This project will also develop a modern township designed on sustainable principles of equity, livability, and competitiveness, and it will be integrated into the fabric of the existing municipality and preserve Bhutan's unique architectural heritage.

34. The project is divided into five zones: A to E. Zone D represents Kaileshwar Hill which is currently not included in the project development. The remaining four Zones will require about 15 kilometers of riverbank protection works with subsequent development of about 464 hectares of Amochhu riparian land. The development comprises new common urban infrastructure such as roads, bridges, water supply and waste water system, municipal solid waste system, power and telecommunications. Ultimately, ALDTP is expected to support about 50,000 inhabitants. The implementation of the project will be phased in relation to the scale and demand for the development. The allocation of land and riverbank protection for the project's development is shown in ***Table 1-1***.

***Table 1-1: Land Allocation for ALDTP***

| Zone A | Area (ha) | Riverbank Protection Length (m) |
|---|---|---|
| A | 66 | 3,974 |
| B | 94 | 3,046 |
| C | 277 | 4,872 |
| E | 27 | 3,083 |
| **Total** | **464** | **14,975** |

35. The project area extends on the eastern bank of the Amochhu from the existing Phuentsholing town under Phuentsholing Thromde to the western bank at the base of Kaileshwar hill under Samtse Dzongkhag.

The location details of the project area in relation to the country and Dzongkhag (district) is shown in ***Figure 1-1***.

36. To implement this plan, the RGoB has requested Asian Development Bank (ADB) to fund the 1st phase of the project (Zone A) through concessionaire loan from ADB ordinary capital resources and grant from ADB's grand special resources. The ownership of the project will lie with Druk Holding and Investments (DHI), who is the Executing Agency (EA), while Construction Development Corporation Limited (CDCL), a subsidiary company of DHI, will be the Implementing Agency (IA) of the project.

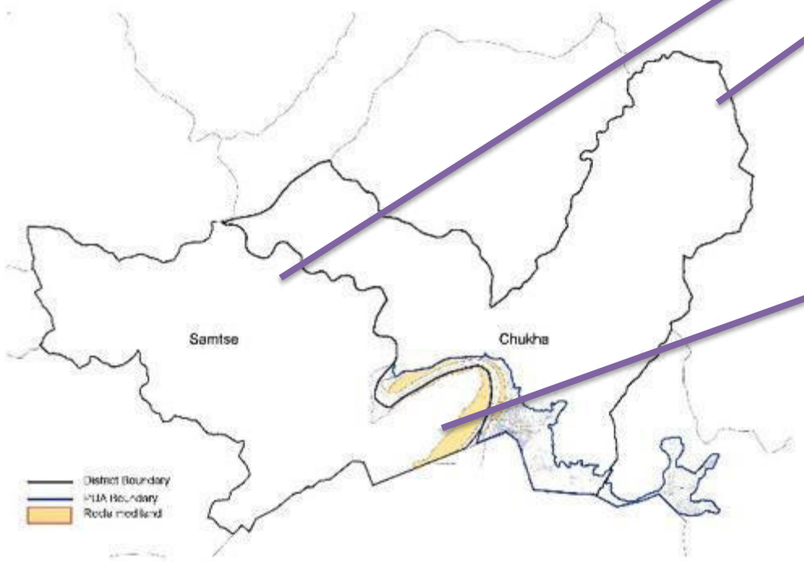
37. As required by the Environmental Assessment Act 2000 and its Regulation 2002, a Terms of Reference (ToR) providing the scope and framework for conducting the EIA of the project was submitted to the National Environment Commission (NEC) and was subsequently endorsed on 23rd October 2012. A Scanned copy of ToR is attached as ***Appendix 1***. CDCL has recruited Ms. HCP Design, Planning and Management Pvt. Ltd. to prepare the Integrated Detailed Project Report (IDPR) which includes preparing an Environmental Impact Assessment (EIA) report.

38. To comply with the ADB requirement, the project has been screened by using ADB Safeguard Policy Statement (SPS) 2009 and has been categorized as "A" project that needs an EIA study. The EIA report that has been has prepared as per the RGoB requirement that also complies with ADB' SPS 2009. The additional requirements under SPS 2009 includes conducting (i) Rapid Biodiversity assessment; (ii) detail impact assessment and proposed mitigation for each project component; (iii) addressing trans-boundary impacts (iv) two formal public consultations; (v) addressing health and safety impacts and (vi) establishing grievance redress mechanisms. All of these have been included in the TOR endorsed by NEC. Therefore, this EIA report will be serve as a guidance in managing environmental concerns related with the project where all stakeholders will be able to refer to the same EIA report and Environmental Management Plan (EMP).

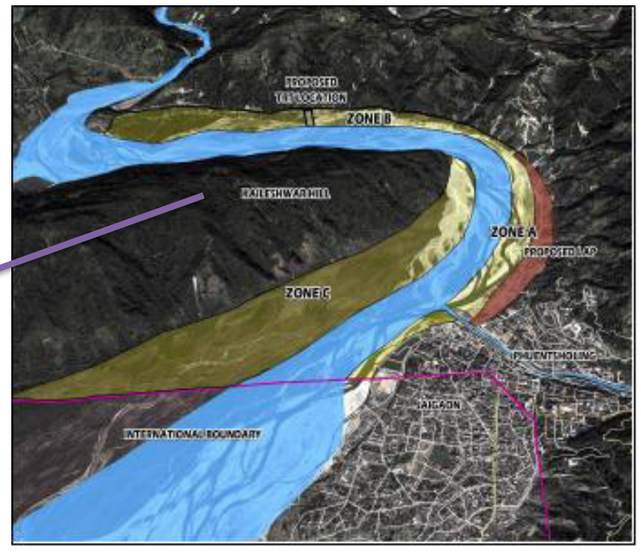
***Figure 1-1: Locations Details of the Project Area in relation to the Country and District***


Location of Kingdom of Bhutan


Administrative map of Bhutan




Chhukha and Samtse District




Project Area Map

## 1.2 OBJECTIVES

39. This EIA study focuses on the 'Study Area' (involving the project site or Core area for the ALDTP and within a radius of 1.0 km from the edge of the project boundary) as specified in NEC's ToR. It's broad objectives are to:

i. Identify and evaluate the potential impacts (positive and negative) that the project may have on the biophysical and socio-economic environment of the Study Area.

ii. Propose mitigation measures that need to be implemented in order to avoid, minimize or reduce the negative impacts and enhance positive impacts.

iii. Provide a framework to ensure that the mitigation measures are budgeted for, have an organizational structure in place for implementing the mitigation measures and a grievance redress mechanism for use by affected stakeholders that addresses issues arising from inadequate implementation of the mitigation measures.

iv. The approach and methodology for the ALDTP involved following a well-established and approved procedure by the National Environment Commission Secretariat, RGoB for commencing, completing and presenting studies involving Environmental Impact Assessments.

v. Address concerns of the ADB and demonstrate compliance with the SPS 2009.

## 1.3 APPROACH AND METHODOLOGY

40. The approach and methodology of conducting the EIA study includes the following:

i Understanding relevant issues through literature survey pertaining to the location and proposed development.

ii Identifying likely impacts and therefore, areas of concern.

iii Planning and conducting a two season baseline survey in and around the study area based on sl. no. ii above.

iv Discussing the project as it evolves with erstwhile DHI-INFRA and CDCL.

v Preparing an initial one season EIA report presenting the impacts traceable to the initial master plan to be developed for the ALDTP.

vi Working with CDCL in understanding the impacts and shaping the project so as to reduce the overall environmental footprint of the project.

vii Completing two seasons of baseline studies once the Master Plan was completed.

viii Presenting the EIA study to all relevant stakeholders for their comments through public consultations.

ix Including the feedback from the stakeholders in preparing the final report to be submitted to the NEC, Bhutan

- x Presenting and discussing the studies, outputs with the NEC to acquire environmental clearance for the project and implement mitigation measures, monitoring and grievance redressed of affected stakeholders, along with project development

41. The methodology used for the collection of primary baseline study is summarized as follows:

***Table 1-2: Summary of the environmental baseline data collection***

| SN | Items | Items for investigation | Methodology |
|---|---|---|---|
| 1. | Land Use | • Land cover pattern | • Review of existing data including the Topographical map prepared by National Land Commission.<br>• Reconnaissance site survey, Google Earth Pro using remote sensing |
| 2. | Geology & Hydrogeology | • Geology: Subsurface information, nature and behavior of the soil under application of loads of proposed structures and backfill materials.<br>• Hydrogeology: Testing the groundwater quality using the parameters given for surface water. | • Review of existing documents<br>• Geo-technical investigation through test bore holes and trial pits at various locations within the project<br>• Collection of samples from certified quarry sites for backfill materials<br>• Ground water samples from the existing bore well of Phuentsholing Thromde. |
| 3. | Surface water | • pH, Color, Electrical conductivity, TDS, Turbidity, Ammonial Nitrogen, Ca, Mg, Na, K, Salinity, COD, BOD, Cl, Phenol, Sulphates, Nitrate, fluoride, DO, SAR, TSS, cyanide, Heavy metals, total coliform and faecal coliform | • Sample collected from 10 locations within the project study and testing carried out using APHA and IS standard. |
| 4. | Meteorology | • Wind speed, Wind direction, Temperature, Relative humidity and rainfall. | • IS 8829-1978 |
| 5. | Ambient Air | PM 10, PM 2.5, $SO_2$, NOx and CO | • Electronic balance, Spectro-photometer, PID detector. |
| 6. | Ecology and Biodiversity | • Terrestrial flora and fauna, Zooplankton, Phytoplankton, Benthos & fishes | • Land use map<br>• Terrestrial survey<br>• Aquatic sample using CPUE method<br>• Fish market survey |
| 7. | Ambient noise and Vibration | Decibels- dB (A) | • Noise level meter |
| 8. | Soil conservation | • Porosity, water holding capacity, permeability, moisture content, texture, Particle size distribution, SAR, pH, Electrical conductivity, Ca, Mg, Na, K, Dry bulk density, OC, Total nitrogen, P, K | • Trial pit method analyzed as per APHA and IS methods |
| 9. | Socio-economics | • Economic profile, social characteristics, Traffic, Health and Safety, Existing infrastructures, Health Education, water supply and sanitation | • Review of existing documents<br>• Focus Group Discussions and One-to-One interviews. |

## 1.4 REPORT PRESENTATION

42. The EIA report has been prepared based on the ToR endorsed by NEC by taking into consideration the guidance in preparing EIA in accordance with ADB SPS 2009.

I. Executive Summary
II. Chapter One: Introduction and Background
III. Chapter Two: Policy, Legal and Administrative Framework
IV. Chapter Three: Description of the Project
V. Chapter Four: Baseline Environment Data
VI. Chapter Five: Analysis of Alternatives
VII. Chapter Six: Anticipated Environmental Impact Identification and Mitigation Measures
VIII. Chapter Seven: Public Consultation and Information Disclosure
IX. Chapter Eight: Environmental Management Plan
X. Chapter Nine: Conclusions and Recommendations
XI. Appendices

# 2 POLICY, LEGAL AND ADMINSTRATIVE FRAME WORK

## 2.1 NATIONAL POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

### 2.1.1 NATIONAL LAW AND REGULATION

43. The EIA document has been carried out within the overall framework for environmental and related regulations in the form of Policies, Acts, Rules, Notifications and Standards existing within Royal Government of Bhutan (RGoB). The applicability of relevant international statutes and guidelines that regulate the infrastructure sector development project has also been considered. The following Acts and Regulations were found to be relevant for the Project.

**THE ENVIRONMENT ASSESSMENT ACT (2000)**

44. This Act requires the government to ensure that environmental concerns are considered when formulating, renewing, modifying and implementing any policy, plan or programs. During the construction as well as operational phase of the project, the terms and conditions of the environmental clearance must be complied with. CDCL will also ensure that the concerned people and organizations are informed and consulted before submission of the environmental assessment documents to the competent authority.

**REGULATION FOR ENVIRONMENTAL CLEARANCE OF PROJECTS (2016)**

45. This Regulation is adopted under the Environmental Assessment Act, 2000. It applies to all projects which are subject to the environmental assessment process. The Regulation defines the responsibilities and procedures for the implementation of the Environmental Assessment Act, 2000
Including as follows:

i. To provide meaningful opportunities for public review of potential environmental impacts of projects
ii. To ensure that all projects are implemented in line with the sustainable development policy of the RGoB.
iii. To ensure that foreseeable impacts on the environment, including cumulative effects are considered prior to any irrevocable commitments of resources of funds.
iv. To ensure that feasible alternatives are considered.
v. To ensure that feasible means to avoid or mitigate damage to the environment are implemented.
vi. To encourage the use of renewable resources and clean technologies
vii. To provide information on environmental clearance towards uniform, comprehensive data base on the environmental and cultural conditions in Bhutan.

46. The Secretariat or Competent Authority shall issue an Environmental Clearance for five years unless the project requires a shorter/lesser period. The application for renewing the said EC (accompanied with a Compliance report) must be submitted to the Secretariat or the concerned Competent Authority at least three months before the expiry date of the EC.

47. The Secretariat or Competent Authority would also carry out post project monitoring of the project and report their findings including enforcement of directives and reporting.

48. Under this Regulation, provision of Appeals, Resolution of disputes, Complaint Redress are also mentioned. The Regulation also calls for establishment of an Environmental Unit responsible for reporting on implementation, enforcement and monitoring compliance of the EA Act, 2000 and this Regulation. It also

requires that the applicant designate a focal person to ensure compliance with the environmental clearance terms and conditions.

49. The Environmental Clearance process of the proposed ALDTP project shall adhere to the requirements stated in the Regulation and shall comply with the Regulation as well as all the conditions specified in the environmental clearance to be subsequently granted. All EC require a review every five years.

**THE BIODIVERSITY ACT (2003)**

50. Among the many objectives of this Act, the relevant ones are to ensure the conservation and sustainable use of the biological and genetic resources; to promote the equitable sharing of benefits derived from the use of genetic resources, to recognize and protect traditional knowledge, innovation and practices of local communities associated with biodiversity and to promote technology transfer and capacity building relevant to the conservation and sustainable use of biological diversity.

**FOREST AND NATURE CONSERVATION ACT (1995)**

51. This Act allows community stewardship of forests and aims to provide protection and sustainable use of forests, wildlife, and related natural resources.

52. Schedule I of the Act, lists those wild animals and plants that are given full protection under the Act. The FNCA establishes that all forests in Bhutan are Government Reserved Forests (GRF), and prohibits any development activity in these areas except with a permit.

**THE FOREST AND NATURE CONSERVATION RULES AND REGULATIONS OF BHUTAN (2017)**

53. For any developmental activity in a Government Reserve Forest, the proponent is required to seek Forestry Clearance from the Respective Divisional Forest Office in the District (there are 12 Forest Divisions and 9 Protected Areas). The proposal after being reviewed in the field by the District Forest Officer (now known as Chief Forestry Officer) is forwarded to the Department of Forest and Park Services where the final Clearance is granted based on the field review.

**NATIONAL ENVIRONMENT PROTECTION ACT (2007)**

54. The National Environment Protection Act (2007) outlines principles and a legal framework that have implications for forest governance and management. It requires that a person taking natural resources from the environment, or deriving economic benefits from it, should ensure sustainable use and management of the resources and ecosystems.

**WASTE PREVENTION AND MANAGEMENT ACT (2009) AND WASTE PREVENTION AND MANAGEMENT RULES (2012)**

55. This Act and Rules requires all developmental activities that generate waste to be planned and executed in harmony with the carrying capacity of the country's fragile ecological settings and geographical terrains, in line with the concept of 3R's (Reduce, Reuse and Recycle). Any person polluting the environment or causing ecological harm shall be responsible for the costs of avoidance, containment, abatement, medical compensation, mitigation, remediation and restoration. Implementing agencies shall ensure that the minimization, storage, treatment and disposal of hazardous waste are addressed in an environmentally sound manner.

**THE WATER ACT OF BHUTAN (2011) & WATER REGULATION OF BHUTAN (2014)**

56. This Act and its implementing regulations applies to all issues related to water resources with the objective to ensure water is protected, conserved and/or sustainably managed through:

i. Prioritization of water use
ii. Protection of Water Catchments
iii. Development of National Integrated Water Resources Management Plans for the conservation, development and management of water resources and river basins, ensuring Minimum Environmental Flow requirement of Rivers
iv. Prohibition to abstract or use water without Environmental Clearance (except for exemptions) and
v. Ensuring Prevention and Control of Water Pollution

**ELECTRICITY ACT OF BHUTAN (2000)**

57. This act provides a framework for licensing and regulating the operations of power companies. Under this act, the Bhutan Electricity Authority has been established as an autonomous body and the custodian for enforcing this act. The Electricity Act provides power to acquire land and water for generation and supply of electricity.

**GENERAL RULES AND REGULATIONS ON OCCUPATIONAL HEALTH AND SAFETY (OHS) IN CONSTRUCTION, MANUFACTURING, MINING AND SERVICE INDUSTRIES, 2006**

58. The purpose of the OHS Rules and Regulations is to ensure a safe and healthful working conditions for workingmen and women, as well as other persons present at workplaces, and protect them from work-related risks to their health, safety, and well-being. The rules apply to all employers and workers (both Bhutanese and non-Bhutanese) of licensed manufacturing, mining and service enterprise, construction companies, bodies corporate incorporated under the Companies Act 2000 of the Kingdom of Bhutan, and any other agency employing large numbers of workers at the work site.

**THE LABOUR AND EMPLOYMENT ACT OF BHUTAN, 2007**

59. The labour and employment Act of Bhutan 2007 provide policies and programs in the areas of employment promotion, labour protection and relations, vocational education and training, and occupational standards setting and certification. The proposed development will adhere to the policies provided under different sections of the Act.

**INTEGRATED SOLID WASTE MANAGEMENT STRATEGY (2014)**

60. This strategy document suggests a stepwise planning approach covering the planning phase up to the start of implementation for Integrated Solid Waste Management (ISWM). All Thromdes / Municipalities should ideally adopt this planning process to develop their local strategy for management of solid wastes.

61. The strategic goals and objectives for ISWM in Bhutan, in combination with both the Waste Prevention Act 2009 and Waste Prevention and Management Regulation of 2012 mentioned in ISWM strategy are:

i. Continuously move / promote towards "Zero Waste Bhutan" in partnership with the public, industry, civil society organizations and government / municipalities / donors.
ii. Each ISWM planning is to honour the principles of GNH and Zero Waste principles through increased participation in segregation, resource conservation, maximum processing and landfill diversion.
iii. Ensure environmental accountability and social responsibility of all waste generators, waste managers and service providers
iv. Introduce the principles of Extended Producers Responsibility (EPR) for all non-recyclable products
v. Assist in the development of Public Private Partnership (PPP) both with private sector and civil society organizations with public contribution via service fees for waste management
vi. Create and protect livelihoods through promoting and reforming the recycling sector
vii. Take up long term extensive awareness on waste management strategy

62. The strategy also proposes that in order to operationalize the ISWM activities, it is important that all aspects of waste management system such as storage, segregation, collection and transportation including processing and disposal be considered and designed before initiating any action.

63. The strategy reflects that waste segregation at source to be conducted and wastes to be disposed in designated colored bins such as:

i. All organic waste shall be segregated in GREEN bins and inorganic waste in BLUE bins
ii. All kinds of Healthcare wastes should be kept in RED bags / bins and other domestic hazardous waste and E-waste such as bulbs, CFL, batteries etc. should be kept in a YELLOW bag / bin and should not be mixed with any other waste.
iii. All municipalities shall strive for separate collection of inert wastes like road sweep, drain silt, etc.
iv. Construction and demolition wastes shall be stored separately.

**THE LOCAL GOVERNMENT ACT OF BHUTAN (2009)**

64. This Act repeals the Local Government Act 2007; Thromde Act 2007; Dzongkhag Yargay Tshogdu Chathrim, 2002; Gewog Yargay Tshogchung Chathrim, 2002. According to this Act, local Governments shall comprise the following categories:

i. The Dzongkhag (District) Tshogdu shall be the highest decision making body in the Dzongkhag. It shall comprise the Gup and Mangmi as the two elected representatives from each Gewog (Block), one elected representative to represent the Dzongkhag Thromde and one elected representative to represent the Yenla Throm.

ii. The Gewog Tshogde (Committee) shall be the highest decision making body in the Gewog. It shall comprise the Gup, Mangmi and Tshogpas.

65. Under this Act, the Dzongkhag and Gewog Tsogde must ensure the provision of social and economic services for the general wellbeing of the residents of the communities in a sustainable and equitable manner. Local Governments shall be supported by the National Government to promote holistic and integrated area-based development planning.

**ENVIRONMENTAL STANDARDS, 2010**

66. The Environmental Standards document prescribes the ambient water quality criteria for various uses, standard for Ambient Water quality, final effluent from Sewage Treatment Plant (STP), Ambient air quality standards, Vehicle emission standards and Noise level Limits levels in the proposed study area to determine

the appropriate category for point source or impacting emissions and effluent standards for the pre-construction, construction and operational stage of project.

**ENVIRONMENTAL CODE OF PRACTICES**

67. Environmental codes of practice for overhead and underground utilities and storm water and drainage systems have been proposed for the project.

### 2.1.2 INTERNATIONAL CONVENTIONS RELEVANT WITH THE ALDTP

68. Bhutan is well represented in the international and regional environmental arena as part of its commitment to environmental conservation and protection. The National Environment Commission Secretariat, as a key environmental policymaking body/nodal agency of the country, participates in various international meetings relating to conventions and agreements that Bhutan has signed or ratified. Bhutan is party to Multilateral Environmental Agreements as given in ***Table 2-1***

***Table 2-1: International Convention***

| S. No. | International Conventions | Dates of Ratification |
|---|---|---|
| 1 | UN Framework Convention on Climate Change | 1995 |
| 2 | UN Convention on Biological Diversity | 1995 |
| 3 | Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal Bhutan became a party in 2004 | 2002 |
| 4 | Kyoto Protocol to United Nations Framework Convention on Climate Change | 2002 |
| 5 | Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) | 2002 |
| 6 | Vienna Convention for the Protection of the Ozone Layer | 2004 |
| 7 | Montreal Protocol on Substances that Deplete the Ozone Layer | 2004 |
| 8 | Kyoto Protocol to the United Nations Framework Convention on Climate change | 2005 |
| 9 | International Union for Conservation of Nature (IUCN) | 2011 |

## 2.2 ADB'S ENVIRONMENTAL SAFEGUARD POLICY AND REQUIREMENT

69. The ADB Safeguard Policy Statement (SPS) 2009 covers three important risks to be taken into consideration for ADB's funded projects. These three risks are risks associated with environment impact, involuntary resettlement impacts, and indigenous people impacts. The SPS 2009 describes the objective of adopting these environmental requirements to ensure the environmental soundness and sustainability of ADB's funded projects, and to support the integration of environmental considerations into project decision making process. The environmental safeguard requirements are triggered by screening of the likely environmental impacts and environmental risks. Therefore, all ADB activities has to be screened as early as possible to determine the appropriate extent and type of environmental assessment, and appropriate study to be undertaken to enable identifying potential impacts and potential mitigation measures. Under the ADB SPS 2009, aside from category "A" project, ADB is also categorizes a project with no significant environmental impacts as "B" project, which require the preparation of Initial Environmental Examination (IEE). While a project with no potential environmental impacts will require only the inclusion of environmental requirements in the project design and no environmental impact study will be required

70. With regard to the critical habitat, ADB prohibited any activities in the critical habitat, unless (i) there are no measurable adverse impacts on the critical habitat that could impair its ability to function, (ii) there is no reduction in the population of any recognized endangered or critical endangered species, and (iii) any lesser impact are mitigated. If a project is located within or nearby legally protected area, there must be no significant

conversion or degradation unless (i) alternatives are not available, (ii) the overall benefit from the project substantially outweigh the environmental cost and any conversion or degradation is appropriately mitigated. In an area of natural habitats, there must be no significant conversion or degradation, unless (i) alternatives are not available, (ii) the overall benefits from the project substantially outweigh the environmental costs, and (iii) any conversion or degradation is appropriately mitigated.

71. On the basis of ADB's safeguard policy objective and considering ADB's principle of using a precautionary approach in dealing with a project located nearby a legally protected area (i.e. Jaldapara National Park, India), the ALDTP has been categorized as an "A" project. The environmental impact assessment is required to be prepared in order to identify potential impacts on the protected areas and prepare mitigation measures if required.

72. For category "A", projects will require careful monitoring and management of environmental and social implications to ensure that impacts are manageable, and will not become a trigger to generate cumulative and irreversible impacts. On this basis, the ALDTP project will also become the subject of strict environmental monitoring, in which, a semi-annual report has to be submitted to be used as a tool to monitor the effectiveness of implementation of environmental management and monitoring plan.

## 2.3 INSTITUTIONAL AND ADMINISTRATIVE FRAMEWORK

73. The National Environmental Protection Act of 2007 is the overall law on environmental protection and specifies the powers, functions, and operational framework of the National Environment Commission (NEC), the government agency with responsibility for all issues related to the environment. Their mandate includes the maintenance of environmental quality through the enforcement of environmental standards and promotion of best environmental management practices to address pollution and environmental hazards.

74. The Environmental Assessment Act of 2000 was enacted to establish procedures for the assessment of the potential effects of strategic plans, policies, programs, and projects on the environment, and for the determination of policies and measures to reduce potential adverse effects and to promote environmental benefits. Under this law, no development consent can be issued without first seeking an environmental clearance. The permission is given under Chapter III of the act and is issued in writing by the secretariat or the competent authority, to let a project proceed, which includes terms to ensure that the project shall be managed in an environmentally sound and sustainable way. Any NEC environmental clearance is subject review after five years.

## 2.4 ENVIRONMENTAL ROLES OF RELEVANT AGENCIES

### National Environmental Commission Secretariat (NECS)

75. NECS will be directly involved in the environmental management of the proposed project where NECS will issue an environmental clearance and provide guidance when needed. NECS has overall responsibility for enforcing environmental assessment and management in Bhutan.

### Thromde Level Environmental Committee (DEC)

76. Currently Phuentsholing Thromde has a separate Environment Division headed by a Division Chief. The mandate includes environment compliance monitoring, disaster management among others. A regular check on various construction activities within the Thromde is mandated to the Division.

# 3 PROJECT DESCRIPTION

## 3.1 PROJECT BACKGROUND

77. Due to increasing population and limited area, the Phuentsholing city faces an acute shortage of land for development and expansion. As well, the western limit of the city is currently threatened by flooding, erosion, sedimentation and loss of valuable land due to uncontrolled flow of Amochhu River. The flow has eroded vast areas of land on the eastern bank of Amochhu, restricting the scope for growth and sustainability of the economy of the city. The Phuentsholing Thromde is constantly battling the River to protect further encroachment into the City. There is private land and properties along the eastern bank of the River, which are extremely vulnerable to flood damage. Some private land is already affected, which has been relocated under a Local Area Plan (LAP) of the Thromde, separate from the ALDTP. Therefore, the Government considers an urgent need for the project to save the city from floods and erosion and to reclaim the eroded land for sustainable use.

78. The project area has been identified as a flood prone area putting Phuentsholing city under significant risk. Through flood protection, the project has large potential to make additional land available for future development. The project area extends on the left bank of the Amochhu River from the existing Phuentsholing town under Phuentsholing Thromde to the right bank at the base of Kaileshwar hill under Samtse Dzongkhag.

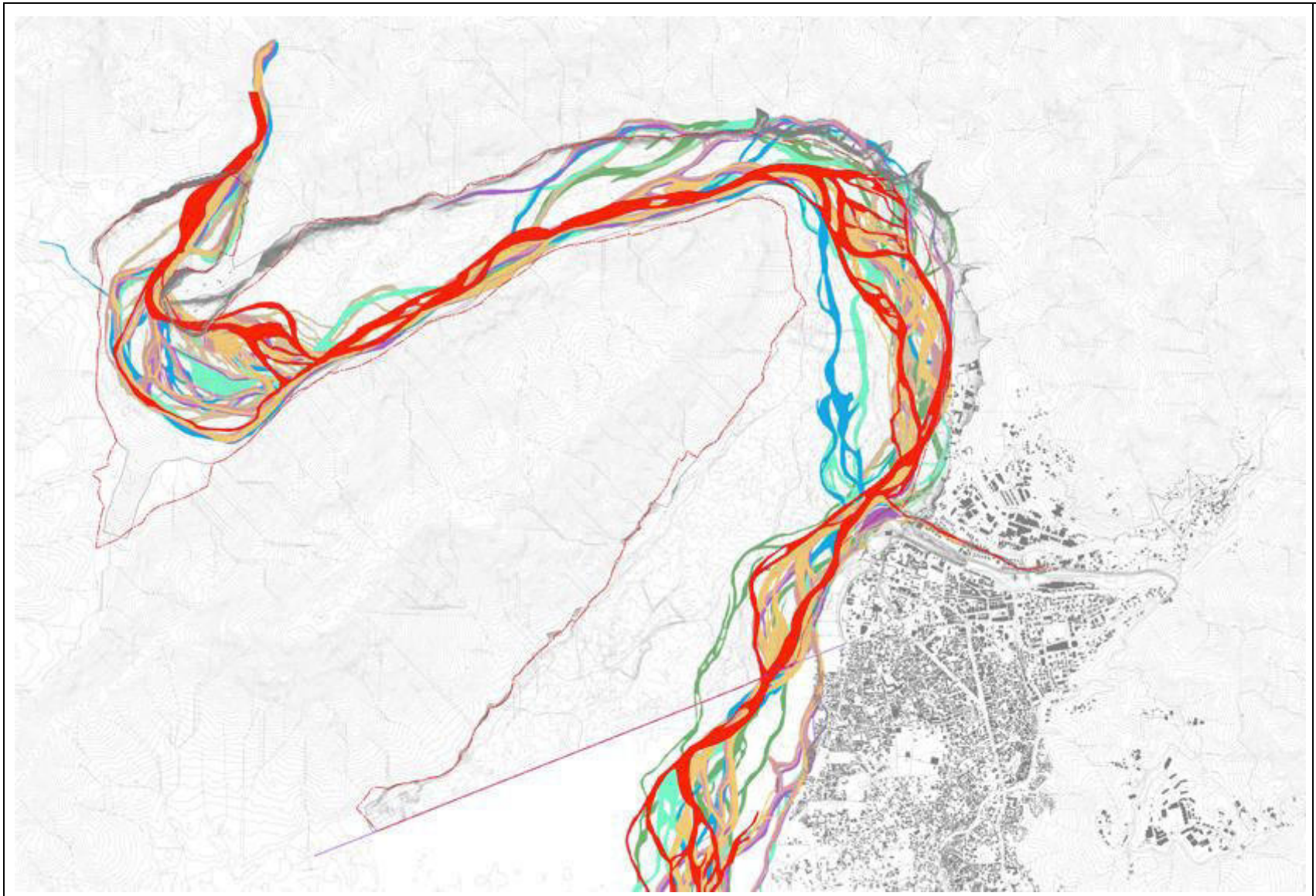
## 3.2 PROJECT OBJECTIVES

79. The project is expected to fulfill the following objectives: (i) Protection from flooding, (ii) Expansion of Phuentsholing city, (iii) Improvement of the built environment and cultural fabric of Phuentsholing, (iv) Economic growth and employment for residents of Phuentsholing and (v) Promoting the importance to region and country. A brief summary of each objective is outlined as follows:

### i. Protection from Flooding

80. The major objective of the proposed ALDTP is to save the city from floods. ***Figure 3-1*** graphically explains the incidence of flooding in the Amochhu River in the last 12 years. The flood patterns clearly indicate that Amochhu changes its course every year and the threat from flood has always been towards the existing Phuentsholing city, which underlines the necessity for flood protection works.

***Figure 3-1: Incidence of Floods in the Amochhu River***



**ii. Expansion of Phuentsholing**

82. The second key objective of the proposed project is to reclaim the eroded land for sustainable use. Phuentsholing is the country's largest commercial and industrial hub and main trading gateway with India, however, the city has reached a limit where it can no longer expand to accommodate its ever-growing population and commercial activities. On the other hand, along the western limit of the City, sedimentation and erosion resulting directly from the uncontrolled Amochhu flow has been a contributor to the loss of valuable flat land.

83. Further, due to limited space for housing, about 5600 Bhutanese live across the border in Jaigaon (India), who commute daily to work in Phuentsholing. Hence, there is a strong demand for expansion of Phuentsholing by developing a new township for which the project aims to develop around 1146 acres of land on both sides of the Amochhu.

**iii. Improvement of the built environment and cultural fabric of Phuentsholing**

84. Being the oldest town, the developmental activities in Phuentsholing has not followed a proper planning standards resulting in haphazard construction in large parts of the city. There is an obvious variance with the national architectural aesthetics and built characters of Bhutan due to its location adjacent to the Indian border. Hence, there is a need to have a well-planned township with distinctive cultural fabric.

85. The project will provide resilient river training and construct a smart urban infrastructures. The land available will be used for building a modern township based on sustainable principles of equity, livability and competitiveness which will be integrated into the fabric of the existing municipality and preserve Bhutan's unique architectural heritage. The new township will also provide spaces for public recreation and services.

**iv. Economic Growth and Employment for Residents of Phuentsholing**

86. Phuentsholing has an ample scope to increase its economic profile and become a strong magnet for growth and employment. A thriving ALDTP project will increase the capacity of Phuentsholing to become a business and economic hub of the country. The Government desires that future urban growth happens in a planned manner and it is concentrated in proximity to established economic centers to have the highest potential for providing employment and economic growth opportunities. During the construction stage about 1300 workers (skilled and unskilled) are expected to be employed for the whole project duration. Further, there are likely to be about 30,000 direct jobs and twice as many indirect jobs due to the proposed development during the operational stage.

**v. Importance to Region and Country**

87. The project site is considered to be the most appropriate for allowing Phuentsholing City to expand. The City is also located between two trading corridors that have been developed under the framework of SASEC, hence, the growth of Phuentsholing is critical as it is directly linked with the economic growth of Bhutan. ALDTP will also be able to accommodate increasing population including the floating population.

## 3.3 PROJECT COMPONENT

88. The project consists of the following components:

i River Training
ii Embankment work
iii Land reclamation
iv Alluvial Fan Discharge Cross Drainage

v Landscape strategy
vi Common urban Infrastructure, namely:

- Roads
- Bridges
- Water Drawl and Supply
- Sewerage System
- Storm water Collection, Conveyance and Disposal
- Solid Waste system
- Power supply and distribution system
- Telecommunication system
- Fire Fighting System
- Flood warning system

89. The project encompasses various zones as mentioned earlier, which would be developed in different phases as per the Master Plan. These zones include:

i Zone A: abutting the Phuentsholing Local Area Plan (LAP) and adjacent to the Phuentsholing Town within the floodplain on the eastern bank of Amochhu.

ii Zone B: Further north of Zone A on the eastern bank of Amochhu abutting Torsa Tar.

iii Zone C: Across the Amochhu River (along its western bank) at the base of the Kaileshwar Hill

iv Zone E: Along the western bank of the Amochhu River that bends along the Kaileshwar Hill and north of Zone C.

## 3.4 STRATEGY FOLLOWED FOR THE DEVELOPMENT OF THE ALDTP

90. The ALDTP will be developed using the following strategy and vision:

i A Resilient Riverfront - utilize river training to create resilient riverfront that protects the new development and creates new opportunities for development benefiting both sides of Indo-Bhutan border.
ii Inclusive Development for all – result in an inclusive development for all that provides opportunities and accommodates people of all ethnicities and income groups through affordable housing.
iii Cultural and Economic Hub - take benefit of its strategic location on Indo-Bhutan border and make it a cultural & economic hub of Bhutan.
iv Opportunities for Economic Development – generate opportunities for economic development that will improve the quality of life of the people.
v Environmentally sustainable approach – make efficient use of local resources for sustainable development and preservation of natural areas and ecology.
vi Formulate and implement a socio-cultural ethos combined with architectural styles to establish / reinforce the Bhutanese identity.

## 3.5 ALDTP MASTER PLAN

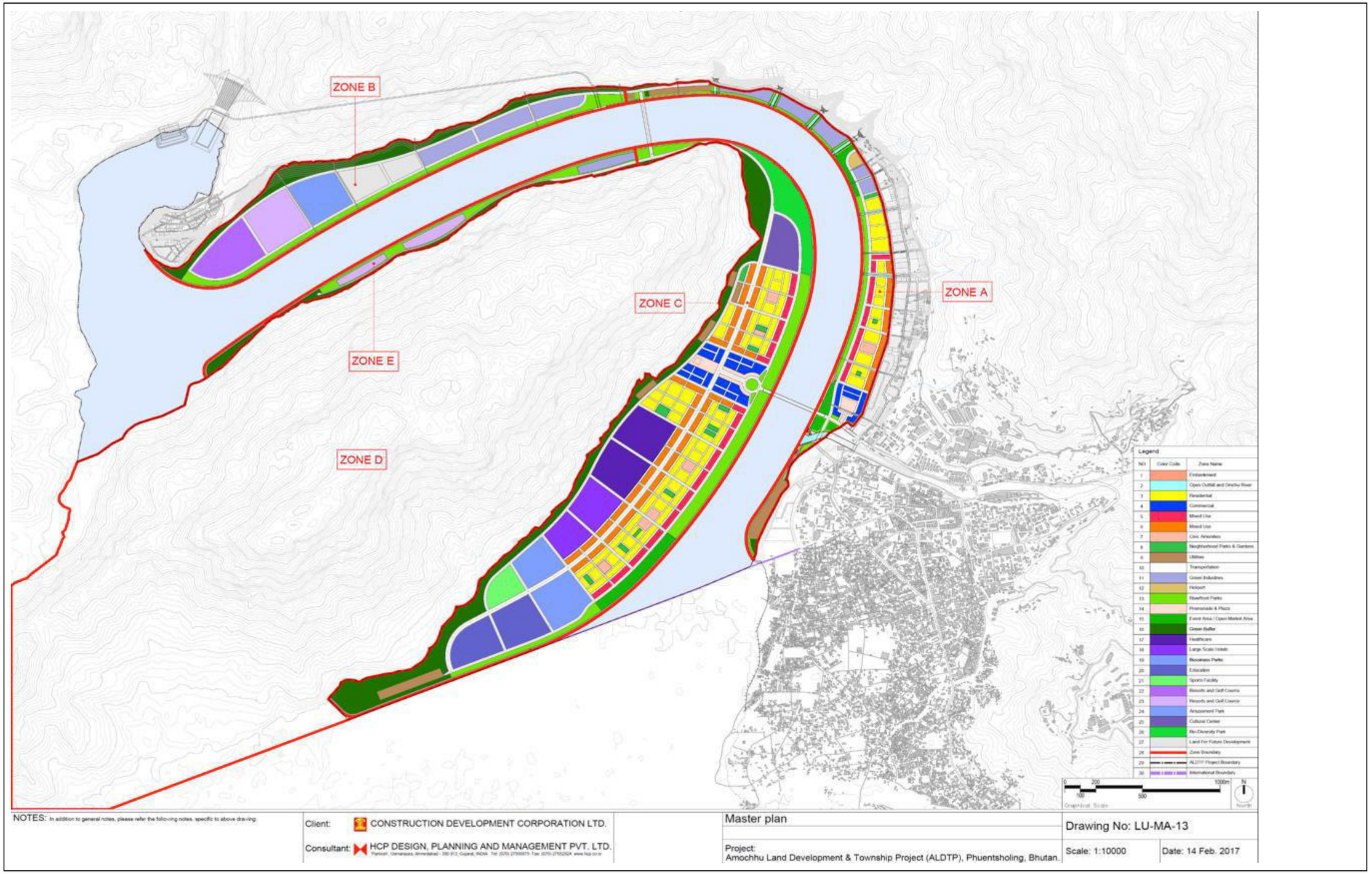
91. The total project area including the river channel is about 2076 acres. After the river training and land reclamation, there would be 464 Ha of reclaimed land area available for development. ***Table 3-1*** shows the zone wise development areas as per the master plan. In summary, Zone A has 66 Ha, Zone B has 94 Ha, Zone C has 277, and Zone E has 27 making up a total of 464 Ha or 1146 Acres.

***Table 3-1: Proposed Development Areas as per the Master Plan with Area***

| | | Zone Wise Area Table as per Master plan | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Land use Category Proposed/ Suggested for the Project** | **Zone-A** | | **Zone-B** | | **Zone-C** | | **Zone-E** | | **Total Area** | |
| | | **Area (Acres)** | **Area (Sq.Mt.)** | **Area (Acres)** | **Area (Sq.Mt.)** | **Area (Acres)** | **Area (Sq.Mt.)** | **Area (Acres)** | **Area (Sq.Mt.)** | **Area (Acres)** | **Area (Sq.Mt.)** |
| **A.** | **Embankment and Flood Protection** | **17.50** | **70,811.49** | **10.94** | **44,255.67** | **19.27** | **77,984.06** | **10.38** | **42,011.73** | **58.09** | **235,062.94** |
| | Embankments | 12.27 | 49,667.40 | 10.94 | 44,255.67 | 19.27 | 77,984.06 | 10.38 | 42,011.73 | 52.86 | 213,918.86 |
| | Outfalls (Open Outfalls) | 5.22 | 21,144.08 | | | | | | | 5.22 | 21,144.08 |
| **B.** | **Township Development Areas** | **86.80** | **351,270.52** | **31.96** | **129,346.76** | **309.28** | **1,251,595.70** | **5.75** | **23,274.41** | **433.79** | **1,755,487.39** |
| | Residential | 20.90 | 84,592.20 | | | 70.26 | 284,334.37 | | | 91.16 | 368,926.56 |
| | Commercial | 5.09 | 20,604.18 | | | 16.39 | 66,328.22 | | | 21.48 | 86,932.40 |
| | Mixed Use(Residential+ Commercial) | 12.62 | 51,080.26 | | | 58.00 | 234,713.91 | | | 70.62 | 285,794.17 |
| | Civic Amenities/ Social Infrastructure | 1.71 | 6,903.69 | | | 6.74 | 27,277.94 | | | 8.45 | 34,181.62 |
| | Neighborhood Parks & Gardens | 0.99 | 4,025.69 | | | 6.93 | 28,050.77 | | | 7.93 | 32,076.46 |
| | Utilities | 10.97 | 44,392.68 | | | 10.81 | 43,728.77 | | | 21.78 | 88,121.45 |
| | Transportation | 34.51 | 139,671.83 | 31.96 | 129,346.76 | 140.15 | 567,161.72 | 5.75 | 23,274.41 | 212.38 | 859,454.72 |
| **C.** | **Special Development Areas** | **21.29** | **86,171.49** | **95.97** | **388,387.79** | **194.63** | **787,640.44** | **16.91** | **68,420.72** | **328.80** | **1,330,620.44** |
| | Education | | | | | 38.34 | 155,161.60 | | | 38.34 | 155,161.60 |
| | Healthcare with Medical Institutes | | | | | 41.20 | 166,724.77 | | | 41.20 | 166,724.77 |
| | **Hospitality** | | | **71.29** | **288,490.05** | **67.84** | **274,555.11** | **11.39** | **46,104.85** | **150.52** | **609,150.01** |
| | Large Scale Hotels | | | | | 29.20 | 118,180.54 | | | 29.20 | 118,180.54 |
| | Resorts | | | 25.00 | 101,163.26 | | | 11.39 | 46,104.85 | 36.39 | 147,268.11 |
| | Golf Course | | | 25.07 | 101,462.69 | | | | | 25.07 | 101,462.69 |
| | Amusement Park | | | 21.22 | 85,864.10 | | | | | 21.22 | 85,864.10 |
| | Bio diversity Park with Cultural Center | | | | | 38.64 | 156,374.58 | | | 38.64 | 156,374.58 |
| | **Business Park** | | | | | **37.08** | **150,075.57** | | | **37.08** | **150,075.57** |
| | **Green Industries** | **19.02** | **76,974.04** | **24.69** | **99,897.74** | | | **5.51** | **22,315.87** | **49.22** | **199,187.65** |
| | **Sports Facilities** | | | | | **10.16** | **41,123.40** | | | **10.16** | **41,123.40** |
| | **Heliport** | **2.27** | **9,197.45** | | | | | | | **2.27** | **9,197.45** |
| **D.** | **Green Areas** | **37.28** | **150,885.65** | **31.87** | **304,018.21** | **75.77** | **651,306.28** | **17.82** | **135,847.58** | **306.92** | **1,242,057.71** |
| | **Riverfront Green** | | | | | | | | | | |
| | Riverfront Parks | 18.46 | 74,716.94 | 27.45 | 111,102.54 | 49.65 | 200,935.04 | 13.85 | 56,030.55 | 109.41 | 442,785.07 |
| | Promenade & Paved Plazas | 8.74 | 35,379.03 | 4.41 | 17,866.45 | 14.46 | 58,517.56 | 3.97 | 16,073.84 | 31.59 | 127,836.89 |
| | Open Market Area / Event Area | 6.03 | 24,406.43 | | | 11.66 | 47,194.09 | | | 17.69 | 71,600.51 |
| | **Green Buffer** | | | | | | | | | | |
| | Walking & Biking Trails | 4.05 | 16,383.25 | | 175,049.22 | | 344,659.58 | | 63,743.19 | 148.22 | 599,835.24 |
| | Detention Ponds | | | | | | | | | | |
| **E.** | **Balance land available for future development** | | | **19.10** | **77,275.49** | | | | | **19.10** | **77,275.49** |
| | **Area Available for development** | **162.88** | **659,139.15** | **233.09** | **943,283.92** | **684.12** | **2,768,526.48** | **66.61** | **269,554.43** | **1,146.69** | **4,640,503.98** |
| | **Total land area ( A + B + C + D )** | **162.88** | | **170.74** | | **598.95** | | **50.86** | | **1,127.60** | |

92. The proposed Project Master Plan ('Master Plan') is shown in ***Figure 3-2***

***Figure 3-2: The proposed Project Master Plan ('Master Plan')***



## 3.6 PROJECT SEQUENCE AND SCHEDULE

93. As per the master plan, ALDTP has been divided into 4 zones for development. The project implementation will be phased in relation to scale, demand and financial viability of the project. The first phase will develop Zone A while the remaining zones will be developed in subsequent phases. The proposed timeline for the construction is about 15 years, the details of which are mentioned in, ***Table 3-2.***

***Table 3-2: Proposed timeline for Zone wise construction***

| Zone | Duration of Construction |
|---|---|
| Zone A | Oct-2017 to Sept-2022 |
| Zone B | Oct-2021 to Jan-2026 |
| Zone C & E | Oct-2025 to Jul-2035 |

94. The main construction activities in first phase are as follows:

i Civil Works Contract ALDTP-CW-01: duration October 2017 – June 2020 (33 months). River Training, Embankment, Land Filling, Cross Drainage, Promenade Finishing.

ii Civil Works Contract ALDTP-CW-02: duration October 2019 – September 2022 (36 months). Common Urban Infrastructure including water supply and distribution, wastewater collation and treatment, storm water drainage, Road Network, Solid Waste Management.

iii Civil Work Contract ALDTP-CW-03: duration October 2020 – January 2022 (15 months). Power and telecommunication services.

### CONSTRUCTION SEQUENCE AND SCHEDULE FOR THE PHASE 1

95. A work plan for construction of Zone A as per the Master Plan has been completed which is presented in the subsequent paragraphs of this Section.

96. ***Other phases of the project will be developed at future dates which will be determined based on market demand, financial viability and availability of funds. However, the general planning and concepts discussed for Zone A will be applicable for all the project phases since the rest of the phases follow same construction activities and sequence.***

97. The construction requirements for manpower, materials, equipment etc. defined here are indicative of what is likely to occur at the site during construction stage.

### PRE-CONSTRUCTION SEQUENCE

98. All administrative, financial, legal and other formalities will be finalized before the start of construction activities. The activities that needs to be completed before start of construction are:

i Tenders and Contracts
ii Establishment of project site office
iii Establishment of contractor and workers camps
iv Hiring of buildings for offices (offsite) and out station workers residential quarters

v Arrangement for electricity, water supply and waste management system.
vi Deputation of project staff from CDCL.
vii Delineation of project area boundary.
viii Site clearance activities.
ix Identification and establishment of stores, warehouses and parking areas for machinery, material, etc.
x Preparation of Contractor's Environmental Management Plan (CEMP)

**CONSTRUCTION SEQUENCE**

99. The project's construction sequence and cost for the Phase 1 is given in ***Table 3-3.***

- Table 3-3: ALDTP construction sequence and cost for the Phase 1

| S. No. | Component | Construction Sequence | Schedule | Cost (Million Nu) |
|---|---|---|---|---|
| **Civil Works Package-ZA-1** | | | | |
| 1 | River Training Works | Mobilization of diaphragm wall rigs, setting of concrete plant, etc. | 2 months | 821 |
| | | Construction of Diaphragm Wall | 19 months | |
| | | Cast in situ wall above Diaphragm Wall | 15 months | |
| | | Construction of Dead man Anchor/Anchor Slab | 11 months | |
| 2 | Embankment Works includes Alluvial Fan Discharges | General Earth Filling | 15 months | 445 |
| | | Stones in wire crates | 10 months | |
| | | Retaining Wall | 9 months | |
| | | Cross drainage work | 8 months | |
| | | Access - steps from upper walkway to lower walkway | 8 months | |
| | | Hill slope stability | 8 months | |
| | | Service bridge over open outfall | 12 months | |
| 3 | General Earth Filling | Earth filling within site area | 24 months | 550 |
| | | Earth filling from outside site area | 24 months | |
| 4 | Promenade Finishing | Lower level walkway | 8 months | 65 |
| | | Upper level walkway | 8 months | |
| 5 | Irrigation and Landscape Works | Irrigation works | 8 months | 4 |
| | | Landscape works | 8 months | |
| **Civil Works Package-ZA-2** | | | | |
| 1 | Road & Bridge Works | Road Works | 21 months | 264 |
| | | Bridge Works | 18 months | |
| 2 | Common Urban Infrastructure | Water Supply Network | 12 months | 422 |
| | | Water Treatment Plant | 24 months | |
| | | Sewerage Network | 12 months | |
| | | Sewerage Treatment Plant | 24 months | |
| | | Storm Water Collection Network | 12 months | |
| | | Electrical & Communication Network | 12 months | |
| | | Street and Embankment Lighting Works | 12 months | |
| | | Solid Waste Treatment Plant | 24 months | |
| 3 | Utilities & Others | Toilet Block | 15 months | 14 |
| | | Signage Works | 6 months | |
| | | Horticulture Works | 12 months | |

100. The current project schedule is shown in ***Figure 3-3.***

***Figure 3-3: Project Schedule for Phase 1***

## 3.7 PROJECT IMPLEMENTATION BY ACTIVITY

101. Project implementation will be undertaken in three stages, (i) Pre-construction, (ii) Construction and (iii) Operation & Maintenance. These stages are described in subsequent paragraphs of this section.

**PRE-CONSTRUCTION STAGE**

102. The pre-construction activities mainly includes (i) Site Access and Traffic Management (ii) Equipment Delivery and Assembly and (iii) Material Storage, Work Areas and Housing for Workers

**SITE ACCESS AND TRAFFIC MANAGEMENT**

103. The project site will be accessed mainly through Phuentsholing-Thimphu Northern Bypass road which is currently under construction with Asian Development Bank funding. The bypass road is connected by a dry port to the 2nd Indo-Bhutan entry point which is also currently under development.

104. Since, the project shares its boundary with the proposed Samtse-Phuentsholing Highway (under Phuentsholing Thromde) and the project site is currently being used by Natural Resource Development Corporation (NRDCL) to supply sand and stones, the site is already accessible.

105. All efforts will be made to streamline the traffic and ensure that the vehicular movements do not cause undue disturbance to the surrounding areas. A Traffic Management Strategy to be prepared by the PIC will provide overall guidelines for the contractors to prepare their site-specific Traffic Management Sub Plan as part of their CEMP which will be approved by CDCL prior to commencement of field activities.

**EQUIPMENT DELIVERY AND ASSEMBLY**

106. The project is expected to set up various equipment and machineries within 2 months after the contract has been awarded. A list of important equipment are proposed in in ***Table 3-4.***

***Table 3-4: Equipment details for construction activity***

| S. No. | Type of Machine | Noise Generation at Source dB(A) | Number |
|---|---|---|---|
| 1 | 10 ton Vibratory Roller | 74 | 03 |
| 2 | Diaphragm Grabbing MAT machine | - | 06 |
| 3 | 100 T and 50T Capacity Crane | 83 | 01 |
| 4 | 60T Concrete batching Plant | - | 03 |
| 5 | Transit Mixer | - | 06 |
| 6 | AIWA 30T capacity | - | 30 |
| 7 | Reinforcement cutting bonding machine | - | 01 |
| 8 | JCB | 95 | 10 |
| 9 | Grader | 85 | 03 |
| 10 | Tractor Trolley | 95 | 10 |
| 11 | Dozer | 85 | 03 |
| 12 | Concrete pumps | 82 | 03 |
| 13 | Piling Rigs | - | 02 |
| 14 | Water hammer | - | 03 |
| 15 | Excavator | 85 | 03 |
| 16 | Aggregate Crusher | 100 | 02 |
| 17 | Compressor | 80 | 02 |

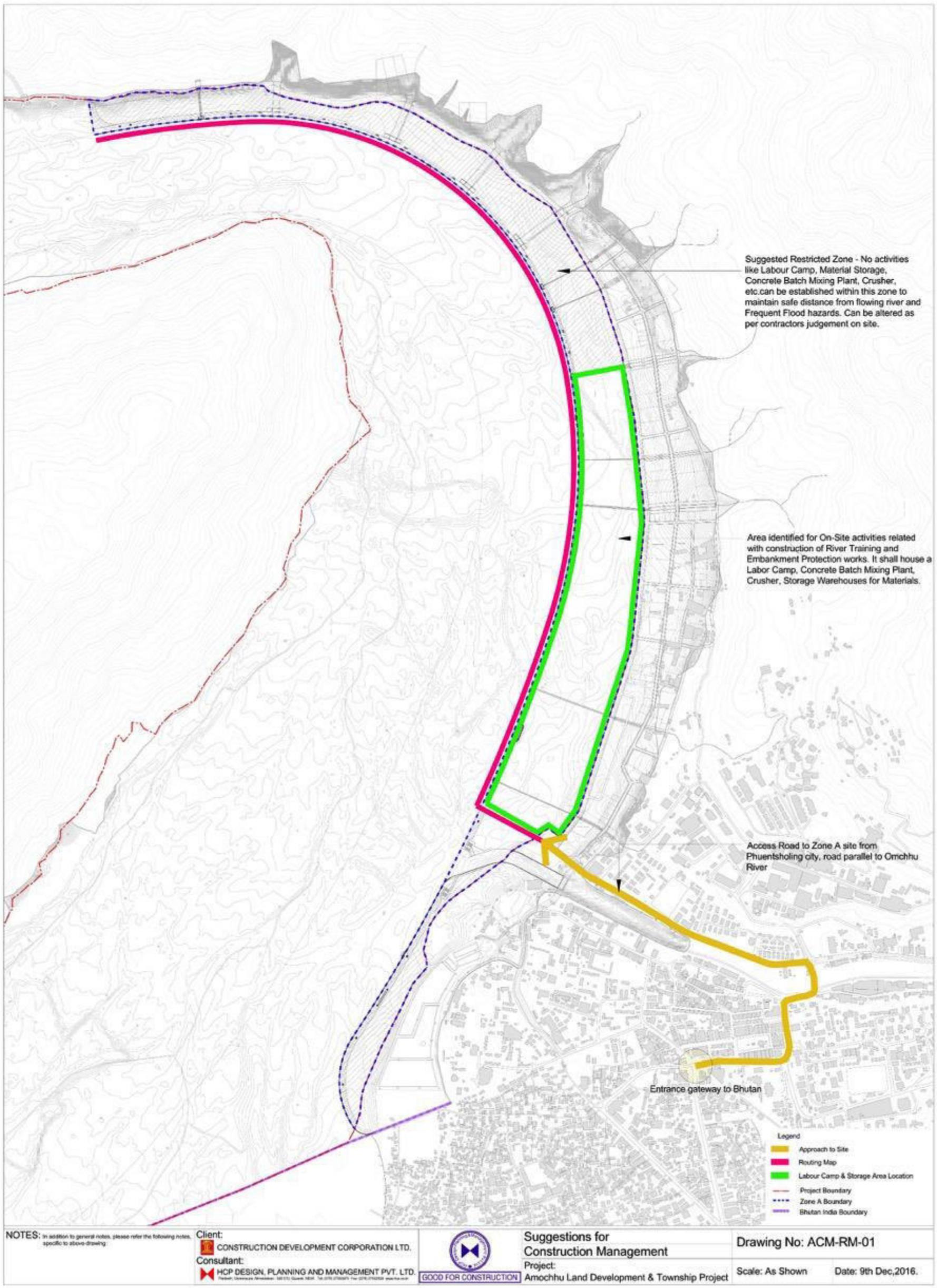
**MATERIAL STORAGE, WORK AREAS AND HOUSING FOR WORKERS**

107. An area of approx. 1.1 Ha has been identified for housing workers camps, warehouse, storage yards and parking areas. This will also accommodate house concrete batch mixing plant and storage warehouses for cement and steel.

108. The contractors will be required to provide facilities to the workers such as (i) clean drinking water (ii) clean fuel other than fire wood (iii) separate toilets and bathing/shower space (minimum 1 toilet per 20 persons), and suitable disposal facilities acceptable to the local administration and environmental regulators.

109. The locations of housing for workers, material storage and other work areas are given areas are given in ***Figure 3-4***

***Figure 3-4: The locations for the worker housing, other work areas and material storage***



110. The projects requires 11.3 million $m^3$ of borrow (backfill) materials over a 15-year time frame. It also requires around 0.4 million $m^3$ of construction materials (cement, coarse aggregates, sand and steel reinforcements).

111. **Backfill material:** The project will require a substantial amount of backfill materials for construction of embankments and filling up the reclaimed area. It is estimated that Zone A and B will require an additional fill of about 2 - 2.5 meters and Zone C and E will require about 1.5 - 2 meters on average. For Stage 1, around 80% of the fill materials will be made available while carrying out the leveling of the river bed. The remaining quantity will be taken from alluvial deposits of Purbay Khola which is within the project boundary. The backfill materials for other phases will be taken from (i) river bed along which the material deposits are expected to occur every monsoon over a period of time and (ii) overburden material from the existing certified quarry site within the vicinity of the project.

112. The certified quarry sites in and around the project site were earmarked and identified within 30km radius of Project site which are presented in ***Table 3-5*** below. From the listed quarry sites, the most feasible site was identified as Tshering Mining at Hourikhola area which has sufficient amount of over burden materials. Since it is located toward western side of the project area, the traffic movement within the city will be minimized. The samples were collected from the identified quarry sites to check the quality of fill materials.

***Table 3-5: Quarry details for filling material***

| SN No. | Location | UTM Coordinates |
|---|---|---|
| 1 | Amochhu River Bed, Purbay Khola, near test point BH2 | E 735130, N 2976200<br>E 731438, N 2974401 |
| 2 | Druk Mining Pvt. Ltd., Omchena area, Chhukha, about 30km North of Phuentsholing on Phuentsholing- Thimphu highway | E 741857, N 2978993 |
| 3 | Shimamo Quartzite Mine, Yangtsho Export & Minerals, Shimamo, Chhukha, after Pasakha Industrial Estate, about 30km East of Phuentsholing on Phuentsholing- Pasakha Highway | E 748059, N 2970875 |
| 4 | Tshering Mining, Hourikhola area, Samtse, about 15 km West-South West of Phuentsholing, unpaved road through river bed and Indian territory | E 725981, N 2970457 |

113. ***Table 3-6*** below provides information on the material transportation requirements and arrangements proposed for the same.

***Table 3-6: Material Transportation Requirement***

| SN | Zone | Material ($m^3$) | Months Available | Days Available for Trucking | Fill Material to be transported per day | Truck Capacity ($m^3$) | Truck Trips Required / Day | Max. No. of truck / day | No. of Trucks to be deployed / day |
|---|---|---|---|---|---|---|---|---|---|
| **Trucks trips required for transporting fill materials** | | | | | | | | | |
| 1 | Zone A | 2,600,000.00 | 36 | 900 | 2889 | 14 | 206 | 10 | 21 |
| 2 | Zone B | 2,000,000.00 | 36 | 900 | 2222 | 14 | 159 | 10 | 16 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | Zone C & E | 6,700,000.00 | 44 | 1100 | 6091 | 14 | 435 | 10 | 44 |
| 4 | Total | 11,300,000.00 | | | | | | | |
| **Trucks trips required for transporting construction materials** | | | | | | | | | |
| 1 | Cement | 78,780 | 92 | 2,300 | 34 | 14 | 2 | 10 | 0 |
| 2 | Coarse Aggregates | 227,754 | 92 | 2,300 | 99 | 14 | 7 | 10 | 1 |
| 3 | Sand | 133,627 | 92 | 2,300 | 58 | 14 | 4 | 10 | 0 |
| 4 | Steel | 9,375 | 92 | 2,300 | 4 | 14 | 0 | 10 | 0 |
| 5 | Total | 449,536 | 92 | 2,300 | 195 | | | | ~2 |

114. For convenience and practical purposes, truck movements would be limited to 10 hours per day (during times of low traffic elsewhere in the City and region). The exact timings would be determined in consultation with the Road Safety and Transport Authority and the Project Office. Further, it is assumed that it will be possible to transfer materials for 300 days (about 10 months) each year, with two months of non-operations owing to limitations imposed by weather conditions.

115. Assuming the trucks deployed can carry 14.0 $m^3$ of materials it is expected that during Zone A construction a maximum of 21 trucks would be deployed completing about 206 trips per day for carrying fill and construction materials. The duration of transportation would be for 36 months.

116. Likewise, for construction of Zone B, a maximum of 16 trucks would be deployed completing about 159 trips per day for 36 months and for construction of Zone C and applicable portion of Zone E, a maximum of 44 trucks would be deployed completing about 435 trips per day for carrying fill and construction materials over a period of 44 months.. Over the total of 116 months, the average truck trips per day would be 267,

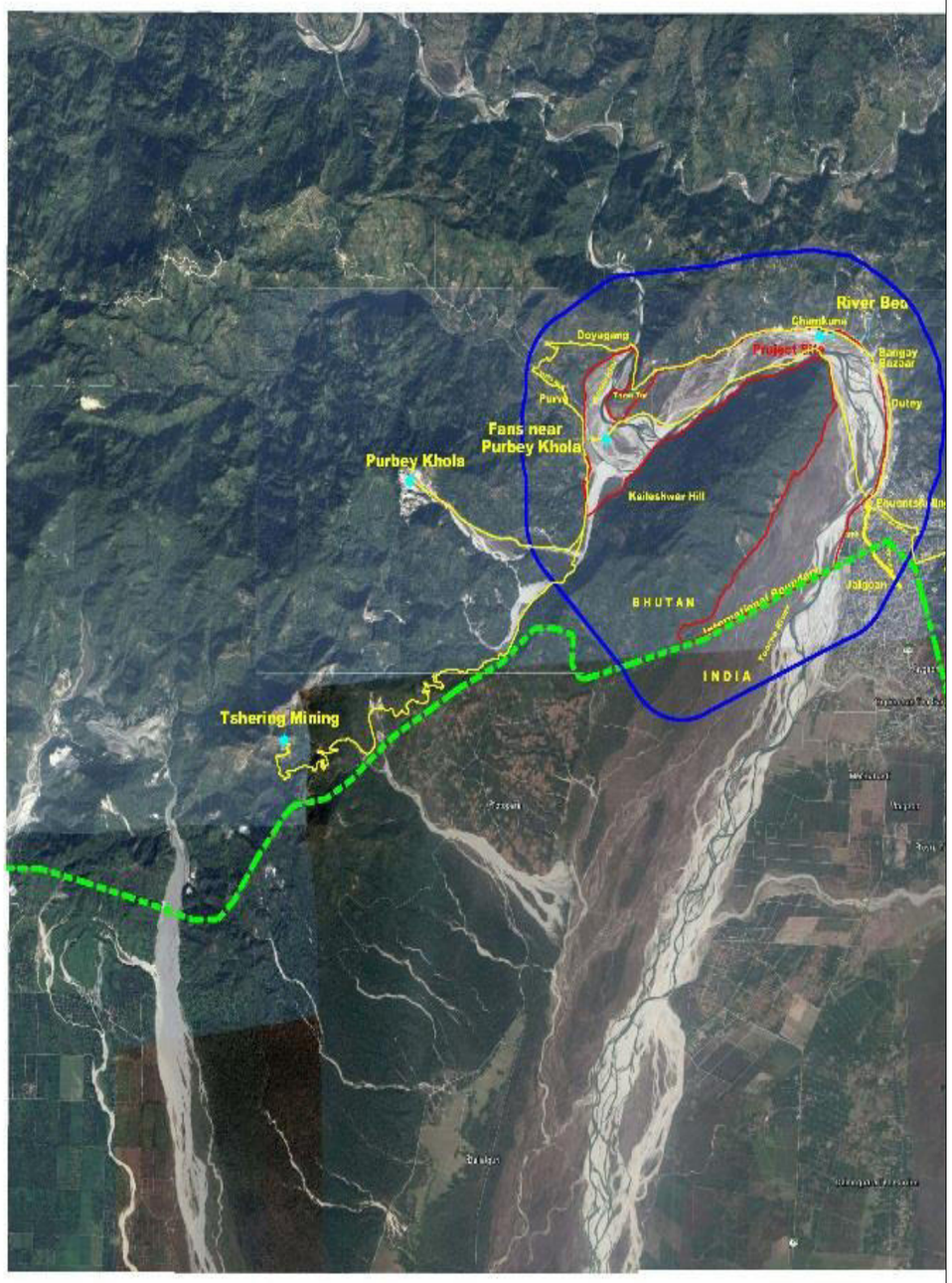
117. **Construction Materials:** Details of construction material requirement for ALDTP and their sourcing is given in ***Table 3-7***.

***Table 3-7: Details of the construction material requirement for ALDTP***

| S. No. | Material | Units | Quantity Required (approx.) | Source | Transport Mode |
|---|---|---|---|---|---|
| 1 | Cement | tonnes | 78,780 | Dungsam Cement Corporation Ltd., Penden Cement Factory & Lhaki Cement | Trucks with HDPE plastic sheet covers |
| 2 | Coarse aggregates | tonnes | 227,754 | Within the project site and nearby existing quarries | |
| 3 | Sand | tonnes | 133,627 | Within the project site | |
| 4 | Steel | tonnes | 9,375 | Pasakha Industrial Area | |

118. The Quarry location details for sourcing of fill material are shown in ***Figure 3-5.***

*Figure 3-5: Location of the Backfill Quarry Sites*



**MANPOWER REQUIRED**

119. The details of the manpower requirement are shown in ***Table 3-8***

***Table 3-8: Proposed Manpower requirement for ALDTP project***

| S. No. | Type of Manpower | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|
| 1 | Skilled | 93 | 204 | 248 | 239 | 189 |
| 2 | Unskilled | 227 | 514 | 728 | 673 | 426 |
| 3 | Operator | 161 | 388 | 276 | 110 | 75 |
| 4 | Managerial | 7 | 19 | 15 | 13 | 10 |
| 5 | Engineers | 6 | 14 | 8 | 8 | 5 |
| 6 | Technicians | 13 | 18 | 7 | 7 | 5 |
| 7 | PIU | 4 | 12 | 9 | 9 | 9 |
| 8 | PMC | 4 | 12 | 9 | 9 | 9 |
| **9** | **Total** | **515** | **1181** | **1300** | **1068** | **723** |

### 2.1.3 CONSTRUCTION STAGE

120. The activities that are considered during the construction stage of the project are (i) river training (ii) embankment works (iii) land reclamation (iv) alluvial fan cross drainage (v) common urban infrastructure (roads, bridges, water drawl and supply, sewerage system, storm water collection, conveyance and disposal, solid waste management, power supply and distribution system, telecommunication system, firefighting system, flood warning system) and (vi) construction stage decommissioning plan.

121. **Temporary River Training:** The actual construction work in each zone will commence with river training works involving bed levelling in selected locations particularly along curving channels. The hydraulic parameters such as velocity, maximum flood level, scour depth, etc. within the trained river channel have been considered for 100 years Probable Maximum Flood (PMF). The width of trained river was optimized at 300 m which would allow the 464 Ha of land available for development.

122. **Riverbed Leveling:** Amochhu Riverbed is uneven due to deposits and sedimentation causing random flows. At the sharp curvature, excessive silting takes place during receding flood. To maintain a controlled river flow and prevent random flows, a uniform riverbed gradient has been proposed which is expected to remain intact along the straight portion of the river. However, at the curvature (around the bend of Kaileshwar Hill), the bed gradient may change slightly due to scouring on outer edge and siltation on inner edge during and after flood. Hence, a periodic leveling of the riverbed is recommended which will also ensure consistent embankment heights from the river bed level.

123. The details of river training works are attached as ***Appendix*** 3***.***

124. **Embankment Construction:** A reinforced concrete (RCC) diaphragm wall will be used for riverbed protection which will extend below the normal river scour depth and will be supported using “dead man anchors” and “anchor slab” techniques. A combination of structures with both sloped and vertical embankments will be used based on the location, velocity, impact points and curvature of the river. For protection of the diaphragm wall, boulder rip-rap will be placed to dissipate the high velocity flows on the embankment structure.

125. The Amochhu River will be trained using a robust embankment structure. It will consist of riverbed and bank protection structures. The RCC Diaphragm Wall will be used for riverbed protection which will extend

below the scour depth and will be supported using Dead Man Anchors and Anchor Slabs. For the riverbank protection, a combination of structures (Sloped and vertical embankments) will be used based on the location, velocity, impact points, bends etc. For protecting the diaphragm wall, boulder rip-raps will be placed to dissipate the velocity impact on the diaphragm wall. The different types of embankments are explained below and shown in ***Figure 3-6.***

126. **Slope embankment with stone in wire crates**: In most of the areas the trapezoidal cross-section with slope embankments consisting of stone in wire crates has been proposed. This type structure will be constructed over a length of 10.5 km along the project riverfront. Vetiver grasses will be grown on the slopes of these embankments for aesthetic purpose which will also provide additional protection to the embankments

127. **RCC retaining wall embankment:** Along the outer edge of the curvature, a rectangular cross-section RCC retaining wall has been designed that will withstand the maximum velocity impacts of the river. It will also optimize the space utilization and are particularly appropriate for constrained areas with high flow of water. This structure will be constructed over a length of about 1.8 km at the outer bend of Amochhu.

128. **Stone retaining wall embankment:** Such embankments have stone masonry structures with high load bearing capacity which serves as an alternative to the RCC retaining wall. This type of wall embankment will run about 1.0 km along the inner bend of the Amochhu River at the base of Kaileshwar hill.

129. **Stone pitching embankment:** Stone pitching embankments have large interlocking stones to create small irregular steps that blend into the landscape. Such embankments are proposed to be located in areas less vulnerable to floods with gentle gradient. This form of embankment is proposed in the Zone C, near the India-Bhutan Border. The embankment is expected to run about 1.4 km and at a distance of 1.5 m from the international border.

130. The Construction sequence for embankment work is shown in ***Appendix 4.***

**BACK FILL / LAND RECLAMATION:**

131. Backfilling is then required to create the reclaimed land and will be carried out using selected fill materials that will be spread in layers not exceeding 300mm. The compaction shall be done with 10-ton vibratory rollers for achieving 95% of maximum dry density. After river training and embankment work a total area of **1146 acres** or 464 hectares (approx.) will become available (Zone A: 148 Acres, Zone B: 246 Acres, Zone C: 675 Acres and Zone E: 77 Acres).

***Figure 3-6: The different type of embankments***

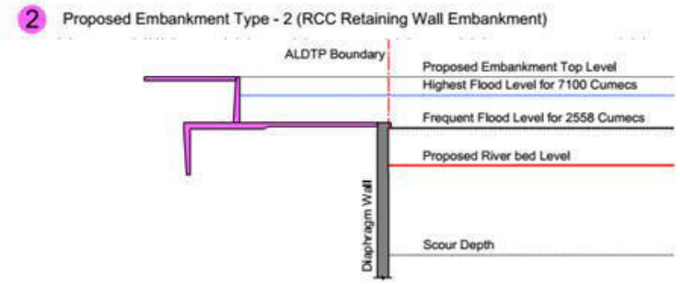



Figure 4.94. RCC retaining Wall

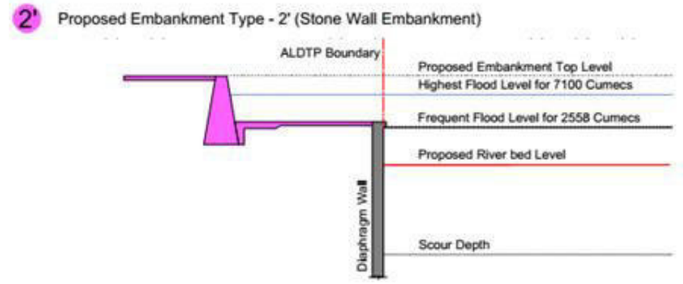



Figure 4.95. Stone retaining Wall

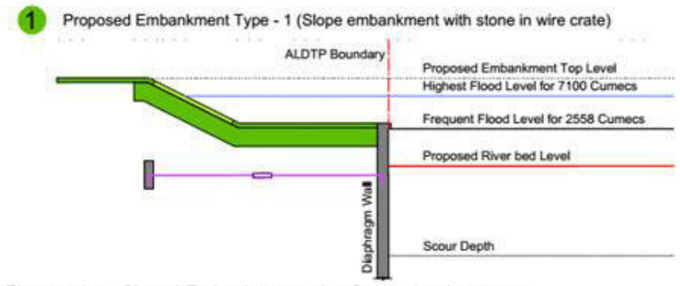



Figure 4.96. Sloped Embankment using Stones in wire crates

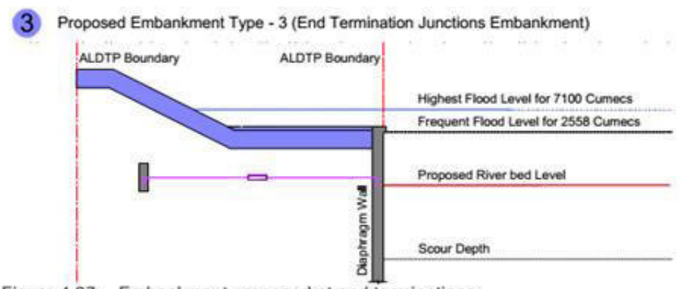



Figure 4.97. Embankment proposed at end terminations

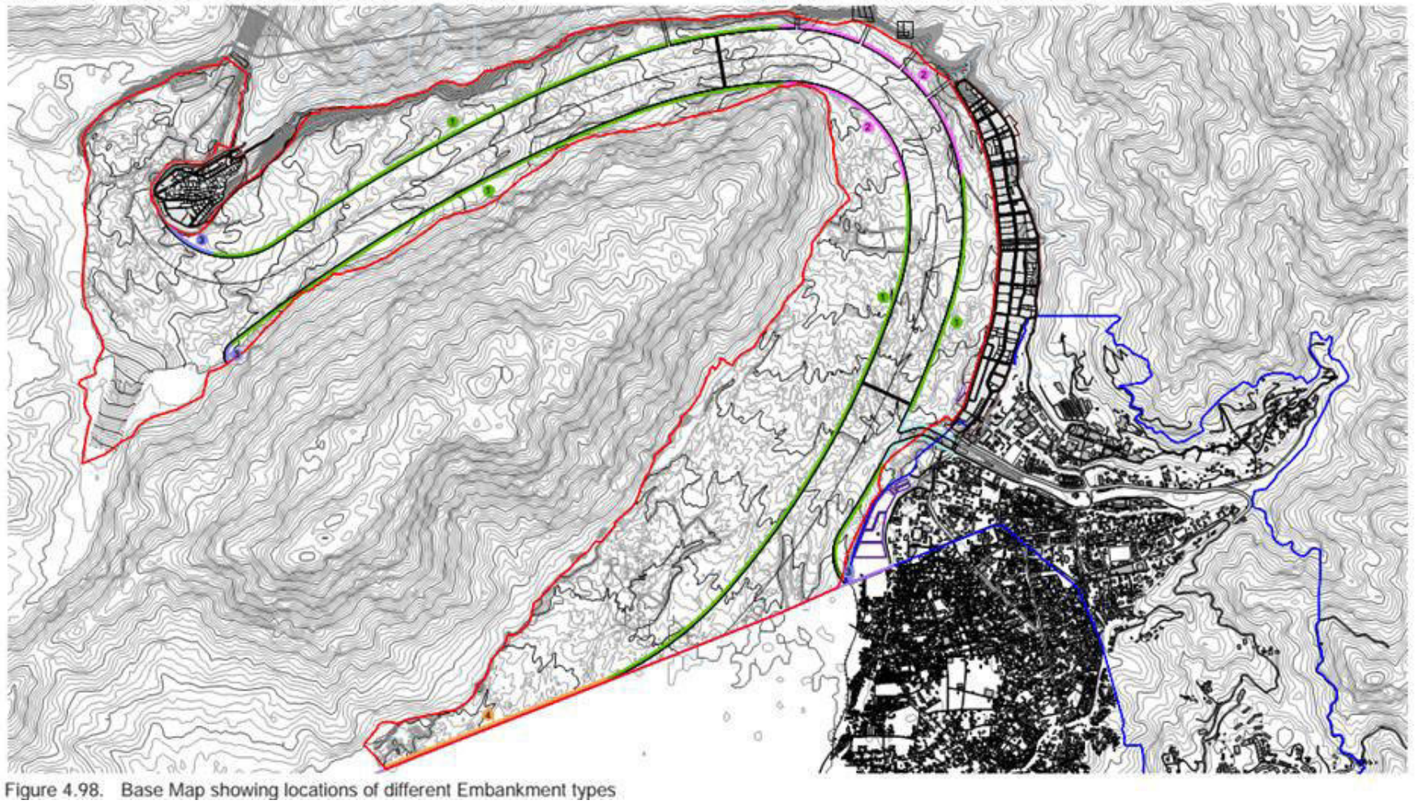


Figure 4.98. Base Map showing locations of different Embankment types

**ALLUVIAL FAN CROSS DRAINAGE**

132. **Alluvial Fan Discharge Cross Drainage:** The steep hill slopes that are aligned on both sides of the river channel vary in their stability and erodibility. Seasonal flows discharge large quantities of water and material forming alluvial fans at the junction with the channel riverbed. Without proper measures to stabilize the slopes and channelize the outfalls, there would be higher risks to the integrity of the embankment. On the eastern side of the river, the slopes are more fragile due to a combination of geology, type and size of material and urban development pressure .Adjoining the Zone A site, there a number of alluvial fans below unstable hill slopes along the proposed Samtse-Phuentsholing Highway. Hill slope stability works will be carried out as part of the Highway project. Cross drainage channels to accommodate the outflow from the alluvial fans have been integrated into the design of all of the embankment structures. Zones on the western side of the river have slopes with higher stability due to geology, less erodibility and extensive vegetation cover down to the river channel.

133. **Cross Drainage Outfall Management:** The Outfall management is proposed as follows:

i From Kaileshwar hills (western bank): There are buffer zones proposed in the Master plan along the base of Kaileshwar hill which will have interconnected detention pond at various locations. These ponds will be kept as natural as possible which will help in reducing the velocity and soil erosion in the premises thus maintaining the natural flow regime of outfalls towards the Amochhu.

ii Hill slope along eastern bank: There are 16 outfalls in total coming from the hills along the eastern bank, out of which 8 has been proposed as open outfalls and the remaining 8 as ducted. The outfalls with large volume of discharge has been designed as open outfalls in order to accommodate the peak discharge and avoid choking of the drainage network. The surface runoff during monsoon from ALDTP will be discharged to these outfalls which will ultimately be connected to Amochhu.

134. The detail figures and diagrams are presented in Appendix 7***.***

**COMMON URBAN INFRASTRUCTURE**

135. CUI refers to the essential infrastructures to be provided and built into the project after land reclamation is done as an essential base for sustainable and quality habitation before building constructions.

136. CUI consist of construction of roads, bridges, water drawl and supply, sewerage system, storm water collection, conveyance and disposal, solid waste system, power supply and distribution system, telecommunication system, firefighting system and flood warning system. These are individually discussed as follows:

**ROADS**

137. A network of streets providing efficient routes will be constructed based on the Master Plan. The roads within the ALDTP consist of river front roads, major arterials, minor arterials, pedestrian walkways and bicycle tracks/lanes. The details of the road networks are attached as ***Appendix*** 35***.***

138. It is important to integrate the road network of the project with the Samtse-Phuentsholing Highway and the Local Area Plan (LAP) which are adjacent to the project area as shown in ***Figure 3-7*** and ***Figure 3-8*** below.

***Figure 3-7: Integration of ALDTP with Phuentsholing LAP and Phuentsholing- Samtse Highway***

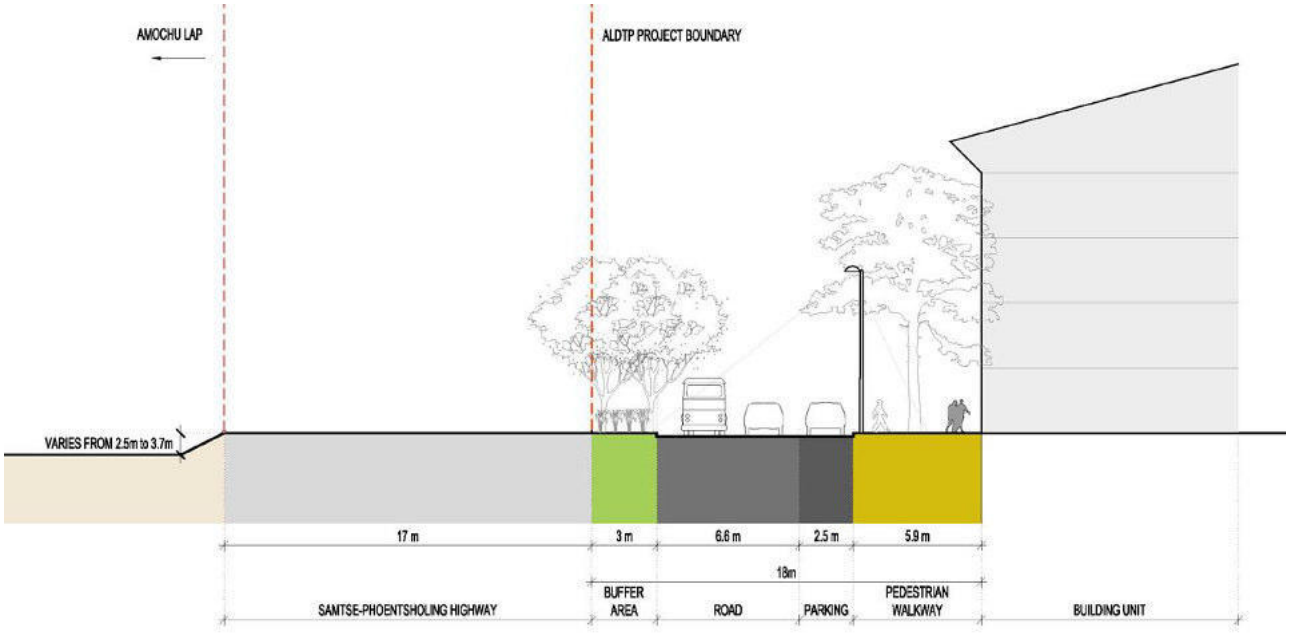
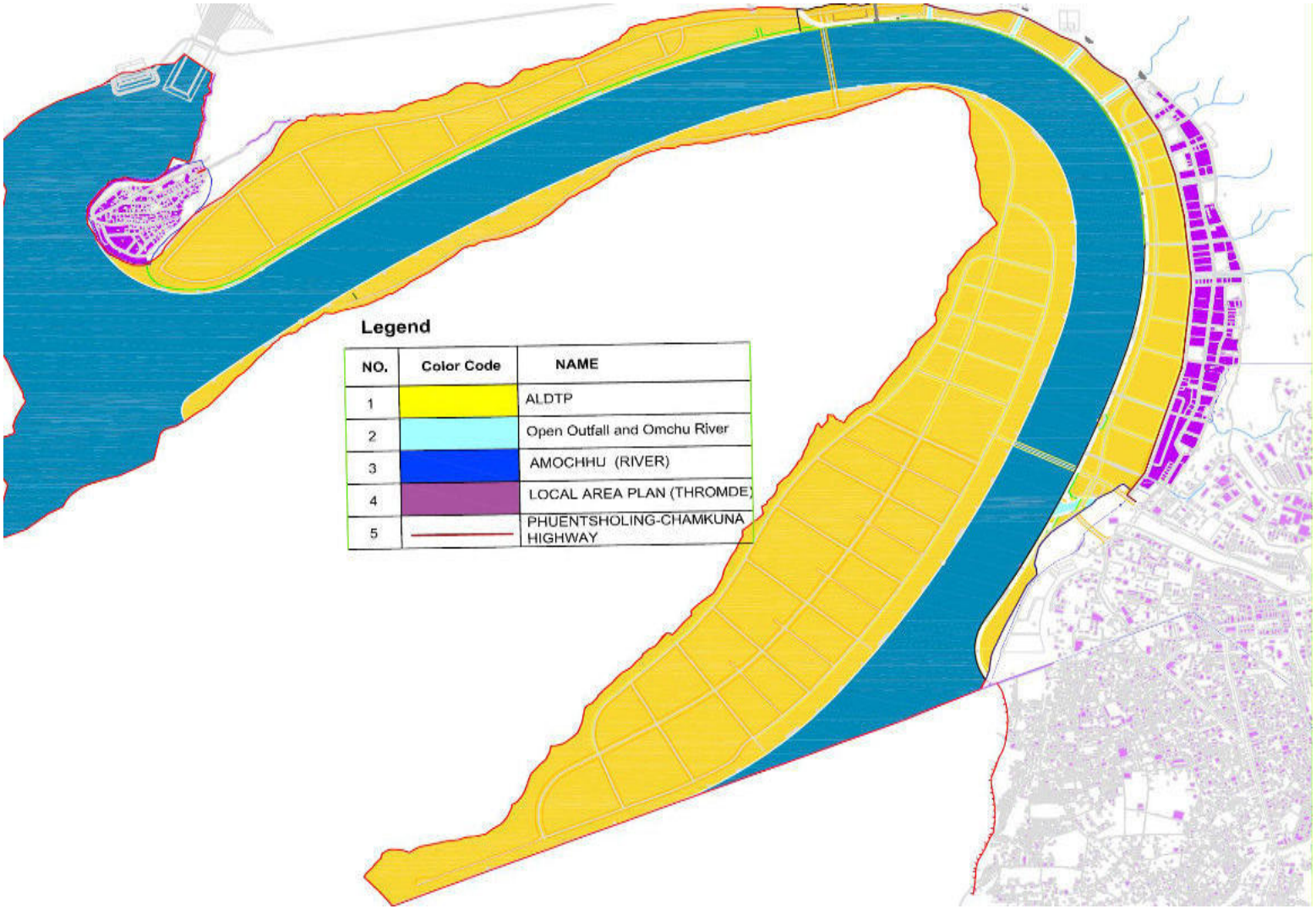


***Figure 3-8: Map showing the Integration of ALDTP with Phuentsholing LAP and Phuentsholing- Samtse Highway***



## BRIDGES

139. **Temporary bridges** will be constructed and used for transfer of construction and fill materials from identified sources to different locations within the Project Site during construction.

140. **Permanent Bridges:** There are two primary bridges proposed for the project with the possibility of an additional one in case of future requirements.

i Primary bridge – from Zone A to Zone C with connection to the city though existing round-about and road along the Omchhu river.

ii Second primary bridge is located further upstream connecting Zone E with Zone B, and from there to the Phuentsholing Samtse highway.

iii A third bridge is envisioned near the Bhutan – India border. This may only be built when the other two bridges are used to optimum capacity causing traffic congestion. The details of the bridges are attached as *Appendix 36.*

## WATER DRAWL AND SUPPLY

### WATER DRAWL AND SUPPLY FOR CONSTRUCTION ACTIVITY

141. During construction stage water is required for various activities. Initially, the water demand is estimated to meet the demands for construction activities like concreting, curing, dust suppression etc. and also for domestic purpose at the construction labour camps and site offices.

142. It is estimated that 100 KLD (70 lpcd[2]) of water will be required for the 1300 (both skilled and unskilled) workers that will be deployed at site during the construction stage. This water will be supplied through a dedicated tube well, and will later be used for irrigating the plantations that will be carried out as part of the project landscape strategy. This water will be fit for drinking purpose with minimal disinfection. The location of the tube well will be close to the labor camp.

143. Further, about 7200 KLD (40-60 lit/m$^2$) of water will be required during the peak construction stage to meet the demand for construction activities. These requirements will be met primarily from the Amochhu surface water flow.

### WATER DRAWL AND SUPPLY FOR PROJECT OPERATIONS

144. The water supply system for the operation stage will be constructed based on the projected population. The estimated water requirement for the operation of the entire ALDTP is shown in **Table 3-9.**

***Table 3-9: Water Demand, Source and Facilities***

| S. No. | Zone | Population | Water Demand (KLD) | Source and Facilities |
|---|---|---|---|---|
| 1 | Zone A + LAP | 15000 (10000 for Zone A and 5000 for LAP) | 4000 | 4 tube wells (including one tube well drilled for construction activities) connected to a water treatment plant comprising of sand filtration and disinfection. |
| 2 | Zone B + Torsa Tar | 5000 | 3000 | Water sourced from the Amochhu River through an intake facility and a water treatment plant |

[2] Litres per capita per day

| | | | | |
|---|---|---|---|---|
| 3 | Zone C + Zone E | 48000 | 8000 | comprising of aeration, flocculation and sand filtration and disinfection. On commissioning of this facility the Zone A + LAP will also be supplied water from this arrangement. |

145. The total water demand estimated is about 17000 KLD (<0.3 KL per second). This amounts to less 1% of the lean season flow of the River (i.e. ~37 KL per second), clearly indicating the sustainability of the project with regards to water management.

146. All technical details pertaining to the water supply system are attached in Appendix 5**.**

## SEWERAGE SYSTEM

### SEWERAGE SYSTEM FOR CONSTRUCTION ACTIVITY

147. The sewage flow during the construction has been estimated based on the population during construction. During this stage, the labour camps will be connected to a septic tank and soak pit system with up-flow filters having capability for providing primary treatment. Community toilets will be provided where the waste water having high organic load from these latrines will be connected to the septic tanks. Generally, 80% of the water consumption (100 KLD of fresh water demand) gets converted to sewerage, based on which four numbers of 25 KLD septic tanks are proposed. The overflow from the up-flow filters from soak pits will be discharged into the nearest streams. The sludge generated from the septic tanks will be cleaned periodically by the local operator at Phuentsholing. No waste water will be disposed into the river without treatment. At minimal an activated carbon will be used.

### SEWERAGE SYSTEM FOR PROJECT OPERATION

148. For the operation of the project, the design of the sewerage system was proposed considering (i) Service Delivery Norms (ii) Identification of Deficiency Areas, and (iii) Estimation of Demand.

149. Sewage Treatment Plant (STP) has been designed as **Sequential Batch Reactor** (**SBR) System** which is cost effective and space efficient. The system will allow for discharge of treated effluent meeting required norms set by Environmental Standards, Bhutan, 2010 and by Central Pollution Control Board (CPCB), India. The capacity of the STP proposed for different zones is shown in ***Table 3-10.*** And the details are attached In ***Appendix 6.***

***Table 3-10: STP location and Capacity***

| S. No. | Zone / Area Served | STP Capacity Proposed |
|---|---|---|
| 1 | Zone-A and LAP Area | 3.00 MLD x 1 No. = 3.0 MLD |
| 2 | Zone-B and Toorsa Tar | 1.50 MLD x 1 No. = 1.50 MLD<br>& 0.3 MLD x 1 No.= 0.3 MLD |
| 3 | Zone-C | 3.00 MLD x 2 Nos. = 6.0 MLD |
| **4** | **Total STP Design Capacity** | **10.8 MLD** |

## STORM WATER MANAGEMENT

150. The average annual rainfall in the region is about 2500mm and the peak intensity is 100mm/hr. During construction stage, the labour camps and office areas will be hard paved. The runoff from the hard paved area will be allowed to infiltrate into the natural ground or discharged into Amochhu with proper screening arrangements.

151. The annual precipitation is in the range 4000–5000 mm in the monsoon (peak season) between April and October leading to substantial run-off and consequent Storm water generation. The project development phase is to be considered for 15 years with 2017 as the base year. The overall system has been designed for the next 30 years (2021-2051).

152. RCC pipe network has been proposed along the road in utility corridor along with the inspection manholes at an interval of 30m. The runoff from the premises shall be collected into this network which will be connected to the existing river without changing the flow pattern.

## SOLID WASTE MANAGEMENT

### SOLID WASTE GENERATION AND MANAGEMENT - CONSTRUCTION

153. For the construction stage, the solid waste will be generated from the labour camps, site offices and construction which will mainly comprise of the biodegradable, non-biodegradable and construction waste. The estimated solid waste generation and management plan during construction stage is as provided in in ***Table 3-11.***

***Table 3-11: Waste Estimates for Construction stage***

| SN | Source | Quantity (MT/Day) | Source | Collection | Storage | Recycling and Treatment | Disposal |
|---|---|---|---|---|---|---|---|
| 1 | Construction waste | 0.60 | Project Site | Manual or Vehicle | Storage yard within Project Site | Scrap metal will be sold to scrap dealers | Cement and concrete wastes will be used as fill material |
| 2 | Bio degradable waste | 2.25 | Labour camp and offices | Manual | Green Bins | Composting | Manure for landscaping |
| 3 | Non bio - degradable waste | 1.5 | Project Site, Labour Camp, Offices | Manual | Blue Bins | Scrap dealers | Landfill (Phuentsholing Thromde) |
| 4 | Total | 4.35 | - | - | - | - | - |

### SOLID WASTE GENERATION AND MANAGEMENT - PROJECT OPERATION

154. For the operation stage, the solid waste will be generated from the residential area, commercial areas, hospitality, institutional etc. The waste generated will mainly comprise of biodegradable and non-biodegradable waste, the detail of which is produced in of which is produced in ***Table 3-12*** and ***Table 3-13.***

***Table 3-12: Waste Generation during Project Operation***

| S. No. | Description | Unit | Residential | Non-Residential | Total |
|---|---|---|---|---|---|
| 1 | Residential Population | Nos. | 48500 | 25600 | 74100 |
| 2 | Per Capita Waste Generation | kg/capita/day | 0.40 | 0.20 | - |
| 3 | Total Waste Generation | Tonnes per day | 19.40 | 5.12 | 24.52 |
| 4 | Biodegradable Waste (~65% of total) | Tonnes per day | 12.60 | 3.33 | 15.94 |
| 5 | Non- Biodegradable Waste | Tonnes per day | 6.79 | 1.79 | 8.58 |

| S. No. | Description | Unit | Residential | Non-Residential | Total |
|---|---|---|---|---|---|
| | (~35% of total) | | | | |
| 6 | Inert Waste (~10% of non-biodegradable) | Tonnes per day | 1.02 | 0.27 | 1.29 |

***Table 3-13: Waste Estimates for Operation stage***

| S. No. | Source | Qty. (MTD) | Source | Collection | Storage | Recycling and Treatment | Disposal |
|---|---|---|---|---|---|---|---|
| 1 | Bio degradable waste | 15.94 | Residential/ commercial & other area | Manual / Vehicles | Transportation to the Treatment yards | Wind row composting | Manure for landscaping |
| 2 | Non bio - degradable waste | 8.58 | Residential/ commercial & other area | Manual / Vehicles | Transportation to the Treatment yards | Segregation and storages within SWM | Selling out the Scrap dealers |
| 3 | Inert Waste | 1.29 | Residential/ commercial & other area | Manual / Vehicles | Transportation to the Treatment yards | Transportation to the landfill | Landfill (Phuentsholing Thromde) |
| 4 | Total | 24.52 | - | - | - | - | - |

155. There are 2 solid waste segregation and management yards proposed within the project area. The treatment facility will be developed in 2 phases in Zone-A and Zone-C respectively. The solid waste management facility proposed is in the tune of 30 tonnes (15 tonnes each) for the ultimate stage.

156. No sanitary landfill is proposed considering the risk of surface or soil / groundwater contamination. Inert waste (after segregation in the solid waste management yard) will be sent to the existing landfill site in Phuentsholing Thromde during operation of Zone A. However, upon the development of the future zones the existing landfill will be jointly developed / upgraded in close consultation with the Phuentsholing Thromde administration.

157. It is also expected that the medical waste will be generated from the ALDTP. The treatment facility for the medical waste has not been proposed within the Solid waste management yard. The medical waste treatment facility has to be developed by the respective developer within the premises of the specific medical facility areas. Prior to the construction of any medical facilities, clearance and approvals need to be sought from the relevant competent agency like Ministry of Health. The details of the solid waste management are provided in ***Appendix*** 8***.***

**POWER SUPPLY AND DISTRIBUTION SYSTEM**

158. The temporary (construction) and permanent (operation) power supply requirement is proposed in ***Table 3-14*** and the details of the power supply can be seen in ***Appendix 9.***

***Table 3-14: Power supply Requirements***

| **Zones** | **Temporary** (construction) | **Permanent** (operation) |
|---|---|---|

| | | |
|---|---|---|
| Zone A | 150 kVA | 18,000kVA |
| Zone B | 150 kVA | 18,000kVA |
| Zone C and E | 250 kVA (in two phases) | 54,000kVA in two phases of 27000 kVA of each phase |

159. The ALDTP infrastructures will provide ducts for laying of power cables. The service provider will install the substations of required capacity at the designated area from where the power supply will be distributed.

**TELECOMMUNICATION SYSTEM**

160. The telecommunication system requirement has been defined based on the number of household, capacity of the existing infrastructure in the vicinity, present status of the development, living standards, economy group, general requirement for the residential and commercial development. Presently there are about 10,750 residential units proposed as per the master plan. At the same time, there are some commercial premises of school, institutions, and shopping areas.

161. The ALDTP infrastructures will provide ducts for laying of telecommunication cables. Through these ducts the service provider will be required to install the necessary telecommunication facilities in the area.

**FIRE FIGHTING SYSTEM**

162. During Project construction, the firefighting equipment will be installed and maintained as per the project's Occupational Health and Safety Plan. For the construction period, the primary firefighting system in the form of dry chemical extinguisher will be installed at identified locations. These areas are mainly labour housing, site offices, project offices and electrical installations. The construction & labour colonies will be developed with the proper access roads (minimum 6m width) in case of emergency.

163. During Project operation the firefighting system will be maintained based on their schedules and operated by authorized national agency. The firefighting systems during the operation of ALDTP is shown in Table 3-15.

***Table 3-15: Fire system requirement based on building typology***

| S. No. | Type of the Building | Height of the Building | | |
|---|---|---|---|---|
| | | **Height up to 15 m** | **More than 15m not exceeding 35m** | **More than 35 up to 45 m** |
| 1 | Residential Building: Apartment Houses | Fire extinguishers, overhead tank 5.00KL if basement exceeding 200M² | Fire extinguishers, hose reel, down comer, Automatic sprinkler if basement exceeds 200 M², manually operated fire alarm system, terrace level storage tank 10KL, pump with 450LPM flow. | Fire extinguishers, hose reel, down comer, Automatic sprinkler if basement exceeds 200 M², manually operated fire alarm system, terrace level storage tank 25KL, pump with 900LPM flow at 2kg/cm² pressure, UGT 75KL. |
| 2 | Hotels: | Fire extinguishers, Hose reel, Wet riser, | Fire extinguishers, Hose reel, Wet riser, | Fire extinguishers, Hose reel, Wet riser, automatic sprinkler if basement area |

| S. No. | Type of the Building | Height of the Building | | |
|---|---|---|---|---|
| | | **Height up to 15 m** | **More than 15m not exceeding 35m** | **More than 35 up to 45 m** |
| | | automatic sprinkler if basement area exceeds 200m², Fire alarm, UGT min. 50KL, OHT 10KL pump 450 LPM at 2 kg/cm² | automatic sprinkler if basement area exceeds 200M², Fire alarm, UGT min. 150KL, OHT 20KL pump 900 LPM at 2 kg/cm². | exceeds 200M², Fire alarm, UGT min. 200KL, OHT 20KL pump 900 LPM at 2 kg/cm². |
| 3 | Educational Building: | Fire extinguishers, automatic sprinkler if basement area exceeds 200m², OHT 10KL pump 450 LPM at 2 kg/cm². | Fire extinguishers, Hose reel, Wet riser, automatic sprinkler if basement area exceeds 200m², Fire alarm, OHT 25KL pump 450 LPM at 2 kg/cm². | |
| 4 | Commercial Building: | Fire extinguishers, hose reel, Fire alarm & detection, wet riser, hydrants, automatic sprinkler if basement area exceeds 200m², UGT 100KL, OHT 5KL 450 LPM at 2 kg/cm². | Fire extinguishers, hose reel, Fire alarm & detection, wet riser, hydrants, automatic sprinkler if basement area exceeds 200M², UGT 200KL, OHT 5KL 450 LPM at 2 kg/cm². | Fire extinguishers, hose reel, Fire alarm & detection, wet riser, hydrants, automatic sprinkler if basement area exceeds 200m², UGT 200KL, OHT 5KL 900 LPM at 2 kg/cm². |

**FLOOD WARNING SYSTEM**

164. The project is proposed above the highest flood recorded as per the design. Due to threats posed by Amochhu, a flood warning system will be established for detecting threatening flooding events in advance. This will enable the public to be warned that actions can be taken to reduce the adverse effects of the event. As such, the primary objective of a flood warning system is to reduce exposure to flooding of all the Project Infrastructure and residents. The flood warning system will be monitored in a control room within the Project office and will be maintained as per specifications to keep it functioning at all times. The infrastructure master plan showing the location of the utilities are shown in ***Appendix 37.***

165. For the entire operation of the project, the flood warning system would comprise the following components:

i. Rainfall and water level sensors at selected locations
ii. Data loggers for the rainfall and water level data
iii. Satellite based transmission of the rainfall and water level data
iv. Reception of the satellite transmissions at a central control
v. A computer based system to monitor the status of the rainfall and water level, with a range of alert levels
vi. A procedure for warning dissemination via various media
vii. Procedures for action by the emergency services and the public

166. The flood warning system network will be strengthened by installing additional rainfall and water level gauging stations in the upstream catchment in addition to the existing ones. Information on flood will be transmitted to the flood warning center set up within the ALDTP from the gauging stations by means of satellite communication. The nearest existing hydrological stations are at Dorokha, Doyagang and Hashimara (India). There are few existing rain gauges at Dorokha, Doyagang, Dhuti Khola, Sewage Treatment Plant and Hashimara (India).

167. In the proposed Flood Warning Centre in ALDTP, sensors will be installed which will provide warnings using the SCADA system. At the time of frequent flood, warnings if any, will be disseminated to the public every 2 hours. If the situation demands, evacuation works will be carried out by the fire and safety agency.

168. When the flood reaches frequent flood level, local authorities or Thromde will be intimated, who in turn will share the information with relevant officials across the border. If required, the information for the rainfall and water level gauging stations could be shared with any downstream users through an integrated information system.

169. The details can be referred under ***Appendix 38.***

**LANDSCAPING**

**LANDSCAPE AND GREEN BELT DEVELOPMENT**

170. The Landscaping and the Green belt development plays an important role in the development of the project. There are primarily three zones the Forest zone, Buffer zones and the Biodiversity Park which contributes to the landscaping strategy. The creation and preservation of such habitats will have a large impact on the lifestyle of the residents.
171. There are extensive existing grasslands in Zone C which will be disturbed during construction of Zone C. In order to compensate for the loss of these grasslands, a large bio-diversity park has been proposed in the Master Plan.
172. A detailed Landscape Assessment and Strategy for the ALDTP is attached as ***Appendix 40.***

**CONSTRUCTION STAGE DECOMMISSIONING PLAN**

173. Once the construction activities of various components listed above are completed, de-commissioning activities are required to be undertaken. These would typically include Waste and scrap disposals, removal of construction equipment, formwork removal (for RCC structures), etc.

174. Some of the de-commissioning plan include but not limited to the following activities:

i Inventory of all plant and equipment to be removed;

ii Removal of all mobile construction equipment deployed at various locations from the site. These could typically include removal and transportation of equipment like Dumpers, Dozers, JCBs, and Cranes etc. away from the site;
iii Decommissioning and removal of Batching and crushing plants;
iv Hydraulic testing of all water retaining structures constructed in the project;
v Clean up of all spillages;
vi Disposal of all wastes including scrap in an environmentally sound and legally accepted manner;
vii Dismantling of labour colonies including toilets;
viii Phasing out of all labour and construction site supervisor staff;
ix Closure of on-site material testing laboratories;
x De-commissioning / Emptying soak pits of toilets constructed for Construction stage;
xi Final checks before handing over the sites / equipment before closure;
xii Maintaining records and documentary evidence of all de-commissioning activities.

### 2.1.4 OPERATION AND MAINTENANCE STAGE

175. The details pertaining to different activities during the operation and maintenance phase of the project are described as follows:

i Observation and maintenance of river embankment structures.
ii Roads and traffic management.
iii Bridge maintenance.
iv Operation and maintenance of water drawl and supply facilities.
v Operation and maintenance of sewerage system.
vi Storm water management.
vii Operation of solid waste management facilities.
viii Operation of power supply and distribution systems.
ix Operation of telecommunications systems and
x Maintenance of existing landscape works.

#### OBSERVATION AND MAINTENANCE OF RIVER EMBANKMENT STRUCTURES

176. Periodic observation is required after the construction of river training structures in order to plan for timely maintenance of the river training structures, embankments works and river bed levels. Periodic maintenance will be required after each subsequent flood to prevent the flood hazards.

177. The following post construction measures shall be carried out for ALDTP:

i. Maintenance of river bed level with temporary river training and bed levelling
ii. Maintenance of river embankment structures like Diaphragm wall.
iii. Maintenance of Dead Man Anchor / Anchor Slab.
iv. Maintenance of Embankment including stone in wire crates, paver block and vetiver grass (10.5 km) over dead man anchor, Stone retaining wall over anchor slab, RCC retaining wall over anchor and Stone pitching works.

#### ROADS AND TRAFFIC MANAGEMENT

178. Road markers will be repainted annually with thermoplastic paint. Pavements/footpaths/sidewalks will be maintained annually.

**MAINTENANCE OF BRIDGES**

179. Generally excessive scour occurs at bridge piers. If excessive scour is observed than predicted scour, bridge protection shall be carried out by garlanding the pier by PCC blocks placed over geo-synthetic filter membrane. The PCC blocks will launch in scour holes during scour and prevent further scour around pier and abutment.

180. Bridge structure will be repainted every five-years with anti-carbonate paint. Flood/water level markers and surface markers will be repainted annually.

**OPERATION AND MAINTENANCE OF WATER DRAWL AND SUPPLY FACILITIES**

181. For the operation of the water supply facility in the project, three systems are found to be feasible - gravity, pressurized and hybrid (combination of gravity and pressurized). Being located in an undulating topography the hybrid type of water distribution is more reliable and workable and therefore suggested.

182. For improved efficiency of water supply in the ALDTP area, the following advanced systems will be implemented:

i Metered water supply – accountability, identification of losses, avoid wastage, reduce overall costs.

ii SCADA system – The Supervisory Control and Data Acquisition (SCADA) is a system operating with coded signals over communication channels to provide control of remote equipment. In ALDTP, a SCADA system will be monitoring the entire flow of water from the intake point to final distribution and thus identify theft, losses and leakages in the system. The Inlet and output raw water will also be monitored as per the provided standards and accordingly the treatment will be automatically controlled to obtain potable water.

183. The metered supply shall be integrated with the SCADA system. The billing and recovery system will be in place with telescopic tariff structures.

**OPERATION AND MAINTENANCE OF SEWERAGE SYSTEM**

184. Sewerage Treatment Plants (STP) have been designed using the Sequential Batch Reactor (SBR) System - a cost effective & area economical design.

185. All sewerage main and trunk lines from the leased premises till the sewerage treatment plants will be maintained to prevent blockages and leakages. Scheduled maintenance of Sewerage Treatment Plants (STPs) will be carried out to ensure its functionality. The sewerage system will be operated and monitored with the help of SCADA system. The waste water from the STPs will be tested periodically to check if it conforms to the national water discharge standards. The Running and Maintenance (R&M) of sewerage systems will be outsourced to a competent independent Service Provider for efficient service delivery.

186. The operational standards include regular checking of the electro-mechanical parts of the STP. The regular operation required for STPs are intake water weir, screens, grit chamber, sludge disposal system and recirculation system. Periodic maintenance along with providing adequate barriers in the form of green belt around STP will be provided to prevent odour generation and nuisance.

187. The sludge produced will be taken for windrow composting which will be used later as a soil conditioner for horticultural purpose for the project landscape.

**STORM WATER MANAGEMENT**

188. The storm water drainage system includes storm water drainages, ground water recharge wells and, open and ducted channels for outfalls from the hill sides. The storm water drainage and pipelines once constructed will be regularly inspected and cleaned during pre-monsoon and post monsoon seasons. The rubbish and silt that has been removed from the drainage system will be taken to the existing sanitary landfill site at Phuentsholing Thromde.

189. Cleaning and maintenance of these facilities will be carried out on scheduled periods to prevent blockages and leakages and to ensure that the storm water is safely discharged to the ground water and Amochhu to maintain the ground water levels.

**OPERATION OF SOLID WASTE MANAGEMENT FACILITIES**

190. Solid Waste Management will be taken up in a planned manner to avoid littering and piling up of waste. Waste will be segregated at source by providing colour coded bins for separate disposal of organic and inorganic wastes. These wastes will then be collected on schedules and transferred to waste segregation yards. All the recyclable wastes will be handed over to recyclers, organic waste will be decomposed and used as manure for project parks and landscaping. Possibility of treating all inorganic waste with available technologies such as energy recovery etc. will be explored with land filling as the last option. Solid waste management will be outsourced to independent Service Provider whose operations will be supervised by ALDTP.

**OPERATION OF POWER SUPPLY AND DISTRIBUTION SYSTEMS**

191. Electrical Infrastructure till the energy meter point of Lessee premises will be handed over to Bhutan Power Corporation Ltd. (BPC) for R&M since they are the only Government agency in the country mandated for transmission and distribution of electricity. Maintenance of Electrical Infrastructure will be carried out as per the maintenance schedule adopted by BPC.

**OPERATION OF TELECOMMUNICATIONS SYSTEMS**

192. Similar to electrical Infrastructure, the R&M of telecommunication Infrastructure will be taken up by authorized telecom Service Providers in the country. All telecom related maintenance will be carried out based on the telecom operators' schedules.

**MAINTENANCE OF THE EXISTING LANDSCAPE WORKS**

193. The total area for green spaces is about 130 Ha (riverfront greens + green buffer). An additional area of 5 Ha is reserved for Neighborhood parks and gardens. This strategy covers landscaping for hill slope stability, green spaces and bio-diversity Park within the Project boundary recommending technologies and various plant species that could be used in these areas. To avoid invasion, most of these species are those which are locally available or those which are suited to the climatic conditions of Project area.

194. The periodic maintenance will be carried out for existing community parks and gardens, pocket parks, natural and semi-natural spaces, riverside promenade / parks, green corridors, outdoor / stadia amenity green spaces, roadside green spaces, city farms, and greenery incorporated in cultural centres. Landscaping being critical and since it involves a lot of expertise, this will be implemented, operated and maintained with the help of independent service providers with proven experience.

195. For the smooth running and maintenance of the facilities within the premises and safety in operations within Project, a ***Running and Maintenance Guidelines for ALDTP*** has been proposed which is attached as ***Appendix 42.***

# 4 BASELINE ENVIRONMENT DATA

## 4.1 INTRODUCTION

196. The baseline is the environmental condition in the absence of the project and is constituted by its physical, biological and socio-economic characteristics. It is in this environment that the proposed project and various activities will take place and for which resultant impacts are anticipated. The mitigation measures are implemented to minimize these impacts and maintain the environmental conditions as close to the baseline as possible.

### STUDY AREA ZONES

197. The study area was divided in two zones, namely, 'Core Zone' and 'Buffer Zone'. The Core Zone is the ALDTP area where the development activities are planned. The Buffer Zone is an area of 1.0 km around the edge of the ALDTP project area as specified in the ToR issued by the NEC.

### SECONDARY DATA COLLECTION

198. Secondary data plays an important role in the proper assessment of the baseline conditions and provides background and contextual information before the start of primary data collection regarding the historical and present conditions of the area. Secondary data are collected from already published and reliable sources. For the ALDTP project secondary data on existing environment, ecology and demography were collected from various sources, including:

- Publication of The Royal Govt. of Bhutan including guidelines, acts, reports, policy documents
- Other data and documents collected including maps, data, guidelines and reports
- Information from authentic websites associated with the subject matter.

### PRIMARY DATA COLLECTION

199. The following was studied with respect to the environmental baseline:

| Physical Environment | Biological Environment | Socio-Economics |
|---|---|---|
| • Land use – land cover pattern<br>• Ambient air quality<br>• Site specific meteorological condition<br>• Ambient noise quality<br>• Water resources – surface and ground<br>• Hydrology and flood condition<br>• Geology, earthquake and landslide condition<br>• Soil quality | • Terrestrial Ecology<br>• Aquatic Ecology | • Social and economic baseline including demography, social profile, infrastructure and social need assessment |

200. For the physical environment, sampling and analysis with respect to ambient air, meteorology, water quality, soil quality and noise, were carried out by M/s Kadam Environmental Consultants, Vadodara, Gujarat, India, a MoEFCC (Ministry of Environment, Forests and Climate Change, Govt. of India) gazette environmental laboratory and a laboratory accredited by National Accreditation Board for Testing & Calibration Laboratories (NABL).

201. A limited, site laboratory was established within Phuentsholing for the purpose of analyzing the baseline parameters and other samples that could not be sent to India. The data was collected over two seasons as per the NEC's ToR for the project.

## 4.2 LANDUSE

202. For the secondary data, the map with some topography and land use (Figure 4-1) prepared by National Land Commission for the project was used and for primary data, remote sensing data with high resolution Google earth Pro and a reconnaissance survey was conducted. Table 4-1 enumerates the land features and its corresponding GPS readings of all the ground truth locations selected.

Figure 4-1: Topography & Land Use Overlay map

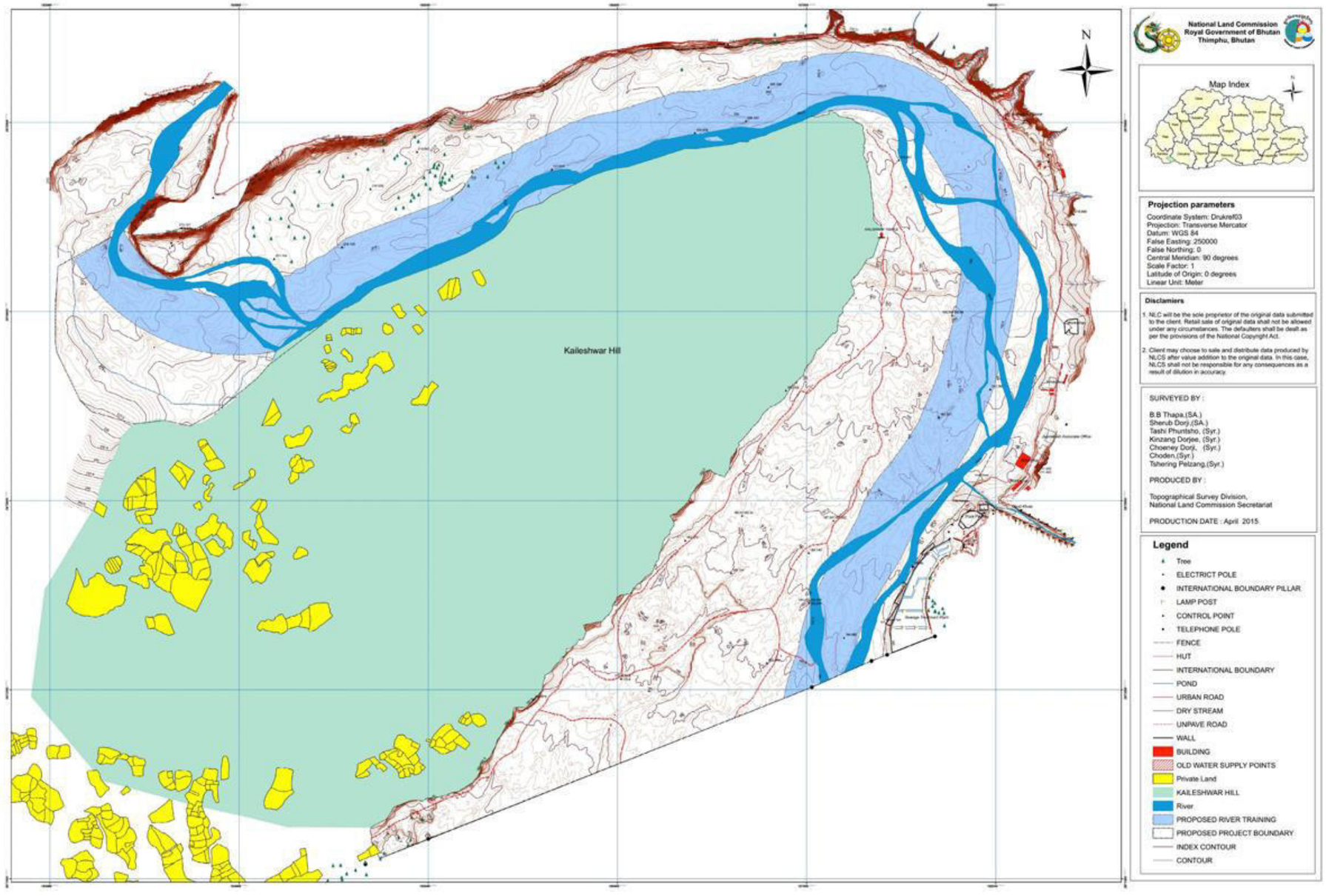


***Table 4-1: GPS reading within the ALDTP study area***

| S. No. | Location | Photograph | Photograph Location Co-ordinates | Land use / Land cover classification | Observation / Remarks |
|---|---|---|---|---|---|
| 1. | River area behind parking |  | 26°51'53.5" N; 89°22'22.2" E; Elevation: ~193 | Vegetation | Grasses in the river body between waste water flow and main river |
| 2. | West side of STP in River body |  | 26°51'36.9" N; 89°22'13.0" E; Elevation: 183 | Water body | Observed Sewage discharge into river |
| 3. | Near Chamkuna |  | 26°53'16.1" N; 89°21'41.2" E; Elevation: 221 | Water body | Stream coming from Hill<br>SW sampling collection SW08 |
| 4. | Doyagang Village |  | 26°53'11.6" N; 89°19'11.8" E; Elevation: 328 | Habitation | This area is having human settlement on the way to Samtse, which is also district HQ. Arecanut, palm and mango are cultivated here. |
| 5. | Near Purvey |  | 26°53'0.7" N; 89°19'5.4" E; Elevation: 252 | Water body | River namely Lorika (Lodarika) between villages Purvey and Doyagang on the west part of study area, upstream |
| 6. | Near Purvey |  | 26°52'27.0" N; 89°19'39.8" E; Elevation: 231 | Water body | Riparian vegetation in river bed-Amochhu river |
| 7. | Near Purvey Foothill of Kaileshwar |  | 26°52'14.2" N; 89°19'40.8" E; Elevation: 232 | River | Dry river on foothill of Kaileshwar on west bank of river Amochhu (on up-stream side of |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Project). These dry river beds are a common feature of the Region and are typical of the Himalayan foothills |
| 8. | Near Purvey |  | 26°52'33" N; 89°19'33.5" E; Elevation: 239 | Road | Approach road to Purvey on west bank of the Amochhu in study area |
| 9. | Near Mobile tower |  | 26°52'2" N; 89°22'28.9" E; Elevation: 184 | Water body | Location where the Omchhu (Dhuti Khola) river meets the Amochhu river |
| 10. | Near Torsa Tar Village |  | 26°52'33.2" N; 89°20'28.1" E; Elevation: 225 | Water body | SW Sampling Location SW02 Kaileshwar Hill, west side |
| 11. | Near Torsa Tar |  | 26°52'40.5" N; 89°20'16.3" E; Elevation: 226 | Vegetation | Dense vegetation on west bank of river |
| 12. | Western area Amochhu River |  | 26°57'7.8" N; 89°20'47.0" E; Elevation: 176 | Vegetation | Vegetation at foothill of Kaileshwar Hill on area on western bank of the Amochhu |
| 13. | Amochhu River |  | 26°50'52.1" N; 89°20'20.5" E; Elevation: 177 | Land Without Scrub | India-Bhutan border marker |
| 14. | Amochhu River |  | 26°50'45.8" N; 89°20'3.6" E; Elevation: 174 | Agriculture | Farm near India-Bhutan border with temporary structure (watch tower) and wooden fencing |
| 15. | Phuentsholing |  | 26°52'44.2" N; 89°22'45.4" E; Elevation: 213 | Habitation | Built structures / houses, Dutay |

| | | | | | |
|---|---|---|---|---|---|
| 16. | Phuentsholing |  | 26°53'3.3" N; 89°22'34.9" E; Elevation: 221 | Habitation | Dutay Market / Bangay Bazar. This is a temporary trading centre for dispatch of Bhutanese oranges to different markets outside Bhutan |
| 17. | Chamkuna Village |  | 26°53.3'19.5" N; 89°21'54.1" E; Elevation: 225 | Habitation | Habitation, hilly area, Amochhu east bank |
| 18. | Chamkuna Village |  | 26°53.3'19.7" N; 89°21'50.8" E; Elevation: 235 | Agriculture | Village houses and subsistence farming |
| 19. | Phuentsholing |  | 26°51'40.4" N; 89°22'50.7" E; Elevation: 218 | Habitation | Entry Gate, Indo-Bhutan border |

**KEY FINDINGS**

203. It was observed from the study that the dominant land cover is *natural vegetation* comprising 36.46% of the total core area, followed by *forested area* of 25.19% of the total ALDTP and *mostly covering the Kaileshwar Hill* (which falls outside project boundary). While the natural vegetation (found in areas outside the Kaileshwar Hill) consists mostly of open types along with scrubs and medium trees, the dominant forest type is closed forest in the Kaileshwar Hill.

204. The next land cover type is wastelands covering nearly 12%. Mostly is sandy type and is scattered throughout the area. Grassland in the Zone C covers an area of 6.34% of the total Core area, while the water bodies including the Amochhu River covers area of 4.12%. Over 200Ha of Zone C is made up of riparian and grassland vegetation.

205. Land use classes based on the land use study, mapping and estimation and the area statistics are presented in ***Table 4-2***

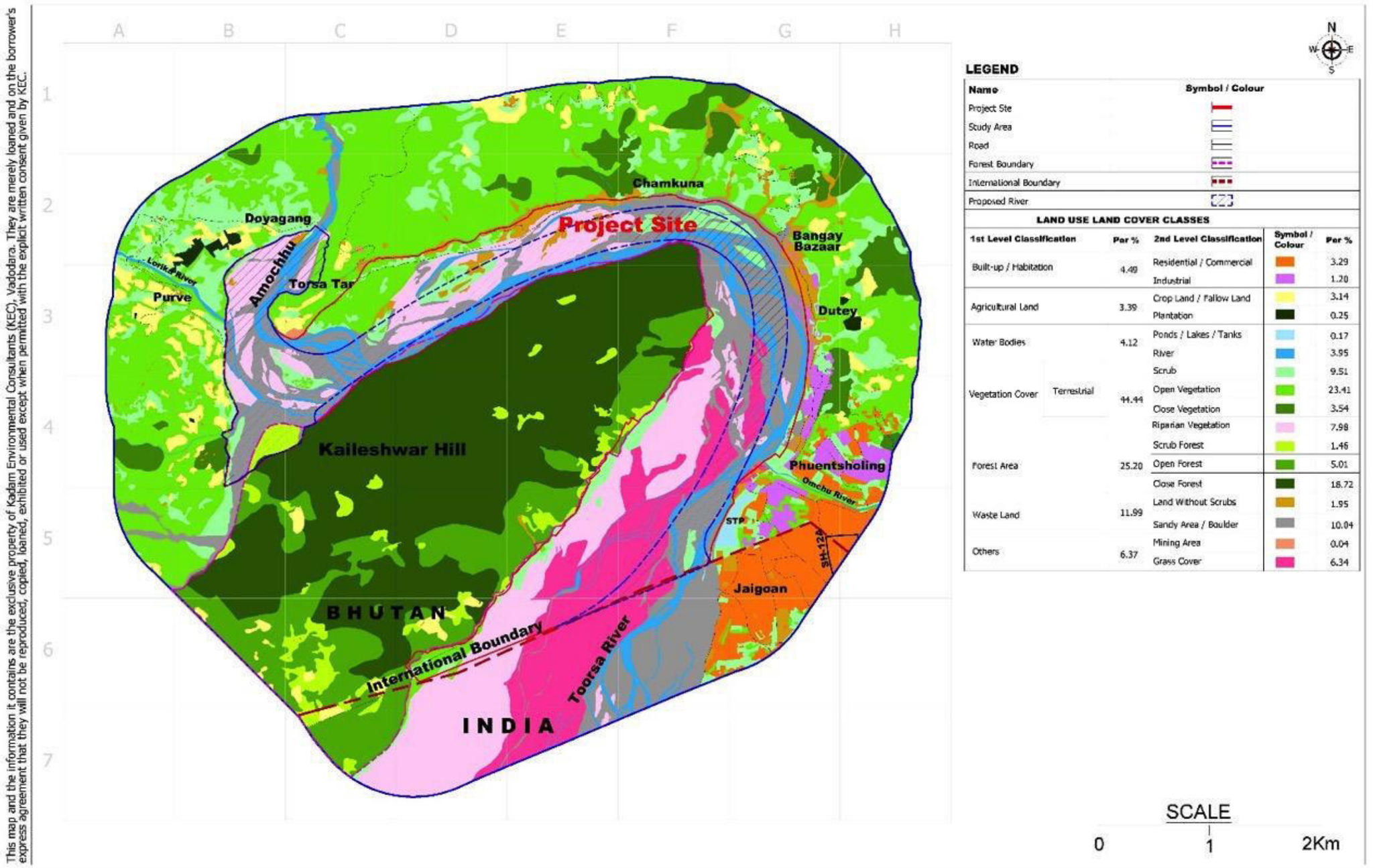
***Table 4-2: Area Statistics for Land Use / Land Cover Categories in the ALDTP Study Area***

| S. No. | Level 1 Classification | | Level 2 Classification | Area, Level 2 Class(Zone A) | Area, Level 2 Class(Zone B) | Area, Level 2 Class(Zone C) | Area, Level 2 Class(Zone E) | Area, Level 2 Class (Proposed Trained River) | Area, Level 2 Class(All Zones including River) | | Area, Level 1 Class( All Zones Including River) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ~Ha. | ~Ha. | ~Ha. | ~Ha. | ~Ha. | ~Ha. | ~% | ~Ha. | ~% |
| 1. | Built-up Land or Habitation | | Residential / Commercial | - | - | - | - | - | - | - | 0.9 | 0.11 |
| | | | Industrial | 0.9 | - | - | - | - | 0.9 | 0.11 | | |
| 2. | Water Bodies | | Pond/Lakes/Tanks/Reservoir | 0.2 | - | - | - | - | 0.2 | 0.02 | 93.86 | 11.30 |
| | | | River | 14.8 | 8.8 | 6.4 | 16.86 | 46.6 | 93.46 | 11.28 | | |
| 3. | Vegetation Cover | Terrestrial | Scrub | 4.6 | 12.9 | 23.0 | - | 30.9 | 71.4 | 8.62 | 115.5 | 13.92 |
| | | | Open vegetation | - | 30.7 | 8.5 | - | 4.9 | 44.1 | 5.30 | | |
| | | | Close Vegetation | - | - | - | - | - | - | - | | |
| | | Riparian | Riparian Vegetation | 1.7 | 20.7 | 105.8 | 0.3 | 85.3 | 213.8 | 25.80 | 213.8 | 25.80 |
| 4. | Forest Area | | Scrub Forest | - | - | 1.9 | - | 9.3 | 11.2 | 1.35 | 15.9 | 1.91 |
| | | | Open Forest | - | - | 2.1 | - | - | 2.1 | 0.25 | | |
| | | | Close Forest | - | - | - | 1.7 | 0.9 | 2.6 | 0.31 | | |
| 5. | Waste Land | | Land Without Scrub | 2.2 | 14.5 | - | - | 6.0 | 22.7 | 2.74 | 276.06 | 33.32 |
| | | | Sandy Area/Boulders | 34 | 16.8 | 35.7 | 7.96 | 158.9 | 253.36 | 30.58 | | |
| | | | Mining Area | - | - | - | - | - | - | - | | |
| 6. | Others | | Grass Cover | 0.5 | - | 95.1 | - | 35.1 | 103.7 | 12.51 | 103.7 | 12.51 |

| S. No. | Level 1 Classification | | Level 2 | Zone A | | Zone B | | Zone C | | Zone E | | Area, Level 2 Class (Proposed Trained River) | | Area, Level 2 Class(All Zones including River) | | Area, Level 1 Class( All Zones Including River) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Classification | ~Ha. | | ~Ha. | | ~Ha. | | ~Ha. | | ~Ha. | | ~Ha. | ~% | ~Ha. | ~% |
| 1 | Built-up Land or Habitation | | Residential / Commercial | | 0% | | 0% | | 0% | | 0% | | 0% | | 0.0% | 0.9 | 0.1% |
| | | | Industrial | 0.9 | 2% | | 0% | | 0% | | 0% | | 0% | 0.9 | 0.1% | | 0.0% |
| 2 | Water Bodies | | Pond/Lakes/Tanks/Reservoir | 0.2 | 0% | | 0% | | 0% | | 0% | | 0% | 0.2 | 0.0% | 93.86 | 11.5% |
| | | | River | 14.8 | 25% | 8.8 | 8% | 6.4 | 2% | 16.86 | 63% | 46.6 | 12% | 93.46 | 11.4% | | 0.0% |
| 3 | Vegetation Cover | Terrestrial | Scrub | 4.6 | 8% | 12.9 | 12% | 23 | 8% | | 0% | 30.9 | 8% | 71.4 | 8.7% | 115.5 | 14.1% |
| | | | Open vegetation | | 0% | 30.7 | 29% | 8.5 | 3% | | 0% | 4.9 | 1% | 44.1 | 5.4% | | 0.0% |
| | | | Close Vegetation | | 0% | | 0% | | 0% | | 0% | | 0% | | 0.0% | | 0.0% |
| | | Riparian | Riparian Vegetation | 1.7 | 3% | 20.7 | 20% | 105.8 | 38% | 0.3 | 1% | 85.3 | 23% | 213.8 | 26.1% | 213.8 | 26.1% |
| 4 | Forest Area | | Scrub Forest | | 0% | | 0% | 1.9 | 1% | | 0% | 9.3 | 2% | 11.2 | 1.4% | 15.9 | 1.9% |
| | | | Open Forest | | 0% | | 0% | 2.1 | 1% | | 0% | | 0% | 2.1 | 0.3% | | 0.0% |
| | | | Close Forest | | 0% | | 0% | | 0% | 1.7 | 6% | 0.9 | 0% | 2.6 | 0.3% | | 0.0% |
| 5 | Waste Land | | Land Without Scrub | 2.2 | 4% | 14.5 | 14% | | 0% | | 0% | 6 | 2% | 22.7 | 2.8% | 276.06 | 33.7% |
| | | | Sandy Area/Boulders | 34 | 58% | 16.8 | 16% | 35.7 | 13% | 7.96 | 30% | 158.9 | 42% | 253.36 | 30.9% | | 0.0% |
| | | | Mining Area | | 0% | | 0% | | 0% | | 0% | | 0% | | 0.0% | | 0.0% |
| 6 | Others | | Grass Cover | 0.5 | 1% | | 0% | 95.1 | 34% | | 0% | 35.1 | 9% | 103.7 | 12.7% | 103.7 | 12.7% |
| Totals | | | | 58.9 | 100% | 104.4 | 100% | 278.5 | 100% | 26.82 | 100% | 377.9 | 100% | 819.52 | 100.0% | 819.72 | 100.0% |

206. Land use land cover pattern is shown in ***Figure 4-2.*** The Detail of the land Use cover classes can be referred in ***Appendix*** 10***.***

***Figure 4-2: Land use land cover pattern***



## 4.3 GEOLOGY AND HYDROGEOLOGY

207. The detailed methodology for undertaking the Geology and Hydrogeology study is shown in ***Appendix 12.***

**GEOLOGY**

208. A comprehensive geotechnical investigation was carried out to understand and define the nature and behavior of soil under application of loads of proposed structures through drilling boreholes, test bore and trial pit at different locations of the project.

209. *For river training works*, the location of test bores were selected in such a manner that subsoil profile could be obtained for both the banks of the river. For these the test bores were selected at an interval of about 500m to 1000m in staggered manner along each bank. The terrain and accessibility of river bed were also considered during selection of location of test bores.

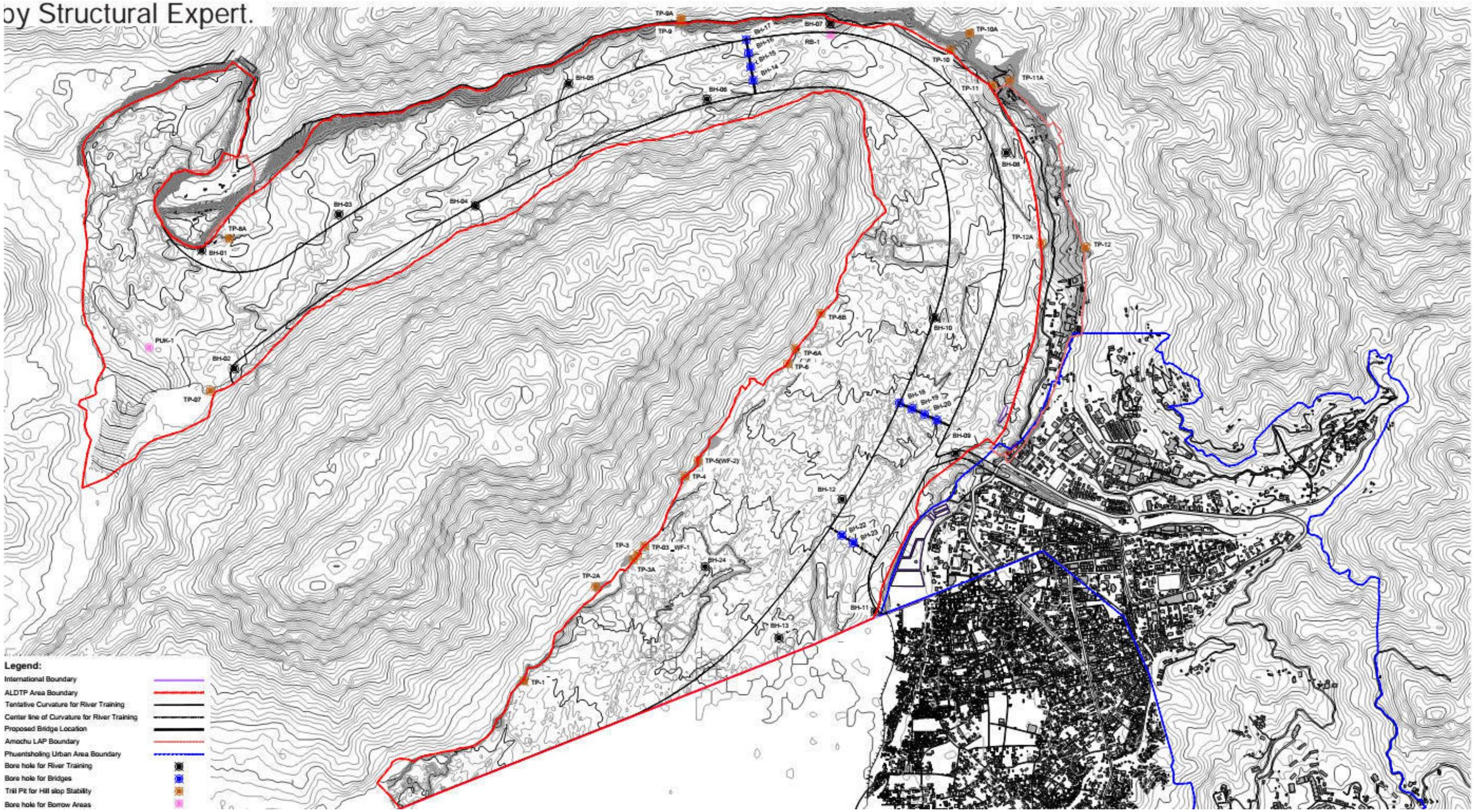
210. *At the location of the proposed bridges*, the test bores were selected in such manner that sub soil profile could be obtained across the river bed between both the river banks. These test bores were selected at an interval of about 75m between the abutments of proposed bridge. The depth of test bore was considered based on scour depth and anticipated deepest foundation level.

211. *For the proposed township area*, tests for surface, sub-surface, and seismic conditions were performed. This helped provide a detailed understanding geotechnical conditions where township can be proposed and technical details of the type and depth of foundation that would be best suited here.

212. *For land reclamation material*, certified quarry sites were jointly identified with clients within 100 km radius of Project site. The samples were collected from the quarries to check adequacy of the same as fill material.

213. Location of bore holes are shown in ***Figure 4-3.***

*Figure 4-3: Location of bore holes*



**KEY FINDINGS:**

214. SLOPES: The catchment is elongated in shape with rapidly changing conditions from bottom to top. The upper portion of the Amochhu is characterized by an extremely steep slope of 32.3 m/km. The middle portion continues at a very steep slope of the order of 19.8 m/km. The lowest portion has a steep slope of 5.3 m/km.

215. SOIL THICKNESS: The most typical observation is made on the thickness of soil in the meandering part of Amochhu which is higher as compared to other parts of the river bed, which could be because of the abrupt change in velocity during high flood and its impact of vegetation cover (plantation) on controlling bank erosion.

216. SEISMICITY: There is no detailed seismic micro-zonation of the country. However, since the north-eastern parts of India (next to Bhutan) fall under seismic zone V (seismically most active), it can reasonably be assumed that Bhutan is contiguous with this zone and either in seismic zone IV or V. Hence, there is a threat of a significant earthquake.

**HYDROGEOLOGY**

217. There are eight bore wells near the left bank of Phuentsholing Thromde for water supply. Out of these eight bore wells, six were installed with pump sets and two were without installation of pump set. Water level in these bore wells were measured and water samples were also collected for chemical analysis. The groundwater sampling locations are given in ***Table 4-3*** and results shown in ***Appendix*** 11**.** Ground water sampling location map is shown in ***Figure 4-4.***

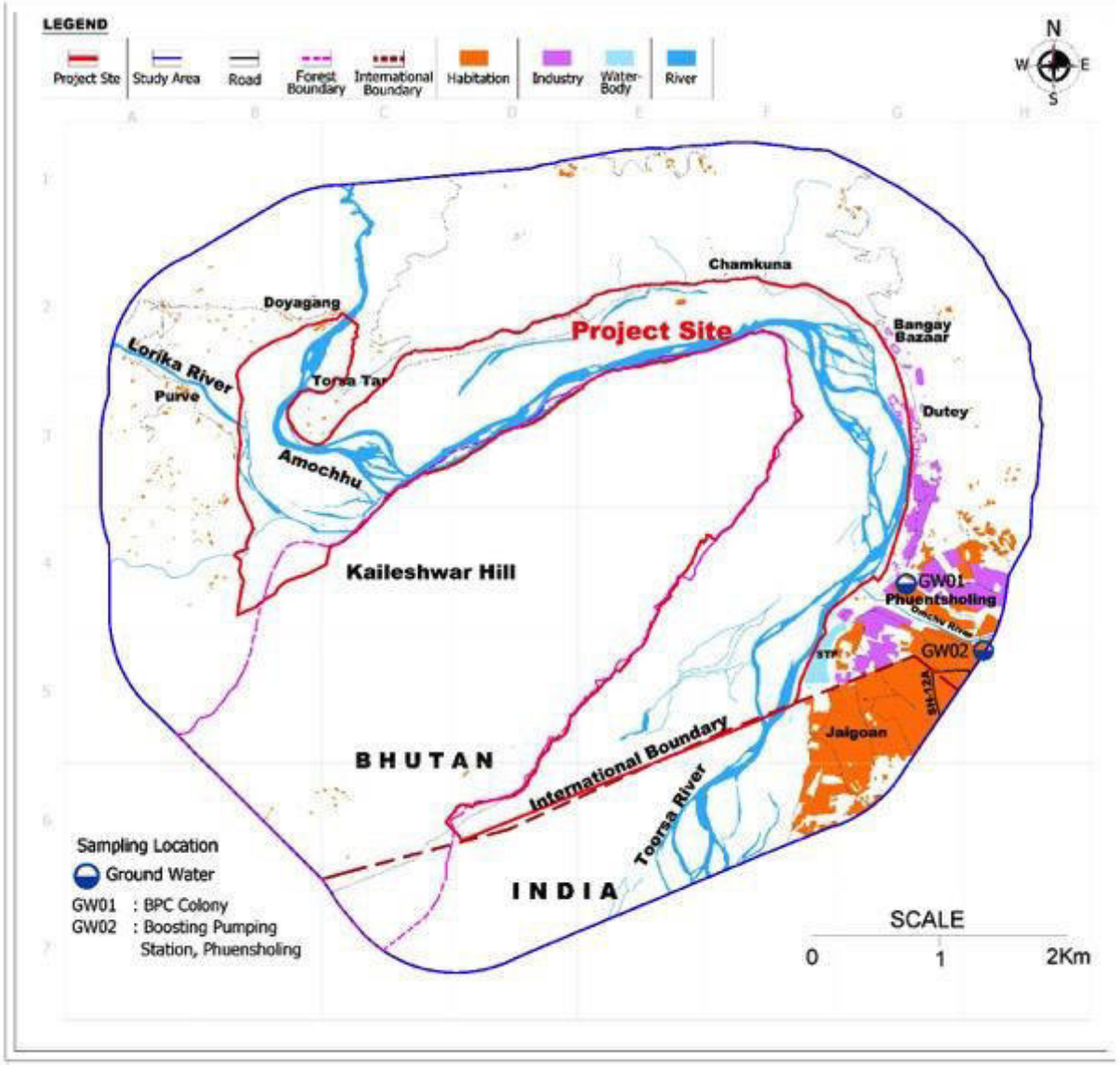
***Table 4-3: Groundwater Sampling Locations (1st season and 2nd season)***

| Code | Location | Distance from Project Site in Km | Direction w.r.t. Project Site | Latitude | Longitude | Date of Sampling |
|---|---|---|---|---|---|---|
| GW1 | BPC colony | 0.33 | NE | 26°52’ 2.65” N | 89°22’42.49” E | 03.03.2016<br>31.05.2016 |
| GW2 | Boosting Pumping Station Phuentsholing | 1.32 | E | 26°51’ 45.91” N | 89°23’ 4.72” E | 03.03.2016<br>31.05.2016 |

**KEY FINDINGS**

218. From the results of chemical analysis of ground water samples, it was observed that the water quality is “Class A” standard, which is fit for a drinking water source without the conventional treatment, but after disinfection. It may not require any treatment as it is naturally filtered water through the riverbed, which has not been subjected to any pollution due to manmade activities upstream.

***Figure 4-4: Map showing the Ground Water Sampling Location***



## 4.4 SURFACE WATER QUALITY

**GENERAL STUDY METHODOLOGY:** The detailed methodology used in undertaking this study is shown in ***Appendix*** 12***.*** The surface water quality monitoring was carried out in the study area using the land use pattern. The selection of sampling locations near surface water bodies upstream and downstream of the site, based on its drainage pattern and prevalent direction of general gradient of its flow. ***Table 4-4*** describes the analytical methodology for parameters with minimum detection limit.

***Table 4-4: Analysis Methods Adopted for water quality***

| S. No | Parameters | Methodology | Minimum Detection Limit |
|---|---|---|---|
| 1 | pH | APHA: 4500 - H+ B(22nd Edition), pH meter | 0.1 |
| 2 | Colour | APHA: 2120 B (22nd Edition), Visual Comparison | 1 Pt-Co |
| 3 | Electrical conductivity | APHA: 2510 B (22nd Edition), Conductivity meter | 1µmoh/cm |
| 4 | TDS | APHA: 2540 C (22nd Edition), Gravimetric | 3 mg/l |
| 5 | Turbidity | APHA: 2130 B (22nd Edition), Nephelometric | 0.1 NTU |
| 6 | Ammonical Nitrogen | IS:3025(part-34), 1988, Distillation & colorimetric | 0.1 mg/l |
| 7 | Ca Hardness | APHA: 3500 – Ca B (22nd Edition) Titrimetric,(EDTA method) | 2 mg/l |
| 8 | Mg Hardness | APHA: 3500 - Mg B (22nd Edition), By difference | 2 mg/l |
| 9 | Calcium | APHA: 3500 – Ca B (22nd Edition) Titrimetric,(EDTA method) | 2 mg/l |
| 10 | Magnesium | APHA: 3500 - Mg B (22nd Edition), By difference | 2 mg/l |
| 11 | Sodium | APHA:3500 - Na B (22nd Edition), Flame emission Photometric | 1 mg/l |
| 12 | Potassium | APHA: 3500- K B (22nd Edition) Flame emission Photometric | 1 mg/l |
| 13 | Salinity | APHA: 2520 B (22nd Edition), Electrical Conductivity method | - |
| 14 | COD | APHA: 5220 B(22nd Edition), Titrimetric Open reflux method | 2 mg/l |
| 15 | BOD | IS: 3025(part-44), Iodometric | 4 mg/l |
| 16 | Chlorides | APHA:4500 – Cl- B (22nd Edition), Titrimetric | 1 mg/l |
| 17 | Phenol | APHA: 5530- D(22nd Edition), colorimetric | 0.02 mg/l |
| 18 | Sulphates | APHA:4500- SO4 E (22nd Edition), Turbid metric | 1 mg/l |
| 19 | Nitrate | IS:3025 (part-34), 1988 (RA 2003) (ii) , Colorimetric | 0.2 mg/l |
| 20 | Fluoride | APHA:4500 F- D(22nd Edition),Colorimetric | 0.05 mg/l |
| 21 | Total Nitrogen | APHA: 4500 N Org, Micro Kjeldahl Distillation (22nd Edition), Titrimetric | - |
| 22 | Total Phosphorous | APHA: 4500 P-C (22nd Edition), colorimetric | 1 mg/l |
| 23 | Dissolved Oxygen | APHA: 4500 O-C (22nd Edition), Iodometric | 0.2 mg/l |
| 24 | SAR | Flamephotmetric & EDTA method | - |
| 25 | TSS | APHA: 2540 - D (22nd Edition), gravimetric | 2 mg/l |
| 26 | Surfactants | APHA: 5540 - C (22nd Edition) tuition | 0.1 |
| 27 | Cyanide (as CN) | APHA: 4500 CN- D & E(22nd Edition), colorimetric | 0.001 mg/l |
| 28 | Heavy Metals | - | - |
| a | Arsenic (as As) | APHA: 3500-As-B (22nd Edition | 0.01 mg/l |
| b | Cadmium (as Cd) | APHA: 3111-B (22nd Edition | 0.01 mg/l |
| c | Chromium (as Cr) | APHA: 3500-Cr-B (22nd Edition), colorimetric | 0.02 mg/l |
| d | Copper (as Cu) | APHA: 3111-B & 3500-Cu-B (22nd Edition) | 0.03 mg/l |
| e | Iron (as Fe) | APHA: 3111-B & 3500-Fe-B (22nd Edition) | 0.05 mg/l |
| f | Lead (as Pb) | APHA: 3111-B (22nd Edition) | 0.02 mg/l |
| g | Mercury (as Hg) | APHA: 3111-B (22nd Edition) | 0.002 mg/l |
| h | Zinc (as Zn) | APHA: 3111-B (22nd Edition) | 0.03 mg/ |
| i | Boron (as B) | APHA: 4500 B-C (22nd Edition), colorimetric | 0.1 mg/l |

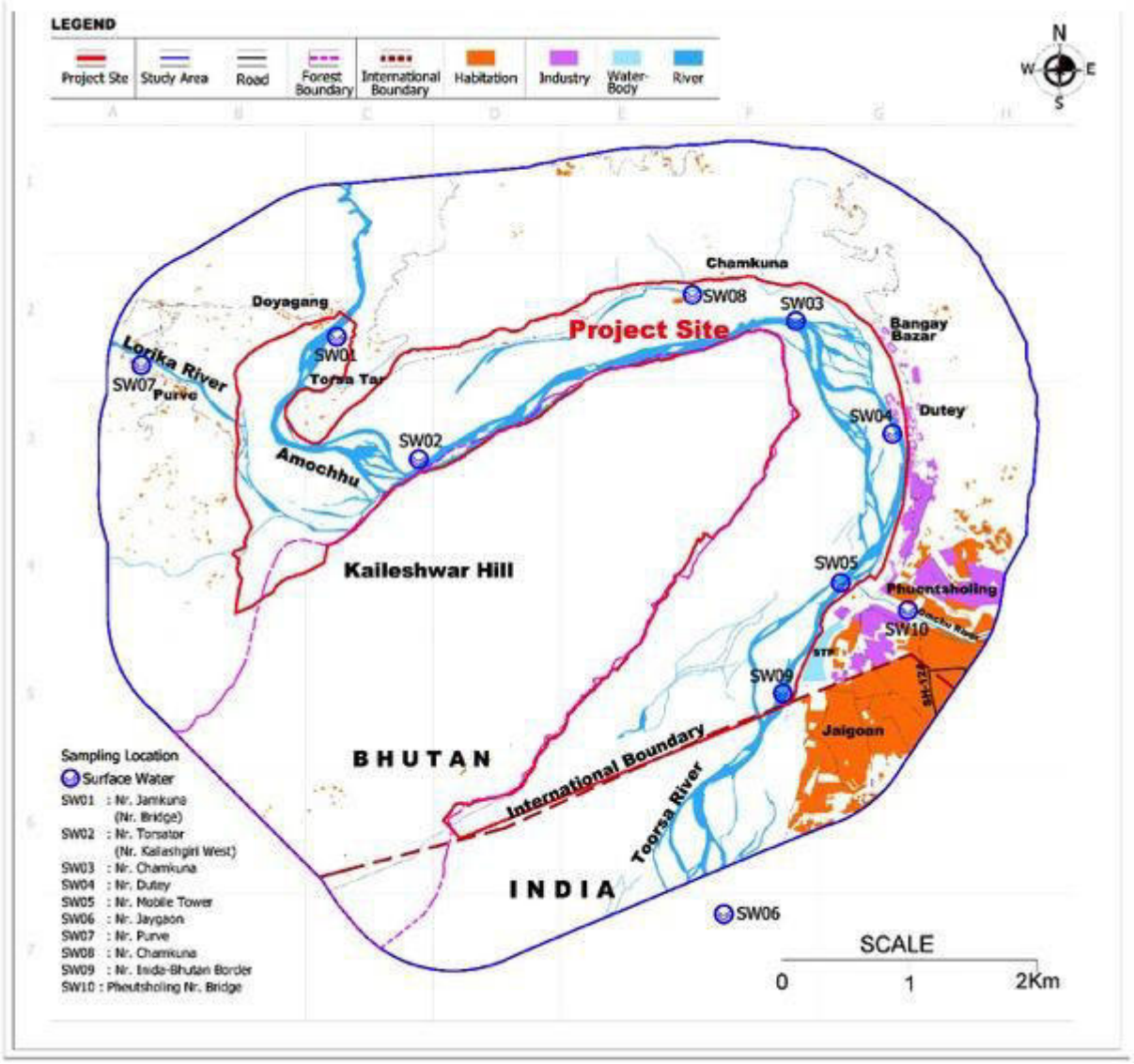
| | | | |
|---|---|---|---|
| 29 | Total Coliform | APHA: 9221-B (22nd Edition), Multiple Tube Fermentation | 1.8 MPN/100ml |
| 30 | Faecal Coliform | APHA: 9221-E (22nd Edition), Multiple Tube Fermentation | 1.8 MPN/100ml |

219. The details of surface water sampling locations for two seasons and its justification are presented in
220. Table 4-5 and its sampling Location map is shown in Figure 4-5. In addition, the photographs of surface water sampling locations are shown in ***Appendix*** 13***.***

***Table 4-5: Details Surface Water Sampling Locations (2 seasons- winter & spring)***

| Code | Location | Source | Date of Sampling | Latitude | Longitude | Justification of Sampling location |
|---|---|---|---|---|---|---|
| SW1 | Nr. Doyagang Village (Nr. Bridge) | River Amochhu | 28.02.16 | 26°53'5.49" | 89°20'1.84" | Upstream of the river entry in study area |
| SW2 | Nr. Torsatar (Nr Kailashgiri west) | River Amochhu | 28.02.16 | 26°52'31.89" | 89°20'25.57" | Downstream after joining of tributary |
| SW3 | Nr. Chamkuna Village | River Amochhu | 28.02.16 | 26°53'8.52" | 89°22'9.86" | Junction of two streams |
| SW4 | Nr. Dutay | River Amochhu | 28.02.16 | 26°52'41.71" | 89°22'41.12" | Beside industrial area |
| SW5 | Nr. Mobile Tower | River Amochhu | 28.02.16 | 26°52'1.16" | 89°22'25.49" | Mixed zone of Amochhu and Omchhu |
| SW6 | Nr. Jaigaon Village | River Amochhu | 01.03.16 | 26°50'39.50"N | 89°21'50.15"E | Upstream of River |
| SW7 | Nr. Purvey Village | River Lorika | 29.02.16 | 26°53'0.01"N | 89°19'5.99"E | Tributary of Amochhu river |
| SW8 | Nr. Chamkuna Village | Stream | 29.02.16 | 26°53’ 16.1” | 89°21’ 41.2” | Stream coming from hill |
| SW9 | Nr. India Bhutan Border | River Amochhu | 01.03.16 | 26°51’ 32.2” | 89°22’ 10.3” | Downstream of river after existing from STP and Bhutan |
| SW10 | Phuentsholing Nr. Bridge | River Omchhu | 01.03.16 | 26°51'54.96" | 89°22'44.06" | Tributary of Amochhu river |

***Figure 4-5: Sampling Location map for Surface water***



**KEY FINDINGS:**

221. Test results of surface water samples are tabulated and compared with relevant NEC's environmental standards in ***Appendix*** 14***.***

222. In the dry autumn and winter season, the quality of river water when compared with relevant ambient water quality criteria of Bhutan indicates that for all the stretches of the River except SW9 (near the India-Bhutan border) and SW10 (near the Omchhu Bridge) during winter, the quality of the water is class A and the water is suitable for drinking purpose after disinfection.

223. With regards to SW9 and SW10, it was observed that the water quality during the autumn season meets Class A as well, but in the winter (when the flow is much reduced) it meets class C of the national standards, indicating that the water is fit for industrial cooling and irrigation.

224. From the above analysis, it is recommended that the sample locations (Table 4.5) and the methodology (Table 4.4) proposed could be used for monitoring the quality of various parameters of surface water during project's construction and operation stages which can serve as a basis to evaluate the site specific changes in environmental baseline components.

## 4.5 METEROLOGY AND AMBIENT AIR QUALITY

225. **GENERAL STUDY METHODOLOGY:** The general approach and methodology for meteorology and ambient air quality are provided in ***Appendix*** 15***.***

**METEOROLOGY**

226. Monitoring Methodology of meteorological data is shown in ***Table 4-6*** and the photographs of the stations are attached as ***Appendix*** 16***.***

***Table 4-6: Monitoring Methodology of Meteorological Data***

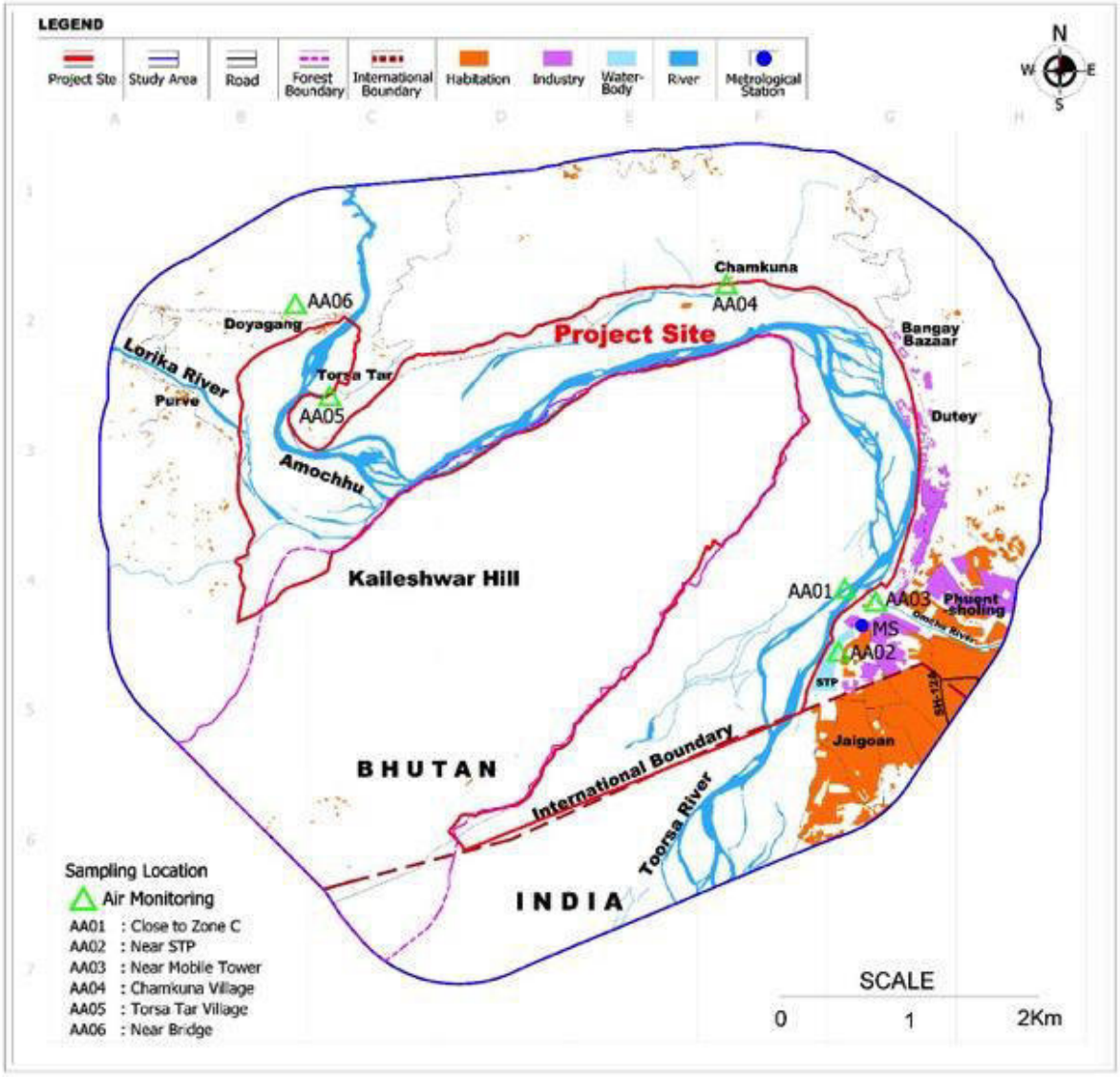
| Env. Component | Location | Coordinates | Parameters | Period | Frequency | Methodology |
|---|---|---|---|---|---|---|
| Meteorology | BAFRA office, Phuentsholing | 26°51' 53.75"N 89° 22' 28.00"E | Wind speed, wind direction, temperature, Relative humidity, and rainfall | November 2015 – May 2016 | Hourly for all parameters | As per IS: 8829-1978 |

227. Phuentsholing is at a relatively low altitude corresponding to the surrounding plains of India in West Bengal. The nearest meteorological observatory is located at Jalpaiguri, West Bengal, India. At Hashimara, the mean annual temperature is 24.2ºC.

228. An automatic meteorological station (*Envirotech WM 271 Wind Monitor*) was installed at Phuentsholing, near the access road to ALDTP area, during the study period to record various meteorological parameters. The station was installed at a height of 6 m above ground for continuous monitoring data after calibration. Site-specific meteorological data were collected from the site. Meteorological and Ambient Air location map is shown in ***Figure 4-6***

.

***Figure 4-6: Meteorological and Ambient Air location map***



229. The summary of the micro-meteorological data for two season 2015-2016 for ALDTP is shown in ***Table 4-7.***

***Table 4-7: Summary micrometeorological data for two seasons (winter 2015-16 & spring 2016)***

| S. No. | Parameters | Units | December 2015 | January 2016 | February 2016 |
|---|---|---|---|---|---|
| 1 | Min air temperature | deg C | 9.5 | 8.1 | 13.2 |
| 2 | Avg. air temperature | deg C | 17.7 | 16.3 | 20.3 |
| 3 | Max air temperature | deg C | 29.1 | 25.1 | 30.2 |
| 4 | Min humidity | % | 35.5 | 34.3 | 23.2 |
| 5 | Average humidity | % | 65 | 62.3 | 54.8 |
| 6 | Max humidity | % | 94.1 | 96.3 | 85.3 |
| 7 | Min precipitation | mm | 0 | 0 | 0 |
| 8 | Max precipitation | mm | 4 | 8.5 | 0 |
| 9 | Total precipitation | mm | 8.5 | 52.6 | 0 |
| 10 | Min wind speed | Kmph | 0 | 0 | 0 |
| 11 | Average wind speed | Kmph | 3.7 | 4.5 | 4.5 |
| 12 | Max wind speed | Kmph | 12.5 | 30.9 | 19.5 |
| 13 | Dominant wind flow (from) | Direction | NNE | NNE | NNE |
| 14 | 2nd major wind flow (from) | Direction | NE | NNW | NE |

230. The data obtained has been compiled to obtain average data. Compiled mean meteorological data are shown in ***Appendix*** 17***.***

231. **WINTER (DEC 2015 – FEB 2016): I**n the winter season, wind blows mostly from North sector. The calm wind contributes to about 6.14%. Average temperature recorded for winter season is 19°C with maximum temperature of 35.1°C and minimum of 8.1 C. The wind rose diagram for Winter Season, Phuentsholing is shown in ***Figure 4-7.***

232. **SPRING (MARCH 2016 – MAY 2016):** In spring season, predominant wind direction also blows from North to South where the calm wind contributes to about 9.35%.The average wind speed is observed 1.1 m/s. the average temperature recorded for summer season was 24 °C with maximum temperature of 37.1°C and minimum of 16.6°C. The wind rose diagram for the Spring Season, Phuentsholing, Mar-May, 2016 is shown in ***Figure 4-8.***

233. Based on the above findings, it is recommended that the sample locations & methodology for the proposed locations could be used for monitoring meteorological parameters like Temperature, Wind Speed, Wind Direction, Rainfall & Relative Humidity during project construction and operation stage which can serve as a basis to evaluate the site specific changes in environmental baseline components.

***Figure 4-7: Wind rose Diagram for Winter Season, Phuentsholing, Dec- 2015 to February 2016***

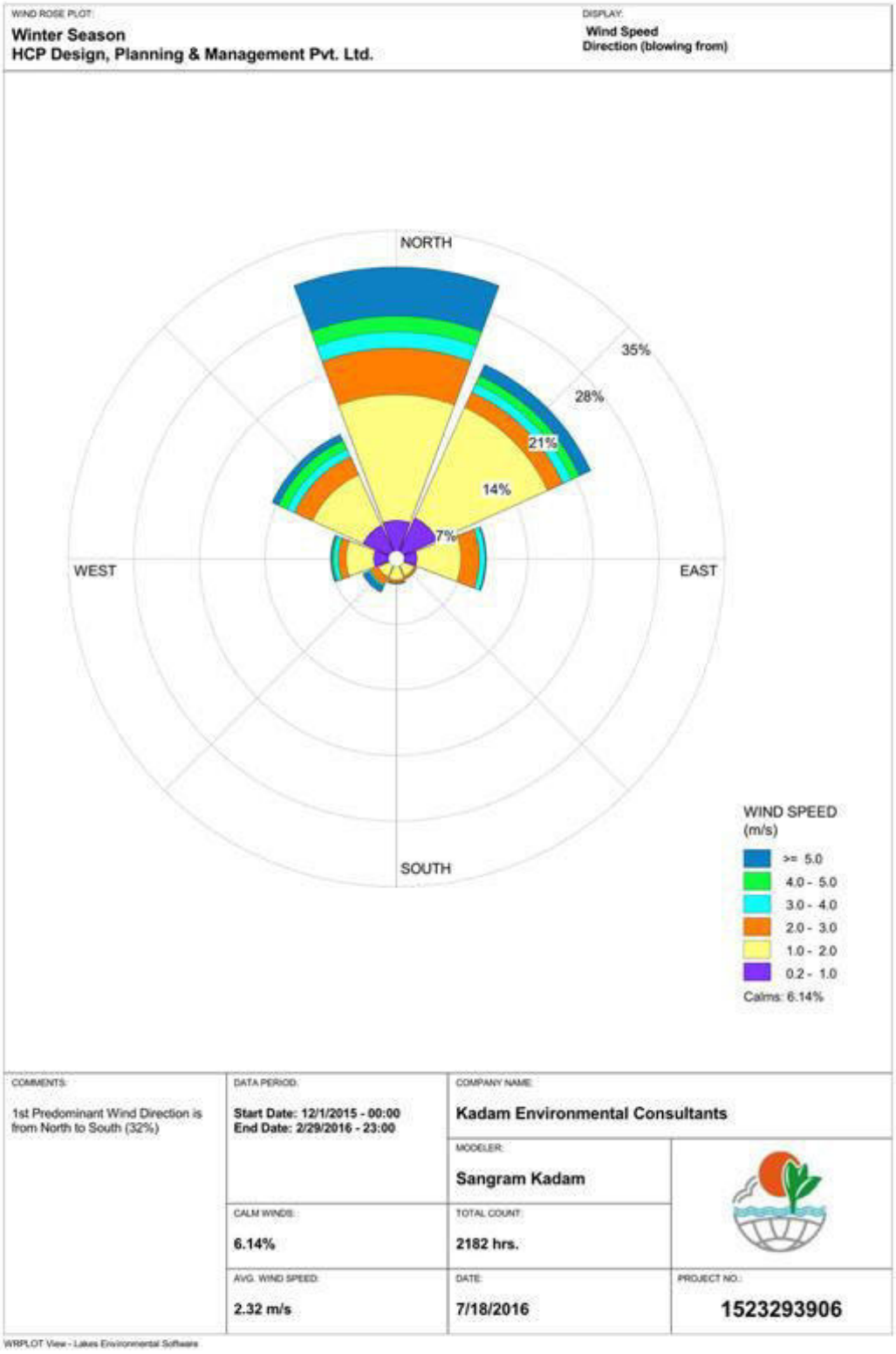
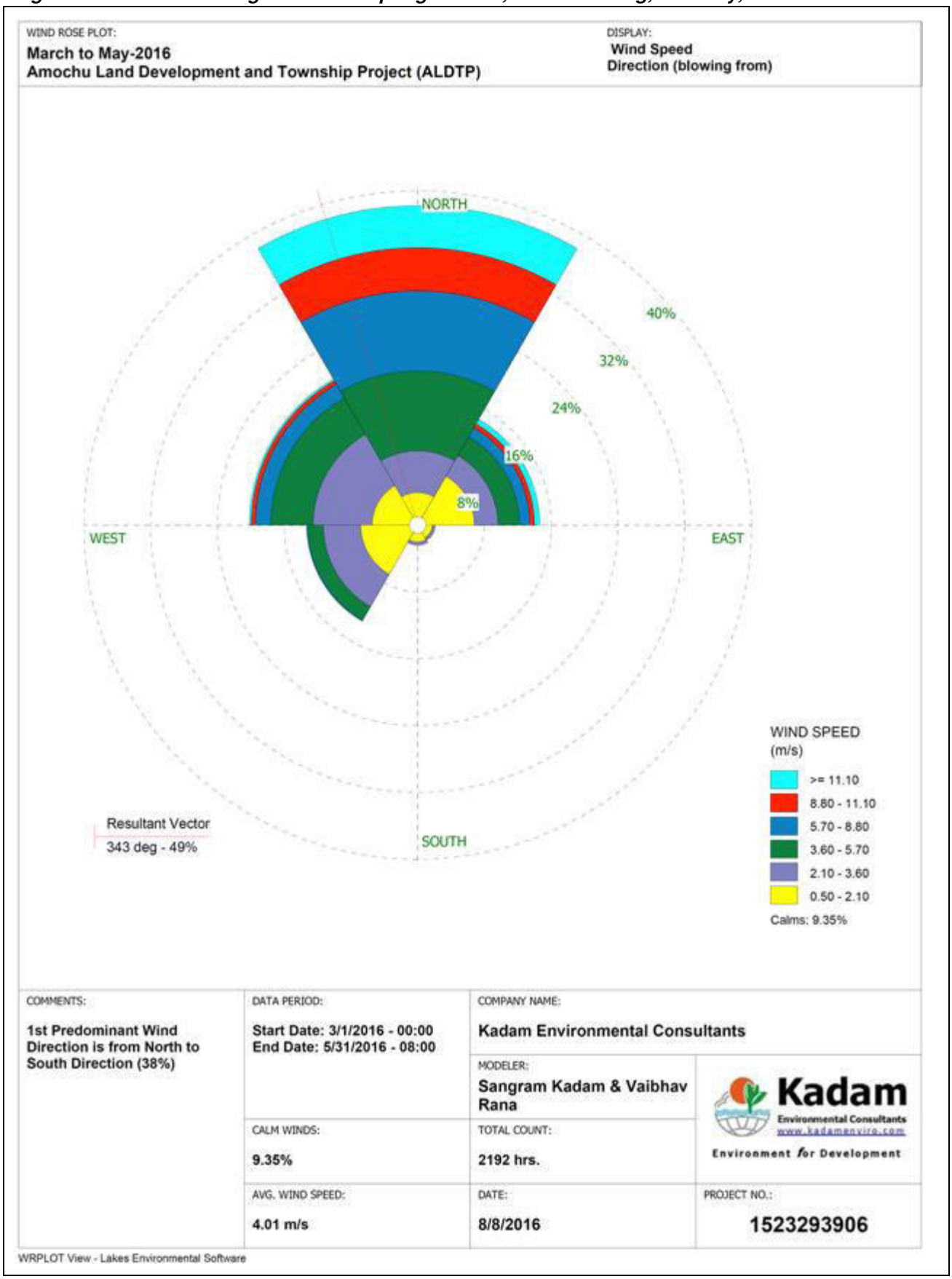


***Figure 4-8: Wind rose Diagram for the Spring Season, Phuentsholing, Mar-May, 2016***



234. The methodology for the Ambient Air quality has been presented in conjunction with the same already presented for meteorology in ***Appendix*** 15***.***

235. Sampling sites has been carefully selected so that the collected samples represent air that is actually inhaled by the exposed population and working groups. In order to design ambient air quality monitoring network, the topography, the residential and sensitive areas and population density were taken into account.

236. Similar to meteorology, the ambient air monitoring was carried out for two seasons; first season (winter: December 2015 to February 2016) and second season (spring: March 2016 to May 2016). Monitoring locations and rationale for selecting of the ambient air stations are presented in ***Table 4-8.*** Ambient air monitoring along with laboratory set-up at Phuentsholing photographs are shown in ***Appendix*** 18***.***

***Table 4-8: Ambient air quality monitoring locations***

| S N. | Station Code | AAQM Station | Coordinates (Lat. & Long.) | Direction | Distance Km | Rationale |
|---|---|---|---|---|---|---|
| 1 | AA01 | Close to Zone C | 26° 52' 01.29"N 89° 22' 23.7"E | Inside Site | 00 | Project site-The nearest, safest accessible point to collect the seasonal baseline ambient air quality status in Zone C |
| 2 | AA02 | Nr. STP Area | 26° 51' 45.3"N 89° 22' 21.5"E | SE | 0.2 | Residential area – to collect seasonal baseline Ambient air quality status in crosswind direction i.e. in SE direction |
| 3 | AA03 | Nr. Mobile Tower | 26° 51' 59.0"N 89° 22' 31.1"E | SE | 0.2 | Commercial area - to collect the seasonal baseline ambient air quality data in crosswind direction i.e. in SE direction |
| 4 | AA04 | Chamkuna Village | 26° 53' 20.1"N 89° 21' 52.1"E | Near Edge of Site (Zone B) | 00 | Residential area- to collect the seasonal baseline ambient air quality status in the first predominant upwind direction i.e. in NNE direction |
| 5 | AA05 | Torsa Tar Village | 26° 52' 51.6"N 89° 20' 03.9"E | NW | 0.15 | Residential area- to collect seasonal baseline ambient air quality status in the cross wind direction i.e. in NW direction |
| 6 | AA06 | Near Bridge | 26°53' 09.5"N 89° 19' 48.4"E | NW | 0.8 | Mixed area – to collect the seasonal baseline ambient air quality status in the cross wind direction i.e. in NW direction |

238. The details of the methodology for ambient quality air monitoring is shown in ***Table*** 4-9***.***

***Table 4-9: Methodology for Ambient Quality Air Monitoring***

| **Descriptor and Details** | **Sample Analysis** | | | **Method** |
|---|---|---|---|---|
| | **Analytical Equipment** | **Sensitivity / Detection Limit** | | |
| Sampling locations: 6 locations<br>Sampling Parameters: TSPM,SPM, PM10, PM2.5, $SO^2$, $NO_x$ and CO<br>Total Sampling Period: December 2015 to May 2016<br>Sampling Frequency: Two 24 –hour samples every week at each station | PM10 – Respirable Dust Sampler (*Envirotech-BL, K-112)* APM - 460 | TSPM: Electronic balance | 0.001 mg | Gravimetric (HVS) – IS: 5182: Part 4, with cyclone |
| | PM2.5 – Respirable Dust Sampler (*Envirotech – BL, K–113*) APM - 460 | RPM: Electronic balance | 0.001 mg | Gravimetric (HVS) – IS: 5182: Part 4 |
| | $SO^2$: Flow Meter with impinge module | SO2: Spectro-photometer | 1.27 µg/m3 | IS: 5182(part-2): 2001, Colorimetric |
| | $NO_x$: Flow Meter with impinge module | $NO_x$: Spectro-photometer | 0.19 µg/m3 | IS: 5182(part-6): 2006, Colorimetric |
| | CO: (*GasAlertMicro 5)* PID Detector | CO:*(GasAlertMicro 5)* - PID Detector | 1 ppm | PID Sensor |

**KEY FINDINGS**

239. Based on the ambient monitoring in and around the ALDTP project area, data on critical pollution parameters were generated. The summary of the AQM data is given in Table and ***Table 4-11.*** The detailed data can be found in the ***Appendix*** 19***.***

***Table 4-10: Summary air quality data (1st season, winter) for ALDTP project***

| **Station code** | **AAQM Location (AAQM stations as per NEC, Bhutan, Environmental Standards, 2010)** | **Parameters & Results**<br>**Note: All units are in µg/m3except. Figures in brackets '(…)' indicate Ambient air quality standard by NEC Bhutan, 2010. Minimum Reportable Readings are 8 µg/m3 for SO2 and 10 µg/m3 for $NO_x$; 1142 µg/m3 for CO.** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **AA 01** | **Close to Zone C [0 Km, Inside Site] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | **$NO_x$ (80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 231 | 161 | 77 | 43 | 19 | 20 | 1210 |
| | Minimum | 109 | 66 | 42 | 16 | < 8 | < 10 | 1158 |
| | Average | 168 | 110 | 58 | 29 | < 8 | 12 | 1184 |
| | 98% tile | 225 | 158 | 75 | 42 | 17 | 20 | 1209 |

| **AA 02** | **Nr. STP Area [0.2 Km, SE direction] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | $NO_x$ **(80) [24 Hours]** | **CO (2000) [8 Hours]** |
|---|---|---|---|---|---|---|---|---|
| | Maximum | 372 | 246 | 176 | 51 | 15 | 18 | 1365 |
| | Minimum | 106 | 62 | 41 | 11 | < 8 | < 10 | 1172 |
| | Average | 193 | 119 | 73 | 27 | < 8 | 11 | 1270 |
| | 98% tile | 362 | 229 | 183 | 45 | 14 | 17 | 1359 |
| **AA 03** | **Nr. Mobile Tower [0.2 Km, SE direction] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | $NO_x$ **(80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 464 | 330 | 172 | 59 | 11.9 | 16.5 | 1462 |
| | Minimum | 135 | 52 | 53 | 14 | < 8 | < 10 | <1142 |
| | Average | 247 | 153 | 98 | 33 | < 8 | < 10 | 1295 |
| | 98% tile | 425 | 293 | 165 | 58 | 10.4 | 15.7 | 1446 |
| **AA 04** | **Chamkuna Village [00 Km, Near Edge of Site (Zone B)] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | $NO_x$ **(80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 220 | 146 | 136 | 38.0 | 14.0 | 26.7 | 1256 |
| | Minimum | 90 | 61 | 28 | 12.5 | < 8 | < 10 | <1142 |
| | Average | 157 | 101 | 68 | 23.0 | < 8 | < 10 | 1191 |
| | 98% tile | 218 | 141 | 132 | 36.5 | 13.4 | 22.4 | 1252 |
| **AA 05** | **Torsa Tar Village [0.15 Km, NW direction] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | **NOX (80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 216 | 140 | 91 | 35 | 13.1 | 16.4 | 1227 |
| | Minimum | 77 | 56 | 20 | 10 | < 8 | < 10 | <1142 |
| | Average | 155 | 102 | 52 | 23 | < 8 | < 10 | 1185 |
| | 98% tile | 216 | 140 | 85 | 35 | 11.9 | 15.3 | 1224 |
| **AA 06** | **Near Bridge [0.8 Km, NW direction] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | $NO_x$ **(80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 347 | 207 | 140 | 31 | 14.1 | 19.3 | 1235 |
| | Minimum | 81 | 48 | 27 | 13 | < 8 | < 10 | <1142 |
| | Average | 141 | 89 | 52 | 21 | < 8 | < 10 | 1235 |
| | 98% tile | 312 | 187 | 125 | 30 | 13.6 | 18.3 | 1235 |

***Table 4-11: Summary air quality data 2nd season, spring) for ALDTP project***

| Station code | AAQM Location (AAQM stations as per NEC, Bhutan, Environmental Standards, 2010) | Parameters & Results<br>Note: All units are in µg/m3except. Figures in brackets '(…)' indicate Ambient air quality standard by NEC Bhutan, 2010. Minimum Reportable Readings are 8 µg/m3 for SO2 and 10 µg/m3 for $NO_x$; 1142 µg/m3 for CO. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **AA 01** | **Close to Zone C [0 Km, Inside Site] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | **$NO_x$ (80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 210 | 139 | 87 | 50 | 10 | 16 | <1142 |
| | Minimum | 127 | 80 | 42 | 17 | <8 | <10 | <1142 |
| | Average | 159 | 101 | 58 | 30 | 8 | 12 | <1142 |
| | 98% tile | 203 | 129 | 86 | 49 | 10 | 15 | <1142 |
| **AA 02** | **Nr. STP Area [0.2 Km, SE direction] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | **$NO_x$ (80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 173 | 103 | 78 | 34 | 11 | 15 | <1142 |
| | Minimum | 96 | 69 | 27 | 17 | <8 | <10 | <1142 |
| | Average | 137 | 85 | 52 | 26 | 8 | 12 | <1142 |
| | 98% tile | 189 | 106 | 86 | 39 | 11 | 16 | <1142 |
| **AA 03** | **Nr. Mobile Tower [0.2 Km, SE direction] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | **$NO_x$ (80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 217 | 141 | 138 | 55 | 11.5 | 16.5 | <1142 |
| | Minimum | 156 | 99 | 43 | 22 | <8 | <10 | <1142 |
| | Average | 184 | 116 | 74 | 34 | 8.9 | 12.0 | <1142 |
| | 98% tile | 215 | 139 | 123 | 54 | 11.4 | 16.2 | <1142 |
| **AA 04** | **Chamkuna Village [00 Km, Near Edge of Site (Zone B)] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | **$NO_x$ (80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 162 | 109 | 98 | 48 | 15.5 | 16.9 | <1142 |
| | Minimum | 127 | 84 | 30 | 16 | <8 | <10 | <1142 |
| | Average | 149 | 97 | 60 | 29 | 9.5 | 11.9 | <1142 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 98% tile | 158 | 108 | 97 | 45 | 15.0 | 16.1 | <1142 |
| **AA 05** | **Torsa Tar Village [0.15 Km, NW direction] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | **$NO_x$ (80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 162 | 105 | 104 | 51 | 12.8 | 14.1 | <1142 |
| | Minimum | 129 | 81 | 33 | 18 | <8 | <10 | <1142 |
| | Average | 144 | 93 | 59 | 29 | <8 | 10.3 | <1142 |
| | 98% tile | 159 | 103 | 104 | 48 | 11.6 | 14.0 | <1142 |
| **AA 06** | **Near Bridge [0.8 Km, NW direction] (Mixed Area*)** | **TSPM (200) [24 Hours]** | **SPM (NS) [24 Hours]** | **PM10 (100) [24 Hours]** | **PM2.5 (NS) [24 Hours]** | **SO2 (80) [24 Hours]** | **$NO_x$ (80) [24 Hours]** | **CO (2000) [8 Hours]** |
| | Maximum | 226 | 138 | 98 | 55 | 10.4 | 14.2 | <1142 |
| | Minimum | 113 | 78 | 30 | 17 | <8 | <10 | <1142 |
| | Average | 156 | 101 | 54 | 27 | <8 | 11.1 | <1142 |
| | 98% tile | 225 | 135 | 95 | 54 | 10.3 | 13.6 | <1142 |

240. Based on the data generated for the first season at the representative stations in the study area, it may be said that PM10 levels are moderately high at certain locations like near the STP and the bridge due to ongoing works. The dust is mostly from wind-blown type that detaches the medium to fine particles from the open and fragmented ground, transports and disperses them. A part of this material settles while the rest remains suspended.

241. The concentration of SO2 and NOx is much less due to the absence of large-scale emission from fossil fuel burning in the form of stack and fugitive industrial operations and limited vehicle movement. Overall, it can also be said that vehicle movements are responsible for suspending dust and dirt from the unpaved roads. Otherwise, the overall ambient air quality in the ALDTP is well within the clean and healthy type, except for certain locations where due to various types of activities the emission levels are increasing. Generally, PM10 figures are higher in winter while PM2.5 figures are marginally higher in spring.

242. Based on the above findings, it is recommended that the sample locations & methodology proposed could be used for monitoring ambient air quality parameters, namely TSPM, PM10, PM2.5, SO2, NOx, HC and CO during project construction stage which can serve as a basis to evaluate the site specific changes in environmental baseline components. An air quality modelling assessment of ALDTP has also been carried out, the details of which is attached as ***Appendix*** 32***.***

## 4.6 NOISE AND VIBRATION

243. This section presents the assessment of ambient noise quality in the ALDTP baseline condition to monitor the noise level at a particular site for future assessment of noise quality during the various development activities.

244. **GENERAL STUDY METHODOLOGY:** The overall approach towards the study of noise and vibration is given in ***Appendix*** 20***.***

245. The methodology for the assessment of the baseline noise quality includes identification of locations for monitoring after field survey, monitoring of noise levels in the locations for particular time period and frequency and analysis of results. The method for monitoring of ambient noise quality is given in ***Table 4-12.***

***Table 4-12: Methodology of Monitoring of Noise***

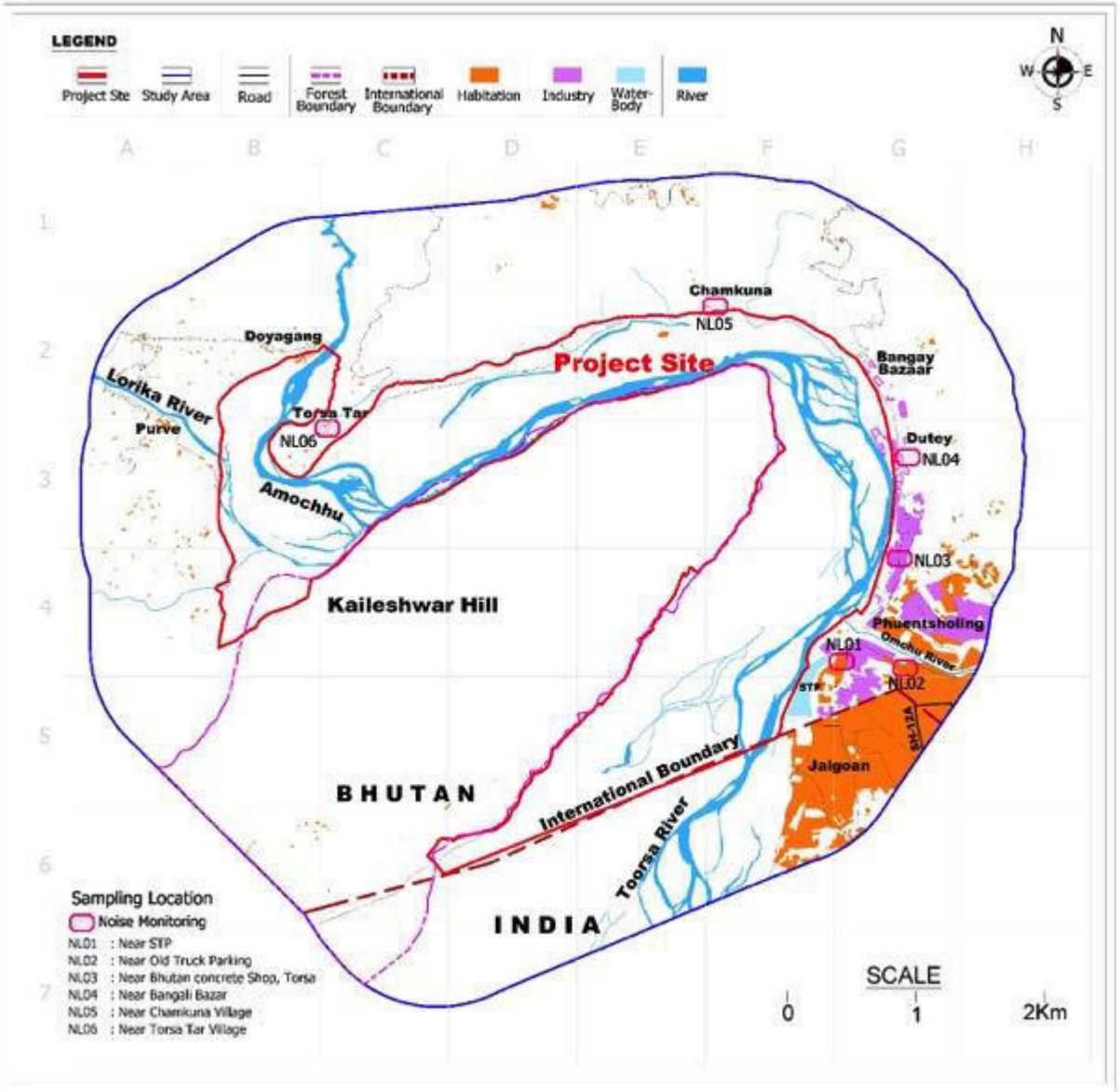
| Environmental Component | Sampling location | Sampling Parameters | Sampling Frequency | Sample collection | | Methodology |
|---|---|---|---|---|---|---|
| | | | | Sampling equipment | Detection Limit | |
| Ambient Noise Levels | 6 locations | Decibels – dB (A) | Once during the study (Hourly reading for 24 hours at each location) | Noise Level Meter (SLM-100) | 0.1 dB (A) | IS9989 |

246. The locations selected for ambient noise quality monitoring are presented in ***Table 4-13*** and shown in ***Figure 4-9.***

***Table 4-13: Ambient noise quality monitoring locations***

| SN. | Station Code | Location | Coordinates (Lat. & Long.) | Direction | Distance from Site in Km | Rationale |
|---|---|---|---|---|---|---|
| 1 | NL01 | Nr STP Area | 26°51'49.34" N 89°22'23.10" E | East | Core area | Mixed area |
| 2 | NL02 | Nr Old Truck Parking | 26°51'50.83" N 89°22'45.82" E | East | 0.68 | Parking area, traffic |
| 3 | NL03 | Nr. Bhutan Concrete bricks shop, Torsha | 26°52'15.72" N 89°22'44.43" E | East | Core area | Commercial |
| 4 | NL04 | Nr Bangay Bazar | 26°52'43.44" N 89°22'44.68" E | East | Core area | Commercial, Residential |
| 5 | NL05 | Chamkuna Village | 26°53'20.19"N 89°21'51.51"E | North | Core area | Residential |
| 6 | NL06 | Torsatar village | 26°52'51.31"N 89°20'04.71"E | NW | Core area | Residential, sensitive area |

***Figure 4-9: Ambient Noise monitoring location map***



247. The detail ambient noise monitoring results are given in ***Appendix*** 21***.*** However, the average ambient noise monitoring results as compared to environmental standard has been tabulated in ***Table 4-14.***

***Table 4-14: Average Ambient Noise Monitoring Results at Various Locations***

| Location and Date of Monitoring | NEC's Standard | Nr. STP area (08.03.16 | Nr. Old Truck Parking (10.03.16) | Nr. BCB Shop, Torsa (22.03.16) | Nr. Bengali Bazar (24.03.16) | Chamkuna Village (28.03.16) | Torsa Tar Village (30.03.16) |
|---|---|---|---|---|---|---|---|
| **Day time in dB(A)** | **65.00** | 56.52 | 60.16 | 60.36 | 58.62 | 51.38 | 62.82 |
| **Night time in dB(A)** | **55.00** | 52.66 | 53.58 | 47.88 | 52.88 | 44.46 | 65.08 |

248. The noise level during daytime and night-time were observed to be within the standards, except night time average noise level at Torsa Tar Village. The probable reason is due to truck movement.

249. Based on the above findings, it is recommended that the sample locations proposed could be used for monitoring noise level limits during project construction stage which can serve as a basis to evaluate the site specific changes in environmental baseline components.

## 4.7 ECOLOGY AND BIO-DIVERSITY

**TERRESTRIAL ENVIRONMENT**

250. As per the national forest inventory report (vol. i), 2016, the forest in Bhutan occupies a total area of 2,730,889 ha which represents 71% of the country, with the highest forest cover in Wanduephodrang and the lowest in Tsirang Dzongkhag.

251. Bhutan's biodiversity is outstanding with more than 5,600 of vascular plants, 600 species of birds and 190 species of mammals and 14 species of bird. The nearest protected area is the Jaldapara National Park across the International border in India.

252. General **STUDY AND METHODOLOGY:** The overall approach towards the study of ecology and biodiversity is shown in Appendix 22.

253. The land-use map and topographical map were used as a secondary data source. For primary data collection, a reconnaissance visit was conducted to examine the immediate status of the ecology and biodiversity in and around project site. Direct interactions were made with the individuals of communities residing in the areas visited (including in particular information regarding wild animals) and officials of Department of Forest and Park Services. A rapid bio-diversity assessment to gauge the movement and behaviour of elephants was carried out and sampling with standard methods (quadrates / transacts) was carried out to understand different floral and faunal components of the project site.

**KEY FINDINGS**

**FLORA**

254. **Core Zone:** *Acacia catechu* was dominant tree species found. The dominant species of herbs, shrubs and grasses were *Eupatorium odoratum, Diplazium esculentum, Marsilea minuta, Alternanthera pungens,*

*Urena lobata, Chenopodium ambrosioides, Aerva lanata, Digitaria ciliaris, Cyndon dactylon, Thysanolaena maxima, and Saccharum Sp*.

255. **Buffer Zone:** About 97 species were reported from buffer zone outside proposed site, out of which there were maximum species of trees (39) followed by herbs (30), shrubs (17) and climbers (6) and grasses (5). All species of tree, shrubs, herbs and grasses reported from the core and buffer area along with their vernacular names/local names and families are reported in ***Appendix*** 24**.**

**FAUNA:**

256. **Core Zone:** A total of 19 species were reported out of which maximum species of birds (15) followed by mammals (3) and amphibian (1). Only one species of amphibian i.e. *Bufo melanostictus* was encountered during the site visit. However, there were reports on the presence of *Muntiacus muntjak* (Barking deer). *Bos frontalis* (Mithun) and Maccaca Mulata (monkey) from some secondary evidence.

257. **Buffer Zone:** Overall 18 species were reported from the buffer zone including 13 species of birds and 9 species of mammals. As part of this study, a rapid biodiversity assessment was undertaken as required by ADB to understand the possible route of the elephants from the Jaldapara National Park in India into Bhutan, the possible reason for such movement and evaluate the potential impact of the ALDTP project on the elephant movement.

258. Detailed lists of species followed by common/English names has been attached as ***Appendix*** 25**.** Some of the important species found in the buffer zone are listed in ***Table 4-15.***

***Table 4-15: Status of major wildlife present in the buffer zones***

| SN. | Common name | Scientific name | Status in Bhutan | IUCN Status |
|---|---|---|---|---|
| 1 | Indian Elephant | Elephas maximus | Sch-1 | Endangered |
| 3 | Leopard | Panthera pardus | Sch-I | Near threatened |
| 5 | Gaur/Bison | Bos gaurus | Sch-I | Vulnerable |
| 6 | Assamese macaque | Macaca assamensis | - | Near threatened |

**JALDAPARA NATIONAL PARK**

259. Jaldapara National Park is situated at the foothills of Eastern Himalayas in Alipurduar Sub-Division of Jalpaiguri District in West Bengal. Jaldapara, the vast grassland with patches of riverine forests was declared a Park in 1941 for protection of the great variety flora and fauna, particularly the one-horned rhinoceros, an animal threatened with extinction. The Jaldapara Park covers 216 sq. km, is a mosaic of woods, grasslands, perennial streams, sandy river banks and extensive belts of tall grass. It contains a great diversity of flora and fauna of mixed deciduous forest, grasslands and river banks. The Malangi River also flows nearby from east to west. Drained by rivers Toorsa, Malangi, Hollong, Chirakhawa, Kalijhora, Sissamara, Bhaluka and Buri Torsa, the Park provides extensive grassland which is last refuge to a wide variety of mammals, amphibians, reptiles and birds.

260. The forest is mainly savannah covered with tall elephant grasses. The main attraction of the Park is Asiatic one-horned rhinoceros. The Park holds the maximum number of rhino's population in India after Kaziranga National Park in Assam. The other animals consists of Royal Bengal Tigers, elephants, deers, sambhar, barking deer, spotted deer and hog deer, wild pig, bisons. The wild life, in addition to the famous Great Indian One Horned rhinos, consists of Royal Bengal Tigers, wild elephants, deers, swamp deers, hog deers, wild pigs and bisons. Some rare species like the hispid hare and the hog-badger are also found here. Jaldapara is one of the very few places in India, where the Bengal Florican is sighted (***Appendix*** 25, Table

9-37) The other birds to be found here are the Crested Eagle, Pallas's Fishing Eagle and shikra, besides Jungle fowl, peafowl, partridges, Bengal Florican and lesser Pied Hornbill. Python, monitor lizards, kraits, cobras, geckos and about 8 species of fresh water turtles have also found Park here[3].

261. Jaldapara National Park has been designated as an Important Bird Area by Bird Life International. It has been designated due to the presence of several threaten bird species including the critically endangered Bengal Floridian[4]. While the species is observed downstream of the project area (across the Indian border), the riparian grassland habitat that support the bird species appears to be similar to the habitat in Zone C.

262. Hence, given there is adequate time before Zone C is developed (Zone A to be developed for the 1st Phase) and since no impact is foreseen with the development of Zone A, a further baseline terrestrial study (Biodiversity Monitoring and Bench Marking Study (BMBMS)) is planned during the implementation of the Phase 1 activity to confirm the presence of such species in Zone C, which could have a transboundary dimension as the habitat is continuous with Jaldapara National Park. The work will be carried out by an Environmental specialist under the supervision of the Project Implementation Consultant (PIC).

**ELEPHANT MOVEMENT**

263. Elephants *(Elephus maximus)* and the one-horned rhino (*Rhinoceros unicornis*) are noted to be present in the region, especially the Jaldapara National Park in India, adjoining the Zone C site area. The Rhinos were reported as not having significant movement outside the National Park. Elephants were reported to move into the Zone C area. The nearest reported elephant corridor in the Jaldapara National Park is about 5.0 km south of the site (from the National Park to the Dalshingpara area). The possibility of elephants using land within the study area could not be ruled out and it was considered important to consider the issue whilst undertaking the faunal evaluation. A specific rapid assessment on elephant movement was required as part of the ADB's requirement.

264. For this survey, the team visited the location and travelled on possible paths of the elephant migratory route along the India-Bhutan border. The team interacted with locals, who live in close proximity to these paths. It was conducted through a face-to-face interview using a standardized questionnaire. Twenty-three interviews were conducted with locals residing in scattered huts in Titiring village and adjoining areas. Responses were recorded and used for interpretation. The datasheets on which information was collected during the field survey are given in ***Appendix* 23** Based on the interviews, the following was inferred:

a. Movement from India to Bhutan takes place in the May-June months, which is the ripening season of maize crops during the wet season. Elephants typically visit during the 'baby corn' stage of the crop, which they apparently savor.
b. Elephant movement sometimes also occurs during October-November months, which corresponds to the ripening season of millets
c. During the survey, it was reported that a group of elephants was observed to have moved towards a mushroom plantation as seen by locals (outside the study area)
d. One local respondent said that elephants were also attracted to the smell of locally made alcohol and during one such event the storage hut of the locals was destroyed by the herd. Further, after this attack, the locals have stopped making alcohol on large scale and prepare only for self-use in small quantities
e. Elephants were observed to be typically moving during the night (usually 6 pm-8 pm). Occasionally, herds were also observed in the daytime.
f. Size of herds varied from 3 to 25. Most commonly reported herd size was five members
g. Elephants were observed to be walking calmly and foraging along the path

[3] Source: http://jaldapara.in/jaldapara.html.

[4] Source: http://datazone.birdlife.org/site/factsheet/18458

h. The route of movement is typically along the slope of the Kaileshwar Hill, moving towards the Shiv temple at the northern end of the Hill adjacent to Zone C. Here bamboo shoots are eaten by them. It is possible that the elephants enter the area and after raiding the local vegetation, crops, vegetables and sometimes fruits, and then they move towards the temple foraging in the area for 1-3 days before returning back to India.

i. The duration of the stay ranged from 1-4 days in the villages and 1-3 days near the temple in Kaileshwar Hill.

265. Based on these results of villager surveys, the movement of the elephants is associated with a selective feeding urge particularly for maize and millets amongst other crops. Movement is only during ripening of these crops, i.e. mostly in the monsoon season and sometimes in early winter. The elephants are mostly in small (3-4) groups, although herds of 25 elephants have also been reported.

266. Although a larger population of elephants have been reported from the census in the Jaldapara National Park, varying numbers were reported to be moving during particular seasons for several days to Bhutan. It may be associated with the availability of fresh grassland vegetation during the monsoon season. Overall elephants prefer habitats where water is available and food plants are palatable. During the onset of rains in May, they disperse over a wider area at lower densities, largely into the tall grasslands, to feed on the fresh grasses, which then has a high protein value. The normal movement pattern could be upset during years of adverse environmental conditions. However, the movement pattern of elephants does not change over centuries. Further, before the electric fences were put up the villages were raided and crops, vegetables and fruits were damaged by the elephants every year. Electric fences have been put up along a portion of the route to arrest the movements into the Titiring village. After the fences were put up, the elephants have taken a different route and they just skirt the village towards the hill edge.

267. The land use inventory shows extensive areas of similar and suitable habitat for a range of terrestrial species subject to seasonal conditions. The rapid assessment of one week conducted in the area of Zone C and D is not sufficient to decide the nature of its range and distribution. For instance, there is a lack of clarity to describe the range of species like elephant which can be generally classified as follows:

i Core range - where elephants are present throughout the year;

ii Seasonal range - where elephants are present seasonally;

iii Erratic range - where elephants may occur periodically but not necessarily every year; and

iv Unknown range - where elephants are known to occur, but where there is no further information available.

268. More importantly, elephant range and distribution data become particularly important where cross-border movements occur and countries share the same elephant population. Hence, given there is adequate time before Zone C is developed (Zone A to be developed for the 1st Phase), a further baseline terrestrial study (Biodiversity Monitoring and Bench Marking Study (BMBMS)) is planned during the implementation of the Phase 1 activity. The work will be carried out by an Environmental specialist under the supervision of the Project Implementation Consultant (PIC). The issues subject to further investigation include:

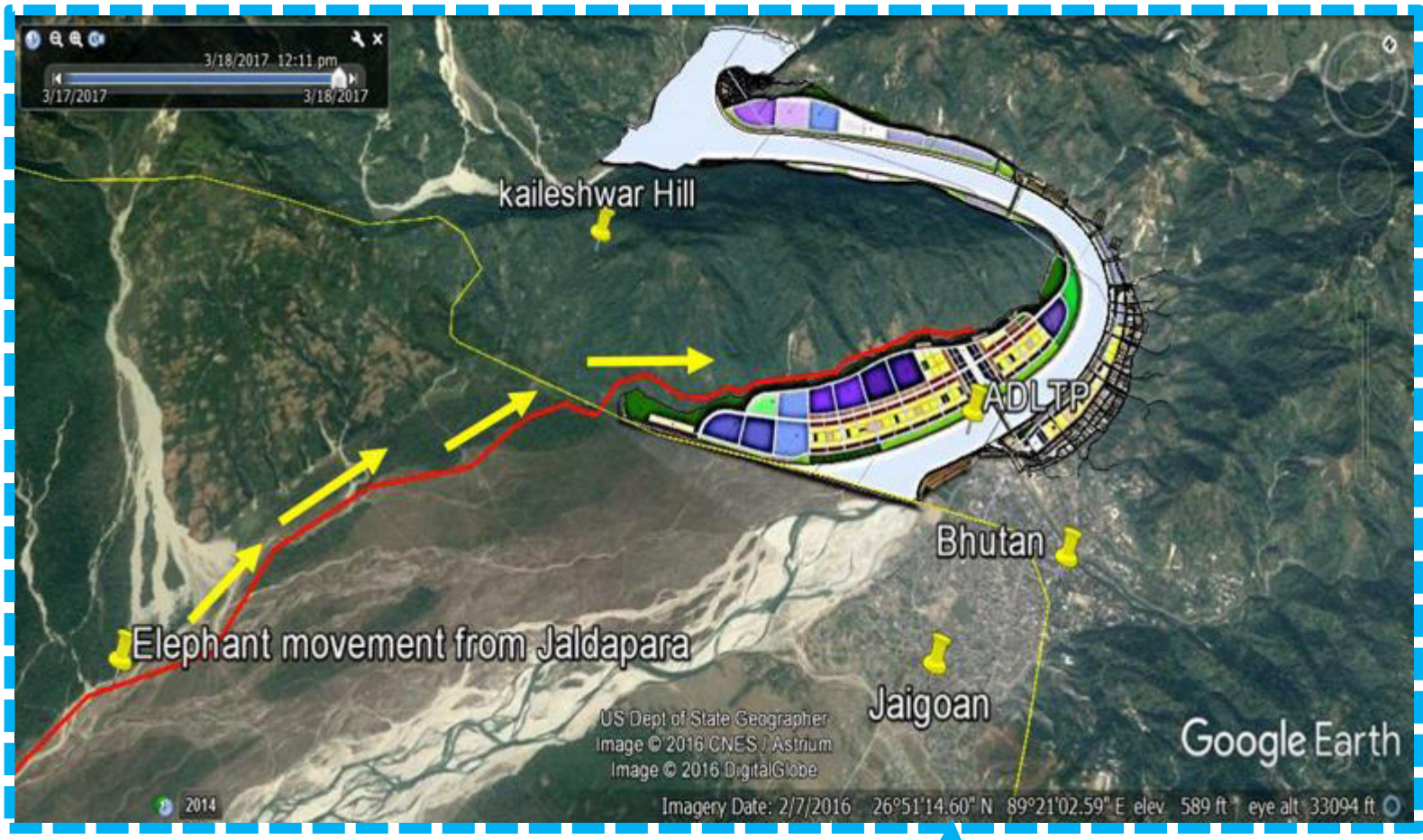
I. Current elephant movement and social behavior.

II. Current presence of other fauna species in the Study Area that may be affected by the development such as the Indian Leopard, the Indian Rhino and Barking Deer.

III. The proposed development of Zone C will take into account the results of the studies mentioned in S. No. I and II above.

269. The possible indicative movement of elephants is shown in ***Figure 4-10.***

***Figure 4-10: The possible movement route of Elephants***




**AQUATIC ENVIRONMENT**

270. The aquatic environment consists of study on Phytoplankton, Zooplankton, Benthos and fisheries. For this, the secondary sources that were reviewed are (i) *Ichthyofaunal Diversity of River Torsa and its tributaries at terai region of West Bengal, India. I.J.S.N., Vol. 6 (2): 256-263, 2015, and (ii) Initial Environmental Examination (IEE) for SASEC Transport, Trade Facilitation and Logistic Project, April 2016* for which an aquatic survey was conducted by National Research Centre for Riverine and Lake Fisheries, , Department of Livestock (DoL), Bhutan at Amochhu.

271. Two seasons of primary data collection were carried out as follows:

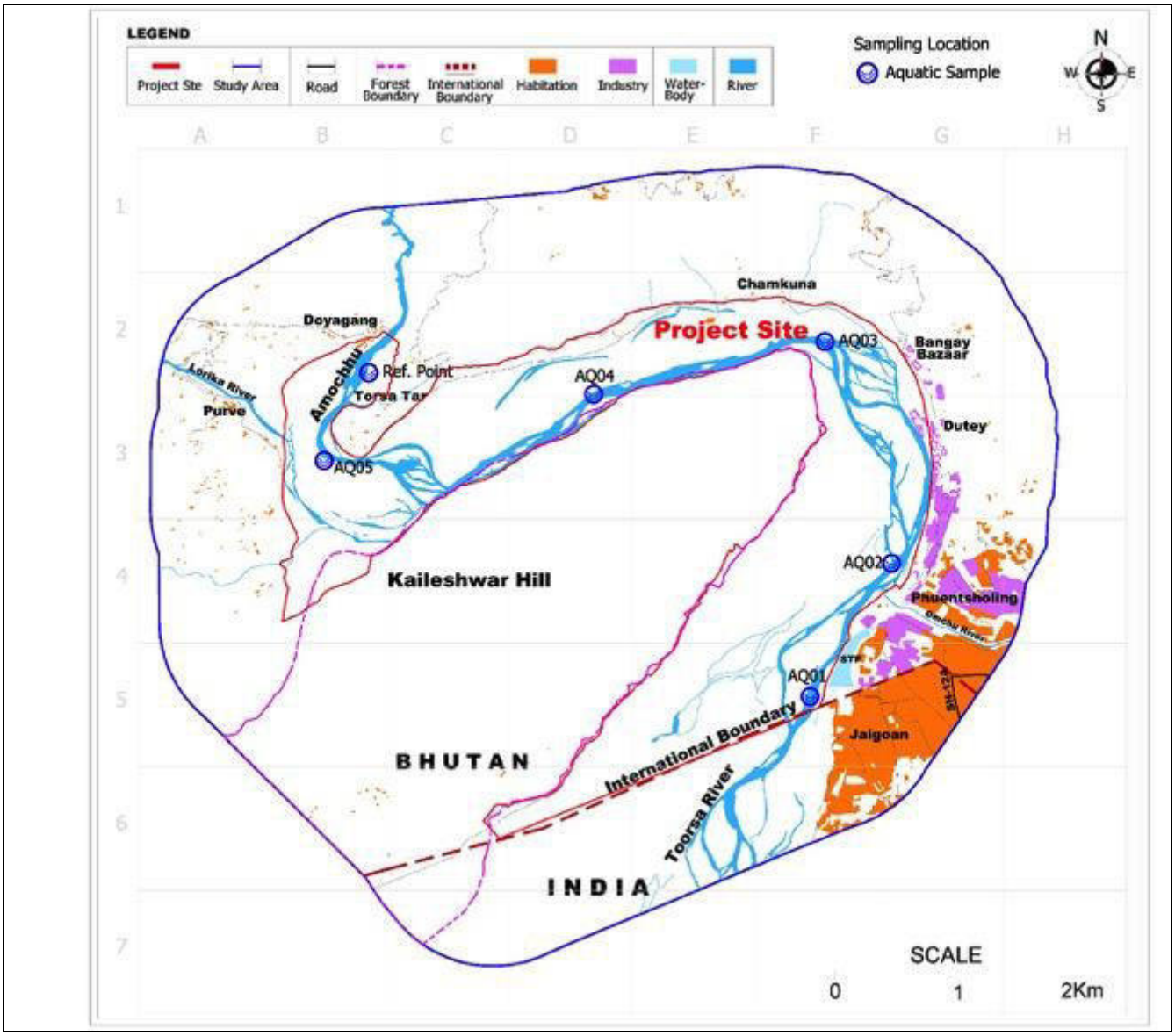
- Surface water sampling using standard plankton net with a mesh size of 51µm for phytoplankton and quantitative analysis of phytoplankton (cell count) was carried out using Sedgwick-rafter counting chamber.
- Zooplankton samples were collected using Standard Heron Trenton nets and measured by displacement method.
- Sediment samples for macro benthos were collected using spatula at the site and macro invertebrates like insects and molluscs were collected by handpicked and dip netting methods.
- A fish study was carried out using ***Catch Per Unit Effort (CPUE)*** with support from Department of Forest and Park Service, Phuentsholing. In addition, a fish market survey at Jaigaon was carried out to determine the sources of fishes sold in the market at Jaigaon, India. The details of the sampling locations in Amochhu are presented in ***Table 4-16 .***

***Table 4-16: Details of sampling locations (1st and 2nd season)***

| S. No. | Station | Latitude | Longitude | 1st Season Sampling date | 2nd Season Sampling date |
|---|---|---|---|---|---|
| 1 | **AQ 1** | 26°51'32.70"N | 89°22'07.48"E | 03-03-2016 | 09/11/2016 |
| 2 | **AQ 2** | 26°52'09.91"N | 89°22'32.90"E | 03-03-2016 | 09/11/2016 |
| 3 | **AQ 3** | 26°53'06.86"N | 89°22'14.16"E | 04-03-2016 | 10/11/2016 |
| 4 | **AQ 4** | 26°52'53.47"N | 89°21'04.93"E | 04-03-2016 | 10/11/2016 |
| 5 | **AQ 5** | 26°52'37.42"N | 89°19'46.99"E | 04-03-2016 | - |
| 6 | **Reference Point** | 26°52'59.15"N | 89°19'57.51"E | 04-03-2016 | 10/11/2016 |

272. Sampling locations during November'16 were fixed within four stations (AQ1 to AQ4) due to velocity of water. The water flows were medium velocity of approximately 0.5 – 1 m/s. Station AQ5 was not included due to strong current at this site which showed a very low incidence of planktonic groups.

*Figure 4-11: Aquatic Sampling location Map*




**PHYTOPLANKTON**

**KEY FINDINGS**

273. 1st Season: The highest cell count of phytoplankton recorded at surface water of station AQ 3 (42 Nos x 103/Lit) whereas lowest at station AQ 5 (30 Nos x 103/Lit). Overall the phytoplankton density is moderate where three groups, i.e. diatoms, Chlorophyceae & Cyanophyceae were recorded. The results of quantitative analysis of phytoplankton in Amochhu river sample is given in ***Table 4-17.***

***Table 4-17: Results of quantitative analysis of phytoplankton in Amochhu***

| Station | Cell Count | Total Genera (No.) | Genera |
|---|---|---|---|
| AQ 1 | 35 | 5 | Melosira sp., Fragilaria sp, Navicula sp, Acanthes sp, Nostoc sp |
| AQ 2 | 39 | 3 | Nitzchia sp,, Acanthes sp, Navicula sp |
| AQ 3 | 42 | 4 | Fragilaria sp, Navicula sp, Acanthes sp, Navicula sp |
| AQ 4 | 40 | 4 | Navicula sp, Nitzchia sp, Ulothrix sp, Anabaena sp. |
| AQ 5 | 30 | 3 | Anabaena sp, Nostoc sp, Fragillaria sp. |

274. 2nd Season: Despite the minimum river flow, few places could be located where water was either stagnant or motionless. Green algae could be found on the stones. On some big boulders diatom cover could

be seen which makes them slippery. Plankton species were less compared to 1st season due to faster current in the water body. Two types of algae among Phytoplankton associations were observed namely Green Algae and Diatoms, the detail of which is shown in ***Table 4-18.***

***Table 4-18: Cell count (No x 103/Lit) of phytoplankton***

| Station | Cell Count | Total Genera (No.) | Genera |
|---|---|---|---|
| AQ 1 | 21 | 3 | Selenastrum sp., Diatoma sp., Navicula sp. |
| AQ 2 | 25 | 2 | Chlamydomonas sp., Fragilaria sp. |
| AQ 3 | 22 | 2 | Navicula sp, Volvox sp. |
| AQ 4 | 17 | 3 | Actinella sp, Nitzchia sp, Fragillaria sp. |

**ZOOPLANKTON**

**KEY FINDINGS**

275. 1st season: The highest population of zooplankton was recorded at station AQ 1 whereas lowest at station AQ 3. On contrary, highest biomass of zooplankton was reported at station AQ 5 whereas lowest at station AQ 3. The *Cyclopoid sp.* and *Nauplius sp*. were two dominant group in found in most locations. All the observed spatial and temporal variations in zooplankton density were normal in this stretch and no events negatively influencing the zooplankton community were noticed during the study. Occurrence of zooplankton in study area is given in ***Table 4-19.***

***Table 4-19: Occurrence of zooplankton in study stations***

| Station | Biomass (ml/100m3) | Population (no.x103/100m3) | Total Group (No.) | Major Genera |
|---|---|---|---|---|
| AQ 1 | 22.5 | 1500 | 3 | Nauplius sp. Cyclops sp. Cyclopoid sp., |
| AQ 2 | 25 | 850 | 3 | Lucifer sp., Cyclopoid sp., Chydorus sp |
| AQ 3 | 20 | 700 | 3 | Nauplius sp., Cyclopoid sp., Alonella sp. |
| AQ 4 | 30 | 250 | 2 | Cyclopoid sp., Nauplius sp. |
| AQ 5 | 35 | 650 | 2 | Cyclopoid sp., Chydorus sp |

276. 2nd Season: Occurrence of zooplankton also found to be very limited due to high turbulent water. The distribution pattern in the four study stations (AQ1 - AQ4) revealed that the number of groups were lesser compared to the 1st season. Station-wise, AQ1 and AQ2 recorded more number of groups followed by AQ4 and AQ3. Groups like Calanoid, Polycheate larvae showed 40% occurrence in this month. Larval forms like gastropod, crustacean and brachyuran larvae showed 20% followed by others. Groups like cumacean and Panaeid larvae showed the least distribution (1%). The details are shown in ***Table 4-20.***

***Table 4-20: Occurrence of zooplankton in study stations***

| Station | Total Group (No.) | Population (no.x103/100m3) | Major Genera |
|---|---|---|---|
| AQ 1 | 2 | 550 | Nauplius sp. Cyclops sp. |
| AQ 2 | 3 | 250 | Lucifer sp., Daphnia sp. |
| AQ 3 | 1 | 375 | Cyclops sp. |
| AQ 4 | 2 | 222 | Daphnia sp. |

**BENTHOS**

**KEY FINDINGS**

277. 1st Season: A total 9 taxa were recorded in this seasonal study in the benthic faunal assemblage. Faunal community were represented by six groups namely, *worms, mayflies, stone flies, crustaceans, molluscs and leeches*. During the study, worms (*oligochaete*) were most dominant followed by Mayflies (*Heptageniidae and Leptophlebiidae),* Stone flies *(Perlidae)*; crustaceans (prawns and isopods or water lice), molluscs (Bivalves and Gastropods) and Leeches *(Hirudidae).*

278. Benthic faunal composition included four major dominant groups of *Oligochaeta* followed by *Perlidae, Heptageniidae and Molluscs*. The Standing Stock of Sub tidal Macro benthos are shown in ***Table 4-21.***

***Table 4-21: Standing Stock of Sub tidal Macro benthos***

| Station | Biomass (gm/m2) | Population (no./m2) | Major Taxa |
|---|---|---|---|
| AQ 1 | 4.5 | 115 | Oligochaeta, Bivalves, Water lice |
| AQ 2 | 5.2 | 250 | Oligochaeta, Crab, Heptageniidae |
| AQ 3 | 3.7 | 118 | Gastropods, Oligochaeta, Prawns |
| AQ 4 | 4.9 | 350 | Leptophlebiidae, Perlidae, Isopods, |
| AQ 5 | 6.9 | 450 | Hirudidae, Perlidae, Oligochaeta |

279. In total, about 5 taxa were recorded in the 2nd season. The number of Stone flies was observed the highest at the AQ4 and Mayflies were the most commonly found at all sites except in AQ3. At AQ3, caddisflies were frequently observed as well. Stoneflies were only observed at AQ2 and AQ4. In addition, water beetle larvae were also observed at AQ2 and adult water beetles found at the AQ4. Standing stock of Macro Invertebrates are shown in ***Table*** 4-22***.***

***Table 4-22: Standing Stock of Macro Invertebrates***

| Station | Population (no./m2) | Major Taxa |
|---|---|---|
| AQ 1 | 125 | Mayflies, Oligochaeta |
| AQ 2 | 275 | Oligochaeta, Stone flies, Water beetle |
| AQ 3 | 175 | Mayflies, Oligochaeta, Caddisflies |
| AQ 4 | 225 | Stone flies, Mayflies, Water beetle |

280. Over all, the maximum benthic population was recorded during the 1st season due to stable environmental conditions. The overall distribution indicates a balanced nutrient utilization in Amochhu. The higher abundance of aquatic insects and benthos help feed the aquatic life retaining the nutrients longer for a healthy ecosystem.

**FISHERIES**

281. Fish production is dependent on production of zooplanktons, which in turn is dependent on the phytoplankton production or primary productivity. All of these components are related to physico-chemical characteristics of the water. Like other Himalayan rivers, the Amochhu and its tributaries provide an ecological niche for many indigenous and a few exotic cold-water fish species. As the proposed study area is relatively limited, few species were observed there. The water carries fine soil particles while the riverbed material is boulders and stones. The water temperature plays a vital role in the distribution of fish in Himalayan Rivers.

**KEY FINDINGS**

282. 1st Season: About 8 species of fish were captured where the dominant group observed was *Cyprinidae*. No endangered species were recorded during the survey. The list of fish species are shown in ***Appendix 27.***

283. Table 4-23 and Photographs are shown in ***Appendix 27.***

***Table 4-23: Fishery Survey during March 2016 in River Amochhu at Phuentsholing***

| SN | Family | Common Name | Scientific Name | IUCN Status5 (ver. 3.1, 2016) |
|---|---|---|---|---|
| 1 | Cyprinidae | Gardi | Labeo bata | LC |
| | | Grass carp | Ctenopharyngodon sp. | Not assessed |
| | | Boirali | Esomus sp. | LC |
| 2 | Heteropneustidae | Singi | Heteropneustes fossilis | LC |
| 3 | Channidae | Hilay | Channa sp. | LC |
| 4 | Anabantidae | Koi | Anabas sp. | DD |
| 5 | Cobitidae | Poia | Acanthocobitis Botia | LC |
| 6 | Penaeid | Chingri | Macrobrachium sp. | NA |

284. 2nd Season: About 12 species of fish species were recorded where the dominant group was Cyprinidae. Recorded fish species during survey are given in ***Table 4-24.***

***Table 4-24: Fishery Survey during November 2016 in River Amochhu at Phuentsholing***

| S. No. | Family | Common Name | Scientific Name | IUCN Status (ver. 3.1, 2016) |
|---|---|---|---|---|
| 1 | Cyprinidae | Chepti | Cyprinion semiplotum | VU |
| 2 | | Katli | Neolissochilus hexagonolepis | NT |
| 3 | | Ghakshi | Barilius bendelisis | LC |
| 4 | | Ghakshi / Boroli | Barilius shacra | LC |
| 5 | | Chela | Securicula gora | LC |
| 6 | | Ghor Rui | Labeo dyocheilus | LC |
| 7 | | Kalbaus | Labeo calbasu | LC |
| 8 | Synbranchidae | Kuchia | Monopterus cuchia | LC |
| 9 | Chacidae | Chega | Chaca chaca | NA |
| 10 | Heteropneustidae | Singi | Heteropneustes fossilis | LC |
| 11 | Cobitinae | Guttum | Somileptes gongota | NA |
| 12 | Belonidae | Kankley | Xenentodon cancila | LC |

[5] IUCN Status: LC=Least Concern; NT= Near Threatened; NA= Not assessed; VU=Vulnerable;
IUCN Trend: D=Decreasing; UK=Unknown; ST=Stable

285. During the survey, captured and recorded ichthyofauna species vulnerable (V) and near threatened (NT) were recorded but no endangered species were found. The vulnerable fish species caught was the *Cyprinion semiplotum* (chepti). A near threatened fish species caught was the *Neolissochilus hexagonolepis* (Katli).

286. An endangered species, the *Tor putitora* (Golden Mahseer) was not found during the field survey but it was identified in a separate study conducted by the National Research Centre for Riverine and Lake Fisheries. As per the IUCN Red List of Threatened Species, this species is mainly distributed in the *mid-hill stretches* of the Himalayan region inhabiting rapid streams with rocky bottoms, riverine pools and lakes. It is therefore unlikely to be commonly found in the lower stretches of the Amochhu, in which the project area lies. As part of the field survey, a local fish market survey was carried out in Jaigaon. The list of fishes is attached as ***Table*** 4-25.

***Table 4-25: Fishes observed in the Jaigaon Fish Market***

| SN | Fishes observed at Jaigaon (Local Name) | Scientific Name | Possibility of species being sourced from Amochhu Bhutan | IUCN List (ver. 3.1, 2016) |
|---|---|---|---|---|
| 1 | Ghakshi/ Boroli | Barilius bendelisis (Hamilton, 1807) | Yes | Least Concern |
| 2 | Ghor Rui | Labeo dyocheilus (McClelland, 1839) | Yes | Least Concern |
| 3 | Kankley | Xenentodon cancila (Hamilton, 1822) | No | Least Concern |
| 4 | Kalbaus | Labeo calbasu (Hamilton, 1822) | No | Least Concern |
| 5 | Kuchia | Monopterus cuchia (Hamilton, 1822) | No | Least Concern |
| 6 | Chega | Chaca Chaca (Hamilton, 1822) | No | Least Concern |
| 7 | Singi | Heteropneustes fossilis (Bloch, 1794) | No | Least Concern |
| 8 | Khorkey | Acanthocobitis sp. | No | NA |

The fishes observed in the fish market can be broadly categorized into riverine fishes and reservoir fishes. Fishes that are riverine are sourced from either the Torsa (i.e. Amochhu) or the Mujnai (a tributary of river Jaldhaka). During the fish market study, about 8 riverine fish species could be identified, out of which only two were found to be present in the Amochhu. This indicates that the fish consumed in the fish market are not necessarily sourced from the Amochhu and that fish found in rivers other than the Amochhu also play a major role in livelihood, both as a means of support to fishermen and food for downstream residents at Jaigaon. It also follows that fishes within the Amochhu are at least partially satisfying market demand. However, all these fishes are of least concern since they are abundant, as per IUCN literature.

## 4.8 SOIL CONSERVATION

287. The overall approach towards the study of soil conservation is given in **Appendix 26.**

288. A field visit was conducted to study site-specific soil quality and conditions includes soil color, texture, mineralogical content, plasticity and any possible impact to the environmental setting due to project. To monitor the quality of soil in the river bed, soil samples from A, B and C zones of Amochhu River were collected along with three soil samples from mining areas to find out the soil quality to be used for landscape.

289. The location for soil sample collection were randomly selected at the project site as well as from the surrounding areas namely Soil-1 to Soil-6. The soil samples from 0-15 cm depth were collected by using spade, shovels, hammers and container tube. The samples were homogenized and about 1 Kg soil sample was collected in the polyethylene bag. These were then labelled with sample ID (location number and project name). The samples were brought to the laboratory for analysis of physical (porosity, water holding capacity, permeability, and particle size distribution) and chemical properties (cation exchange, electrical conductivity, sodium adsorption ratio, pH, Ca, Mg, Na, K, organic carbon (OC), total-N, available-P and available-K. the Methodology proposed for the soil sample is shown in ***Table*** 4-26***.***

***Table 4-26: Methodology of Soil Analysis***

| Sampling Parameters | Analytical Equipment | Methodology | Remarks |
|---|---|---|---|

| Sampling Parameters | Analytical Equipment | Methodology | Remarks |
|---|---|---|---|
| **Porosity** | - | IS: 2720 Part 7 | Trial pit method for topsoil sample collection; disturbed samples |
| **Water holding capacity** | Keen Apparatus | HMSO, UK | |
| **Permeability** | - | IS: 2720 Part 17 | |
| **Moisture content** | Electronic Balance | IS: 2720 Part 2 | |
| **Texture** | - | IS: 2720 Part 4 | |
| **Particle size Distribution** | Glass wares | IS: 2720 Part 4 | 5% Leachate to be made and analysed as per APHA, "Standard Methods"<br>All method numbers are as per APHA "Standard Methods" (21st edition, 2005) |
| **Cation Exchange Capacity** | Centrifuge | IS: 2720 Part 24 (1976) | |
| **SAR** | F. Photometer (Na, K); Titration ( Ca & Mg) | Calculation | |
| **pH** | pH Meter | 4500 H+B | |
| **Electrical Conductivity** | Conductivity Meter | As per IS 14767 - 2000 | |
| **Calcium** | Glass wares | 3500 Ca B | |
| **Magnesium** | Glass Wares | 3500 Mg B | |
| **Sodium (Na)** | F.Photometer | 3500 Na B | |
| **Potassium** | F.Photometer | 3500 K B | |
| **Dry Bulk Density** | Glass wares<br>Measuring cylinder, Balance | IS: 2720-29(1975) | Laboratory Method |
| **OC (Organic carbon)** | Glass wares | IS 2720-22 (1972) | Volumetric Method |
| **Total Nitrogen** | Glass wares | IS 2720-22 (1972) | Calculated from OC |
| **Available Phosphorus** | Spectro photometric Method | Olsen et al. (1954) | Extraction with O.5M NaHCO3, pH 8.5 |
| **Available potassium** | F.Photometer | Jackson (1973) | Extraction with Neutral N NH4OAC (ammonium acetate) |

290. Soil sampling locations for both seasons are given ***in Table 4-27***. Soil sampling location map for 1st and 2nd season are shown in ***Figure 4-13*** and ***Figure 4-12*** respectively. The sampling photographs can be referred in ***Appendix*** 28***.***

***Table 4-27: Soil Sampling Locations***

| Code | Location | 1st Season | | 2nd Season | |
|---|---|---|---|---|---|
| | | **Co-ordinates** | **Sampling Dates** | **Co-ordinates** | **Sampling Dates** |
| ST1 | Zone-A | 26°53' 12.24" N<br>89°2' 24.79" E | 04-03-2016 | 26°53' 12.24" N<br>89°22' 24.79" E | 18-05-2016 |
| ST2 | Zone-B | 26°53' 1.85" N<br>89°20' 54.40" E | 03-03-2016 | 26°53' 6.19" N<br>89°21' 2.07" E | 18-05-2016 |
| ST3 | Zone-C | 26°52' 57.71" N<br>89°2' 23.04" E | 04-03-2016 | 26°51' 59.22" N<br>89°22' 27.24" E | 19-05-2016 |

*Figure 4-12: Soil sampling location map (1st season)*

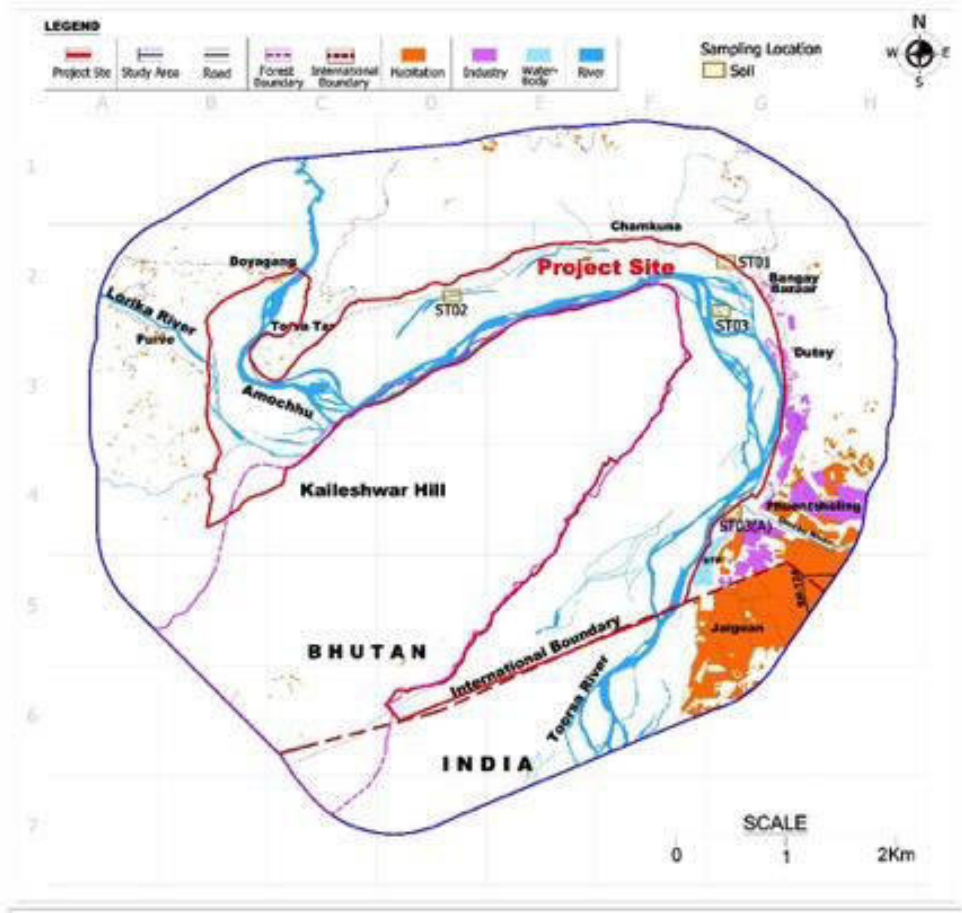
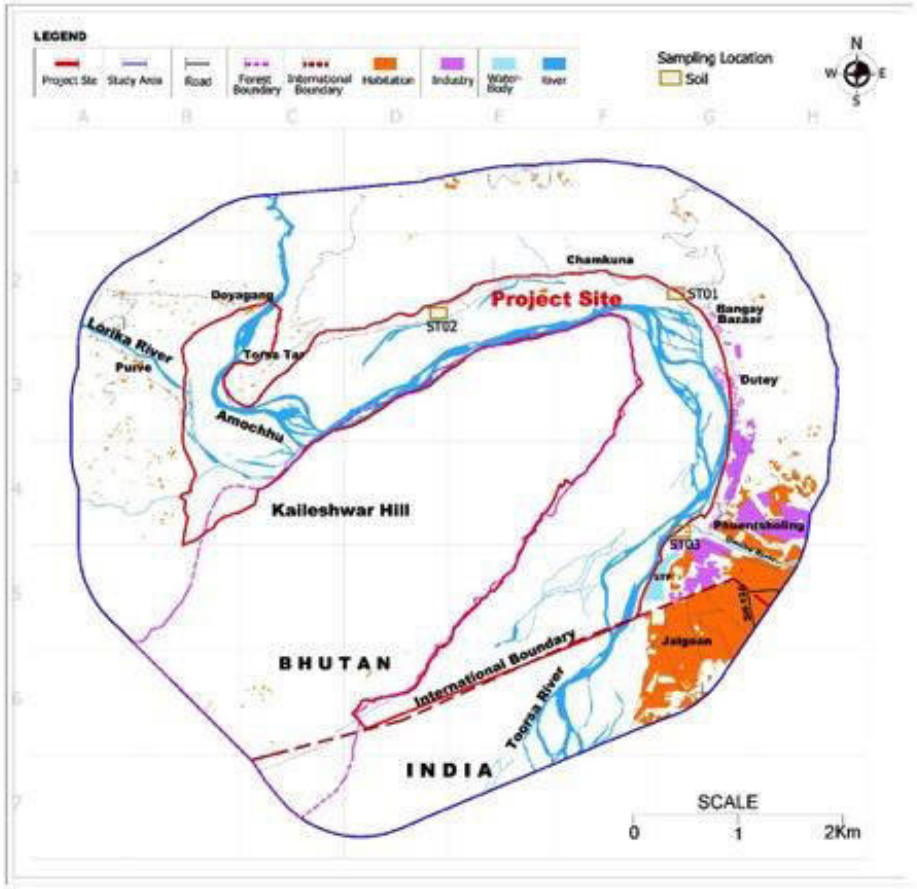



*Figure 4-13: Soil Sampling Location Map (2nd season)*



**KEY FINDINGS**

291. Soil material in the study area basically comprises of reddish brown soil on the top having a thickness of 2.0 m followed by grey quartzite with varying thickness and greenish to grey phyllite which is quite compact. This is underlain by carbonaceous phyllite intermixed with talcose and chlorotic phyllite. Huge boulders of quartzite ranging in size from 1 $m^3$ to 80 $m^3$ were observed in the slide zone. The structure of the rock is well preserved though the rocks are highly fractured. They are also highly weathered and have low strength and cohesion. Soil sampling analysis results are given in ***Appendix*** 29***.***

**WINTER: 2015-16**

292. Among three zones, a sufficient land cover is observed in zone A and C, which has helped in reducing erosion and stabilization of fine sand and this will serve as a good source as top soil land filling. The layer of fine sand is varying from a few mm to 10 cm and thereafter the fine sand is embedded with stones and boulders. Assessment of soil physical properties revealed that porosity ranged from 41 to 45 % and WHC (water holding capacity) varied from 36.71 to 45.40 %, while soil permeability ranged from 20.2 to 62.3 mm/hr.

293. Soils have a sandy to sandy loam soil texture and this is indicative of medium to high permeability. The soil EC (electrical conductivity) varied from 0.116 to 1.620 dS/m, indicating very low (<0.8 dS/m 1:2 Soil: Water ratio) (river bed) to saline soil conditions in mining areas. The ESP (exchangeable sodium percentage) also varied from <0.1 to 0.58, however it was within the prescribed limit of < 5. The pH of soil varied from 6.01 to 7.15, indicating acidic pH to neutral pH. Among water soluble cations Ca , Mg, Na and K varied from 0.05-0.48 g/kg, 0.12 -0.87 g/kg, 0.26-0.32 g/kg and 0.01-0.07 g/kg, respectively, indicating predominance of calcium and magnesium followed by sodium, mainly due to soil samples collected from dolomite and limestone mining areas.

294. The soil samples were assessed for soil fertility parameters (OC, Total-N, Available P2O5 and Available K2O). The soils at the site are deficient in all the parameters, while samples from mining areas are rich (>0.75 % OC) in OC (0.82 to 1.41 % OC), Total-N (1581-2876 kg/ha), but very low (<28 kg P2O5/ha) in available phosphorus (6.10- 23.20 kg/ha) and low (<140 kg K2O/ha) in potassium (49-81.33 kg/ha).

**SPRING: 2016**

295. Three soil samples were collected from the surrounding areas of the river as samples from different zones could not be collected as river was full. The results indicated that soil porosity ranged from 48-50 % and water holding capacity 43.7-47.2 %. The permeability varied from 20.2-27.3 mm/hr. (moderately slow) as soil texture was sandy loam to sandy clay loam. The CEC ranged from 15.10-17.50 meq/100 g soil. The soil EC (0.117-0.132) and ESP (<0.1) were <0.8 dS/m and 5, respectively. The pH of soil varied from 7.25-7.42, indicting neutral soil reaction. Among water soluble cations predominance of calcium was seen followed by Mg, Na and K. However, soil organic carbon (0.77-0.99 %) was in the high category (>0.75 % OC).The comparison of samples collected from riverbed and area close to the respective zones did not show large variations in different soil parameters, except organic carbon content of soil, which was >0.75 per cent in spring as against >0.50 % OC in winter. This is possible as silting will be on the banks of river.

296. From the fore going results it can be concluded that river bed soils are poor in soil fertility as the silt & clay fractions are very low, which could be improved by land fill with overburden material available from certified limestone, dolomite and aggregate mine dealers.

297. The soil layer in the riverbed is only a few cm, but it could be stock piled and used for green belt development after removal of stones and boulders as vegetation is luxuriantly growing in the river bed, but soil is poor with regard to nutrient status. However, it can be enriched with organic manures and chemical fertilizers for successful green belt development. Alternately for horticulture or plantations overburden material available in mining areas could be used and its quality is better than in situ soil, but transportation cost will be very high.

## 4.9 SOCIO-ECONOMICS

298. **GENERAL STUDY AND METHODOLOGY:** The overall approach towards the study of Socio-Economic is given in ***Appendix 30.***

299. In brief, the methodology adopted for conducting SIA included an initial site reconnaissance visit, discussion with local authorities, administrative heads of various departments, observations, desktop review of relevant reports and documentation pertaining to the project area of influence, review of government publications, legislation, and previous social project reports. It also involved repeated site visits, qualitative and quantitative data collection in field through discussions and consultations with various stakeholders, data analysis and reporting.

**KEY FINDINGS:**

300. As per the Urban Development Plan (2004) for Phuentsholing, the population of Phuentsholing urban area in 2002, excluding the Pasakha industrial area, was around 18,600. It was then projected to be around 54,280 by the year 2017, including Pasakha industrial area and the floating population of the city as shown in ***Table* 4-28*.***

***Table 4-28: Population of Phuentsholing Urban Area*** [6]

| Year | Existing population of PUA | Estimated population of Pasakha | Total population of PUA | Floating population | Total population of PUA (Including floating population) |
|---|---|---|---|---|---|
| 2002 | 18600 | - | - | - | - |
| 2007 | 21600 | 13400 | 35,000 | 8750 | 43750 |
| 2012 | 25100 | 15,500 | 40600 | 8120 | 48720 |
| 2017 | 29200 | 18,000 | 47200 | 7080 | 54280 |

301. The increase in population is one of the greatest threats to the urban environment in Phuentsholing. It has greatly burdened the existing facilities, which were not planned for such a heavy load of population. The surrounding forests, land and hills are getting converted into residential, commercial or other uses to accommodate the increasing population.

302. Phuentsholing and Jaigaon city are close to the proposed project. The population of these places is as follows:

- Phuentsholing city: 20573 (as per 2005 census, Govt. of Bhutan)
- Jaigaon city: 42254 (as per 2011 census, Govt. of India)

[6] *Source: Development Plan - Phuentsholing Urban Area (PUA) -2004*

303. There are no private human land holdings or settlements in the project area. This project does not involve any resettlement.

304. **Economic profile:** The understanding about the existing socio-economic profile, housing, infrastructure and basic services has been developed based on preliminary site visits, assessment of secondary data and discussions with officials and local people.

305. **Social Characteristics:** Being a border city and a gateway of Indo-Bhutan border, the city of Phuentsholing hosts people of various ethnicity and socioeconomic background living in it. Other than the natives, people of all ages and sex come to Phuentsholing in search of jobs, to stay with the working person of their family and young students come for vocational trainings. There are people who have settled here with their families for business purpose from other parts of Bhutan. Many people from Indian town Jaigaon come here for their livelihood as “Day workers”. A sense of belonging or ownership is missing here because a large part of population is either migrant from other parts of the country or are day workers from India.

306. **Major economic activities:** Being the commercial hub of the country the city has crucial role in economic development of the country. With extended areas hosting Pasakha industrial estate and Chhukha and Tala Hydro Power Projects it hosts a variety of economic activities including commercial sector, industrial and construction sector, administrative and institutional sectors are located and has a greater role in growth of the city. The commercial sector has the activities like shops, hotels, bars, restaurants, truck repairing workshops and many more, the industrial sector has activities like agro and dairy-based industry, beverages and bottling plants, mining and allied, petrochemical industry. The construction sector is the largest sector in the city due to a large number of coming up Projects. The Administrative and institutional sector hosts government offices, immigration office, College of Science and Technology, other vocational training institutes

307. **Literacy rates:** The literacy rate of the Bhutan is 59.5%. The literacy rate 68% of Phuentsholing is higher than the national literacy rate 59% and Chhukha 63%.

308. **Common Diseases:** The most common diseases in the area are Tuberculosis, Dengu, i.e. vector borne diseases.

309. **Infrastructure facilities available:** Houses in Phuentsholing are of a permanent nature. They are constructed in RCC, stone, timber and other such robust materials. The layout of a typical apartment unit ranges from 1 to 4 bedrooms, a proportionate living room and a kitchen module. The residential buildings are 1 to 5 storied. Most of them have pitched roofs complying with the Attic Rules (2009). The roof is generally observed to be of metal sheets in corrugated profile. Few buildings are also observed to have flat roofs. It is evident that the buildings are spaced very closely to each other. The interstitial spaces become inhabitable areas. The closely spaced buildings also face the danger of catastrophic damage in instance of an earthquake.

310. Due to the rapid growth in population in Phuentsholing the demand of housing has increased which has resulted in high price of housing. Due to high cost of housing units and high interest rate of housing loans from banks people prefer to stay in rented houses. The rates of rent are also very high. On an average a family spends 25-30 % of its income on housing rent. The results of primary data collection also indicate that the availability of houses is less, the cost is high and the rent is also high. The old buildings are also not in very good condition.

311. **Conditions of roads:** The area of Phuentsholing has narrow vehicular roads and insufficient walkways which results in congestion and parking issues. However, the streets are narrow. Most of them also shared that the traffic is too much and this leads to traffic jams making the traffic situation at average level.

312. **Health system:** The only hospital, Phuentsholing General Hospital completed in 2005 is a 40-bedded hospital with specialist services like General Surgery, Obstetrics and Gynaecology besides the general patient care. The hospital provides health care services to people residing in Phuentsholing and other sub-districts

like Sampheling, Lochina and Dagana. The average number of OPD patients per day is around 300 in winter and 500 in summer. The OPD has been recording an annual increase of 25% of patients visiting the hospital since last three years. In addition, there are many expatriate workers who visit for medical check-up and certificates as part of the procedure to obtain work permit. In order to decongest the routine an after-hour clinic service is started for people coming for medical certificate. Besides the general hospital there is a dispensary at BFAL colony in Pasakha and infirmary at the College of Science & Technology in Rinchending. As per the prevailing standards of Bhutan health service, the existing facility in Phuentsholing is sufficient to cater to its population.

313. **Educational institutes:** The city has Middle Secondary, Lower Secondary as well as Higher Secondary Schools. However, the number is still insufficient to accommodate all the children and still maintain the teacher student ratio. Also, the city has College of Science and Technology, located away from the main core of the city, providing education in the various fields of Engineering. The total number of educational institutes are (i)Phuentsholing HSS, (ii) Reldi HSS (Pvt.), (iii) Phuentsholing MSS, (iv) Phuentsholing LSS, (v) Wangdi Gatsel CPS, (vi) Chongaykha CPS, (vii) Pachu CPS , (viii)Phajoding PS and (ix) College of Science & Technology

314. **Water supply and sanitation:** Entire city is covered under individual household level water supply. The frequency of water supply differs in urban and rural areas. Overall supply is sufficient in all area. The sewer system functions at individual building and neighborhood level. Due to overall steep lay of the land, it is difficult to establish and maintain a well-connected sewerage network. Hence local solutions like septic tank and soak pits are set up. Areas where the terrain is relatively flat; there exists a functional drainage system maintained by the Phuentsholing Thromde (City Corporation). The urban area has facility of solid waste collection at street level. As it is not on daily basis, in some areas burning of garbage is evident. A detailed Social Impact Assessment report has been attached as ***Appendix 41.***

### 4.10 TRAFFIC

315. As per the IEE for SASEC Transport, Trade Facilitation and Logistic Project, currently, the major traffic flows to the Project area is between Phuentsholing- Jaigaon, Samtse-West Bengal, and Phuentsholing - Pasakha. Existing daily traffic between Phuentsholing and Jaigaon is about 10,000 vehicles and 47,000 vehicle passengers and pedestrians. At the Samtse border post there are 1,500 vehicles and more than 3,000 passengers a day traveling between Samtse and the North of West Bengal, mostly to the close town of Chamurchi. Other important flows are Phuentsholing on one side and Pasakha area, Gedu, Thimphu, the north of West Bengal, and the State of Sikkim.

316. The existing local traffic along the project road is estimated at 1,617 vehicles/day comprised mostly of 577 car/LCV, 369 LCV, and 354 2-axle. Existing traffic along the Chamkuna road comes from the warehousing and scrap yard activities in the form of temporary industrial sheds. Two significant developments will increase local traffic when the local area plans (LAP) of Amochhu and Toorsa Tar, and Samtse-Phuentsholing Highway (SASEC).

317. A primary Traffic survey was also carried out on 10.03.2016 for 24 hours. Peak hour maximum traffic is shown in ***Table 4-29.***

***Table 4-29: Peak hour traffic survey***

| S. No. | Vehicle / Road | Vehicle Count | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Two-Wheeled Vehicles | Three-Wheeled Vehicles | Cars / Jeeps / Vans | Trucks | Buses | Tractors | Cycles | Cycle Rickshaws |
| 1 | River to City | 28 | 0 | 98 | 99 | 2 | 0 | 0 | 0 |
| 2 | City to River | 45 | 0 | 53 | 54 | 1 | 1 | 0 | 0 |
| 3 | City to STP | 60 | 0 | 93 | 56 | 0 | 0 | 0 | 0 |
| 4 | STP to City | 58 | 0 | 51 | 74 | 0 | 1 | 0 | 0 |

318. From the above the, Predicted traffic is shown in ***Table*** 4-30***.***

***Table 4-30: Predicted traffic***

| SN | Description | Value |
|---|---|---|
| 1 | Parking provided | 34000 |
| 2 | Volume of traffic (up and down)- two times | 68000 |
| 3 | Number of Peak hour | 8 |
| 4 | Hourly traffic in Peak hour | 8500 |
| 5 | Assumed movement of traffic (assuming 20% of vehicles within ALDTP move to Phuentsholing and return back each day) | 5% from River to City; 5 % from City to River; 5 % from City to STP area and 6beyond; 5% from STP area to City |
| 6 | River to City | 425 |
| 7 | City to River | 425 |
| 8 | City to STP | 425 |
| 9 | STP to City | 425 |

# 5 ANALYSIS OF ALTERNATIVES

## 5.1 INTRODUCTION

319. As described above a Master Plan has been prepared for the Project. This Plan is expected to fulfill the following objectives : (i) Protection from flooding, (ii) expansion of Phuentsholing city, (iii) improvement of the built environment and cultural fabric of Phuentsholing, (iv) economic growth and employment for residents of Phuentsholing and (v) Promote the importance of the City to the region and country. In the context of these objectives, the analysis of alternatives first examined the implications for the City of Phuentsholing from the continual threat of serious flooding both with and without the project.

320. Secondly, the analysis addresses alternative construction methods for building the flood protection measures and alternative technologies for addressing the various components of the Master Plan including township development and common urban infrastructure. One of the criteria for evaluation of all options was to establish the most environmentally favorable alternative or which would cause minimum environmental loss to the natural and social environment.

321. A more detailed assessment of the alternatives carried out for township development and selection of its infrastructure, and presented in ***Appendix*** 2***.***

## 5.2 RIVERBANK PROTECTION

### 5.2.1 Without Project Scenario

322. **Physical Environment.** In the “without project' scenario, Phuentsholing will continue to suffer significant impacts from flood damage and riverbank erosion. Flash floods triggered by monsoon rains have become more frequent due to loss of natural ground cover and climate change. The loss of land from erosion and the housing and physical and community infrastructure would continue. Some temporary diversions of the river will occur as short term measures to protect the vulnerable parts of the eastern river bank in return for licenses to operate poorly defined dredging and quarrying activities within the floodplain with very limited environmental supervision.

323. **Biological Environment.** In the “without the project' scenario, the eroded land will turn into a river channel and floodplain and have features of a riverine environment. It will leave more flood plain which cannot be developed as agricultural land because of the constant replacement of sand, gravel and rock and the potential to be flooded and further eroded.

324. **Socioeconomic Environment.** Without the project, there will be a large population that will remain vulnerable to the effects of flooding. Specifically, there will be displacement of people due to river erosion, many of whom may have to be resettled either in the already congested Phuentsholing city, moved out the country or to the neighboring city, Jaigaon, in India. Due to more frequent flooding, the agricultural productivity along the riverside to the north of the City has been reduced, affecting the livelihoods of the population in the subproject areas. Flooding also causes many linked socio-economic and health problems.

### 5.2.2 With Project Scenario

325. **Physical Environment.** In the “with project scenario”, no change is expected in air, soil and water media. Air pollution and noise levels are likely to increase during the construction stage for periods of up to five years for each stage of construction. The bank protection measures will prevent losses of land due to erosion and flood and also win back land area that has already been lost.

326. **Biological Environment.** In the “with project” scenario, there will be changes in the riverine biological environment as the channel is narrowed and confined to 300 meters width even though it will continue to migrate within the more confined channel. The construction of river training wall will generate change in the broader area of distribution of underground river morphology and the aquatic biological system such as the benthos, plankton, fish and other aquatic life. The abundance of species is not expected to change as the river channel will continue to move randomly except for short periods of major events, the terrestrial biological

environment in Zone C will be significantly changed from a relatively undisturbed state supporting grassland and riparian vegetation to an urban environment. Zone A and B have already been modified to urban and mixed rural urban land use.

327. **Socioeconomic Environment.** The 'with project' scenario would bring stability and future growth to the economy of the area, because every year flooding would be avoided. Displacement of population to Jaigaon would be significantly reduced as affordable housing opportunities will increase in Phuentsholing. The post project scenario will enhance the overall economy of the area.

## 5.3 LAND/TOWNSHIP DEVELOPMENT WITH ITS INFRASTRUCTURE

328. Phuentsholing like the other cities in Bhutan suffers from a lack of suitable and safe space for urban growth because of its high prevalence of steep slopes, wide flood plains and encroachment into land designated for agricultural use. Without the project, Phuentsholing City will continue to suffer from congested population with little available area for new development. There will be an increase in nuisance environmental impacts as urban densities will be forced to increase if further population is to be accommodated. Capacity of urban and community infrastructure to address increased densities will be more limited due to deferred maintenance and ageing facilities. Quality of services will decrease as capacity limits of infrastructure are reached. Exposure of more population to increased air pollution and noise. Phuentsholing city presently has no urban park, and limited existing green areas will also need to meet demands for outdoor recreation opportunities.

329. With the project, the construction of the river wall and embankments will not only protect Phuentsholing from floods but would also substantially increase flat areas available for development with modern infrastructure and increased provision of parks and green space. Commercial and business areas and opportunities to create more affordable housing will increase. The capacity of the existing town infrastructure will be under less demand and more time will be available for planning and financing upgrades and service improvements.

330. As indicated above, the detailed assessment alternatives for township development and selection of its infrastructure is presented in ***Appendix*** 2***.***

# 6 ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

## 6.1 INTRODUCTION

331. The environmental impacts of the ALDTP were assessed to identify potential impact and mitigation measures. The assessment of impact is based on the project activities, which consists of pre-construction, construction and operation stages. However, it should be noted that there is a possibility that the construction period of the river training works will overlap with the construction of the urban facilities in the new developed land. The environmental impacts were assessed based on the environmental baseline reported in Chapter 4.

332. The EIA study focusses on the 'Study Area' (involving the project site for the ALDTP and an area equal to 1.0 km from the edge of the project boundary) as specified in NEC's ToR. It's broad objectives are to:

i Identify and evaluate the potential impacts (positive and negative) that the project may have on the biophysical and socio-economic environment of the Study Area for each phase of development
ii Propose mitigation measures that need to be implemented in order to avoid, minimize or reduce the risks of the negative impacts and enhance positive impacts
iii Provide a framework to ensure that the mitigation measures are budgeted for, have an organizational structure in place for implementing the mitigation measures and a grievance redress mechanism for use by affected stakeholders that addresses issues arising from inadequate implementation of the mitigation measures
iv The approach and methodology for the ALDTP involved following a well-established and approved (by the National Environment Commission, Govt. of Bhutan) procedure for commencing, completing and presenting studies involving Environmental Impact Assessments.
v Address concerns of the ADB and demonstrate compliance with the SPS 2009.

333. The following has been the approach and methodology of conducting the study:

i Understanding relevant issues through literature survey pertaining to the location and proposed development
ii Identifying likely impacts and therefore, areas of concern
iii Planning and conducting a two season baseline survey in and around the study area
iv Discussing the project as it evolves with erstwhile DHI-INFRA and CDCL.
v Preparing an initial one season EIA report presenting the impacts traceable to the initial master plan to be developed for the ALDTP
vi Working with CDCL in understanding the impacts and shaping the project so as to reduce the overall environmental footprint of the project
vii Completing two seasons of study once the Master Plan was completed.
viii Presenting the EIA study to all relevant stakeholders for their comments through public consultations.
ix Including the feedback from the stakeholders in preparing the final report to be submitted to the NEC.
x Presenting and discussing the studies, outputs with the NEC to acquire environmental clearance for the project and implement mitigation measures, monitoring and grievance redressal of affected stakeholders, along with project development

## 6.2 IMPACTS OF PROJECT DESIGN STAGE

### River Hydraulics

334. The project has been designed to minimize environmental impacts based on hydrological monitoring data and taking into consideration the result from the Climate Vulnerability Assessment Risk (CVAR). A brief summary of design features to minimize environmental impacts is summarized as follows:

i The proposed river training works will not have any significant impact on river discharge or volume. The river training works do not include abstraction or facilities to store water, so impact on discharge during construction or after development were considered minimal. There are also minimal risks of impacts expected on water level and velocity during floods. During post development, water level during floods may be slightly higher or lower than under existing conditions. The difference depends on location, but is expected to be within 300mm of existing flood levels. For the vast majority of the time, the river channel will continue migrate randomly within the more confined floodplain.

ii From a geo-morphological perspective, the project has been designed to minimize post development impacts. It is anticipated that the braided river will re-form within the 300m width during each dry season and be further modified during each wet season. There will be some very small changes in water depth and velocity distribution within each braid during the dry season, but the changes are not readily calculated, or meaningful in such a dynamic alluvial environment.

### Climate Change Adaptation

332. The SASEC Rd climate change study identified trends in mean annual and seasonal (monsoon/wet and winter/dry) temperature of ~ 3.5$^0$C and ~ 3$^0$C respectively over the period 1980 to 2069, and an increase of up to 30% (600 mm/year) in annual precipitation over the same period. It also identified seasonal differences with an increase in monsoonal mean total precipitation up to 34% (~450 mm/year) over the same period. Key climate change risks include (i) increased frequency and intensity of flood events, and (ii) increased frequency and intensity of precipitation events leading to frequent landslides. In order to address these risks, the Project classified potential climate adaptation options were grouped into: (i) engineering options (structural; specifications, design standards etc.); (ii) non-engineering (management, operation, maintenance, capacity building etc.); and (iii) maintaining the status quo (i.e., 'do nothing'). The following tables outline adaption options for the potential project climate change vulnerabilities.

***Table 6-1: Engineering options for adapting to an increase in flood risk***

| ID | Description | Owner | Phase | Incl |
|---|---|---|---|---|
| E-1 | *Material specification* - Use a high strength/durable concrete mix and increased reinforcement cover on areas of the river training structures which are exposed to abrasion and erosive forces (e.g. the cast in-situ wall on the outside of the bend in Zone A) | CDCL | Project Preparation | Yes |
| E-2 | *Material specification* - Specify riprap size and grading appropriate for the anticipated hydraulic conditions. (e.g. on the outside of the bend in Zone A) | CDCL | Project Preparation | Yes |
| E-3 | *Dimension and capacity standards* - Review design standards for climate change affected infrastructure (river training works, cross drainage and storm water system). Assess effects of potential increase in flood magnitudes, and if warranted, modify the standards and detailed design. | PPTA | Project Preparation | Yes |
| E-4 | *Dimension and capacity standards* – Specify an appropriate freeboard between the estimated flood level for the design event and the top of | CDCL | Project Preparation | Yes |

| ID | Description | Owner | Phase | Incl |
|---|---|---|---|---|
| | the embankments / finished levels in land reclamation areas. | | | |
| E-5 | *Drainage and soil conservation* - Use bio-engineering to promote soil conservation in the project area and in areas adjacent to it, notably in the tributary catchments that feed the cross drainage facilities | Phuentsholing Thromde | Implementation, Operation | TBA |
| E-6 | *Protective engineering structures* - Provide adequately sized debris dams on the tributary catchments that feed the cross drainage facilities | DoR, part of Phuentsholing-Chamkuna Road project. | Project Preparation | Yes |
| E-7 | *Protective engineering structures* - Provide scour counter measures for cross drainage facilities. | CDCL | Project Preparation | Yes |
| E-8 | *Protective engineering structures* - Provide scour counter measures for river training works to protect foundations. | CDCL | Project Preparation | Yes |

***Table 6-2: Non-engineering options for adapting to an increase in flood risk***

| ID | Description | Owner | Phase | |
|---|---|---|---|---|
| N-1 | *Flood management* - Improve catchment and river basin management to achieve better capacity, planning and monitoring to reduce flood risk. | CDCL | Implementation | Yes |
| N-2 | *Flood management* - Improve meteorological and hydrological data collection in the catchment to improve the database used for making decisions | CDCL | Implementation, Operation | Yes |
| N-3 | *Infrastructure operation and maintenance planning* - Implement regular and detailed monitoring of channels and structures, particularly prior to and during the monsoon season when flood risk is highest. Vigilant management of sediment deposition is vital to maintain conveyance capacity of the natural and engineered channels. | CDCL | Operation | Yes |
| N-4 | *Master planning and land use management* – Development within the project area should avoid geologically unstable areas, flood prone areas. It should promote green zones and build in egress routes. | CDCL | Project Preparation | Yes |
| N-5 | *Training/capacity building* - Provide training for CDCL maintenance personnel related to climate change impacts, use of climate information, weather forecasting and early warning systems. | PIC | Implementation | Yes |
| N-6 | *Information systems* - Implement a flood early warning system (FEWS) and operate it in accordance with a flood management plan (FMP). Phuentsholing Thromde does not have an existing operational flood management plan. | CDCL, PIC | Implementation, Operation | Yes |

**Implementation of Mitigations**

333. The majority of the options listed in Tables 6-1 and 6-2 will be adopted in the project preparation phase. E-5 comprises use bio-engineering to promote soil conservation in the project area and in areas adjacent to it. Any works outside of the project boundary would be under the control of others. The Phuentsholing-Chamkuna Road project may undertake some bio-engineering. The Phuentsholing Thromde would be responsible for all other areas, if this is pursued.

## 6.3 IMPACTS OF PRECONSTRUCTION STAGE

334. The assessment of impact for pre-construction stage covers the impacts from the following activities: (1) Access road to the project site (2) Establishment of assembly areas for equipment delivery (3) Establishment of storage area for construction material, other materials, and office area and construction camps.

335. The project will use the existing access road to the site and therefore there will be no significant impact compared to new construction but there will be slight traffic increases and consequent increases in noise, dust and air pollution associated with car and truck emissions. The proposed mitigation for the impact will involve a requirement to prepare a Traffic management sub plan of the CEMP as soon as possible after mobilization of each Contractor.

336. The other two activities in the pre-construction stage will be located in the riverbed above the High Food Level (HFL). There will be no significant environmental impact due to land clearing since it is located in the area with no vegetation cover. The construction of office, storage, camps will have no significant impact, except from transporting materials for the construction of these facilities that cause increase traffic in the vicinity in the project area.

## 6.4 IMPACTS OF CONSTRUCTION STAGE

337. The construction stage will involve the following activities: (1) River Training Work. (2) Embankment work, (3) Land reclamation, (4) Alluvial Fan Cross Drainage and (5) Common urban Infrastructure. The construction will be carried out in phases for different Zones with a total duration of 15 -17 years for the entire project. The actual elapsed time for completion of the whole project could be considerably more. On average, there will be around 800 project staff and construction workers (see under ***Table 3-8*** under **Chapter 3**) stationed in the project area to carry out these construction activities over the period of time and at peak could go as high as 1300.

338. On average, the skilled workers will be around ~ 230 and the unskilled workers will be ~ 570. The construction workers will be mostly from the surrounding project areas that will easily commute to the project site. Therefore, the number of worker who would need to stay in the project camp site is expected to be less than 1300 at peak. The environmental impacts due to the presence of workers are mostly due to: (i) generation of solid wastes from domestic activities, which will be around 2.25 ton per day and, (ii) generation of waste water, which will be around 80 KLD per day. There are also the significant occupational health and safety risks associated with a large workforce.

339. To mitigate these impacts the following measures are to be adopted by each Contractor in close consultation with Local government:

i Obtain agreement with Phuentsholing Thromde to enable the project to dispose the solid waste from their domestic activity to the existing landfill.

ii Establish septic tanks (25 KLD) and soak pit system with up-flow filters having capability for providing primary treatment of black water.

iii Make arrangement for regularly emptying the septic tank with the local operator at Phuentsholing Thromde.

iv Grease trap systems to be installed on all kitchen and bathroom facilities and no grey waste water to be disposed to the river without treatment. At minimum, an activated carbon system should be used.

340. The detailed assessment of environmental impacts from this construction activities including the presence of above workers is presented in ***Appendix 39***. The summary of the assessment of impact associated with the construction stage is explained as follows:

### 6.4.1. Impact on Air

341. **Dust:** An Air Dispersion Modelling Exercise was carried out for the ALDTP Project. From this exercise, as part of the ALDTP the following sources of air pollution are likely to occur:

i SPM emissions from truck movements (~350 trucks considered as worst case as a peak load, per day)
ii SPM, NOx, SO2, HC & CO emissions from vehicular movements
iii SPM emissions from stockpiles of fill material stored in open area due to wind
iv SPM, NOx & SO2 emissions from DG Sets and diesel operated construction machineries
v SPM emissions from crushers and other construction equipment like cement concrete batch mix plants
vi Emissions from use of cooking fuel in kitchen for ~1,300 persons.

***Figure 6-1: Air Conditions adjacent to Zone A southern end without Quarrying and Dredging in the Riverbed Sept 2016 looking North West***

***Figure 6-2: Air Conditions adjacent to Zone A northern end with Quarrying, Dredging Activities Jan, 2017 looking south-east***

342. Amongst these, the particulate emissions from truck movements is the predominant source of air pollution, and has been considered for the air dispersion modelling exercise.

343. For determining ground level concentrations of TSPM, line source emissions from movement of trucks were considered due to the proposed activities in the proposed land and township development project. The software used for determining Ground Level Concentrations (GLCs) was AMS/EPA Regulatory Model (AERMOD) which is steady-state plume model.

344. Maximum GLC's due to the movement of trucks on the paved and unpaved roads is 74.4 µg/m3 & 71.9 µg/m3 in Zone A+B & Zone C respectively. Whereas at the densely populated areas, it is unlikely to have such higher GLCs of TSPM. Expected GLC's will be during construction stage only.

345. The predicted incremental GLC's (Baseline levels + increase in GLC due to proposed activities) shall exceed the prescribed limits of the ambient air quality, at Nr. STP area, Nr. mobile tower area and near Chamkuna village during 10 hours of truck movement. The rest of the time it would meet the Bhutan Environmental Standard 2010.

346. It is expected (based on empirical information provided by the USEPA Emission Factor Database) that a total reduction of up to 75% in peak emissions is likely if water sprays and tankers are fully utilised. Since water is available in abundance, this is not expected to pose a problem.

347. In that, case the peak GLC will drop to ~ 17.5 µg/m3, and the air quality deterioration, due to construction activities associated with truck movement and point sources will drop significantly. This has therefore been specified in the mitigation measures. The water requirement for sprays and tankers is addressed in the construction water demand.

348. Further, dust would be generated due to the following operations during the construction stage:

i *Riverbed Levelling*: Crusher operations, Concrete batch mix plant, riverbed levelling, Channelization.

ii *Embankment Works*: Construction of Diaphragm wall, Embankment construction including stone in wire crates for a duration of ~6 months (will include landfilling, stone pitching, pouring of concrete and finishing in different combinations).

iii *Reclamation work*: Cut, Fill and compaction (This will entail the movement of on average 267 trucks a day from the Riverbed levelling and cut areas to the fill areas to raise the level of the ground) as well as truck movements due to transport borrow materials from local quarries.

iv *Construction of Common Urban Infrastructure*: Roads, Bridges, Water Drawl and supply, Sewerage, Power Supply and distribution systems

349. Proposed mitigation measures would include:

i Installation of air pollution control equipment (such as venturi cyclones / bag filters) to reduce particulate air emissions to <100 mg/nm$^3$.

ii Construction of paved apron for the entire batch mix plants. Ensure that sand and aggregates are wet during transfer and storage. These should be stored in hoppers, or bunkers with water sprays that shield them from wind. Ensure air pollution control equipment are attached to the cement-concrete batch mix plants. Use of closed conveyer belts with double rubber curtain seals at transfer point outlets and belt cleaners at return side transferring materials in a closed bin. Cement to be stored in storage silos and delivered in sealed vehicles with pneumatic transfer facility. Use of fabric filter dust collectors (FFDC) at all particulate exhaust points is mandatory. FFDCs must be maintained as per manufacturer's instructions. Particulate Matter exhaust from FFDC to be <100 mg/nm$^3$.

iii Trucks transporting the materials should be covered with HDPE sheets; trucks should be having emission norms (valid emission test certificate) or equivalent; trucks should be following preventive maintenance requirements of manufacturers. tyres should be cleaned before entering public roads through suitable washing / scraping equipment

iv Worker protection including PPE with protective uniform, safety glasses and goggles. Masks & random use of personal samplers to check dust levels at the work site.

v Agreed restrictions on operations above critical wind velocities and directions.

vi Community awareness programs on the hazards associated with airborne dust during the dry season and how to reduce risks.

### 6.4.2 Impact of Noise and Vibration:

350. Noise would be generated and Vibrations may occur due to the following operations:

i *Riverbed Levelling:* Crusher operations, Concrete batch mix plant.

ii *Embankment Works:* Construction of Diaphragm wall, Embankment construction including stone in wire crates for a duration of ~6 months (will include landfilling, stone pitching, pouring of concrete and finishing in different combinations).

iii *Reclamation work:* Cut, Fill and compaction (This will entail the movement on average of 267 hundred trucks a day from the Riverbed levelling and cut areas to the fill areas to raise the level of the ground) and truck movements due to transport borrow materials from local quarries.

iv *Common Urban Infrastructure:* Roads, Bridges, Water Drawl and supply, Sewerage, Power Supply and distribution systems

351. The mitigation measures would include:

i Installation of Noise level barriers, Use of low noise generating equipment, provision of Ear plugs to workers.

ii Enclose noisy equipment behind acoustic enclosures, fit silencing devices on all operated equipment, visual alarms preferred over hooters, muffling devices on engines, personal paging devices preferred to public address systems, barricading all around the site.

### 6.4.3 IMPACT ON RIVER HYDRAULICS (FLOW AND SPEED OF RIVER)

352. Presently, the proposed section of the Amochhu riverbed is uneven due to boulder deposits and sedimentation causing the river to break up into multiple streams (referred to as braiding) and having more uneven and inconsistent flows. During high floods the river aggrades and degrades during receding flood. This highly unpredictable river flow results in excessive scour and siltation and can result in the high amount of erosion experienced along the river edge adjacent to Phuentsholing and Jaigaon. During these floods the natural velocity distribution is highly variable at various locations particularly in places where the riverbed is uneven.

353. By training the river between embankments during these high flood events, the water flows within a defined cross section with a more uniform riverbed gradient to improve laminar and streamlined flow and a more even velocity can be maintained and prevent random abrupt changes in velocity. Erosion and scour risk is significantly reduced. Flood modelling has been carried out to ensure that the velocity of the water is not increased from its present condition.

354. Most of the time when the river is not at or near possible flood level and forms natural braids with several different channels moving randomly sideways across the river bed. The more uniform riverbed from the upstream start point and downstream end point are matched with existing bed levels to reduce any significant change in the river's flow velocity. The natural migration of the multiple river channels or braids is maintained.

355. An analysis of velocity distribution of the water flow shows that there is no significant change in the average velocity in the proposed trained uniform riverbed condition

***Figure 6-3:** Normal Low Flow Main Channel Conditions (Jan, 2017) which changes location year to year*

### 6.4.3 Impact on Surface and Ground water

356. Water Quality: There are two sources of impact on water quality (i) the domestic activity mostly from labour camps and offices and (ii) construction activity from the operation of crushers, concrete batch mix plant, construction machinery, excavation and other earth works for the river bed levelling, embankment work, land reclamation, alluvial fan cross drainage and development of urban infrastructure. The impact on water quality from the construction activity will be mostly from the leakage of oils from machineries and storage areas.

357. The proposed mitigation to address potential impact from oil spill and leakage will include :

i Routine inspection on all machinery used in the construction has to be undertaken to ensure that all machineries are in good condition. Each contractor have to include the report on this inspection in the monthly progress report submitted to the PIU.

ii Oil Storage areas have to be constructed with concrete floors, bunding and perimeter drainage taking into account the possible spillage and leakage. An emergency response is to be developed to address oil spillage and leakage and communicated to all the project staff including construction workers.

iii The used oil has to be collected and temporary storage of used oil has to be placed in the confined structure to avoid water contamination. The used oil can only be disposed to the certified operator(s) for handling used oil.

iv Providing oil and grease filtration prior to disposing any water related to construction of storm water drainage network, laying of water supply pipeline, internal road development and other urban infrastructures.

358. **Turbidity:** All these construction activities will involve generating construction debris and earthworks that will cause an increase in suspended sediments in the water. The increase of turbidity from earthwork activities such as river bed levelling, embankment work, land reclamation, cross drainage and development of urban infrastructure is unavoidable. However, it will be minimized by concentrating the work in the dry season and by undertaking the following mitigation measures:

i Avoiding temporary storage for excavation materials and directly placing in the fill location
ii Providing bunding around the muck storage area with silt mesh, garland drains and gabions
iii Developing a proper garland drains and muck arresting barriers around the crushing, concrete batch mix plants, and other processing facilities to support construction, to enable screening and settling suspended material before disposing to the surface water bodies.
iv Providing silt mesh or silt trap filtration prior to disposing any water related to construction of storm water drainage network, laying of water supply pipeline, internal road development and other urban infrastructures.

359. **Quantity of ground water: T**he construction stage will use the ground water for domestic use by tube well for about 100KLD and no significant impact to the quantity of ground water is expected.

360. **Quantity of Surface water:** About **7200 KLD** (40-60 lit./$m^2$ of construction) of water will be required during the peak construction stage to meet the demand for construction activities (including cement concrete preparation, curing sprinkling for dust suppression, moisture control of compacted soil and all other construction activities). These requirements will be met as primarily met from the Amochhu surface water flow. The water drawl for construction purposes amounts to less than 1% of the lean season flow of the River. Therefore no significant impact on the quantity of surface water is expected.

### 6.4.4 Impact on Soil:

361. The source of soil contamination during construction stage mostly will be from (i) use of oil in the construction activities including the firefighting system, diesel generating (DG) sets and (ii) domestic waste from construction camps and site offices. To minimize this impact, the following activities will be undertaken:

i Developing and adopting re-use. Recycle solid waste and therefore segregation system need to be employed
ii Developing temporary storage for soil waste with proper paved floor to avoid leakage and the soil waste from temporary storage should be regularly emptied to avoid over flow
iii Ensuring sludge from sewer and soak pit/septic tanks is regularly emptied by local operators.
iv Applying similar measures to avoid contamination of water from oil as explain above under water quality.

### 6.4.5 Impact on Ecology:

362. The construction activities will have impacts on terrestrial as well as aquatic faunal bio-diversity and possible trans-boundary impacts.

363. Impact on Terrestrial Ecology (Flora): The project sites for river training components will be located in the dry river bed channel without any vegetation. No significant terrestrial ecological impact is foreseen. The development of urban areas and their infrastructure in Zone B and Zone C is expected to affect (i) the riparian grass and shrubs in Zone C and (ii) shrubs, grass and some trees from the unused/abandoned timber concession area in Zone B. There is no existing vegetation cover in Zone A and Zone E.

364. Zone C is going to be elevated and back filled by about 2 meters and therefore the riparian grass will be significantly affected (Figure 6-4:). However, it will be compensated by developing green belt which includes retaining around 30% of this riparian grass as part of the landscape program. For Zone B, there will also be compensation of loss of vegetation cover by retaining some area with *acacia catechu* as part of the proposed “City Park”.

365. **Impact on Terrestrial Ecology (Fauna including Avifauna):** As described in the baseline, it was observed that elephants from Jaldapara National Park have been roaming in Titiring Village (Bhutan) which is nearby Zone C (approx. 1 KM). Zone C will be developed at least 5 years after the development of Zone A and Zone B. A more thorough biodiversity assessment called as BMBMS on the *Elephas Maximus* (elephant) movement and its social behavior as well as other fauna (reptiles, amphibians and avifauna), that may use the area, will be carried out for a period of 3 years during development of Zone A. A critical habitat assessment would then be prepared for any observed endangered species such as the bird species - the Bengali Florian (*Houbaropsis bengalensi*) which has been observed in the nearby Jaldapara National Park and favors flood plain and grassland habitats similar to the areas found in Zone C. The result of this assessment will provide recommendations for the planning and development of Zone C which may need to consider mitigation measures and the need for biodiversity offsets.

***Figure 6-4: Existing vegetation in Zone C***

366. As reported in the baseline study, the project area for Zone A has been heavily disturbed with human activities, therefore no significant presence of wild fauna has been observed in the project area. Consequently no other impact related to construction works to the terrestrial ecology is expected.

367. Impact on Aquatic Ecology: During the aquatic survey one Vulnerable (as per IUCN classification) species of Cyprinion semiplotum (Chepti) and one Near Threatened (as per IUCN classification) species of Neolissochilus hexagonolepis (Katli) were observed. In the literature survey, one source reported (i.e. IEE for the SASEC project) the presence of an endangered species of Tor putitora (Golden Mahseer). Other species were of Least Concern as per the IUCN red list.

368. A fish market survey at Jaigaon in India as part of the downstream of the project area found 2 fish species (Katla and Mujnai) as important saleable products. These two fishes are also found in Amochhu. The other 6 fish species found in the Jaigaon market are not found in the Amochhu.

369. The construction of river training, embankment, and cross drainage will involve some work directly affecting the river. However, this project has been designed to minimize impacts to the river system by undertaking the above construction works only during the dry season, and maintaining the natural flow of river. Use of the riverbed for both illegal and legal mining and quarrying activities has been occurring for many years and has involved bunding activities at the start of each dry season to move the main channel away from areas being used for mining and quarrying activities. Consequently the risk to the smaller aquatic organisms and fish using the main channel is considered moderate to low.

370. In order to further mitigate the risk, a Biodiversity Monitoring and Bench Marking Study (BMBMS) will be carried out for a period of 3 years, to study (i) species habitat, (ii) type of aquatic species (iii) utilization for breeding and (iv.) impacts of the project on aquatic fauna. If the study indicate that there is any reduction on the population of aquatic fauna, a joint program will be developed with the National Research Centre for Riverine and Lake Fisheries, Haa (functioning under the Department of Livestock) to replenish the loss of the species.

### 6.4.6 Impact on Land Use:

371. During the construction stage, there is temporary impact on the land use in Zone A particularly with the development of construction camps, offices, which will be located at an area of High Flood level (HFL). All these structures are temporary. In Zone C, the backfill for new development areas will permanently change the land use of 201 Ha of rural grasslands and riparian vegetation to urban land use. This activity will have permanent residual impacts.

### 6.4.7 Occupational Health and Safety:

372. During the construction stage, it is expected that up to 1300 workers will be engaged at peak periods in various construction activities and a lot of heavy machinery and equipment will be used for construction. Therefore, potential accidents related to the occupational health and safety can occur anytime not only during the working hours but accidents can also occur in the domestic environment. The following measures will be included in all Contractor's Environmental Management Plans (CEMP's):

i Develop specific emergency response procedure and Occupational Health and Safety Management Plan (OHSMP) by the PMU and contractors have to develop a sub-plan as part of their CEMP to be approved by PIU.

ii Build and train an Emergency team involving all parties (representatives from Contractors, Sub-contractors, construction worker, PIU and PIC).

iii Establish Emergency contact, communication protocol, permanent stations for keeping emergency equipment (first aid, fire extinguisher, and sprinkler system), and Emergency clinic with health worker

and basic health facilities, emergency vehicle service and conduct regular drill for fire, flood, earthquake.

iv Placing signage at construction site, area with high risk zone and periodic maintenance of the construction equipment and machineries.

v Provision of Protective Personal Equipment (PPEs)

vi Develop transport safety management plan by contractors in close consultation with local communities which will be approved by PIU.

### 6.4.8 Impact on Socio-economics:

373. The construction stage will bring opportunities for local workers to participate in this project. At peak 248 skilled, 728 unskilled and 388 operators would be required. Therefore, there is a wide range of opportunities from the project for the people living in the surrounding project area. The project will also create opportunities for the local community to provide services that will also improve their income and livelihood. However, the increasing number of people living in this area will also increase the risks such as transmission of communicable and other diseases. To address these impacts, the following mitigation measures will be adopted:

- The contractor has to conduct routine awareness programs on the risk of communicable and other diseases.
- The project (PIU) will conduct the same awareness program for the communities in the neighbouring project areas.

### 6.4.9 Impact on Traffic:

374. Based on the survey, the current traffic situation has shown that the vicinity of the project area already experiences traffic congestion. The carrying capacity of the street network will be inadequate to carry additional traffic generated by the project. Based on this prediction, Zone A has been designed to use filling materials from the project area by using the excess material from river bed levelling activities and local quarries immediately north of the project area. The fill material for Zone B, C and E will be supplied by certified quarrying companies located in the areas to the west and north of the project area. If necessary, quarries further to the east of the City would be used. Trucks would use the by-pass road around the City which is presently under construction and reduce the impacts of heavy vehicle traffic in downtown Phuentsholing. In addition, the following mitigations will be adopted during the construction:

i A Traffic Management- Sub Plan will need to be prepared by each contractor to be approved by PIU before commencement of civil works.

ii PIU will lead the coordination with the Road Safety and Transport Authority and Phuentsholing Thromde to provide a traffic route that will not disturb school activities, hospital and other health facilities, market and other business activities within Phuentsholing City if considered necessary for Zone B, C & E.

## 6.5 IMPACTS OF OPERATION STAGE

375. During the operation stage, the potential environmental impact will be generated mostly from the routine operation of common urban infrastructure and maintenance of the river channel.

### 6.5.1 Impact on Air

376. **Dust:** During operation stage, dust / air emissions would be generated due to Common Urban Infrastructure Operations viz. Traffic Management and Roads, Operation of Biomedical waste facilities and e-waste generation after end of life use.

377. Mitigation measures include:

i Vehicle exhaust compliance as per Environmental Standard 2010.
ii Implementation of a strategic public transportation plan
iii Proper storage of wastes in designated color coded containers as per Bhutan's Waste Prevention and Management Regulation, 2012 as amended in 2016 as well as Integrated solid Waste Management strategy
iv Seel relevant approval and clearance from competent authority like Ministry of Health/National Environment Commission prior to commencement of medical institute.
v Design, installation and operation of a scientific biomedical waste treatment (Autoclaving), the emissions of which conform to the National Air emission standards
vi Ensure that all e-wastes are handled as per Bhutan's Waste Prevention and Management Regulation, 2012 as amended in 2016 as well as Integrated solid Waste Management strategy

378. **Noise:** Noise would be generated due to vehicular movement on roads. This could be mitigated by providing Natural or Artificial noise barriers at sensitive receptor locations such as Hospitals and residential areas.

### 6.5.2 Impact on Surface and Ground water

379. **Surface Water Quality:** Surface water quality of the Amochhu River and its tributaries will be subject to the Bhutanese water quality standards of 2010 and no significant impacts from the operation of the common urban infrastructure are anticipated.

380. **Surface Water Quantity:** Increased storm water runoff has potential to cause floods within the city. This can be mitigated by provision and laying of storm water drainage network for safe conveyance of storm water and its discharge at selected points in the river.

381. **Ground Water quality:** Ground water quality would be adversely affected due to generation of leachates from E-wastes (generated at their end-of-life) To mitigate such negative impacts, it must be ensured that all e-wastes are handled as per Bhutan's Waste Prevention and Management Regulation, 2012 as amended in 2016 as well as Integrated solid Waste Management strategy, 2014.

382. **Ground Water quantity:** There would be potential impact on ground water level reduction in the future. Withdrawal of water for various purposes may lead to depletion of water table but is not anticipated using the planned rates of extraction in the Master Plan.

### 6.5.3 Impact on Ecology:

383. Ecology may be adversely impacted during operation of biomedical waste facilities. Improperly stored biomedical wastes could lead to bird and disease vectors like rodents etc. which can spread infectious diseases to the populace if these come into contact with such improperly stored wastes. To mitigate such negative impacts, the biomedical wastes must be stored in enclosed paved segregated storage areas with access restrictions as well as ensure minimum storage duration and treatment using Autoclaving or similar methods with prior approvals from competent agency.

### 6.5.4 Impact on Soil and Land use:

384. E-wastes would be generated at their end-of-life Land use would be impacted due to E-Waste storage in the open as well as unorganized waste processing operations of any kind thereby leading to leachate

generation especially during rainy seasons. This has the potential to contaminate land. To mitigate such negative impacts, it must be ensured that all e-wastes are handled as per Bhutan's Waste Prevention and Management Regulation, 2012 as amended in 2016 as well as Integrated solid Waste Management strategy

### 6.5.5 Occupational and Health Safety / Risks and Hazards:

385. The Risks and Hazards associated with the relevant activities / operations are as under:

i *Maintenance of embankment structures and their components*: Diaphragm wall, Dead Man Anchor / Anchor Slab, Stone in wire crates, paver block and vetiver grass (10.5 km) over dead man anchor, Stone retaining wall over anchor slab (at the turn of the river around the Hill on the west bank) and RCC retaining wall over anchor slab (at the turn of the river on the Hill on the east bank).

ii *Common Urban Infrastructure*: Accidents, Operation of Biomedical waste facilities, Maintenance of Power Supply & Distribution network as well as Telecom network

386. The mitigation measures for operations of *maintenance of embankment structures and their components* would include:

i Carry out routine safety training including water safety for all operations and maintenance staff
ii Performing cleaning activities during non-flood seasons only
iii Provision of PPEs
iv Installation of air pollution control equipment (such as venturi cyclones / bag filters) to reduce particulate air emissions to <100 mg/nm$^3$.

387. The mitigation measures for operations of Common Urban Infrastructure components – *Accidents due to Traffic*, would include:

i Provision of legible traffic signage.
ii Deputing requisite number of Traffic Police personnel
iii Adoption of Strict norms by Road Safety Transport Authority (RSTA) for issue of Driving licenses
iv Levying strict penalties for rash driving
v Provision of Street Lights during night time / low light duration as per road width
vi Local administration to ensure availability of adequate ambulance / Medevac vehicles.

388. The mitigation measures for operations of Common Urban Infrastructure components – *Operation of Biomedical wastes, Power Supply & Distribution network as well as Telecom network,* would include:

i Conduct training to personnel in handling sharp wastes.
ii Disinfect sharp wastes before disposal.
iii Store wastes in packed bags in enclosed paved segregated storage areas with access restrictions
iv Ensure minimum storage duration and timely waste disposal
v Placing signage
vi Ensuring adequate initial and follow up training is imparted to relevant personnel
vii Provision and use of PPEs

### 6.5.6 Impact on Socio-economics:

389. Due to abstraction of groundwater from ground water bore wells for supplying water to the ALDTP – Initial Phase (Zone A) only, there would be Socio Economic benefits in terms of Sharing of water with Amochhu Local Area Plan and Torsa Tar communities. It would also result in availability of additional usable water for these communities. Further, presence of a proper storm water management system would also prevent in flooding of the city thereby providing a safe living environment to the inhabitants

### 6.5.7 Impacts on Traffic:

390. Increased traffic in the project would cause increased air pollution. The mitigation measures include:

i Ensure that vehicles exhausts of Public transport vehicles are compliant with equivalent National Standard

**ii** Implementing a strategic public transportation plan which provides for plying of public transport vehicles as per road type.

391. Further, the increase in traffic would also cause occurrence of accidents. The mitigation measures include:

i Provision of signage
ii Deputing requisite number of Traffic Police personnel
iii Adoption of Strict norms by Regional Transport office (RTO) for issue of Driving licenses
iv Levying penalties for rash driving
v Provision of Street Lights during night time / low light duration as per road width
vi Local administration to ensure availability of adequate ambulance / Medevac vehicles.

### 6.5.8 Flooding:

392. Blockages in Cross-drainage / Outfalls – Zone A and B as well as those Zone C have the potential to cause flash floods and backflow of water. The blockages due to obstructions like silting, debris etc. in the cross-drainage networks / outfalls will cause blockages resulting in back flow of flood water thereby putting the area under sever flood risk. This would be mitigated by ensuring regular inspection, de-silting, maintenance and repair work of these cross drainages and outfalls. Further, Increased storm water runoff has potential to cause floods within the city. Provision and Laying of storm water drainage network for safe conveyance of storm water and its discharge at selected points in the river was included in the scope of the project.

## 6.6 OTHER IMPACTS

393. Other impacts occurring in all 3 phases (Pre-Construction, Construction and Operation) of the proposed ALDTP project include:

i Cumulative Impacts: These are impacts occurring on multiple indices (Air, Water, Noise, Soil, etc.) due to a single activity or sub-activity thereof.

ii Residual Impacts: These are impacts which persist even after implementation of all mitigation measures and relevant components in the Environmental Management Plan (EMP).

iii Trans-boundary Impacts: These are impacts due to project activities which extend beyond the project boundaries, particularly if there is an international boundary between two nations, as is the case in ALDTP – the international boundary between the Bhutan and India.

### 6.6.1 Cumulative impacts

394. The assessment of cumulative effects is subject to a lack of information on past and present project management activities and the uncertainty of future events. Secondary and interacting effects between projects add to complexity and uncertainty. The construction of the ALDTP project will occur during the implementation of at least two other infrastructure projects that are known – the Samtse – Phuentsholing Highway project and the Northern By-Pass project. These development projects and no doubt other related projects will compete for the supply of the same resources such as:

- Mining and quarrying products
- Sand cement and building materials
- Physical infrastructure such as energy, water, solid waste and sanitation
- Demand for truck transport
- Skilled and unskilled construction workers.

395. The most significant cumulative impact of these combined activities will be on the sub regional air shed with all the projects requiring dust generating activities in a concentrated period over each dry season. Modelling for the ALDTP project predicts that there will be a high risk of exceeding standards at some

baseline locations. Other projects requiring the same resources from the same locations will lead to excessive particulate matter loads.

396. These impacts interact with other elements of the environment including water quality, terrestrial and human ecology. There will be moderate to high risks on the workforce at each project without strict controls on monitoring and implementation of specific mitigations, Various human receptors particularly in nearby Phuentsholing will have more moderate risks but will still require broad based community education to reduce the risks particularly during times when wind velocities optimise the movement of dust particles into residential areas.

### 6.6.1 Residual Impacts:

397. The residual impacts of the project include:

i The loss of the natural migration of the main river channel across the entire floodplain during the dry season due to riverbed leveling and channelization. This should be modified by the fact that within the 300 meter river channel design the river will still migrate in a random fashion during the dry season.

ii The possible removal of natural habitat including grassland and riparian vegetation for the Development of Zone C and Zone E. The proposed Biodiversity Monitoring and Bench Marking Study (BMBMS) will be required before the development of Zone C in order to determine the extent of interactions of this loss of habitat with other terrestrial and riverine fauna determining its biodiversity offset plan considering the biodiversity needs and options.

### 6.6.2 Trans-boundary impacts:

398. The downstream part of the Project area is bordered by Bhutan - India international border where the Indian city of Jaigaon abuts Phuentsholing. Amochhu River flows by both these cities and during floods it erodes banks of both cities. Presently, bank protection works in a sporadic manner have been carried out in Jaigaon also. Thus, to protect banks of both these cities, it is imperative to ensure that the river training for ALDTP does not have any negative impacts downstream.

399. Towards the India-Bhutan border, the trained river embankment widens out to meet the existing natural river bank within India. The diverging section at border alignment of the embankment acts as guide bund with streamlined geometry which will prevent any cross current and scour. At present groins with stones in wire crates along the sewage treatment plant protect the Indian counterpart. However, additional measures with the new embankment bund have been designed to further protect the existing embankment abutting Jaigaon.

400. The model estimates that the velocity from the trained portion (300m) into the larger natural width (approximately 1.5km) will return to its natural velocity within a distance of 150 – 200m and that there will be no significant impact of the ALDTP on the downstream area

#### 6.6.2.2 IMPACT ON THE NORMAL AND FLOOD VOLUME OF WATER

401. No dam or dam like structures are being considered for the Project. The entire volume of water is expected to flow naturally. During 100-year return flood, as stipulated by the engineering standards, the total discharge is 7,100 $m^3$/sec in the existing condition. The highest flood recorded in Hashimara, India located 15km downstream of the Project Area in 1993, is 5,397 $m^3$/sec is marked on the bridge pylon.

402. The inundation caused by this 100-year return flood is spread over the entire River flood plain. After the River is trained the cross sectional width of the trained river (300m) and height of the embankments are derived to ensure that the total cross sectional area available for the 100-year return flood remains unchanged. The height of this proposed embankment is designed with a 1m freeboard as per standard (IS

12094-2000). This factor of safety will ensure that under no circumstance will the 100-year return flood discharge of 7,100 m³/sec flood the proposed development.

403. Furthermore, it is estimated that when the township is fully occupied and functional by 2046, the fresh water demand will be 17000 KLD. It is proposed to source the fresh water from tube wells during construction stage and from Amochhu River for the meeting the demand of population in the operation stage. This amounts to less 1% of the lean season flow of the River (i.e. ~37 KL per second), clearly indicating the sustainability of the project with regards to water management. Thus, drawing of fresh water will also not have any impact on the total volume of water flowing downstream of Bhutan-India border.

#### 6.6.2.3 IMPACT ON AQUATIC AND TERRESTRIAL FAUNA

404. The downstream livelihood impacts and the mitigation measures have been duly addressed under sub-section ***6.4.5: Impact on Ecology***

#### 6.6.2.4 POTENTIAL BENEFITS DOWNSTREAM OF PROJECT AREA

**Flood Warning System**

405. The flood warning system will alert settlements downstream in the event of a major flood in the Amochhu catchment. The main flood risk is to Phuentsholing and adjacent settlements including Jaigaon is from monsoon rainfall over the catchment in Bhutan (from Bhutan-India border to the Chinese border upstream). Further upstream, the rainfall declines and impact on flooding downstream is of limited significance.

406. The flood warning system would comprise the following components:

i Rainfall and water level sensors at selected locations
ii Data loggers for the rainfall and water level data
iii Satellite based transmission of the rainfall and water level data
iv Reception of the satellite transmissions at a central control
v A computer based system to monitor the status of the rainfall and water level, with a range of alert levels
vi A procedure for warning dissemination via various media
vii Procedures for action by the emergency services and the public The flood warning system network will be strengthened by installing additional rainfall and water level gauging stations in the upstream catchment. Information of any approaching flood will be transmitted to the flood warning centre set up within the ALDTP from the gauging stations by means of satellite communication. Rain gauges are proposed at Dorokha, Doyagang, Dhuti Khola, Sewage Treatment Plant and Hashimara.

407. Within the Flood Warning Centre in ALDTP, sensors have been proposed to provide warning through the SCADA system. This warning will be circulated in the city at an interval of 8 hours. At the time of frequent flood warning will be circulated after each every 2 hours, at the same time evacuation work will be carried out by fire and safety agency. At foot of Kaileshwar hills channels are created at HFL for flood protection. This complete system is designed to function for the next 100 years. Once frequent flood level is reached, local authorities or Thromde will be intimated, who in turn could share the information with relevant officials across the border. If required, the information for the rainfall and water level gauging stations could be shared with any downstream users through an integrated information system.

#### 6.6.2.5 Pollution mitigation - Sewage Treatment Plant

408. Various norms were studied for finalisation of the design concept of Sewage Treatment Plant for the proposed ALDTP. The merits and demerits of the same were studied and based on the recommendation, it was recommended to adopt Indian norms (CPHEEO Manual on Sewerage System and Treatment 2012) for designing the sewage collection and conveyance system for ALDTP and Environmental Standard, 2010 for checking the outlet parameters.

409. The sewage treatment plant is proposed for 100% waste water generation. It is proposed to reuse the recycled water in the premises. The recycled water is proposed to reuse for flushing, gardening & landscape irrigation purpose in the premise. There will not be any disposal of the recycled treated water except during Monsoon. In case of monsoon, the excess recycled water quantity is estimated as 1.50 MLD. This excess recycled water will be allowed to flow into the River only after treatment to ensure it is well within prescribed safety limits. The minimum flow after intake works (for ALDTP) is 17.12m3 / Sec. The surplus water after treatment is added into the river i.e. 1.50 MLD will be discharged in 16 hours (i.e. 0.026m3 / sec say 0.03m3 / sec) and the increased discharge into the river will be 17.15 m3 / sec. There will not be any negative impact as the required velocity of the water and the oxygen demand will get fulfilled.

410. The quantity of treated waste water is very small compare to the river flow even in fair weather flow, hence, the waste water will be diluted considerable as such this will be no adverse effect on the aquatic life.

#### 6.6.2.6 Solid Waste Management

411. A Zero Waste policy as per Integrated Solid Waste Management Strategy, 2014 is proposed for ALDTP wherein a full-fledged waste collection, conveyance treatment is proposed for Solid Waste Management. The waste collected from the various sources will be segregated at the source in biodegradable & non-biodegradable waste. The biodegradable waste will be treated to the full extent and recycled to the form. The recycled waste will be converted to the manure. This manure will be used for landscape area. The non-biodegradable waste will further classified in to recyclable & non-recyclable waste. The recycle waste will be crushed and sold out to the manufacturers or further treatment to the power generation form which can be used in saving energy and will contribute to protecting the environment.

# 7 PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

## 7.1 POST STUDY 1ST PUBLIC CONSULTATION MEETING

### MEETING DETAILS, DATES AND ATTENDEES

413. 1st public consultation meeting was held at the Regional Revenue and Customs Office (RRCO) conference hall at Phuentsholing on October 28, 2016. Detailed Minutes of Meeting along with the attendance sheet is attached as ***Appendix*** 31***.***

414. The 1st public consultation meeting was conducted to disclose relevant information and collect relevant feedbacks to take into account stakeholders' right at the early planning stage from both public and private sectors. There were participants from Government agencies, Civil Society Organizations, Corporations, Private land owners and general public.

415. Extensive deliberation were made on the Project's Master Plan, Environmental Impact Assessment procedure, Impacts and mitigation measures and substantive feedbacks and suggestions were taken from the stakeholders to improve the project and the EIA report.

***Table 7-1: Brief summary of 1st public consultation meeting***

| S. No. | Speaker | Against Project | In Favor of Project | Not against the project however made suggestion | Project Related Question in general | Issue Raised | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Regarding recent flood and diversion of river | Selection of location which attract people | Project carrying capacity | Connectivity with India | Report should be shared with public | Site alternative | Some correction in EIA report | Traffic Issue | Land and Resettlement | Impact of project on Dishes availability |
| 1 | Private Land Representative | | | | √ | 0 | | | | | | | | | |
| 2 | Aum Damchoe BAOWE | | | √ | | | 0 | | | | | | | | |
| 3 | Department of Culture | | | | √ | | 0 | 0 | 0 | | | | | | |
| 4 | WWF | | √ | | √ | 0 | | | | 0 | | | | | |
| 5 | National Environment Commission | | | √ | | | | | | | 0 | ● | | | |
| 7 | Phuentsholing Thromde | | | | √ | | | | | | | | 0 | | |
| 8 | Environment Officer Chhukha Dzongkhag Administration | | | | √ | | | | | | | ● | | 0 | |
| 9 | Potential affected person | | | √ | | | | | | | | | | | ● |

0 = Positive response, ● = Negative Response

## 7.2 POST STUDY 2ND PUBLIC CONSULTATION MEETING

### MEETING DETAILS, DATES AND ATTENDEES

416. 2nd public consultation meeting was held at hotel Druk Banquet hall at Phuentsholing on January 31, 2017

Detailed Minutes of Meeting is attached as ***Appendix*** 31.

### KEY ISSUES IDENTIFIED/ SUMMARY OF MINUTES

417. The main objective of the second consultation meeting was to disclose information on how the issues raised during the first consultation meeting were addressed in the project planning. It was also to seek further inputs and feedbacks from stakeholders who would be directly or indirectly affected by the environmental impacts of the project. The consultation meeting also provided a platform to the public to influence project design in a positive manner (thereby creating a sense of ownership for the project). The consultation aimed to also improve the transparency and accountability of the decision making process. The summary of the minutes is as given in Table 7-2: :

***Table 7-2: Brief summary of 2nd public consultation meeting***

| S. No. | Speaker | Against Project | In Favor of Project | Not against the project however made suggestion | Issue Raised | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Funding availability with CDCL | Regarding EIA report | Cumulative Impact assessment | Ground water abstraction | River flow / Fish Conservation | Employment And Housing | Over lapping of Project boundary with community forest | Land use and Town center | Location of project | Integration of Project and Project Modality |
| 1 | Rabten Workshop (Private Sector Representative) | | . | √ | 0 | | | | | | | | | |
| 2 | Stapels and Jattu Wood Industry, (Private Sector Representative) | | | √ | 0 | | | | | | | | | |
| 3 | Environment Specialist, National Environment commission (Government Representative) | | | √ | 0 | 0 | | | 0 | 0 | | | | |
| 4 | BAOWE (Civil Society organization Representative) | | √ | | | | | | | | | | | |
| 5 | World Wildlife Fund (Civil Society organization Representative) | | | √ | | | 0 | | | | | | | |
| 6 | Forest Ranger, Tading Gewog (Government Representative) | | | √ | | | | | | | 0 | | | |
| 7 | Private Land Owner at LAP (Private Sector representative) | | | √ | | | | | | | | | | |
| 8 | Urban Department, Phuentsholing Thormde (Government Represntative) | | | √ | | | | | | | | 0 | 0 | |
| 9 | Engineer, Phuentsholing Thormde, (Government Representative) | | | √ | | | | | 0 | | | | | |
| 10 | Stapels and Jattu Wood Industry (Private Sector Representative) | | | √ | | | | | | | | | | 0 |
| 11 | Environment Officer, Chhukha Dzongkhag Administration (Government Represntative) | | | | | | | 0 | | | | | 0 | |

0 = Positive response, ● = Negative Response

## 7.3 TRANSBOUNDARY CONSULTATION WITH INDIA

**General Consulate of India, Phuentsholing:**

418. On May 19th 2014, a presentation and stakeholder meeting on the project was conducted at Hotel Druk in Phuentsholing to update various stakeholders on the revised hydrology and hydraulic study of ALDTP and provide a platform for various interactions between the Stakeholders and experts. Out of the various government and private stakeholders present, the representative of the Consulate General of India, Phuentsholing, also attended the meeting. Several technical interactions were made, some of which included giving clarifications on software/model used for calculating the flood simulations & its reliability, changes in river velocity and assessing the return flood period. The details are attached in ***Appendix*** 31.

419. As part of the primary data collection for Social Impact Assessment report of the project, a One to one interaction with various level of stakeholders had been carried out for understanding the existing situation and obtaining their opinion about the proposed project. Since the ALDTP is located in Phuentsholing which shares its boundary with the Indian state of West Bengal and the Amochhu River flows across to India as Toorsa River, it was imperative that consultations were carried out to discuss on proposed project with Indian Authority in Bhutan regarding the Project to seek their views and concerns.

420. Amongst other stakeholders, a one to one interaction was also carried out with the representative of Counsel General of India, Phuentsholing. The office jurisdiction extends to districts of Chhukha, Samdrup Jongkhar, Samtse, Sarpang, Dagana and Pemagatshel in Bhutan helping Indian nationals in acquiring passports, registrations, sorting out issues with regards to permits for Indians workers and identifying illegal immigrants involved in anti-social activities.

421. The erstwhile DHI INFRA team and the HCP team met with the representatives of the Counsel General on 27th January 2016 where the entire Project was explained by using maps, plans & drawings. The effort to undertake consultations was appreciated, concerns were raised on the impact of the Project on Indian side, since there was river training and embankment works involved. The apprehension was pertaining to frequent floods that were causing major anxiety for the Bhutanese as well as Indian government and if the river training and embankment would increase the water flow on the Indian side. So, the representative from Consulate expressed its desire to see the Project site.

422. The representative from the Consulate was taken for the site visit on 29th January 2016; which helped to understand the plan in a better manner and appreciate benefits of the Project for both the Bhutanese and the Indians i.e. the installation of flood early warning system, flood mitigation measures and other indirect benefits such as boost in the employment generation and business opportunities, etc. It was also explained that the IDPR includes assessing downstream impact and due care was taken to ensure that velocity, volume and extent of riverbed won't have any impact downstream. The reprentatives from the Consulate General looked quite satisfied with the Project, its planned developmental activities and the unsurmountable benefits that project would bring for both the government.

***Figure 7-1: Site visit with Representative of the Consulate General of India, Phuentsholing***

**Jaigaon Merchant Association:**

423. There were also various one-to-one interactions with representatives from various government, private and civil society organizations, the SIA team also got an opportunity to interact with the President of Jaigaon Merchants Association on 28th January 2016, who shared his insight on project. It was informed that JMA (Jaigaon Merchant Association) is mainly involved in taxation, membership registration and advocacy pertaining to any issues faced by Indian trader in Phuentsholing.

424. It was informed that although the business periphery was in India, many of his customers were from Phuentsholing and rest of Bhutan. The Bhutanese customers preferred to come to Jaigaon for shopping instead of Phuentsholing as there were more choices and the shopkeepers were more responsive to their needs. Regarding the project, the president expressed his deep appreciation for the development of the project as it would generate and boost business opportunities for both nations. He also informed that given the opportunity, Indian traders would also be willing to invest in the project area although currently only Bhutanese can do business in Phuentsholing; which restricts their work area.

**Discussion with Indian Day Workers in Phuentsholing:**

425. Phuentsholing is a border town sharing its boundary with Indian State of West Bengal, Jaigaon Town. Indian day workers, hence form a major part of floating population at Phuentsholing. Around 5000 Indian peop le come to Phuentsholing every day for work. As they form an integral part of the working population, it was th erefore very important that their views were taken into consideration regarding the project and its development

426. The respondents shared that they were assured of employment only from Phuentsholing. Except for t he shop owner/ businessman, who had to rely on the local customers, all the workers felt that it was easy to g et work in Phuentsholing. It was also opined that since the local Bhutanese population was not ready to do blu e collar jobs, lacked technical knowledge and also needed to be paid more wages, Indian Day Workers were more likely to be preferred to do blue collar jobs given their sound technical knowledge with less pay. Regardi ng the project, all respondents were of the opinion that it would benefit the people of Bhutan as well as worker s from India during the construction time.

***Figure 7-2: Consultation with an Indian Day worker***

# 8 ENVIRONMENTAL MANAGEMENT PLAN

427. This EMP provides direction to the implementation of the environmental safeguards component of the ALDTP Project. It first outlines the basic regulatory management principles that are required under both National legislation and ADB SPS (2009) policies. It then lays out the roles of each of the major stakeholders particularly during the construction stages of the project. Following this section there is a summary of the proposed mitigation and monitoring matrix showing how the contractor or relevant operating body should mitigate the identified impact and reduce risk. Project Impact Monitoring and Environmental Quality (Ambient) and reporting requirements are included for further implementation of environmental management during the construction stage and subsequent operations.

428. It should be emphasized that the EMP provides advice to all of the Contractors during the Construction stage when each package is required to prepare a site-specific Contractor's Environmental Management Plan (CEMP) which will be implemented in accordance with National legislation and regulations and the relevant provisions of the Contract. The CEMP contains a number of sub- plans which address the issues of concern. A likely set of sub-plans for guidance is as follows:

429. **Construction Works Mitigation Sub-Plan:** - sets out the construction methodology and proposed environmental mitigations. (including site specific plans at each work site with proposed air quality, noise and water quality runoff mitigations

430. **Quarry Management Sub-Plan ( if required subject to proposed location):**

i Site layout showing work areas , proposed air quality, noise and water quality runoff mitigations
ii Operational Monitoring Compliance Checklist

431. **Camp Management & Site Security Sub-Plan:**

- Site layout showing office and security features ( e.g. Guard post, perimeter fencing, Identity card)
- Workforce employment breakdown (Professional, skilled, semi-skilled, unskilled )
- Camp workforce community and security rules and training proposals
- Employment Visa restrictions
- Proposed water supply sources and treatment
- Proposed drainage system
- Proposed liquid waste management system- kitchen grease trap, proposed grey water and black water treatment
- Proposed solid waste system including hazardous waste
- Storage area for fuel, lubricants , hazardous material
- Proposed Operational Monitoring Compliance Checklist

432. **Occupational Health and Safety Sub-Plan:**

- Community Relations Protocol ( by arrangement with PIC)
- STD/ HIV AIDS Implementation & Training Schedule
- Worker Clothing and Equipment
- Weekly Safety Tool Box Schedule
- Proposed Operational Monitoring Checklist

433. **Traffic Management Sub Plan**

- Coordination with Thromde
- Proposed route(s) for truck traffic with weekly haul schedule
- Arrangements to ensure village connectivity
- Proposed Signage
- Equipment including Patrol Vehicles
- Proposed operational Monitoring Checklist

434. Before the ALDTP commences operations, the responsibility for on-going maintenance including operational and ambient monitoring will be the subject of subsequent negotiations with both National, Local Government and possibly private sector entities. The proposed grievance redress mechanism for community feedback and complaints is the final section of the chapter.

## 8.1 MANAGEMENT PRINCIPLES

435. Bhutan has National legislation and a number of accompanying regulations which addresses on-going environmental management planning. The emphasis is on both addressing appropriate mitigations and/or standard operation procedures to reduce risk to the physical and biological environment and also ensuring that occupational health and safety standards are maintained for the various workforces. The EIA legislation requires the preparation of an Occupational Health and Safety Management Plan (OHSMP). Each contractor is required to prepare a sub plan as part of the CEMP to address this requirement during the construction stage.

### 2.1.5 REGULATION FOR THE ENVIRONMENTAL CLEARANCE OF PROJECTS (2016)

436. This Regulation is adopted under the Environmental Assessment Act, 2000. It applies to all projects which are subject to environmental assessment process. The Regulation defines the responsibilities and procedures for the implementation of the Environmental Assessment Act, 2000 concerning environmental asessment process for projects which include (but not limited to):

- To provide meaningful opportunities for public review of potential environmental impacts of projects
- To ensure that all projects are implemented in line with the sustainable development policy of the Royal Government.
- To ensure that foreseeable impacts on the environment, including cumulative effects are considered prior to any irrevocable commitments of resources of funds.
- To ensure that feasible alternatives are considered.
- To ensure that feasible means to avoid or mitigate damage to the environment are implemented
- To encourage the use of renewable resources and clean technologies
- To provide information on environmental clearance towards uniform, comprehensive data base on the environmental and cultural conditions and assets in Bhutan.
-
- Bhutan Environmental Standards, 2010

437. Ambient levels of air, noise, and water quality in a proposed works area have been established through National regulations and determine the appropriate category for point source or impacting emissions and effluent standards for the construction and operational phases of project. Performance standards for each contractor will be agreed between the PIC and each contractor as a part of the approval of the CEMP during the construction stage.

**National Environment Protection Act, 2007**

438. Chapter IV (Protection of Environment Quality) of the National Environment Protection Act 2007 entrusts the National Environment Commission with the responsibility of establishing the standards for emission or discharge of environment pollutions including noise and also laying down of procedures and safeguards of handling hazardous substances. It also discusses the requirement of not handling hazardous substances without taking any preventative measures such as using Personal Protective Equipment and following SOP. The Act is not connected and specific to the work place but the environment at large.

## 8.2 REQUIREMENTS OF OHSMP DURING PRECONSTRUCTION AND CONSTRUCTION

439. National legislation requires that the project provide workers with a safe and healthy working environment, taking into account inherent risks, any hazards in the work areas, including physical, chemical, biological, and radiological hazards. The SPS also requires that the government, through the implementing agency, will take steps to prevent accidents, injury, and disease arising from, associated with, or occurring during the course of work.

440. The ADB ensures that the project adheres to international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environmental Health and Safety Guidelines.

441. An analysis of the environment and impact assessment tables in Chapter 6 indicates that Risk and Hazards play an important role in the management of EHS risks. Consequently a guidance Occupational Health and Safety Management Plan's salient features are presented in this Section.

442. The mitigation measures detailed in Chapter 6 will be followed to minimize hazards and risks at the workplace and ensure the health and safety of workers. The contractor shall be mandated to abide by the directives of the Royal Government of Bhutan, the Ministry of Labour and Human Resources, Rules and Regulations on Occupational Health (OHS) and Safety in Construction, Manufacturing, Mining, and Service Industries, 2006. This requirement shall be incorporated in the Tender and Contract Documents in order to assure safe working environment. As part of the Contract documents each Contractor will be required to prepare a Contractor's Environmental Management Plan (CEMP) which includes a Sub Plan on the OHSMP requirements as detailed below.

**ELEMENTS OF THE OHSMP**

443. **Organization, Responsibility, Accountability:**

- Senior manager/involvement
- Line manager/supervisor duties
- Management accountability and performance measurement

444. **Specific Program Elements**

- Health and safety rules and procedures
- Training program
- Workplace inspections
- Incident reporting and investigation
- Statement of principles for hazard prevention and control
- Data collection and analysis/record keeping
- Purchasing and design

- Emergency procedures
- Medical and first aid
- Monitoring and evaluation

**NOMINATION OF A HEALTH AND SAFETY FOCAL PERSON**

445. The contractor will nominate a Health and Safety Focal Person (HSFP) who will function as the focal person/representative for all health and safety matters at the workplace. The HSFP will be responsible for maintaining records of all accidents and all health and safety issues at each site, the number of accidents and its causes, actions taken and remedial measures undertaken in case of safety issues. She will be the link between the contractor and all workers and submit grievances of the workers to the contractor and instructions/directives on proper health care and safety from the contractors back to the workers. She will also ensure that all workers are adequately informed on the requirement to use Personal Protective Equipment (PPE) and its correct use.

446. **Steps to ensure maximizing of safety at construction sites:** The contactor will be responsible for implementation of the following:

- Barricades shall be put up all around the construction site at all times during construction or demolition activities to deter the passage of vehicles or persons to the construction site
- Installation of signboards and symbols in risky and hazardous areas, to inform workers to be careful
- Ensuring that materials are all stacked, racked, blocked, interlocked, or otherwise secured to prevent sliding, falling, or collapse
- Vehicles will be moved only along pre-assigned routes and have well-functioning hours, reverse light and buzzer, rear view mirrors, etc.
- Removing all scrap and waste material from the immediate work area as the work progresses.
- Use only trained staff to construct, install, handle and repair all electrical equipment to prevent risks of electrical shocks and electrocution
- Install fire extinguishers and/or other fire-fighting equipment at every work site to prepare for any accidental fire hazards
- Safety nets shall be provided when workplaces are more than 25 feet (7.5m) above the ground or other surfaces where the uses of ladders, scaffolds, catch platforms, temporary floor or safety belts is impractical.
- First aid kits shall be made available at all times throughout the entire construction period. Arrangement shall be made to ensure medical attention for workers who have met with an accident or sudden illness at any time during the construction period
- Fire protection: the employer shall be responsible for a fire protection and prevention throughout all phases of the construction or demolishing works
- Hand and power tools: Conditions of all hand and power tools like belts, gears, shafts, pulleys, sprockets, spindles, chains or other reciprocating, rotating or moving parts of equipment shall be maintained by the employer in a safe condition to prevent any accidents
- Aisles and passageways shall be kept clear to provide free and safe movement of material handling equipment and workers. Material if stored/stacked at roadside must not hinder free movement of vehicles and persons
- The areas used for construction shall be kept in good repair to ensure safe movement of vehicle or person

447. **Personal Protective Equipment:** Risks to the health and safety of workers can be prevented by provision of Personal Protective Equipment (PPEs) to all workers. Personal protective equipment like safety gloves, helmet, mufflers etc. will be provided during the construction period and during the maintenance work. This will be included in the construction cost for each Contractor. Depending on the nature of work and the risks involved, contractors must provide without any cost to the workers, the following protective equipment.

- Helmet shall be provided to all workers, or visitors visiting the site, for protection of the head against impact or penetration of falling or flying objects.

- All PPE must be of good quality with mark of quality standard certification.
- Safety belt shall be provided to workers working at heights for bridge construction, etc.
- Safety boots shall be provided to all workers for protection of feet from impact or penetration of falling objects on feet
- Ear protecting/ ear muffs/plugs shall be provided to all workers in high noise zones
- Eye and face protection equipment shall be provided to all welders to protect against sparks
- Respiratory protection devices shall be provided to all workers during occurrence of fumes, dusts, or toxic gas/vapour
- The supervisor must ensure that appropriate personal protective equipment is available to workers; properly worn when required and properly cleaned, inspected, maintained and stored
- A worker shall be responsible for using the items of personal protective equipment provided by the employer
- A worker who is required to use personal protective equipment must;
    - Use the equipment in accordance with training and instruction
    - Inspect the equipment before use
    - Refrain from wearing protective equipment outside of the work area which if done so would constitute a hazard
    - Report any equipment malfunction to the supervisor or employer
- A worker who is assigned responsibility for cleaning, maintaining or storing personal protective equipment must do so in accordance with training and instruction provided.
- The safety and emergency procedures manual will be kept. Necessary training regarding the safety aspects of the personnel working at the project site will be provided.

448. **The ADB SPS (2009**) principle no 4 on environmental safeguards requires the proponent to:

***"Avoid, and where avoidance is not possible, minimize, mitigate, and/or offset adverse impacts and enhance positive impacts by means of environmental planning and management. Prepare an environmental management plan (EMP) that includes the proposed mitigation measures, environmental monitoring and reporting requirements, related institutional or organizational arrangements, capacity development and training measures, implementation schedule, cost estimates, and performance indicators. Key considerations for EMP preparation include mitigation of potential adverse impacts to the level of no significant harm to third parties, and the polluter pays principle…."***

## 8.3 IMPLEMENTATION ARRANGEMENTS

449. The preconstruction and particularly the construction stages of the project will present a variety of significant direct negative impacts with high risks unless these can be adequately mitigated. A clear set of implementation arrangements amongst the various stakeholders is an essential first step in reducing risks.

450. The key stakeholders in the implementation of environmental safeguards during the construction stage are as follows:

- The proponent and implementing agency - the Construction Development Corporation Limited(CDCL)
- The National Environment Commission of Bhutan(NEC)
- The ALDTP project management unit (PMU)
- The Project Implementation Unit (PIU)
- The Contractor(s)
- Phuentsholing municipality and the affected village communities in the projects area of influence
- The Asian Development Bank

451. **Construction Development Corporation Limited (CDCL) is** the proponent of the activity and is responsible for delivering the entire project including environmental management. It will have a Project Management Unit (PMU) located in Thimphu to coordinate activities within the National Government and a Project Implementation Unit (PIU) responsible for overall supervision and management with PIC support of the implementation and the various contractors. It will be located at the site in Phuentsholing.

452. **National Environment Commission (NEC):** The proponent's environmental assessment document is the Environmental Impact Assessment (EIA) prepared in accordance with the Environmental Assessment Act (2000) and regulations. This legislation establishes procedures for assessing the potential impacts of plans, policies, programs and projects and give approvals using an Environmental Clearance (EC) may have conditions attached which lasts for a period maximum up to five years. The NEC is the national body primarily responsible for environmental management of proposed and ongoing development. The NEC is responsible for administering the Act and to review the EIA and decide whether an Environmental Clearance can be issued. The NEC is also legally responsible for monitoring the implementation of the EIA and EMP of the ongoing project.

453. **Project Management Unit (PMU)** The Project Director (PMU) will be supported by an Environmental Manager (PMU) and environmental staff. They will oversee implementation of environmental safeguards work under the project. They will also: (i) continue updating the EMP if necessary throughout project implementation in accordance with ADB's Safeguards Policy Statement (SPS, 2009) and the Environmental Assessment Act (2000), and submit to ADB for review, final approval, and disclosure prior to commencement of works; and (ii) before expiry of the initial EIA after five years, review and revise (if necessary) the EIA and undertake necessary actions as required, to obtain NEC and ADB continued approval.

454. **Project Implementation Unit (PIU)** The Environment Officer in the PIU, assisted by the environmental specialist on the PIC team, will oversee implementation of environmental safeguards work under the project, including the following activities: (i) facilitate and confirm overall compliance with Government of Bhutan rules, oversee timely preparation and finalization of CEMP by contractors, and obtaining all required clearances and environmental permits in a timely manner prior to construction; (ii) monitor CEMP implementation by the contractors during construction including all mitigation measures and environmental parameters (air and water quality, noise, etc.) and taking corrective actions where necessary; (iii) address and record grievances through the Grievance Redress Mechanism in a timely manner, and taking quick corrective actions where necessary; (iv) ensure that all required environmental study (e.g. biodiversity studies on aquatic ecosystem and elephant social behavior) are professionally and comprehensively carried out; (v) ensure that all environmental quality monitoring required for the project are comprehensively done; and (vi) review monthly environmental monitoring reports submitted to PIU by contractors and consultants, and preparing and submitting semi-annual environmental monitoring reports to ADB on behalf of the PMU. All semi-annual monitoring reports submitted to ADB will be disclosed on ADB's website, as per ADB safeguards and communication policies.

455. **Project Implementation Consultant (PIC)** The PIC will support PIU in design review, construction supervision and monitoring and evaluation. The role of the PIC safeguards team is to oversee overall implementation of the EMP and CEMP, and prepare and implement ongoing ambient monitoring at the monitoring sites used for the completion of the EIA. It will also advise the overall project engineer on addressing environmental and social management issues.

456. **Contractors.** Contractors play a critical role in implementing environmental safeguards including the following activities: (i) prepare and obtain approval of the CEMP, based on the EIA/EMP and outline CEMP prepared during detailed designs and comply with *ADB's SPS 2009 and the EMP.* This will be done during the mobilization phase after contract award. The PIC environmental safeguards specialist will approve the CEMP on behalf of PIU before any construction work commences; (ii) carry out all environmental mitigation measures in the approved CEMPs during construction including regular testing and monitoring of environmental parameters outlined; (iii) address public grievances by taking quick corrective actions and

reporting status of grievances and redress to PIU/PMU; (iv) undertake its own monitoring of project related impacts and prepare an environmental section of the monthly report to CDCL environment team and PIC; (v) the contractor is responsible for implementing all environmental, health and safety actions included in the CEMP and relevant clauses in the bidding documents; and (vi) the contractor is required to assign an Environmental Safety Officer whose responsibilities will include:

- Coordinating with the PIC during preparation and approval of the CEMP.
- Ensuring that the contractor engages a suitable expert as a resource person or organization to undertake STIs/ HIV/ AIDS briefings and awareness raising amongst the contractor's employees and neighboring communities with follow-up upon request.
- Coordinating with PIU and PIC in respect of community consultation.
- Participating in monitoring and coordinating with PIC to ensure that environmental management activities are reported as required.
- Ensuring that the contractor does not commence construction activities until requisite Environmental clearance have been received from NEC
- Assigning a Community Liaison Officer (CLO) who would coordinate and communicate with the PIC as required, to facilitate consultation with the affected villages, various stakeholders, and ensuring smooth implementation of the subproject.

457. Provision will be made in the bidding documents of each package for the costs of environmental management and monitoring including preparation of the CEMP.

458. **ADB plays** a due diligence role and emphasizes planning, environmental and social impact assessments and safeguard documentation. Through such due diligence and review, ADB will confirm (i) that all key potential social and environmental impacts and risks of a project are identified; (ii) that effective measures to avoid, minimize, mitigate, or compensate for the adverse impacts are incorporated into the safeguard plans and project design; (iii) that the borrower/client understands ADB's safeguard policy principles and requirements and has the necessary commitment and capacity to manage the risks adequately; (iv) that, as required, the role of third parties is appropriately defined in the safeguard plans; and (v) that consultations with affected people are conducted in accordance with ADB's requirements.

459. **Health and safety**. Just as in the National legislation issued by the Ministry of Labour and Human Resource (MoLHR), the project will be required to provide workers with a safe and healthy working environment, taking into account inherent risks, any hazards in the work areas, including physical, chemical, biological, and radiological hazards. The SPS also requires that the government, through the implementing agency, will take steps to prevent accidents, injury, and disease arising from, associated with, or occurring during the course of work.

460. The ADB ensures that the project adheres to international good practice, as reflected in internationally recognized standards such as the World Bank Group's Environmental Health and Safety Guidelines.

461. **Monitoring and Reporting.** Both government and ADB have their own separate monitoring responsibilities. The extent of monitoring activities, including their scope and periodicity, will be commensurate with the project's risks and impacts. Governments, through the implementing agency, are required to implement safeguard measures and relevant safeguard plans, as provided in the legal agreements, and to submit periodic monitoring reports on their implementation performance. Monitoring and supervising of social and environmental safeguards is integrated into the project performance management system. ADB will monitor projects on an ongoing basis until a project completion report is issued.

462. The roles and responsibilities for all of the above stakeholders during the construction stage are set out in ***Table 8-1***:

***Table 8-1: Roles and responsibilities of key stakeholders for CEMP implementation: Construction stage***

| Stakeholder | Main Role in Implementation of the EMP & OHSMP | Responsibilities | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Decision maker, Policy Advice and Intergovernmental and Inter-Ministerial Coordination on Safeguards** | **Preparation of CEMP** | **Implementation of Mitigations and/or Management Programs in CEMP** | **Daily/Weekly Checklists and Monthly Reporting** | **Quality Control/ Enforcement** | **Consultation, Advice, Complaint, Feedback** | **Audit Quality Assurance** |
| CDCL | Proponent /Owner | Responsible for overall project supervision & implementation | Decision making based on PIC reccs. | Decision making based on PIC reccs | Decision making based on PIC reccs | Decision making based on PIC reccs | Responsible for resolution of comments and grievances | Decision making based on PIC reccs |
| PIC Project Manager/ Site Supervisor | Project Management, Supervision, Contract Management | Support CDCL at meetings on Policy related to GOB Legislation and Contractual Requirements | Supervision and coordination of Environmental & OHS Implementation | Supervision and coordination of Quality control by engineering supervising engineers | Supervision and coordination of Quality control by engineering supervising engineers on contractual requirements | Supervision and coordination of Quality control by engineering supervising engineers on contractual requirements | Coordination | Support Implementation of QA Audit by NEC or Delegated authority to enforce if DEPC constrained by budget or personnel |
| PIC Safeguards Team | Support to Project Manager& Supervising Engineers | Support Project Manager at meetings | Coordination preparation and approval of CEMP documents | Responsible for Supervision | Responsible for Supervision | Input and Support | Preparation of feedback on comments and GRM | Implementation of QA Audit Delegated authority to enforce if DEPC constrained by budget or personnel |

| Stakeholder | Main Role in Implementation of the EMP & OHSMP | Responsibilities | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Decision maker, Policy Advice and Intergovernmental and Inter-Ministerial Coordination on Safeguards** | **Preparation of CEMP** | **Implementation of Mitigations and/or Management Programs in CEMP** | **Daily/Weekly Checklists and Monthly Reporting** | **Quality Control/ Enforcement** | **Consultation, Advice, Complaint, Feedback** | **Audit Quality Assurance** |
| Each Contractor | Construction | Provides technical support at meetings on request | Responsible for Preparation | Responsible for Implementation | Responsible for preparation | Implementation in accordance with legislative and contractual requirements | Provides requested information from site visits | Provides requested information from site visits |
| Provincial Government | Consultation and advice | Input to Technical meetings | Inputs to regular consultation | Inputs to regular consultation | Inputs to regular consultation | Monitors contractor performance | Facilitation of feedback to communities | Input |
| Village Communities | Consultation and advice | Provide Advice through CCP process | Inputs to regular consultation | Inputs to regular consultation | Inputs to regular consultation | Monitors contractor performance | Prepares comments and/or grievances | Input |
| NEC | Monitoring of Compliance of Project Impact Monitoring | Responsible for Safeguards Implementation Approval of EC Provide Advice to CDCL on conditions of approval | Review of CEMP | Monitoring of Implementation | Monitoring of Implementation | Monitoring of Implementation | Monitoring of Implementation | Responsible for review and enforcement of EMP & OHSMP provisions |
| ADB | Due Diligence and Monitoring of Safeguard Monitoring Reports | Review of EIA and CEMP before approval | Review of CEMP | Monitoring of Implementation | Monitoring of Implementation | Monitoring of Implementation | Monitoring of Implementation | Monitoring of Implementation |

## 8.4 IMPACT IDENTIFICATION MANAGEMENT MATRIX

463. The chapter 6 of the report and **Appendix 39** analyzed the many different impacts of the project and their relative significance and level of risk to the various components of the environment. The impact identification management matrix now gives guidance on the likely mitigation measures (MM) and or standard operating procedures (SOP) that will be required to be implemented by the Contractor during pre-construction and construction and the responsible authority during operations.

### 2.1.6 IMPLEMENTATION OF MITIGATION MEASURES

***Table 8-2: Impact identification Management Matrix for Pre –Construction stage***

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| 1. | Site Access and Traffic Management - Preparing and implementing road planning for access to site and management of traffic | Risk Hazards / Air / Noise | Construction hazards: Injuries of a permanent nature or fatalities | Construction hazards leading to permanent injury or fatality. MM: **Traffic Management Sub-Plan:** preparation of a suitable management plan that considers smooth movement of traffic and protects traffic already existing on the Samtse-Phuentsholing Highway from site related hazards including accidents caused by site vehicular movement. **Occupational Safety and Health Management Sub Plan (OHSMP):** | Contractor | PIC | To be considered by each contractor as part of the project mobilisation and included as project cost. |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| 2. | Site Access and Traffic Management - Establishment of equipment and machinery including concrete batch mix plant and crushers (getting heavy machinery to site and setting it up – the activity is likely to take up to two months. | Risk Hazards | Construction hazards: Injuries of a permanent nature or fatalities | Construction hazards leading to permanent injury or fatality. MM: **Occupational Safety and Health Management Sub Plan (OHSMP**), Location of the equipment shall be at an elevation higher than the High Flood Level (HFL). | Contractors | PIC | To be considered by each contractor as part of the project mobilisation and included as project cost. |
| 3. | Material Storage, Work areas and housing for workers: establishment of worker camps for housing construction workers | Risk / Hazard | Construction hazards: Injuries of a permanent nature or fatalities | Construction hazards leading to permanent injury or fatality. MM: Occupational Safety and Health Management Plan (OHSMP). P**reparation of preliminary Camp Management Sub Plan** .Location of the camp should be at an elevation higher than the HFL. | Contractors | PIC | To be considered by each contractor as part of the project mobilisation and included as project cost. |
| 4. | Material Storage, Work areas and | Risk / Hazard | Construction hazards / injuries of | Construction hazards leading to permanent injury or fatality. MM: To be considered by the contractor as part | Contractor | PIC | To be considered |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | housing for workers - Establishment of stores, warehouse and parking areas (duration ~2 months) | | a permanent nature or fatalities | of the project mobilisation and included as project cost.**MM:** Location of the equipment should be at an elevation higher than the high flood level. | | | by each contractor as part of the project mobilisation and included as project cost. |

***Table 8-3: Construction Stage EMP Impact identification Mitigation Matrix***

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| 1.1 | *Riverbed Levelling* – Truck Delivery and operation of crushers to produce gravel and coarse materials for channelization and for subsequent phases of construction (24 months) including embankment works and establishment of urban infrastructure. | Air | Release of dust from operations: particulate emissions | Particulate emissions from the trucks and crushers. **MM:** Ensure that air pollution control equipment (such as venturi cyclones / bag filters) are available in all equipment to reduce particulate air emissions to <100 mg/nm$^3$. All exposed surfaces on access roads have waters truck on standby. All loads to be covered. All stockpiles to be sprayed during dry windy conditions. Workforce PPE in place with random personal samplers. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 1.2 | | Noise | Crusher plant operations: noise | Noise from truck transport and crushing operations. **MM:** Enclose the crusher has acoustic wall enclosures to reduce in / out noise insertion loss by >10 dB(A), bring the crusher to the floor levels, preventive maintenance programme on all vehicles, a sound traffic management plan to ensure that back-up beepers on trucks are required less frequently, lined transfer points of rubber to reduce noise, rubber lined truck bodies to ensure reduced noise of falling stones | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| | | Soil | Release of dust from operations: soil pollution | Release of dust particulates can settle and contaminate soil. MM: As mentioned in Air Pollution (S. No. 1.1) All crusher areas have perimeter rock drains. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 1.3 | | Ecology | Release of dust from operations: | Release of dust particulates can impact flora and fauna. **MM:** as mentioned in in air pollution (S. No. 1.1) | Contractor | PIC | To be included |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | | | dry deposition on River or vegetation nearby | All crusher areas have perimeter rock drains. | | | by the contractor as part of the project BOQ |
| 1.4 | | Risk / Hazard | Construction hazards: Injuries of a permanent nature or fatalities | Construction hazards leading to permanent injury or fatality. **MM:** Occupational Health and Safety Management Sub-Plan (OHSMP) All operators issued with PPE including protective masks and safety glasses. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 2.1 | *Riverbed Levelling* - Truck supply and operation of Concrete Batch Mix Plant (a concrete plant is needed to supply the concrete of different specifications for the duration of the project: ~24 months). It will consume water for the mix | Air | Operation: particulate emissions | Particulate emissions from the cement concrete plant. **MM:** Construct paved apron for the entire batch mix plants. Ensure that sand and aggregates are wet during transfer and storage. These should be stored in hoppers, or bunkers with water sprays that shield them from wind. Ensure air pollution control equipment are attached to the cement-concrete batch mix plants. Use of closed conveyer belts with double rubber curtain seals at transfer point outlets and belt cleaners at return side transferring materials in a closed bin. Cement to be stored in storage silos and delivered in sealed vehicles with pneumatic transfer facility. Use of fabric filter dust collectors (FFDC) at all particulate exhaust points is mandatory. FFDCs must be maintained as per manufacturer's instructions. Particulate Matter exhaust from FFDC to be <100 | Contractor | PIC | To be included by the contractor as part of the project BOQ |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | preparation along with cement, fine and coarse gravel. It will need fuel to operate. | | | mg/nm$^3$. Worker PPE in place. | | | |
| 2.2 | | Noise | Plant operations: noise | Noise from charging, conveyance, mixing and evacuation by trucks. **MM:** Enclose noisy equipment behind acoustic enclosures, use self-cleaning weigh hoppers, enclose compressors and pumps, fit silencing devices on all pressure operated equipment, line hoppers with rubber, all access roads and internal roads of concrete or bitumen, visual alarms preferred over hooters, muffling devices on engines, personal paging devices preferred to public address systems, weigh fine aggregates *before* coarse aggregates, barricading all around the site. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 2.3 | | Soil | Plant operations: particulate dry deposition | Dry deposition from (dry) mixing plants over time in case of absence of filters. **MM**: as per S. No. 2.1 above. Perimeter rock drainage for storm water flows | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 2.4 | | Risk / Hazard | Construction hazards: Injuries of a permanent nature or fatalities | Construction hazards leading to permanent injury or fatality. **MM:** Occupational Safety and Health Management Sub Plan (OHSMP) to include all worker protection gear including head gear, clothing, safety boots, masks and goggles. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 3.1 | Riverbed levelling (Riverbed | Air | Equipment operation: | Dust generation will persist during the duration of the Riverbed levelling. **MM**: Ensure that the earth being | Contractors | PIC | To be included |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | levelling is required for making the river bottom uniform. This will be done through earth moving equipment in dry riverbed). | | generation of dust and gaseous air emissions (from vehicles) | levelled is moist to the extent possible using high volume hoses during windy dry conditions so that dust generation is minimised. PPE in place for all workers. | | | by the contractor as part of the project BOQ |
| 3.2 | | Water Quality | Excavated material mixing with water: turbidity increase | The activity of Riverbed levelling can increase turbidity and suspended particles in the water for the duration of the Riverbed levelling. **MM:** partial diversion of river portion being levelled to ensure that the levelling is only done in dry areas. Levelling in those areas where there are 'humps' on the riverbed only, and not at other places. Disposal of excess excavated material to fill locations. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 3.3 | | Ecology | Riverbed levelling operations: changes in river bottom profile leading to disturbances to benthic organisms and fishes. The levelling activities are limited and will be done only in those locations where there are "Humps" or Crests on the riverbed. | **MM**: Ensure that the riverbed levelling programme doesn't increase turbidity in the River. This is done through suitable Engineering techniques including those described in S. No. 3.2. Diversion of main channel away from working areas. Already completed for Stage 1. Any site which has high risk of storm water discharge to main channel to be bunded to define work area for levelling. Silt mesh to be installed if storm water does not percolate within bunded area. | Contractor | PIC | To be included by the contractor as part of the project BOQ |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | | | This will lead to a smooth surface profile and better design performance during floods | | | | |
| 3.4 | | Water Regime | Works: Changes in river flow pattern during low flows from the current turbulent, braided river system to a smooth river system post Riverbed levelling (and embankment construction) | Riverbed levelling will lead to less turbulent river flow and change the flow pattern of the current river... Post development it is anticipated that a braided river will re-form within the 300m river width during each dry season and be changed during each wet season. Inevitably there will be some very small changes in water depth and velocity distribution within each braid during the dry season, but the changes are not significant in such a dynamic alluvial environment. | No action suggested | No action suggested | - |
| 3.5 | | Risk / Hazard | Construction hazards: Injuries of a permanent nature or fatalities | Construction hazards leading to permanent injury or fatality. **MM:** Occupational Safety and Health Management Sub Plan (OHSMP) | Contractor | PIC | |
| 4.1 | *Riverbed Levelling* - Channelization (2 months duration) consisting of: Grading, i.e. removal of | Air | Equipment / vehicle operation: generation of dust and gaseous air emissions (from vehicles) | Dust generation will persist during the duration of the channelization. **MM:** As detailed above ensure trucks used for transportation of materials are covered with HDPE sheets; trucks should be well maintained (as per manufacturer's instructions with Environmental Standard emission norms or equivalent; tyres should be cleaned before entering public roads through | Contractor | PIC | To be included by the contractor as part of the project BOQ |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | vegetation above and below the water for clearing the bank | | | suitable washing / scraping equipment. | | | |
| 4.2 | Dispatch of stones from river bank to site of work, Earthworks including: excavation of pit for apron, construction of approach banks, laying of stones in apron and slopes, Construction of guide bunds at termination ends. | Ecology | Plant operations: dry deposition on aquatic and terrestrial flora / fauna | A low risk of impacts on two fish species one endangered and one vulnerable. The possibility of combined impacts from different sources impacting riverine and terrestrial ecology. This interaction to be further analysed in longer term study. **MM:** Preparation of important fish species conservation monitoring plan in consultation with the Fisheries Department. Support by CDCL to existing Fisheries conservation programs. | PIC | PMU | 3.5 million (study for 3 years) 20 million (budget for conservation plan after study) |
| 4.3 | | Water Regime | Works: permanent change in the River Morphology in low flows due to training works | The river alignment will be permanently changed during low flows in the project area. Post development it is anticipated that a braided river will re-form within the 300m river width during each dry season and be changed during each wet season. Inevitably there will be some very small changes in water depth and velocity distribution within each braid during the dry season, but the changes are not significant in such a dynamic alluvial environment. | No action suggested | No action suggested | - |
| 4.4 | | Risk / Hazard | Construction hazards: Injuries of a permanent nature or fatalities | Construction hazards leading to permanent injury or fatality. **MM:** Occupational Health and Safety Management Sub-Plan (OHSMP) | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 5.1 | *Embankment* | Risk / Hazard | Construction | Construction hazards leading to permanent injury or | Contractor | PIC | To be |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | *works* - Construction of Diaphragm Wall (Excavation, insertion of reinforcements, pouring of concrete, covering with finished material / walkway: duration of activity: 8 months) | | hazards: Injuries of a permanent nature or fatalities | fatality. **MM:** Occupational Health and Safety Management Sub-Plan (OHSMP) | | | included by the contractor as part of the project BOQ |
| 6.1 | *Embankment works* - Embankment construction including stone in wire crates for a duration of ~6 months (will include landfilling, stone pitching, pouring of concrete and finishing in different combinations). | Risk / Hazard | Construction hazards: Injuries of a permanent nature or fatalities | Construction hazards leading to permanent injury or fatality. **MM:** Occupational Health and Safety Management Sub-Plan (OHSMP) with Operator PPE in place. | Contractor | PIC | To be included by the contractor as part of the project BOQ |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | Embankments will be:<br>Stone in wire crates, paver block and vetiver grass (10.5 km) over dead man anchor;<br>Stone retaining wall over anchor slab (at the turn of the river around the Hill on the west bank);<br>RCC retaining wall over anchor slab (at the turn of the river on the Hill on the east bank);<br>Stone pitching at termination points | | | | | | |
| 7.1 | *Reclamation Work* – Cut, Fill and Compaction: this will entail the movement of few hundred trucks a | Air Quality | Works: Dust suspension from site clearance, machinery | Substantial cut and fill work for 88weeks over the entire life of the project **MM:** Trucks transporting the materials should be covered with HDPE sheets; trucks should be having emission norms (valid emission test certificate) or equivalent; trucks should be following preventive maintenance requirements of manufacturers | Contractor | PIC | To be included by the contractor as part of the project |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | day from the Riverbed levelling and cut areas to the fill areas to raise the level of the ground. ~2.64 million $m^3$ of soil will be locally shifted to raise levels and 10.93 million tons of earth will be filled from surrounding borrow areas. Duration of work will be 88 months over the entire life of the project. | | | | | | BOQ |
| 7.2 | | Water Quality | Works: Dry deposition into the River. Runoff from stores, parking. | Substantial cut and fill work for 88 months over the life of the project **MM**: Provision of runoff capture bunding to allow infiltration into the substrate. Any discharge of water from designated work areas would require approval of PIC after method of discharge is agreed. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 7.3 | | Noise | Works: Site clearing, compaction, filling, cutting | Substantial cut and fill work for 88 months over the project. **MM:** Installation of Noise level barriers, Use of low noise generating equipment, provision of Ear plugs to workers | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 7.4 | | Ecology | Removal of grassland and vegetation | Cutting of existing grasslands (Zone C) and vegetation. **MM**: Assuming approval of Zone C implementation a revised greenbelt plan implementation would be required to provide an offset as compensation for the estimated loss of vegetation. A detailed landscape plan has been prepared which has assumed full implementation of the Zone C Plan | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 7.5 | | Ecology | Development of Zone C – Impacts on Aquatic / Terrestrial Bio-Diversity in Zone C (for e.g. large | Cutting of existing grasslands (Zone C) and vegetation will affect existing natural habitat. There may be an impact on movement of large terrestrial fauna (for e.g. elephants). **MM**: A comprehensive bio-diversity assessment spread over 3 years to determine the actual status of protected, large terrestrial fauna and | PIC | PMU | As covered in S. No. 4.2. |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | | | terrestrial fauna such as elephants and two threatened and vulnerable species in River) | potential impacts of other faunal or aquatic bio-diversity due to development of Zone C will be prepared as a condition of phase 1 loan approval. This study will be done prior to development of Zone C and will be shared with relevant stakeholders / regulators for their comments. | | | |
| 7.6 | | Risk / Hazard | Accidents and Hazards due to works | Construction hazards leading to permanent injury or fatality. **MM:** Occupational Health and Safety Management Sub-Plan (OHSMP) | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 7.7 | | Land use / Landover | Grassland to landscaped urban area | Loss of grassland **MM:** Available soil from the grassland will be reused to the extent possible; a detailed landscape plan has been prepared and will be implemented in different phases. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 8.1 | *Reclamation Work* Transport of borrow materials from local quarries (three quarries identified: 10.93 million $m^3$ of materials will be | Air | Transport: Dust and emission during transport, loading, unloading | Transmission of dust to atmosphere en-route to site at the time of transport of materials en-route and at / near site. **MM:** Trucks transporting the materials should be covered with HDPE sheets; trucks should be having emission norms complying with Environmental Standards, Bhutan or equivalent; trucks should be following preventive maintenance requirements of manufacturers | Contractor | PIC | To be included by the contractor as part of the project BOQ |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| 8.2 | brought from quarries within the region (<30.0 km) from the site to the site for filling. Likely that several hundred trucks trips per day for short periods will be required for conveying the materials to the site for the duration of the project construction. | Noise | Vehicle noise, loading, unloading: Noise | Several hundred truck trips daily along one or more sources 88 months. **MM:** Enclose noisy equipment behind acoustic enclosures, fit silencing devices on all operated equipment, visual alarms preferred over hooters, muffling devices on engines, personal paging devices preferred to public address systems, barricading all around the site | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 8.3 | | Socio-Economics | Traffic Management in transportation | Traffic issues in transport of reclamation materials vis-à-vis road carriage capacity. **MM:** a traffic management sub plan will be prepared in order to reduce potential traffic congestion within Phuentsholing and surrounding areas. If required, transportation of materials may have to be only done during the night time. Special haul roads may be required near the site to ensure that the traffic from the Samtse-Phuentsholing area is not held up due to the transport of borrow materials during times of intensive filling. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 8.4 | | Risk / Hazard | Transport: accidents leading to injuries / fatalities | The possibility that transport of materials will pose a risk to safety of surrounding communities. **MM**: A Traffic management sub plan to be put in place by each Contractor and approved by the project authorities prior to commencement of borrow material transport, covering driver training, transport timings, transport routes, traffic segregation (separation of construction and non-construction traffic) near the construction site and liaison with local community. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 9.1 | *Common Urban Infrastructure* – | Risk / Hazard | Construction hazards: Injuries of | Construction hazards leading to permanent injury or fatality. **MM:** Occupational Health and Safety | Contractor | PIC | To be included |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | *Bridges:* Foundations (Civil Works, 6 months duration) | | a permanent nature or fatalities | Management Sub-Plan (OHSMP) | | | by the contractor as part of the project BOQ |
| 9.2 | *Common Urban Infrastructure – Bridges:* Super and sub-structures (pier, deck, abutment civil works, 16 months duration) | Risk / Hazard | Construction hazards: Injuries of a permanent nature or fatalities | Construction hazards leading to permanent injury or fatality. **MM:** Occupational Health and Safety Management Sub-Plan (OHSMP) | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 10.1 | *Common Urban Infrastructure* - Water drawl and supply network. This will consist of a water intake system from the River (initially ground water from four tube wells for Zone A, treatment plant, ground and elevated storage reservoirs, distribution | Risk / Hazard | Accidents during laying of pipes / working in closed spaces with low oxygen | Substantial risks to workers especially working in enclosed spaces below road levels. **MM**: Signage's, imparting training to workers who may be exposed to such risks. | Contractor | PIC | To be included by the contractor as part of the project BOQ |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | system up to the neighbourhood level). Activity duration: 20 months. | | | | | | |
| 13.1 | *Common Urban Infrastructure* - Sewage collection network and Sewage treatment plant. This will consist of construction of sewer pipes / channels with zonal sewage pumping stations up to the Sewage treatment plant. | Risk / Hazard | Accidents during laying of pipes / working in closed spaces with low oxygen | Substantial risks to workers especially working in enclosed spaces below road levels. **MM**: Sinages, imparting training to workers who may be exposed to such risks. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 14.1 | *Common Urban Infrastructure* - *Storm water network:* This will entail the construction and operation of a run-off system directing run-off | Risk / Hazard | Flood water from outfalls and in Amochhu river owing to excessive runoff damaging the construction site and potentially causing injury. | Flood waters have a potential to cause large scale damage to property and loss of life. **MM:** Establishment and implementation of onsite / offsite emergency sub plan by each Contractor and site evacuation plan in conjunction with upstream flood warning system. | Contractor | PIC | To be included by the contractor as part of the project BOQ |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | from the hard paved areas to the tube well for recharge. | | | | | | |
| 14.2 | *Common Urban Infrastructure* - Storm water network. This will consist of a network of dedicated underground channels / pipelines within the proposed ALDTP to evacuate storm water during rains / similar storms. Activity duration: 20 months. | Risk / Hazard | Accidents during laying of pipes / working in closed spaces with low oxygen or due to flooding during construction stage. | Risks to workers especially working in enclosed spaces below road levels. **MM**: Checking of ambient oxygen levels before entering such areas; signage, imparting training to workers who may be exposed to such risks and flood warning system during construction stage. These issues should be addressed in the OHSMP Sub-plan. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| | | Risk / Hazard | Flooding risk and damage to property / people due to run-off from hill slopes entering/flooding the surrounding areas during the monsoon. | There is a normal risk of floodwater during the monsoon, entering the project site and surrounding residential areas. **MM:** Installation of emergency pumps with designated ducts / channels to ensure the water in necessary volumes can be discharged back into the River without affecting work areas and workforce and local residential housing. As construction will cease during the monsoon, temporary berms to reduce these risks will be installed in all worksites and residential areas. | Contractor | PIC | To be included by the contractor as part of the project BOQ |
| 15.1 | *Common Urban Infrastructure* - Power supply and distribution system: Provision of pre-construction | Risk / Hazard | Injuries due to electric cables and other equipment unloading. | Risk to workers, especially working in enclosed spaces below road levels **MM:** Strict implementation of OHSMP sub-plan, placing signage, ensuring adequate initial and follow-up training is imparted to relevant personnel, provision and use of PPEs. | Contractor | PIC | To be included by the contractor as part of the project BOQ |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | power (including operation of back-up power in the form of Diesel Generator Sets) | | | | | | |
| 15.1 | *Common Urban Infrastructure* - Power supply and distribution system: Construction of 2 switching stations in Zone A and one in Zone C, to step down high voltage to usable high voltage. Further 8 sub-stations are proposed in the ALDTP to step down high voltage to one or three-phase supply. Duration of construction: 18 months. | Risk / Hazard | From electric cable shocks during setup / working in confined spaces in case of underground telecom cables | Risks to workers especially working in enclosed spaces below road levels from electric shock and due to nature of confined spaces. **MM:** Placing signage, ensuring adequate initial and follow up training is imparted to relevant personnel, provision and use of PPEs. | Contractor | PIC | To be included by the contractor as part of the project BOQ |

***Table 8-4: Environment Management Plan for Construction stage Decommissioning***

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| 1.1 | Includes removal of staff housing, equipment, labour camps and all temporary structures safely from the project site (1-2 months) | Risk / Hazard | Construction hazards: injury of a permanent nature or fatalities | Construction Hazards leading to permanent injury and fatality. MM: OHSMP sub-plan | Contractor | PIC | To be considered by the contractor as part of the project |

**OPERATION STAGE**

464. The Impact Identification and Management Matrix for the operation stage is shown in ***Table 8-5***:

***Table 8-5: Environment Impact Identification and Management Matrix for Operation stage***

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| 1.1 | *River Embankment structures* - Maintenance of Diaphragm Wall | Risk Hazard | Risks of Injuries of a permanent nature or fatalities and drowning in the river (during floods) to persons engaged in | Injuries due to fall on hard ground AND / OR falling into the river resulting in drowning leading to permanent injury or fatality. **MM:** Employ trained staff who can swim; performing cleaning activities during non-flood seasons only; Keep life saver floats readily deployed during such activities; perform these activities under supervision of skilled swimmer, Provide PPE to all staff. | CDCL | CDCL | O & M budget to be prepared before operations begin. |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | | | cleaning activity. | | | | |
| 2.1 | *River Embankment structures* - Maintenance of Embankment including stone in wire crates, paver block and vetiver grass (10.5 km) over dead man anchor<br>Stone retaining wall over anchor slab (at the turn of the river around the Hill on the west bank)<br>RCC retaining wall over anchor slab (at the turn of the river on the Hill on the east bank)<br>Stone pitching at termination points | Risk Hazard | Risks of Injuries of a permanent nature or fatalities and drowning in the river (during floods) to persons engaged in cleaning activity. | Injuries due to fall on hard ground AND / OR falling into the river resulting in drowning leading to permanent injury or fatality. **MM:** Employ trained staff who can swim; performing cleaning activities during non-flood seasons only; Keep life saver floats readily deployed during such activities; perform these activities under supervision of skilled swimmer. | CDCL | CDCL | O & M budget to be prepared before operations begin. |
| 4.1 | *Common Urban Infrastructure* - | Air | Increased Traffic | Air pollution resulting in vehicular exhaust emissions. **MM**: Ensure that vehicles exhausts of vehicles are | RSTA, Bhutan | To be determined | O & M budget to |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | *Traffic management and roads* | | | compliant with National Environmental Standards; Implementing a strategic public transportation plan which provides for plying of public transport vehicles as per road type. | | | be prepared before operations begin. |
| 4.2 | | Noise | Increased Traffic | Noise due to vehicular movement on roads. **MM**: Provision of Natural or Artificial noise barriers at sensitive receptor locations such as Hospitals and residential areas. | RSTA, Bhutan | To be determined | O & M budget to be prepared before operations begin. |
| 4.3 | | Risk/Hazard | Road accidents | The potential for Accidents to occur will depend on road, weather and lighting conditions as well as driving habits of vehicle drivers. **MM**: Provision of signage, deputing requisite number of traffic police personnel, ensuring persons have valid driving license, levying penalties for rash driving, provision of street lights during night time / low light condition as per road width; local administration to ensure availability of adequate ambulance / medevac vehicles. | RSTA, Bhutan | To be determined | O & M budget to be prepared before operations begin. |
| 6.1 | *Common Urban Infrastructure – Water Drawl and Supply:* Ongoing abstraction of groundwater from water tube wells (drawl of water @ 17000 KL/D). Of | Hydrogeology | Water Drawl: Potential impact on ground water level reduction in the future | Withdrawal of water for various purposes may lead to depletion of water table. **MM:** Planning and implementing water harvesting methods, strategies, infrastructure including groundwater re-charge. Also stop using groundwater once Zone B and C are commissioned and shift to surface water. | To be determined | To be determined | O & M budget to be prepared before operations begin. |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | this about 6000 KL/D will be from tube well for the initial phase only. Once the full project is completed, the entire 17000 KL/D will be sourced from the River | | | | | | |
| 7.1 | *Common Urban Infrastructure* - Storm Water management system | Water | Increased quantity | Increased storm water runoff has potential to cause floods within the city. **MM**: Provision and Laying storm water drainage network for safe conveyance of storm water and its discharge at selected points in the river. | To be determined | To be determined | O & M budget to be prepared before operations begin. |
| 7.2 | *Common Urban Infrastructure* - Cross-drainage / Outfalls – Zone A and B (within Project Area only[7]) | Water | Blockages: flash floods and backflow of water | The blockages due to obstructions like silting, debris etc. in the cross-drainage networks / outfalls will cause blockages resulting in back flow of flood water thereby putting the area under sever flood risk. **MM:** Ensure regular inspection, de-siling, maintenance and repair work of these cross drainages and outfalls. | To be determined | To be determined | O & M budget to be prepared before operations begin. |
| 8.1 | *Common Urban Infrastructure* - Cross-drainage / | Water | Blockages: flash floods and backflow of water | The blockages due to obstructions like silting, debris etc. in the cross-drainage networks / outfalls will cause blockages resulting in back flow of flood water thereby | To be determined | To be determined | O & M budget to be prepared |

[7] Outfall construction and maintenance along the Samtse-Phuentsholing Highway will be managed by the Department of Roads, Ministry of Roads and Human Settlements

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | Outfalls – Zone C | | | putting the area under sever flood risk. **MM**: Detention ponds will be provided and allow the entrapment and removal of debris and allow a steady flow of water into the Amochhu River; Ensure regular inspection, de-siling, maintenance and repair work of these cross drainages and outfalls. | | | before operations begin. |
| 9.1 | *Common Urban Infrastructure* - Operation of Biomedical waste facilities | Air | Suspended particles and matter from operation of biomedical treatment facilities, Odour | Improper waste storage can lead to bad odours due to decomposition. Improper treatment of wastes can lead to deterioration in local air quality. **MM:** Proper storage of wastes in designated colour coded containers as per Bhutan's Waste Prevention and Management Regulation, 2012 as amended in 2016 as well as Integrated solid Waste Management strategy; Design, installation and operation of a scientific biomedical waste treatment like autoclaving, the emissions of which conform to the National Air emission standards. | Operating staff of biomedical waste facility, Health centres and Hospitals | Ministry of Health (MOH) / NEC | O & M budget to be prepared before operations begin. |
| 9.2 | | Ecology | Disease vectors like birds, rodents, flies attracted towards improperly stored waste | Birds and disease vectors like rodents etc. can spread infectious diseases to the populace if these come into contact with improperly stored wastes. **MM:** Store wastes in enclosed paved segregated storage areas with access restrictions; Ensure minimum storage duration and timely disposal | Operating staff of biomedical waste facility, Health centres and Hospitals | MOH / NEC | O & M budget to be prepared before operations begin. |
| 9.3 | | Risk/Hazard | Exposure to decomposing infected waste; injuries to personnel handling sharp wastes and | Personnel involved in handling of sharp waste may sustain injuries. They would also be exposed to resulting infections. Decomposing waste would also create unhygienic conditions which would result in spread of infectious diseases. **MM:** Training to be imparted to personnel in handling sharp wastes. | Operating staff of biomedical waste facility, Health centres and Hospitals | MOH / NEC | O & M budget to be prepared before operations begin. |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | | | exposing them to infection risks | Disinfect sharp wastes before disposal. Store wastes in packed bags, in enclosed paved segregated storage areas with access restrictions; Ensure minimum storage duration and timely disposal | | | |
| 10.1 | *Common Urban Infrastructure* - E-Waste generation after end-of-life use | Air | Gaseous emissions, noxious fumes due to open burning for material recovery | Some Discarded e-waste would be burnt in the open to recover materials like Gold, Silver, and Aluminium etc. **MM:** Ensure that all e-wastes are handled as per Bhutan's Waste Prevention and Management Regulation, 2012 as amended in 2016 as well as Integrated Solid Waste Management strategy | Operating staff of e-waste facility | NEC | O & M budget to be prepared before operations begin. |
| 10.2 | | Water | Leachate mixing with ground and surface water | E-Waste storage in the open as well as unorganized waste processing operations of any kind would lead to generation of leachates especially during rainy seasons. This has the potential to contaminate water (surface & ground). **MM:** Ensure that all e-wastes are handled as per Bhutan's Waste Prevention and Management Regulation, 2012 as amended in 2016 as well as Integrated Solid Waste Management strategy | Operating staff of e-waste facility | NEC | O & M budget to be prepared before operations begin. |
| 10.3 | | Soil/land | Contamination | E-Wastes lying in the open would contaminate land. **MM:** Same as Sr. No. 10.2 above | Operating staff of e-waste facility | NEC | O & M budget to be prepared before operations begin. |
| 11.1 | *Common Urban Infrastructure* - Power supply and distribution | Risk Hazard | From electric cable shocks during maintenance / working in confined | Substantial risks to workers especially working in enclosed spaces below road levels. **MM:** Placing signage, Ensuring adequate initial and follow up training is imparted to relevant personnel, Provision and | BPC | Bhutan Electricity Authority (BEA) | O & M budget to be prepared before |

| S. No. | Activity | Identification of Impact | | Remarks / Rationale for Intensity and other inputs, along with (as relevant): Mitigation Measures (marked MM) to be added in SOPs or Name and number of Management Plan for Significant Aspects (marked MP) | Implementing Organization | Supervising Organization | Annual Costs (Nu) |
|---|---|---|---|---|---|---|---|
| | | Environmental Component Impacted | Aspect | | | | |
| C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
| | system: Maintenance of 2 switching stations in Zone A and one in Zone C, to step down high voltage to usable high voltage. Further 8 sub-stations are proposed in the ALDTP to step down high voltage to one or three-phase supply. | | spaces in case of underground telecom cables | use of PPEs | | | operations begin. |
| 12.1 | *Common Urban Infrastructure* - Maintenance of telecom network will include inspection and repairs of fibre optic cable network till the houses, telecom transmission towers for cellular phones | Risk / Hazard | From electric cable shocks during setup / working in confined spaces in case of underground telecom cables | Substantial risks to workers especially working in enclosed spaces below road levels. **MM:** Placing signage, Ensuring adequate initial and follow up training is imparted to relevant personnel, Provision and use of PPEs | Bhutan Telecom / Tasha Cell | Ministry of Information and Communication | O & M budget to be prepared before operations begin. |

## 8.5 ENVIRONMENTAL MONITORING

465. Environmental Monitoring for all the three phases viz. Pre-Construction, Construction and Operation ALDTP, will consist of two types:

i Project Impact Monitoring Plan (pre-construction, construction and operation staged): the actions to be taken by the Contractor and supervised by the PIC for pre-construction and construction as part of the CEMP prepared by each Contractor

ii Environmental Quality ( Ambient) Monitoring Plan (Pre-Construction and Construction stage and): to ensure that the ambient environment remains within acceptable ranges based on the baseline levels established during the EIA investigations or on- going by responsible government authorities. This Plan would be conducted by agreement with the NEC which is the responsible authority as part of the conditions of the Environmental Clearance.

### 2.1.7 PROJECT IMPACT MONITORING PLAN

466. The proposed project impact monitoring (pre-construction, construction and operation stages) plans are shown in ***Table 8-6***:

467. ***Table*** 8-7: and ***Table 8-8***: . These plans should be considered for guidance only. Each Contractor will negotiate the controls with the PIC during the preparation of the CEMP. ***Table 8-6***: shows a sample of the minimum supervisory requirements for the preconstruction stage expected to be implemented by each Contractor.

468. ***Table*** 8-7: shows a typical set of qualitative controls for use by the Contractor and ***Table 8-8***: shows a proposed set of project impact quantitative controls which require agreement between the PIC and the Contractor or for the Construction stage and between CDCL and the responsible authority for operations stage.

***Table 8-6: Contractor Checklist for Project Impact Monitoring – Pre Construction (for guidance only)***

| | | | | | |
|---|---|---|---|---|---|
| **Contract Number** | Contractor | | | | |
| **Date:** | | | | | |
| **Preconstruction Management Compliance Basic Checklist for Each Contractor** | | | | | |
| | | **Yes/No** | **Comment** | | |
| 1 | CEMP Prepared | | | | |
| 2 | ESO Appointed and Trained | | | | |
| 3 | CEMP Approved | | | | |
| 4 | Thromde Community Advisory Committee Established & First meeting completed | | | | |
| 5 | HIV/AIDS Training completed for workforce | | | | |
| 6 | HIV AIDS Training completed for community | | | | |
| **Construction Camp Approval if Applicable** | | | | | |
| **1** | All wastewater treated before discharge | | | | |
| **2** | Grease trap fitted for kitchen waste before entering drainage system | | | | |
| **3** | Perimeter Drainage Installed | | | | |
| **4** | Location of discharge agreed with NEC and or local community or responsible authority | | | | |
| **5** | Code of Conduct Explained to workforce | | | | |

***Table 8-7: Project Impact Monitoring – Qualitative Controls for Daily and Weekly Checking Construction Stage (For Guidance only)***

| **On- Going Implementation of Works Minimum Compliance Checklist** | | | | | |
|---|---|---|---|---|---|
| **Package Number** | **Location: Chainage** | | | **Photo Reference Attached** | |
| | | | | | |
| **Date** | Time of Day | Weather Conditions | | | |
| | | Fine & Dry | | | |
| | | Cloudy & Dry | | | |
| | | Cloudy & Wet | | | |
| **Mitigating Measure/ Standard Operating Procedure (SOP)** | | **Yes/ No** | | **Photo Reference If No Measures in Place** | **Comment** |
| **Workforce Safety** | | | | | |
| **1** | Weekly Safety Training completed | | | | |
| **2** | All workers have vests | | | | |
| **3** | All workers have work boots | | | | |
| **4** | All workers have safety helmets | | | | |
| **5** | All workers have safety mask and eye protection in dusty conditions | | | | |
| **6** | First Aid training Completed | | | | |
| **7** | Work Site and machinery secure after hours | | | | |
| **Traffic Management** | | | | | |
| **8** | Safety Signboards being used with Speed Control Advisory | | | | |
| **9** | Stop Go signs in place | | | | |
| **10** | Detour Clearly Marked if applicable | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Water Quality** | | | | | |
| **11** | Drainage from working area does not flow into adjacent drainage lines | | | | |
| **12** | Overflow point protected by Bamboo fences or sediment mesh in place or agreed practical method | | | | |
| **Air Quality** | | | | | |
| **13** | Dump Trucks loads are covered transporting material | | | | |
| **14** | Water Tanker being used for dust control in specified locations | | | | |
| **15** | Exhaust of truck not generating black smoke | | | | |
| **Storage of Hazardous Material** | | | | | |
| **16** | Is the Storage Area fenced with Hazchem Signage & bunded or with perimeter cut- off drain | | | | |
| **Monthly Reporting** | | | | | |
| **17** | All Environmental & Social Incidents have been reported as a separate one page report to Project Manager | | | | Please list a brief summary of any incident on separate page |
| **18** | Has a one page environmental/social compliance report been prepared and included in project Monthly Report based on this checklist | | | | |
| | | | | | |

- ***An incident is defined as a specific event, sequence of events, or extended condition that had an unwanted or unintended impact on safety, security, health and/or livelihood of people, property, or the environment, or on legal / regulatory compliance***
- Incident management consists of those post incident actions which are performed to ensure the appropriate level of post incident care is provided to people and the environment, address requirements related to good business practices (i.e. notification, understanding corrective actions to prevent recurrence, and liability protection) and ensure regulatory compliance (i.e. notification and reporting).

***Table 8-8: Project Impact Monitoring Quantitative Measurements (Pre-construction, Construction and Operation Stages)***

| Environmental Component | Parameters | Location | Frequency during Construction | Responsibility | Methods |
|---|---|---|---|---|---|
| **Pre-construction stage once Monitoring team is mobilized by each contractor** | | | | | |
| Risks / Hazard | Near Misses, Incidents, Accidents leading to temporary or Permanent injury / Fatality | Project Work Areas | Daily recording | Contractor EHS Officer & Medical Officer of Contractor with PIC | Record keeping and Statistics |
| **Construction stage subject to Agreement on conditions of EC with NEC. Standard Operating Procedures will be used by agreement in order to reduce quantitative monitoring. Frequency of measurements to be subject to negotiation.** | | | | | |
| Air | Dust generation from Crushers during riverbed levelling | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Personal Respirable Particulate Sampler randomly assigned |
| | Dust generation from Concrete batch mix plant during riverbed levelling | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Personal Respirable Particulate Sampler randomly assigned |
| | Emissions from Concrete batch mix plant during riverbed levelling | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Personal Respirable Particulate Sampler randomly assigned |
| | Dust generation from equipment during riverbed levelling | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Personal Respirable Particulate Sampler randomly assigned |
| | Emissions from equipment during riverbed levelling | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Personal Respirable Particulate Sampler randomly assigned |
| | Dust generation from equipment during riverbed Channelization | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Personal Respirable Particulate Sampler randomly assigned |
| | Exhausts from vehicles | Designated Project | Monthly | Monitoring agency( sub | Personal Respirable Particulate |

| Environmental Component | Parameters | Location | Frequency during Construction | Responsibility | Methods |
|---|---|---|---|---|---|
| | riverbed levelling | Work Area defined in Contract | | consultant) appointed by Contractor | Sampler randomly assigned |
| | Dust generation from equipment during reclamation work | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Personal Respirable Particulate Sampler randomly assigned |
| Noise | Due to Crusher operations during riverbed levelling | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Weekly: Noise level meter |
| | Due to Concrete batch mix plant during riverbed levelling | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Noise level meter |
| | Due to Equipment operations – Site clearing, Compaction, Filling, Cutting during reclamation work | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Noise level meter |
| | Due to operation of vehicles during reclamation work | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Noise level meter |
| Soil | Dust from Crushers accumulated during riverbed levelling | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Visual observations, measurements on extent of soil staining |
| | Dust from Concrete batch mix plant falling on the soil during riverbed levelling | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Visual observations, measurements on extent of soil staining |
| Ecology | Dry deposition on River or vegetation nearby | Designated Project Work Area defined in Contract | Monthly | Monitoring agency( | Periodic survey at agreed intervals integrated with Environmental quality (ambient) |

| Environmental Component | Parameters | Location | Frequency during Construction | Responsibility | Methods |
|---|---|---|---|---|---|
| | | | | | monitoring Visual observations |
| Risk / Hazard | Accidents, Permanent or Fatal Injuries during construction activities | Project Area | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Records of such injuries |
| Water Regime | Riverbed levels changes | Project Area | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Water level measurements |
| | Water Course changes | Project Area | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Photographs |
| Land use / Landover | Changes in land use | Project Area | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Photographs, Area measurements |
| Socio-Economics | Traffic | Study area – All roads junctions leading to projects | Monthly | Monitoring agency( sub consultant) appointed by Contractor | Visual observations and Traffic count |
| **Operation stage Subject to Further Agreement with Agency responsible for Operation and Maintenance either CDCL/ Thromde or agreed MOU.** | | | | | |
| Air | Exhausts from vehicles | Project Area | To be decided based on available O & M budgets | Monitoring agency appointed by PIC / EA | Analysis reports |
| | Ambient Air quality | Project Area, Waste management & processing facilities, landfill | To be decided based on available O & M budgets | Monitoring agency appointed by PIC / EA | Field measurements by equipment |
| | Traffic | Study area – All | To be decided | Monitoring agency | Visual observations and Traffic |

| Environmental Component | Parameters | Location | Frequency during Construction | Responsibility | Methods |
|---|---|---|---|---|---|
| | | roads junctions leading to projects | based on available O & M budgets | appointed by PIC / EA | count |
| Noise | Traffic | Study area – All roads junctions leading to projects | To be decided based on available O & M budgets | Monitoring agency appointed by PIC / EA | Noise level meter |
| Risk Hazard | Accidents, Permanent or Fatal Injuries during operation activities | Project Area | To be decided based on available O & M budgets | Occupational Health and Safety officer and Medical Officer PIC | Records of such injuries |
| | Traffic | Study area – All roads junctions leading to projects | To be decided based on available O & M budgets | Monitoring agency appointed by PIC / EA | Visual observations and Traffic count |
| Water | Release of treated sewage | Sewage treatment plant | To be decided based on available O & M budgets | Monitoring agency appointed by PIC / EA | Analysis reports |
| Water | Generation of leachates | Landfill facility | To be decided based on available O & M budgets | Monitoring agency appointed by PIC / EA | Analysis reports |
| Ecology | Health effects due to disease vectors | Biomedical waste facility | To be decided based on available O & M budgets | Monitoring agency appointed by PIC / EA | Health records |
| Soil / Land | Contamination | Activity areas like Waste Management facilities | To be decided based on available O & M budgets | Monitoring agency appointed by PIC / EA | Visual observations, Analysis reports |

### 2.1.8 ENVIRONMENTAL QUALITY (AMBIENT) MONITORING PLAN AND COST

469. ***Table 8-9***: outlines a proposed environmental quality monitoring plan to assess the on- going effects of the project on the general ambient environment using the baseline studies and monitoring locations prepared for the EIA.

***Table 8-9: Environmental Monitoring Plan (Pre-construction and Construction Stages)***

| S. No. | Environmental Component | Sampling location | Sampling Parameters | Sampling Frequency | Sampling Analysis | | | Method | Budget (Nu) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Sampling Instrument | Analytical Equipment | Detection Limit | | |
| 1. | Ambient Air Quality | 6 Locations (Close to Zone C, Near STP, Near Mobile Tower, Chamkuna Village, Torsa Tar Village, Near Doyagang Bridge) used for EIA baseline | SPM, PM10, PM2.5, SO2, NOx and CO | Two 24 –hour samples every six months at each station (6 locations x 2 samples x 40 weeks = 480 samples per annum) | PM10 – Respirable Dust Sampler APM - 460 | Electronic balance | 0.001 mg | Gravimetric (HVS) – IS: 5182: Part 4, with cyclone | 1.8 Million annually |
| | | | | | SO2: Flow Meter with impinge module | Spectro-photometer | 1.27 µg/m$^3$ | IS: 5182: Part 3 | |
| | | | | | NOx: Flow Meter with impinge module | Spectro-photometer | 0.19 µg/m$^3$ | IS: 5182: Part 6 | |
| | | | | | Cl2 - Flow Meter with impinge module | Spectro-photometer | 1 µg/m$^3$ | IS: 5182: Part 19 | |
| | | | | | HCl - Flow Meter with impinge module | Titration | 1 µg/m$^3$ | APHA 4500 $Cl^-$ B 22$^{nd}$ Edition | |

| S. No. | Environmental Component | Sampling location | Sampling Parameters | Sampling Frequency | Sampling Analysis | | | Method | Budget (Nu) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Sampling Instrument | Analytical Equipment | Detection Limit | | |
| | | | | | CO – CO meter | Gas Chromatography | 1.14 mg | IS: 5182: Part 10 | |
| 2. | Meteorology | 1 location (suggested at BAFRA Office, Phuentsholing) | Wind speed, wind direction, temperature, relative humidity and rainfall | Continuous | Online Weather Logger | - | Wind speed: 0.3 m/s | IS:8829-1978 | 100,000: one time investment; 10,000 annual maintenance |
| 3. | Surface Water Quality | 50.0 m downstream of the discharge point of treated sewage: water sample be taken along the middle of the water column and each location used in EIA Baseline | • Oil & Grease<br>• pH<br>• COD<br>• BOD<br>• TSS<br>• DO<br>• Turbidity<br>• Ammonical Nitrogen<br>• Coliforms (Total / Faecal) | Six month each season (the complete suite of surface water tests as per the Environmental Standards of Bhutan for Class A waters) | Niskin Sampler (Depth Sampler) | Appropriate, most recent version of American Public Health Association (APHA) standards | | | 75,000 annually |
| 4. | Ground Water Quality and | From the tube wells being used for the | • Oil & Grease<br>• COD<br>• BOD | Six Months | Ground water pumps or bailers for | Appropriate, most recent version of American Public Health Association (APHA) standards | | | 75,000 annually |

| S. No. | Environmental Component | Sampling location | Sampling Parameters | Sampling Frequency | Sampling Analysis | | | Method | Budget (Nu) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Sampling Instrument | Analytical Equipment | Detection Limit | | |
| | Ground Water Level | project based on EIA baseline | • TSS<br>• TDS<br>• Turbidity<br>• pH<br>• Total Hardness<br>• Colour<br>• Odour<br>• Water Depth below ground level | | sampling and depth indicator for water table | | | | |
| 5 | Ambient Noise Levels | Based on EIA baseline in same locations | dB(A) | Six months | Decibel Meter | - | 0.01 dB(A) | As per Instrument Calibration and Usage Manual | 10,000 annually |
| 6. | Ecology Aquatic<br>Eastern side of river | Aquatic Bio-diversity Survey based on EIA baseline | Fish catch, bio-diversity | Once each season | Fish nets | Visual | - | As per standard methods for bio-diversity surveys | 10000 Annually |

| S. No. | Environmental Component | Sampling location | Sampling Parameters | Sampling Frequency | Sampling Analysis | | | Method | Budget (Nu) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Sampling Instrument | Analytical Equipment | Detection Limit | | |
| | Ecology – Terrestrial Eastern side of the river | Fauna Survey based on EIA Baseline | Terrestrial fauna presence, social behaviour and movement | | - | Questionnaire, visual | - | | |
| 9. | Effects on Benthic, Aqua fauna on western side of river | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out |
| 10. | Effects on terrestrial faunal habitation, movement etc. on western side of the river | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out | As per findings and recommendations of bio-diversity assessment proposed to be carried out |

## 8.6 GRIEVANCE REDRESS MECHANISM

470. The project is required to have a mechanism for people who are affected by the project to submit their grievances and a mechanism for the project to resolve a grievance received from affected people.

471. A two tier mechanism will be adopted by the project. The first tier, will be in the field PIU level. The Secretariat of GRM will be established in the PIU office, with PIC health and safety or social consultant acting as the secretary. At the first level GRM, the team called as Grievance Redress Committee will be established at the PIU level and consist of the PIU head as the lead of GRC, with the following permanent member: (i) the Environment Officer of PIU, and (ii) the PIC consultants (social development, environment, and health and safety), (iii) representative of local leader, (iv) representative from District office, (v) representative from reputable community based organization, and (vi) members on call basis based on the nature of grievance representing relevant section of district office, contractor, and other PIU staff e.g. engineer. There are four options of complaint/grievances received: (i) PIU office, (ii) Contractor office, (iii) local leader office, and (iv) Thromde office, and 1 GRM first level secretariat that will in the PIU office. The secretariat will actively check with other grievance receivers and record submitted grievance, date, concerns/ grievance type. The secretariat will call a regular meeting to invite all member, and conduct special meetings if receive any grievance. The secretariat will responsible to review the grievance, identify potential solutions, and call the meetings with relevant party. Meeting to resolve a grievance should involve the person who submit the grievance. The time to resolve the grievance at the first level will be maximum 14 days. If the first GRM level could not resolve the grievance it will go to second level/tier GRM.

472. The second level/tier GRM will be led by the PMU head with member from PIU and relevant PMU staff, and relevant Department at the central government level, as well as reputable community based organization. All grievances should be resolved at this level. The total time required will not be more than 30 days after PIU receiving the grievance. Depending on the severity of the case, additional time may be agreed by the complainant to resolve the grievances. The meeting to resolve a grievance will be held by involving also the people who submit the grievance.

473. The PMU will develop detail a standard operating procedure for GRM. The GRM is not replacing the court system, so complainants can still bring the complaint/grievance to the court while the Project grievance handling the complaint.