ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, Bangladesh

Final Report

Unique Meghnaghat Power Limited

December 2022

Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position
00	20.04.2020	Raw Draft of ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, Bangladesh		Chetan Zaveri	Executive Director-Environment
01	07.06.2020	Revised Draft ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, Bangladesh		Chetan Zaveri	Executive Director-Environment
02	20.11.2020	ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, Bangladesh		Chetan Zaveri	Executive Director-Environment
03	07.12.2020	ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, Bangladesh		Chetan Zaveri	Executive Director-Environment
04	11.04.2021	Final draft ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, Bangladesh		Chetan Zaveri	Executive Director-Environment
05	12.08.2021	Draft ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, (After addressing Lenders' comments on R4)		Chetan Zaveri	Executive Director-Environment
05	09.03.2022	Final Draft ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, (After addressing Lenders' comments on R5)		Chetan Zaveri	Vice President
06	24.03.2022	Final Draft ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, (After addressing Lenders' comments on R6)		Chetan Zaveri	Vice President
07	26.03.2022	Final Draft ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj, (After addressing Lenders' comments on R7) (For Disclosure)		Chetan Zaveri	Vice President
08	14.09.2022	Final ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj (After addressal of all comments by Lenders and UMPL post disclosure of Final draft ESIA Report)		Chetan Zaveri	Vice President
09	01.12.2022	Final ESIA Report for Proposed 600MW Combined Cycle Power Plant at Sonargaon, Narayanganj (After addressal of comments by Lenders via email dated November 23, 2022)		Chetan Zaveri	Vice President

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Table of Contents

Figures

Tables

Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
AGI	Above Ground Installations
AIIB	Asian Infrastructure Investment Bank
AIP	Access to Information Policy
ALARP	As low as Reasonably Practicable
ANSI	American National Standard Institute
AoI	Area of Influence
ASME	American Society of Mechanical Engineers
BBS	Bangladesh Bureau of Statistics
BDT	Bangladesh Taka (Currency)
BDWD	Bangladesh Water Development Board
BFIDC	Bangladesh Forest Industries Development Corporation
BFRI	Bangladesh Forest Research Institute
BIDA	Bangladesh Industrial Development Authority
BMD	Bangladesh Meteorological Department
BNH	Bangladesh National Herbarium
BOD	Bio-Chemical Oxygen Demand
BOO	Build, Own and Operate
BOP	Balance of Plant
BPDB	Bangladesh Power Development Board
BS	British Standards
CAMS	Continuous Air Monitoring Station
CCGT	Combined Cycle Gas Turbine
CCPP	Combined Cycle Power Plant
CCPS	Centre for Process Safety
CCR	Central Control Room
CEMS	Continuous Emission Monitoring System
CMB	Common Monitoring Basin
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
COVID19	Corona Virus Disease of 2019
CR	Critically Endangered
CSR	Corporate Social Responsibility
DD	Data Deficient
DEG	Deutsche Investitions- und Entwicklungsgesellschaft
DG	Director General
DG	Diesel Generator
DM	Demineralised
DMP	Disaster Management Plan
DoE	Department of Environment
E&S	Environmental and Social Assessment
EBRD	European Bank for Reconstruction and Development

ECA	Ecologically Critical Areas
ECA	Environment Conservation Act
ECC	Environmental Clearance Certificate
ECR	Environment Conservation Rules, Bangladesh, 1997
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
EMF	Electromotive force
EPAP	Equator Principles Action Plan
EPAS	Environmental Perimeter Air Station
EPFIs	Equator Principle Financial Institutions
ESF	Environmental and Social Framework
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESS	Environmental and Social Standards
ETP	Effluent Treatment Plant
FD	Forest Department
FDI	Foreign Direct Investment
FGD	Focus Group Discussion
FGL	Finished Grade Level
FI	Financial Intermediary / Financial Institutions
GAD	Gender and Development
GE	General Electric
GEV	Generalized Extreme Value
GHG	Green House Gases
GIIP	Good International Industry Practice
GIS	Gas Insulated Switchyard
GLC	Ground Level Concentration
GoB	Government of Bangladesh
GSA	Gas Supply Agreement
GSB	Geological Survey of Bangladesh
GT	Gas Turbine
GTG	Gas Turbine and Generator
GWT	Ground Water Table
GBV	Gender Based Violence
HAZID	Hazard Identification
HDD	Horizontal Direction Drilling
HFL	High Flood Level
HHV	Higher Heating Value
HP	High Pressure
HRSG	Heat Recovery Steam Generator
HSD	High Speed Diesel
IA	Implementation Agreement
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IDCT	Induced draft-cooling tower

IDCT	Induced Draft-Cooling Tower
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IP	Indigenous Peoples
IPP	Independent Power Producer
IR	Involuntary Resettlement
IUCN	International Union for Conservation of Nature
IVM	Integrated Vegetation Management Approach
LC	Least Concern
LFL	Lower Flammability Limit
LGED	Local Government Engineering Department
LoI	Letter of Intent
LP	Low pressure
MoEF	Ministry of Environment, Forests and Climate Change
MPEMR	Ministry of Power, Energy and Mineral Resources
NAAQS	National Ambient Air Quality Standards
NDIR	Non-dispersive Infrared
NE	Not Evaluated
NER	Neutral Earthing Resistor
NFPA	National Fire Prevention Association
NOx	Oxides of Nitrogen
NT	Near Threatened
NTP	Notice to Proceed
O&M	Operation and Maintenance
OGP	Oil and Gas Producers
PCB	Polychlorinated biphenyls
PCU	Passenger Car Unit
PED	Project Effective Date
PGCB	Power Grid Company of Bangladesh
PM	Particulate Matter
PMP	Pest Management Plan
PPA	Power Purchase Agreement
PPE	Personal Protective Equipment
PS	Performance Standard
PSMP	Power System Master Plan
QRA	Qualitative Risk Assessment
RLNG	Re-Gasified Liquid Natural Gas
RW	Raw water
S/C	Single Circuit
SCB	Standard Chartered Bank
SEAH	Sexual exploitation and Abuse and Sexual Harassment
SEZ	Special Economic Zone
SFL	Strategic Finance Limited
SO2	Sulphur di-oxide

SPM	Suspended Particulate Matter
SPS	Safeguard Policy Statement
SRDI	Soil Resource Development Institute
ST	Steam Turbine
STG	Steam Turbine Generator
STP	Sewage Treatment Plant
TGTDCL	Titas Gas Transmission and Distribution Company Limited
TSS	Total Suspended Solids
UGI	Underground Installation
UGI	Underground Installation
UHRL	Unique Hotel & Resorts Limited
UMPL	Unique Meghnaghat Power Limited
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
USP	Unsolicited Proposal
VEC	Valued Environmental Component
WB	World Bank
WHO	World Health Organization

Units and Measures

°C	Degree Celsius
dB (A)	Decibel on A weightage
Kg	kilogram
m^3	Cubic metre
µg	Microgram
S	Seconds
µS	Micro-Siemens
mm	Millimetre
kV	Kilo Volt
MW	Megawatt
MWth	Megawatt thermal input
ppm	Parts per Million
mg/Nm^3	Milligrams per Standard Cubic Metre
Mscf	M (1000) Standard Cubic Foot
meq	Milliequivalent

EXECUTIVE SUMMARY

Introduction

The Government of Bangladesh (GoB) has adopted a strategy for the development of the power sector which envisages private participation in the sector. As a part of this strategy, Unique Meghnaghat Power Limited (UMPL), a Joint Venture Company constituted by the consortium consists of Unique Hotel & Resorts Limited (UHRL), GE Capital Global Energy Investments BV and Strategic Finance Limited (SFL), has been incorporated in the year 2018 for development of 600-Megawatt (MW) RLNG based Combined Cycle Power Plant (CCPP) project with net output 588.31 MW at Dudhghata Mauza in Pirojpur union of Sonargaon upazila under Narayanganj district, Bangladesh. This project is expected to be funded by Asian Infrastructure Investment Bank (AIIB), DEG and Standard Chartered Bank (SCB).

UMPL had applied for Environmental Impact Assessment (EIA) approval to Department of Environment (DoE), Bangladesh and site clearance was obtained vide Memo No. 19-29585 dated 01/10/2019 valid through 30/09/2020. Site Clearance was renewed vide Memo No. 21-54203 valid till 30/09/2021. UMPL also received the Environmental Clearance Certificate (ECC) on 19.07.2020 (Memo No: 22.02.6700.140.72.065.19-09).

The Environmental and Social Impact Assessment (ESIA) study is undertaken in line with the applicable policy framework of AIIB, DEG and SCB with the objective of assessment of the major environmental and social (E&S) impacts arising due to the proposed project activity during its construction and operation phases within the area of influence, recommending the possible mitigation measures for any adverse impacts, management and monitoring plan to evaluate the effectiveness of the mitigation measures as a part of the Environmental and Social Management Plan (ESMP). This Executive Summary presents salient features of the project, the main findings and the conclusions of the Environmental and Social Impact Assessment (ESIA). The ESIA report underwent several rounds of revision following comments from the Lenders and the draft final ESIA was published for disclosure on March 26, 2022 online at the website of UMPL and the Lenders. Hard copies of the draft final ESIA Report were made available at Union Parishad and UMPL site Office for the stakeholders. After addressing the comments received from various stakeholders following 90 days of disclosure period, the present version of ESIA report was finalised. This version of ESIA Report takes into account all the comments of the stakeholders for this project. The Executive Summary of final ESIA would be available at UMPL website https://umplbd.com.

In addition to the ESIA, a Livelihood Restoration Plan (LRP) has also been prepared to address the potential adverse livelihood risks and impacts associated with the procurement of land for the project site, widening of approach road and restrictions to the fishing community. The final LRP report would also be available is presented in a separate document, which is available at UMPL website https://umplbd.com.

Any queries or complaints related to this project be raised to the Grievance Redress Committee (GRM) of this Project for free and without fear of reprisal at the following numbers:

Permanent Committee of the GRM

General Manager Site	Chairperson & Head	01787690851
Deputy Manager Site	Chief Grievance Officer	01713205320
Deputy Manager Admin	Member	01713205315
Deputy Manager, EHS	Member	01713205295
Deputy Manager, Social	Member	01713205310

Policy, Legal and Administrative Framework

The policy framework under the purview of which the project and the ESIA study have been governed are:

- Bangladesh national and local policy, legal and institutional framework.
- AIIB Environmental and Social Policy.

- DEG Sustainability Guideline
- IFC Performance Standards and EHS Guidelines.
- Equator Principles 2020

The Power Project falls under the Red Category as per the Environment Conservation Rules, 1997 and is categorized as Category A as per AIIB's ESP, Equator Principles 2020 and IFC's Performance Standards. Implementing agencies involved in implementing any part of project activities would follow the applicable government laid down laws/ acts/ regulation and the guidelines of the sponsors. Salient E&S policies applicable for the project would be National Environment policy, 2018, National Environment Management Action Plan, 1995, Environmental Conservation Act 1995 and subsequent amendments, Environmental Conservation Rule 1997 and subsequent amendments, The Factories Act, 1965 and Bangladesh Labour Law 2006.

The applicable AIIB Environmental and Social Standards include:

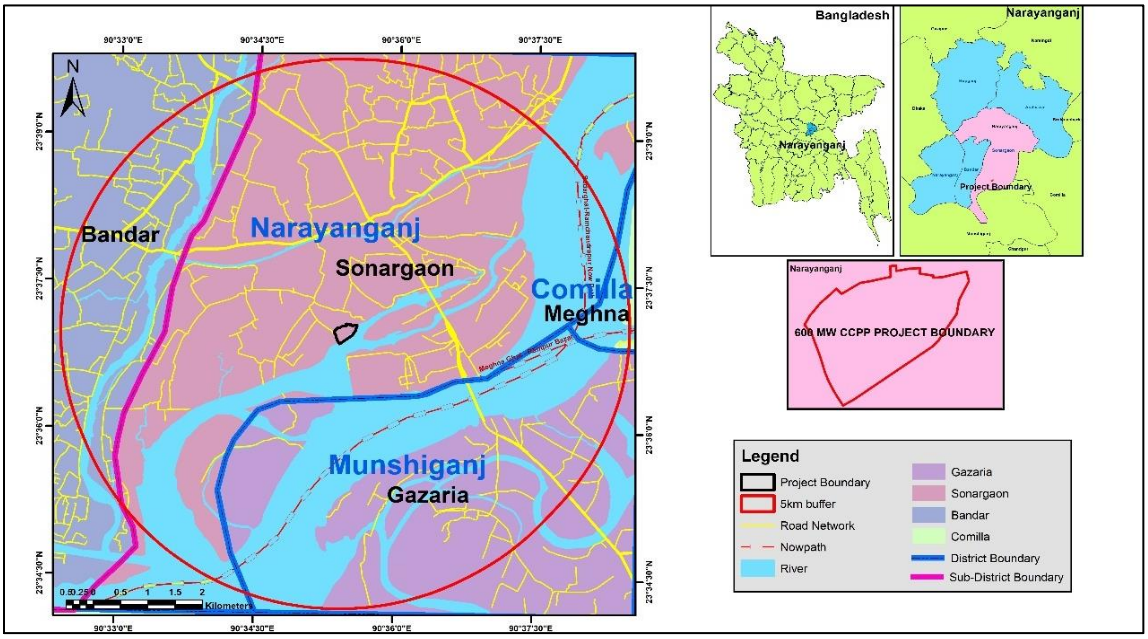
- **AIIB ESS 1:** Environmental and Social Assessment and Management as the project is required to ensure their Environmental and Social assessment and management measures are proportional to project risks and impact are implemented,
- **AIIB ESS 2:** Involuntary Resettlement as despite the project land being procured by willing buyer and willing seller method, there are 90 landowners who have become agriculturally landless. Apart from that 60-fisherman family and 18 land dependents have also been impacted due to land procurement.
- **AIIB ESS 3:** Indigenous Peoples is not applicable for the project as indigenous people are not present within the Area of Impact (AOI).

The applicable IFC Performance Standards (PS) for the project and the requirements include:

- PS 1 (Assessment and Management of Environmental and Social Risks and Impacts): Carry out regular assessment of the potential social and environmental risks and impacts and to implement mitigation measures and manage impacts consistently.
- PS 2 (Labour and Working Conditions): Conduct the project activities in accordance with the four core labour standards (child labour, forced labour, non-discrimination, and freedom of association and collective bargaining)
- PS 3 (Resource Efficiency and Pollution Prevention): Measure the ambient conditions and application of technically and financially feasible resources with pollution prevention principles and techniques to avoid or to minimize adverse impacts on human health during the entire project lifecycle
- PS 4 (Community Health, Safety and Security): Evaluate risk and impact of the affected community during the project life and establishment of mitigation or control measures.
- PS 5 (Land Acquisition and Involuntary Resettlement): Adopt systems to avoid /minimise social and economic impacts related to land acquisition as approximately 90 landowners have become agriculturally landless and 60-fisherman families &18 land dependents are envisaged to be impacted due to land procurement.
- PS 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resource): Evaluate the conservation plan for the project based of the land use of the project site.

Project Location & Key Features of the Site and Surroundings

The proposed project site is situated in Dudhghata Mouza of Pirojpur union, Sonargaon Upazila, Narayanganj district, Bangladesh and a total land area of 21.07 acres has been acquired for the plant. The site is about 27.3 km from Dhaka Zero point. The project site is situated on the right bank of the branch channel of Meghna river. The project location is presented in the figure below.



Project Location Map

Project Description

The proposed 600 MW Re-gasified LNG (RLNG) based CCPP Project is being developed on Build, Own and Operate (BOO) basis for a term of 22 years with a construction period of 3 years for a net output of 588.31 MW. The preferred unit configuration for the project would consist of a power block of 600 MW with Heat Recovery Steam Generator (HRSG), one steam turbine (ST) and two generators. The plant would run on RLNG from Petrobangla through Titas Gas Transmission and Distribution Company Limited (TGTDCL). The major components of the power plant:

Gas Turbine: The function of the Gas Turbine and Generator (GTG) is to generate the electrical power and to provide heat source to HRSG. The gas turbine would be of single flow open cycle type allowing continuous operation at the rated output and the operation would be completely taking place from the Local Control Cubicle and the Central Control Room.

Heat Recovery Steam Generator (HRSG): The HRSG is located at the downstream of gas turbine, generates steam using the exhaust gas from the gas turbine to feed the steam turbine.

Steam Turbine Generator (STG): The STG would generate the electrical power by admitting the steam from the Heat Recovery Steam Generators (HRSG) in order to supply the power to the Grid system.

Feed Water System: The feedwater system delivers feedwater from low pressure drum to the HRSG economizer inlet header and supplies spray water of HP steam system, HP bypass system and reheat steam system.

Condensate System: Low pressure (LP) turbine exhaust steam comes to Condenser where it is condensed to saturate liquid conditions and accumulated into Condenser Hot well. The Condensate System delivers this condensate from the condenser to the LP steam drum of HRSG via the condensate extraction pumps.

Cooling Water System: The functions of the closed loop cooling water system is to supply make-up water for cooling the plant system, indirect cooling of demineralised cooling water circuit for gas turbine oil coolers, gas turbine generator hydrogen coolers, steam turbine oil coolers, steam turbine generator air coolers, pumps, steam and water samplers, air compressors, and any other equipment requiring cooling water and to reject the waste heat to the auxiliary cooling water via the closed cooling water coolers.

Electrical Plant and System Requirement: A 400kV Gas Insulated Switchyard (GIS) would be envisaged for evacuation of power, import of power for start-up / shut down / station auxiliary power through Unit Transformers for the proposed power plant. This switchyard would be located within an area separate from the main powerhouse building and would be surrounded by a chain link fence.

Power Evacuation and Off Take: Power generated from the proposed power plant would be evacuated to the nearest grid substation of PGCB through 400 kV Single Circuit (S/C) line. The detailed interconnection plan with PGCB nearest grid substation with due consideration of capacity addition of proposed 600 MW project would be carried out by PGCB.

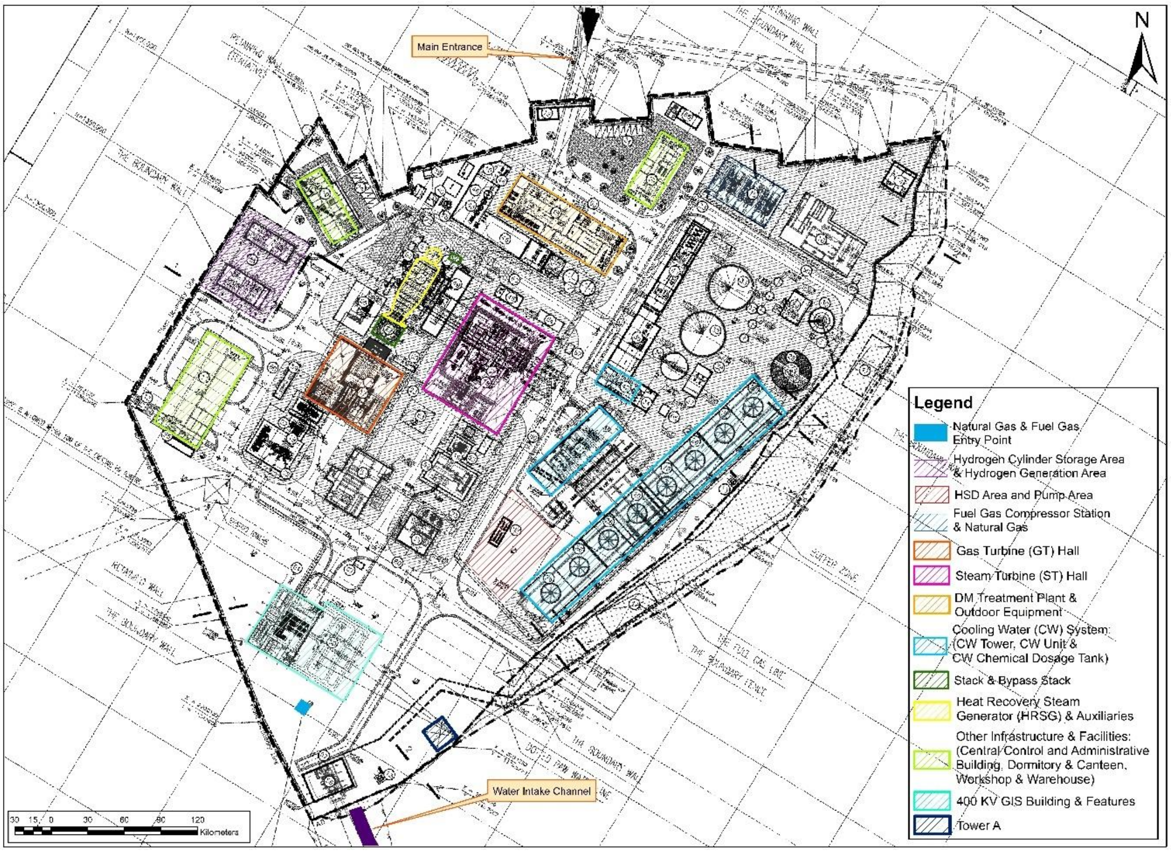
Stack: One un-insulated HRSG stack and one by-pass stack with stack heights of 75m and 60 m respectively would be provided.

Control System: The control system consisting of Distributed Control System that includes complete control, indication, annunciation and supervision of the electrical systems for the proposed power plant from the monitor through plant DCS for main power plant and 400 kV system. A hardwired synchronizing panel, unit wise for both generators would be provided.

The project also consists of the following components:

- Two temporary jetties (operational during construction period only) – for unloading of construction material & heavy equipment
- Transmission line - 400 kV Single Circuit Transmission Line for evacuation of power to the nearest proposed grid substation of Power Grid Company of Bangladesh (PGCB) on the opposite bank of Meghna River
- Water intake channel – Raw water intake channel and fore bay for water withdrawal from Meghna Channel to Raw Water Pump House, located inside plant
- Gas pipeline - A subsurface pipeline of 20-inch diameter for supply of natural gas from PGCB across the river on the opposite side of Meghna River
- Construction camp with treated sewage pipeline (operational during construction period only)– Comprise of offices & living area for UMPL, GE and NEPC, warehouse and open storage yard (separate entry for the yard) along with treated sewage pipeline from the modular STP to public sewage channel through a 105 m pipeline
- Additional land for laydown area- A 1.49-acre land procured on lease located adjacent to the plant site for temporary storage of Construction materials (For a period of 15 months)

The major projects components shown on the layout is presented in the figure below:

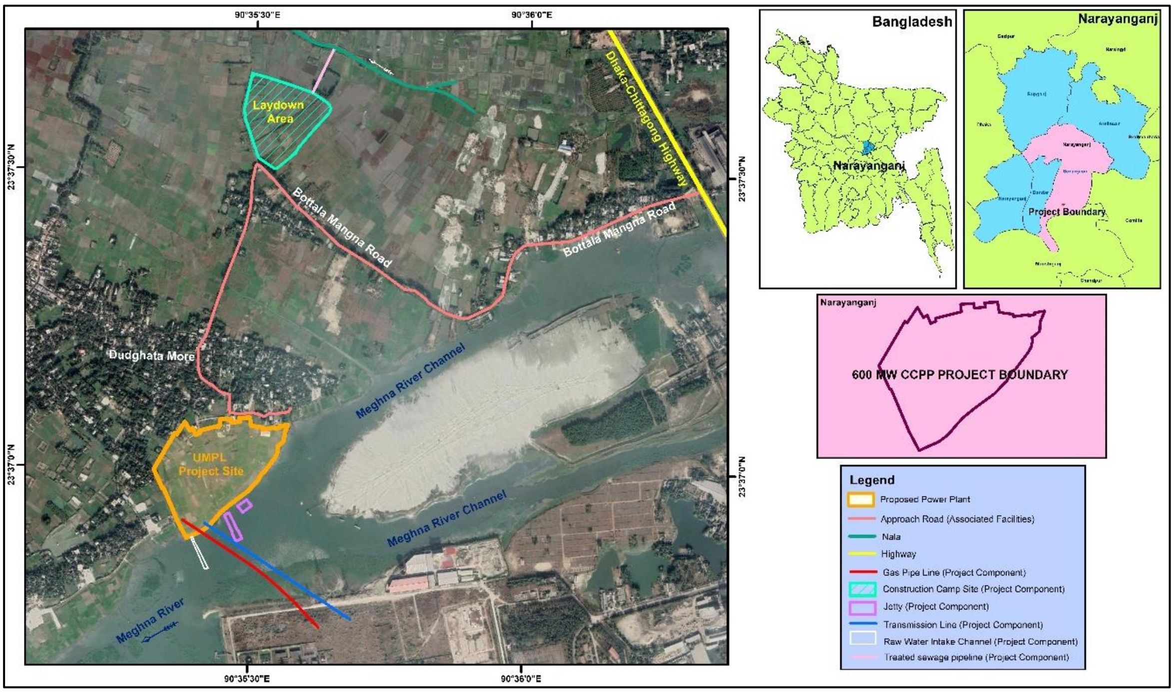


Layout of the proposed plant

Associated Facility: The movement of men & material between the site & the laydown area is dependent on the Approach Road and it is also considered as an Associated facility of this project.

The approach road to the site is a village metal road connecting Dhaka-Chittagong Highway to Dudhghata More. Proposed construction labour camp site is located just beside this road before reaching Dudhghata More. The road is maintained by the Local Government Engineering Department (LGED), Govt. of Bangladesh. The project intends to use 780m-long segment of the existing road for carrying construction materials and ferrying personnel from the campsite/laydown area to the project site. For heavy equipment and machinery for plant erection, UMPL would use the waterway as principal means of transportation. The approach road is not part of the project and considered as an Associated Facility to the project. LGED planned to execute widening of this road from 2.5-3 m to 5 m for welfare of local villagers following national policy on land acquisition and compensation. UMPL has provided additional compensation to the affected households, both formal and informal as per the market price. An assessment of the approach road widening as an associated facility to this project is being conducted and would determine whether the compensation is in line with applicable lenders policy framework.

The map below presents the components of the project and associated facility for proposed UMPL Power Plant.



The overall raw material, land and natural resources requirement for the project is presented below:

Land*

- Total land for the power plant is 21.07 acres
- Procured from 343 landowners (including 7 residential structure owners) based on willing buyer and willing seller land transaction
- Confirmed by the sub register that full and final payment of the land price has been received by all the present landowners who sold their land before registration in the name of UMPL.
- Total 1200 decimal land in Dudhghata Mouja has been taken on 3 years lease from Hamdard Laboratory for construction camp and lay down area.
- STP pipeline would be laid along the ROW of the road.
- Additional Land is not required for gas pipeline and transmission tower
- About 0.19 acres of land procured from the local community for the widening of the approach road from laydown area to plant site.

Earth Filling

- Approximately 566,337 cum of sand was required for developing the proposed project site up to the safer level above HFL.
- Project site was raised upto (+) 7.76 m
- Sand has been procured from Government approved vendor M/s Meghna Enterprise

Manpower

- During peak construction period approximately 1500 manpower would be required
- Average manpower requirement is 900 during construction
- Approximately 100 skilled and semi-skilled manpower would be involved during operation phase

Water Requirement and Source

- The estimated total make up raw water requirement for the plant is 676.22 m3/hr including recirculation water make-up for the cooling water system
- Raw water would be drawn from the Meghna branch channel through the intake water pump house.
- Buried pipeline with carbon steel construction would be used for water supply from the intake water pump house to the clarifier.
- Plant water system would be designed to supply cooling water make-up based on cycle of concentration of 6
- Raw water after treatment would be stored in the filtered water reservoir having storage capacity of 16 hours.

Natural Gas Requirement

- Daily gas requirement is 96,192 Mscf
- Natural Gas woudld contain minimum 85% methane
- Gas would be supplied by Titas Gas Transmission and Distribution Company Limited (TGTDCL)
- A 20-inch diameter pipeline would be laid under the riverbed by using Horizontal Directional Drilling (HDD), from the nearby valve station to supply gas across the river.

** The details of land acquired for this project & associated compensation can be found in a separate document- LRP for this project.*

The plant would be designed with Fire Fighting System which would conform to the NFPA – 850 recommendations and the regulations of the local statutory authorities. Neutral Earthing Resistor (NER) would be connected between neutral point of secondary side winding of all unit transformers and earth. Lightning Protection would be achieved by providing lightning masts on stacks, powerhouse building, towers in switchyard, etc. and connecting them with the earth grid and shielding wires and / or lightning masts to safeguard the equipment of 400 kV switchyard and transformer yard Cathodic protection would be provided for buried section of subsurface gas pipeline.

Pollution Monitoring and Control Measures: The embedded pollution control measures considered for the project are as follows:

- **Air Pollution Control Measures:**
  - One main stack of 75 m height and bypass stack of 60 m height is proposed for venting off the off gas to ensure adequate dispersion of generated SO_2 and NOx into the atmosphere.
  - Latest combustion technology with low NOx burners would be used in the Gas turbines, which maintains NOx level within 25 ppm when firing Natural Gas.
  - Continuous Emission Monitoring System (CEMS) would be considered for online monitoring of stack exhaust with crossflow modulated Non-dispersive Infrared (NDIR) detection. The output would show concentrations of NOx, SO_2, CO, CO_2, O_2.
- **Noise Pollution Control Measures:**
  - Major sources of noise would be kept within the prescribed 85 dB(A) at 1 metre distance from the outer surface of the equipment at the design stage.
  - Individual equipment exceeding this limit would be provided with suitable sound absorption / dampening enclosures.
  - Plant operations personnel would be equipped with earplugs and other safety measures for protection against occupational noise hazard.
- **Water Pollution Control Measures:**
  - Demineralization regeneration wastes are directed to the neutralization basin and the neutralized water would be transferred to Common Monitoring Basin (CMB).
  - Treated effluents would be collected in the common monitoring basin for monitoring and the final effluent would be monitored for TSS, COD, BOD and pH.
  - Sewage Treatment Plan (STP) would be installed for treatment of domestic wastewater generated from the plant area.
  - Treated effluent would be partially used for plantation works and the balance would be routed to the Meghna Branch Channel.

Project Implementation and Schedule

Unique Group assumes overall responsibility for implementation of the project, covering all fronts of activities as well as conflict resolution, drawing necessary expertise and support from implementation consultants on regular basis. The Project will be executed through on a single turnkey EPC mode. On completion of commissioning of the plant, the operation and maintenance would be taken over by the O&M Team.

Assuming 9 months of time period for pre-construction activities, all the required statutory and non-statutory clearances were obtained during this period including the financial closure, and the construction period has been estimated as 32 months from the 'zero date' which is reckoned as the date of Notice to Proceed (NTP). The schedule commissioning is after 32 months from NTP.

Decommissioning: The design life of the power plant is estimated to be 25 years and if the relevant agreements are not extended or renewed and an alternative economical fuel is available, the power plant might be retrofitted to support alternative power generation. In case retrofitting is not feasible the power plant would be decommissioned.

PROJECT COST: The total project cost is estimated to be USD 503 million.

Project Alternatives

The alternatives which have been analysed for the project considering aspects of project location, design and extent of impacts as presented below:

- Considering the current power scenario in Bangladesh, a “no project scenario” would result in power shortage in the country as well as impact upon the quality of life of those affected by the power outages. Furthermore, without the project, creation of employment opportunities in the proposed project area would be lost.
- Considering alternatives of project location, Dudhghata mouza has been selected to avoid physical displacement of household; requirement of land acquisition is less for auxiliary facility like gas pipeline, transmission line, approach road and erodibility.
- Based on the technological alternative analysis, the use of Combined Cycle Gas Turbine (CCGT) system is rationalized based on the OPEX price and significant lower greenhouse gas (GHG) emissions.
- The use of LNG as fuel, particularly from GHGs emissions and climate change perspectives based on the fuel alternative analysis is justified.
- Two options available for cooling are once through cooling system and induced draft cooling tower. Among the two cooling alternatives, induced draft cooling is selected as it would reduce the net make-up water requirement to a significant extent and would also prevent thermal discharge from plant.

Baseline Environmental and Social Condition

The area of influence (AOI) for the present ESIA study is anticipated to be limited to 5 km radius buffer around the Project site boundary on the professional judgement of team of experts that magnitude of impact from the gas based CCPP with closed loop recirculation cooling system would be largely contained within the close vicinity of the project site.

Information related to Physic-chemical, biological and socio-economic conditions of the project area and its surroundings were collected by review of other published literature, site surveys, stakeholder interactions and primary monitoring carried out during two seasons. The first baseline studies were carried over a period of two months from October to November 2019 and the second baseline studies were carried over a period of one month in June 2020 (The second season monitoring had commenced in the second half of March 2020 but had to be suspended due to restrictions imposed on account of COVID-19). The baseline environment is presented below in brief:

Natural hazards

Project site falls under Seismic Zone-2 of Bangladesh National Building Code (2006) which is the zone having intermediate effect. Meghna River is affected due to flood, mostly during the month of July. It was observed that the site is susceptible to flood. The highest value observed for the year 1998 is 6.76 m. Therefore, UMPL has done land filling and levelling works to bring the average existing ground level to the 7.76 m above mean sea level.

Industries in the AOI

The Project Site and its surrounding area is located in the fringe of Meghnaghat Industrial Cluster which was mainly developed on a riverine island in Meghna River. Meghnaghat Industrial Area is divided in two parts e.g. Meghnaghat North Industrial Cluster and Meghnaghat South Industrial Cluster. Industries within the AOI include power plant, paper mill, shipyard, cement plant, steel mill, food processing units, chemical industry and textile/RMG unit.

Land-Use

At the beginning of civil works, the project site was open land, which was elevated and developed by sand filling; the earlier land use being majorly agricultural type. The major land use observed in the study area is agricultural land (39.79%) followed by river (26.59%) and settlements (19.82%). Proportion of the built-up land is high near the plant site within 2 km. There is no declared forest area, but significant area within 5 km radius is covered by plantation.

Drainage Pattern

The present site is about 30 km north from Chandipur in the upper Meghna zone. Meghna carries huge amount of water from the precipitation over large area of the Ganga Brahmaputra Meghna Basin. The project site is drained by river Meghna which flows from East to Southwest of the study area. The entire area lies in the delta region and is drained by several small and large natural drainage features.

Ground water quality

Primary monitoring of ground water quality was conducted at 4 locations during each of the monitoring period to understand the existing condition of groundwater and assess probable impacts of the proposed project activities on the sub surface aquifers. The general trend indicated that Total Dissolved Solids in groundwater is slightly higher in June 2020 due to less water recharge during the summer season in contrast to ample dilution in October 2019 during the inception of post-monsoons in October.

Surface water Quality

Primary monitoring of surface water quality was conducted to understand the existing surface water quality in the AOI as the effluent generated during the project operations will be discharged to the branch channel of Meghna river after ensuring that it meets the applicable standards. From the results of the analysis of the samples of both seasons it may be seen that the values of faecal Coliform, Total Coliform and COD was found to be in the higher range in all the surface water samples indicating possible sewage contamination.

Ambient Air Quality

The 24-hourly average Suspended Particulate Matter (SPM) concentrations in the monitoring locations varied between 81-182 µg/m^3. The 24-hourly average PM_{10} concentrations in the monitoring locations varied between 40-90 µg/m^3. The 24-hourly average SO_2 concentrations at the monitoring locations ranged between 4.8 to 10.3 µg/m^3. The average NOx concentrations in the monitoring locations varied between 14.5 to 26.2 µg/m^3. Average concentration of SO2, NO_X and PM are within the permissible limit.

Ambient Noise Quality

Ambient daytime noise level (Leq day) in the study Area was recorded in the range of 47.8 to 71.19dB (A) during day-time and in the range of 38.02 to 60.58 dB (A) during night-time at the monitoring locations.

Ecology

Ecology and Biodiversity study of the project area was conducted from October - November 2019. No Nationally Designated Area (National Park, Wildlife Sanctuary etc.) and Internationally Designated Area (Ramsar Site, Important Birds Area, Key Biodiversity Area, Alliance of Zero Extinction Area) are present within the 10 km of the project site. Out of all the species having reported range in the study area, there are one (01) Critically Endangered, seven (07) Endangered and ten (10) Vulnerable species as per IUCN Bangladesh status 2015. As per IUCN Global Status, 2021-3 only two (02) vulnerable species (*Python bivittatus*, *Wallago attu*) are present and rest are Near Threatened & Least Concern. As per the result of aquatic ecology, the abundance of phytoplankton, zooplankton and benthos are low in the Meghna river which may be due to the hot water discharge from the nearby thermal power station, high water traffic and wastewater discharge from nearby industries. The proposed project sites do not fall under any of the spawning or nursery grounds of Hilsha. A Critical Habitat Assessment has been conducted and the Project area does not qualify for critical habitat as per IFC PS6, 2012 and its Guidance Note, 2019 and thus does not need a Biodiversity Action Plan.

Socio-economic

Total population of Dudhghata Mouza is 4009, residing in 887 household as per Census 2011. Total number of project affected household is 331 and average household size is 4.24. The major livelihood activity of the project affected households is agriculture and non-farm based economic activities like business. Other livelihood activities include fishing, animal husbandry, labour in agriculture, and industry etc. There are many fishermen communities present in Dudhghata. They have two major concerns- firstly project land was used by them for approaching the river front; now they have to take longer route to approach the river front. Secondly, the project prevents their earlier practice of drying their fishing net in the project land.

The summary of the major impacts and mitigation measures due to the project is outlined below:

Assessment of Environmental Impact: Pre-Construction and Construction Phase

1. Impact due to land filling in proposed power plant area and construction camp area using sand slurry

Proposed power plant area has been filled with sand procured from authorised contractors before construction as this land is very low lying. During filling, the surrounding fertile agricultural land may be impacted by reduction infertility, due to sand deposition from overflow of the sand slurry from the site. The soil and groundwater may get impacted due to presence of contaminants in the fill material.

Mitigation Measures:

- *Bunding or constructing an embankment surrounding the land to be elevated*
- *Use of bamboo stick and plastic sheet before filling to restrict transfer of sand out of the land filling site.*

2. Impact due to return water from sand slurry for land filling

Return water would be generated when the water from sand slurry used for land filling would flow back to the river through the lowest gradient of the proposed land. It is envisaged that some amount of sand would be mixed with water and flow into the river, causing impacts like increased turbidity in the river water and potential change in sediment quality.

Mitigation Measures:

- *Regular surveillance of the condition of the embankment by UMPL personnel during the entire period of sand filling.*
- *Silt trap in the designated channel installed before commencement of sand filling.*

3. Impact due to construction of water intake channel and Jetty

Impact of medium significance is envisaged due to construction of water intake channel and jetties on the movement of boats and trawlers in the Meghna river as there may be temporary suspension in boating in the specific route.

Mitigation Measures:

- *Installation of markers in the construction area to warn the boats & vessels.*

4. Impact due to generation and disposal of drill cuttings and drilling mud

Generation & disposal of 260 m^3 of drill cuttings & drilling mud pose risk to the health and safety of human being and animals, threat to the ecology and may impact the water and soil quality if not stored properly and disposed in an environmentally sound manner as per the prevalent regulations. The drilling mud also acts as quick and pose potential risks to the safety of human being and animals if disposed indiscriminately. The drill cuttings and drilling mud would be disposed though authorised third-party agency.

Mitigation Measures:

- *Storage of drilling mud & drill cuttings in a designated area with paving and secondary containment like dyke to obliterate chances of soil, surface and groundwater contamination due to seepage & surface run-off.*
- *Putting up of adequate barricaded under proper security monitor and signages in the storage area of drilling mud & drill cuttings to alert the working personnel and community from the quicksand properties of bentonite*
- *Restricted access to the storage area of drilling mud & drill cuttings except authorised personnel deputed to work in the area*

5. Impact on ambient air

There would be emissions of SO_2, NOx, CO and VOCs from diesel generator sets to ambient air. Transportation of construction material by barges and other transport vehicles along the approach road during the daytime and operation of construction equipment would also contribute to exhaust emissions containing air pollutants like SOx, NOx, etc. that would impact the air quality. Most of the construction activities, the batching plant and movement of vehicles on the approach road would have the potential to generate dust.

<u>Mitigation Measures:</u>

- *Periodic water-spraying/sprinkling and sweeping of unpaved and paved roads and construction site to minimise dust.*
- *Covered transportation of dusty materials to prevent materials being blown from the running vehicles.*
- *Storing dusty materials away from site boundaries and in appropriate containment (e.g. sheeting, sacks, barrels etc.).*
- *Burning of wastes generated at the construction sites, work camps and any other project activity related site would be strictly prohibited.*
- *Installing wind barriers, particularly across locations of sensitive receptors to prevent dust carry over.*
- *Locating the concrete batching plant away from sensitive receptors and additional net fencing/ solid barrier on section of boundary wall facing the sensitive receptors to minimise the dust.*

Although the baseline PM_{10} and $PM_{2.5}$ exceeded the WHO standards, the impacts of the project related construction activities on air environment would be managed with the mitigation measures . The project as such is not envisaged to degrade the prevailing air quality further in the project region during its construction phase.

6. Impact due to generation of high noise level

There would be generation of high noise due to pre-construction and construction activities that would cause significant impact on the surrounding sensitive receptors.

Noise prediction has been carried out using SoundPLAN 8.2 to predict noise levels that would result from the construction equipment during construction phase. Modelling has considered separate scenarios with 2 m high and 6 m high double layered boundary wall made of NPW sheet. The predicted noise level is on higher side and increasing the height of boundary wall helps in reducing the noise propagation to some extent.

<u>Mitigation Measures:</u>

- *Use of acoustic enclosures for DG sets during construction phase.*
- *Normal working hours of the contractor would be between 06:00 and 18:00 hours from Saturday to Thursday. If work needs to be undertaken outside these hours, it would be limited to activities that do not generate high levels of noise*
- *Conducting noise monitoring at receptors as per the proposed monitoring schedule and in case exceedance happens, adoption of practical mitigation measures to attenuate noise at source level or temporary sound barriers would be used at the working equipment with high sound power level.*
- *Regular maintenance of equipment and machinery used for construction.*
- *Restriction on night-time honking.*
- *Mandatory use of ear plug, ear mufflers by construction workers working in high noise areas.*

7. Impact due to Associated facility

The widening of the existing village road is being conducted by the Local Government Engineering Department (LGED) under the Rural and Culvert Maintenance Program and UMPL has no influence on the construction management of the road widening. The adverse environmental impacts of AF would be generation of fugitive dust & noise, discharge of wastewater from construction site, generation & disposal of solid waste including debris, Blockage of access and congestion of traffic and occupational health & safety issues of workers.

Good practice measures would be adopted including creating of drains to channelize stormwater to nearest public drain, storing of construction & municipal wastes in designated area, water sprinkling during dry period, restriction on use of high noise generating equipment near sensitive receptor during night-time and during period of congregation. These impacts are considered insignificant if managed well. Considering that it is a populated area, land clearance would be kept minimum to the extent practicable for the approach road so that any alteration to the natural topography or landscape is avoided.

8. Impact on terrestrial flora and fauna

Filling of sand would lead to loss of agricultural land and its associated vegetation (small shrubs and herbs) loss and affect the species within the proposed project site and indirectly to those faunal species who use this land as a residence and corridor for movement. During the construction phase regular movement of vehicles, machinery and people would expose the natural environment to vehicular emissions and unnatural levels of noise, light and vibrations, but also dislodges fine soil particles generating dust.

However, there is not IUCN threatened species or critical habitat in the project area, the impact on terrestrial flora and fauna is assessed to be negligible to low.

Mitigation Measures:

- *Minimum clearing of land clearing for the approach road to minimize damage to the natural topography and landscape*
- *Provision of landscaped areas, where possible, around and within the Project Site using indigenous species to provide habitat for terrestrial and riparian species and improve aesthetics.*
- *Green belt development to be initiated with plantation of local species for stabilization of the filled in material and engage with local forest department and Upazilla administration for plantation activities outside the project area.*

9. Impact on aquatic flora and fauna

There would be adverse impact on aquatic flora and fauna from discharge of return Water of sand slurry to river construction of water intake station and jetty, movement of river traffic for transporting construction materials and machinery, discharge of sewage into the river water.

Mitigation Measures:

- *Compaction and stabilization of banks would be done to ensure that no bank soil is washed away.*
- *As faunal activity reduces in mid-afternoon so, the ideal time to enter the branch channel would be preferably mid-afternoon.*
- *Presence of adequate spill kits at site would be ensured to handle accidental oil spillage.*
- *Project proponent would promote local fish breeding sites in consultation with Fishery Department for supporting the local fishermen by fish spawning and introduction of pollutant resistant fish species in the nearby fishing zone.*

Hence, the impacts on aquatic fauna and flora would be negligible with the mitigation measures

10. Impacts on community and project-affected livelihoods

The land procurement has caused physical displacement of seven (7) houses. UMPL land procurement team has negotiated with the affected person on land price along with compensation for the assets. Based on the negotiated price UMPL has procured their land and assets housed on the land. All the moveable assets have been removed by the respective landowners. Additionally, loss of income or livelihood has impacted 90 landowners who have income from other livelihood activities like small business and services. The fishing community will lose access to the river front and ability to dry their fishing nets. This may have an adverse impact on their livelihood during the construction period of the water intake channel, which is 3-4 months. The livelihood impact assessment has also identified vulnerable households, among which those with female heads.

Mitigation Measures (detailed in the LRP):

- *Payment of compensation prior to taking possession of land.*
- *Dissemination of information about the procurement and compensation calculation process.*
- *Preparation of livelihood restoration plan and eligibility for livelihood restoration measures.*
- *Additional compensation for Vulnerable Households.*
- *Enhancement of sustainable livelihood of the affected lessee farmers through skill development for alternate employment.*
- *Unskilled labour during the project construction phase would be sourced from the local community; and*

- *Training would be provided to the local people for their skill enhancement.*
- *Additional facility should be created for the fishermen to dock their boats and fish net drying.*
- *Existing depleted ghat would be renovated for easy access of the fisherman to river front.*
- *During the construction and operations phase, adequate stakeholder engagement measures will be put in place to ensure that the community's access to branch channel and Meghna river is not interrupted due to the movement of barges carrying construction material.*
- *UMPL would help the fishermen to identify alternative location nearby for docking their boats.*

11. Impact due to conflict with local people

UMPL engages construction workers from within and outside Narayanganj, including foreign workers. It is anticipated that occasional conflicts would arise with the local community over the recruitment of migrant workers. Conflicts with the local population are also likely due to the cultural and linguistic differences between migrant workers and host community. These are managed with good labour practices. Since the conflicts can cause temporary disruption in work, the impact is considered to be of medium significance.

<u>Mitigation measure</u>

- *All the workers sign and follow the UMPL Code of Conduct.*
- *Proper communication in the affected villages during the construction phase and implementation of an effective grievance redressal mechanism.*
- *Training on the Code of Conduct and local culture, norms, tradition and value system would be imparted to the workers*
- *Labour camp is provided with all amenities like drinking water, sanitation Facility, cooking facility*
- *Labourers do not enter the nearby villages without prior approval*
- *Access of the local community in labour camp is restricted*
- *Periodic health check-up of labourers is being carried out*
- *Labour Management Plan and Labour Accommodation Plan has been prepared.*

12. Impact due to traffic Movement on newly widened approach road and access restriction

Due to increase in traffic during the peak construction activities there may be blocking in the access roads, congestion and traffic accidents. Considering the implementation of the speed control measures the impact is assessed to be of moderate significance. Community consultations also reveal that apart from this access route through the proposed power plant area, two other walking routes are also used by the local community for accessing the branch channel.

<u>Mitigation Measures:</u>

- *Development and implementation of the Traffic Management Plan by the contractor.*
- *Traffic congestion would be avoided by taking measures like implementing safety training for drivers, employing only licensed drivers, avoiding peal hour construction vehicle movement.*
- *Accidents may be avoided by regular maintenance of vehicles and use of manufacturer approved vehicular parts and implementation of proper signages about visibility and awareness of traffic and pedestrian safety.*

13. Impact Related to Gender Based Violence (GBV)/ Sexual Exploitation, Abuse and Harassment (SEAH)

GBV and SEAH based risks may rise during construction phase of the project where female workers work along with males. Apart from that, these issues may rise between women from the local community and migrant worker who will be working during construction phase. Hence significance of the impact may be medium.

<u>Mitigation Measures</u>

- *UMPL would formulate and implement Gender Policy in the workplace for all the workers working directly under UMPL or their sub-contractor.*

- *UMPL would formulate a sexual harassment committee headed by woman member of UMPL management and formulate SOP for daily working procedure of the committee.*
- *Regular training programme would be carried out during induction of new worker and employee and yearly for the worker and employee working in power plant.*
- *Complaint Box would be installed at various locations within the power plant and worker accommodation*

Assessment of Environmental Impact: Operation and Maintenance Phase

1. Impact on surface water resource and quality

Estimated total raw water abstraction for the plant from Meghana River is about 676 m^3/hr (0.1877 m3/s). Considering the available water (minimum flow) is 766.61 m^3/s, the impact of water abstraction for the project would be imperceptible on the water resource of Meghna River.

Prior to discharge, the treated effluent would be monitored in the CMB to ensure the water quality meets the more stringent standards as per Schedule 9 (Standards for Sewage Discharge) and Schedule 10 (Standards for Sewage Discharge and Standards for Waste from Industrial Units or Project Waste) of ECR 1997 and IFC EHS Guidelines for Effluent Discharge for thermal power plants 2008. About 120 m^3/hr of treated effluent will be discharged to the river while the remaining treated effluent (10-15%) would be used for plantation/green belt within site premises. It is estimated that post discharge of treated effluent into Meghna River from UMPL, the increase in resultant concentration of pollutants in the river water is even less than 0.01% which can be considered as insignificant. The discharge of effluent from the CMB to the Meghna River Branch Chanel will be within 3° C of the river water temperature which is compliant with IFC EHS Guidelines.

Mitigation Measures

- *Discharge system shutdown in event that discharge temperature of effluent at any point of time exceeds standard.*

With implementation of the precautionary and the mitigation measures mentioned above impacts on surface water quality would be low.

2. Impact on Air Quality During Operation Phase

The major sources of air emissions and Impacts during operation phase would include – emission (NO2 and CO with negligible or no Sox due to low sulphur content in the fuel gas) from HRSG system boiler stack; emission (i.e. SOx, CO, NO2, and HC) from emergency DG set stack and vehicles. The dispersion of air pollutants for the proposed power plant was predicted using a Gaussian plume model AERMOD 9.9.0 (USEPA approved). The model was run for NO_2 considering the conservative assumption that other 90% of other oxides of nitrogen was converted to NO_2. The total resultant values of NO_2 are not beyond the limits of Bangladesh standard. This indicate that the expected power plant does not have any significant adverse impact on the prevailing air quality of that area.

Mitigation Measures:

- Periodic monitoring of the ambient air quality and stack emissions
- Work zone air quality monitoring would be carried out at periodic intervals.
- Periodic maintenance and monitoring of air pollution control equipment would be ensured

Particulate matter is not an air pollutant of concern for a CCGT project. PM from other sources during the O&M phase like vehicles would be negligible. Although the baseline PM10 and PM2.5 exceeded the WHO standards, this project as such would not increase the prevailing PM concentration in the ambient air of the project region.

3. Impact due to noise from operation of the Power Plant

Since power generating equipment, cooling tower and traffic would generate considerable noise throughout the project lifecycle, having significant impact on the surrounding sensitive receptors. Noise modelling showed with the stringent mitigation measures and adequate management, the noise level can meet the standards during daytime (55dB (A)) and the impact on sensitive receptors during night-time is negligible since no activities would be envisaged during night-time.

Mitigation Measures

- *Regular monitoring of noise level at receptor locations and if exceedance continues, adoption of feasible mitigation measures to attenuate noise within the respective building sources to the extent possible. In case it is not sufficient to contain the noise attenuation within the respective buildings, UMPL would consider additional increase in height of the boundary wall from 3 m to 6m (additional height of 3m would be Noise Protection wall)., The riverside boundary wall would be of 3 m height only.*
- *Explore provision of padding with noise absorbent materials inside/outside in each industrial building of principal noise generating sources, wherever feasible to enhance attenuation and minimize the noise levels at the receptor at Plant boundary and beyond.*
- *Installation of high noise generating equipment within robust acoustic enclosures.*
- *Based on the land availability, the development of a greenbelt (Plantation of Trees with broad leaves and dense foliage) along the entire periphery of the plant would be undertaken to reduce noise propagation to the receptor end.*

4. Impact on Ecology During Operation Phase

Physical presence of permanent structures, such as the transmission towers and their ancillary components, as well as, the transmission line system would persist throughout the operation phase of the project. The principal direct risk posed by operational transmission line and its ancillary structures to avifauna is the potential for injury or death, either by collision with erected towers or by entanglement with power cables, leading to electrocution. In case of 400 kV lines, which has length of 800m, and electrical separation is above 4m, which is more than the wing span of observed large birds e.g. Egret, Black Kite, Open billed stork etc. Hence, the electrocution risk due to direct contact with conductors is considered low. Further, as per consultation with local people during the primary survey and review of publications and reports of Bangladesh, there are no records of presence of migratory birds found in and around the 10km radius of the project area.

Use of artificial lighting to illuminate the Power plant area and during night-time would lead to unnatural illumination in the area during the night and may disrupt the natural biological cycles of many floristic and faunal species. However as the project site is located away from wildlife habitat, the impact is of low significance.

Water required for the project would be sourced from adjacent Meghna River and discharged after treatment. Though, the intake of water would be done from Meghna River channel, not directly from Meghna river, however, there would be a chance of intake of aquatic organisms with water to power plant. Also, improper management of effluent that may lead to impact on aquatic ecosystem of the Meghna River. The impact significance on aquatic ecology due to discharge of treated wastewater during operation phase is assessed to be low as the treated wastewater would strictly abide by the prescribed standards and the extent of impact is local as the elevated water would equalize at a short distance from discharge.

Mitigation Measures

- To further minimize the collision of birds with the transmission line installation of Bird Diverter[1] would be installed for safe passage of avian species.
- It is recommended that Bird flight diverter is made up of Polyvinyl chloride (PVC) having high resistance against chemicals, high tensile strength and durable against high temperatures. Bird flight diverters would retain good physical conditions within a range of harsh conditions for an extended period. The recommended spacing between bird flights diverter is 10 to 15 m.
- Opting for low-intensity artificial lighting, such as LED, to prevent insects from being attracted to the Substation area
- The water intake structure would have multiple size screen barriers to avoid impingement or entrainment of aquatic organism.
- Usage of barrier nets (seasonal or year-round), fish handling and return systems, fine mesh screens, and wedge-wire screens, and aquatic filter barrier systems would be explored in the water intake system.

With implementation of the precautionary and the mitigation measures mentioned above impacts on ecology especially on aquatic ecosystem would be negligible

[1] *Avian Power Line Interaction Committee (APLIC). 2012. Reducing Avian Collisions with Power Lines: The State of the Art in 2012. Edison Electric Institute and APLIC. Washington, D.C.*

5. Impacts related to Gender based violence

During operation phase, O&M contractor and UMPL may employ women workers for various work. However., as per the workplace scenario in Bangladesh, majority of the workers are male. In this scenario, incidents of Gender Based Violence and Sexual exploitation, Abuse and Harassment may be likely and UMPL does not have any Gender Policy.

Mitigation measure

- UMPL is recommended to formulate and implement Gender Policy in the workplace for all the worker working directly under UMPL or their sub-contractor.
- UMPL is recommended to formulate a sexual harassment committee headed by woman member of UMPL management and formulate SOP for daily working procedure of the committee and formulate and implement code of conduct related to GBV and SEAH for every employee and worker.
- Complaint Box should be installed in various places of the power plant and worker accommodation soliciting any related issues and concerns in this regard
- Developing a system of analysing any reported incidents and implementing remedial measures to prevent any recurrence

With implementation of the precautionary and the mitigation measures mentioned above impacts on GBV and SEAH would be low.

6. Impact on Community Health and Safety

Community health and safety may be impacted during operation phase due to noise generation and deterioration of surface water quality due to discharge of wastewater. Development of green belt within the plant & immediate surrounding would reduce the noise and air pollution impact on surrounding environment significantly. UMPL would install ETP and STP for treatment of waste water generated in their plant before discharge, abiding by prescribed national & IFC standards. Hence impact on community health safety due to plant operation would be medium.

<u>Mitigation Measures</u>

- Periodic maintenance of the plant machinery would be carried out to reduce the noise and air pollution impact
- Periodic Air pollution, noise monitoring and treated wastewater sample analysis would be carried out to assess the impact level.

With implementation of the precautionary and the mitigation measures mentioned above impacts on community health and safety would be low.

7. Impact on Occupational Health and Safety

Occupational health and safety impacts associated with power plant operations include fire and explosion, contact with hot surfaces, chemical hazards, working in confined spaces etc. These risks could create long term impacts to the health and safety of the operation workforce and therefore the impact severity is assessed to be medium. Measures would be implemented to ensure that these risks are considered prior to the commencement of operation, and that all risks are communicated to the workforce. Appropriate PPE would be provided, and equipment maintained and inspected regularly.

Mitigation Measures:

- Occupational Health & Safety Plan would be prepared by UMPL/O & M Contractor engaged by UMPL
- OHS Manual will be prepared and stringently followed during the operation of the plant
- Project would adopt a total safety control system, which aims to prevent the probable accidents such as fire accidents or chemical spills.
- Firefighting systems, such as sprinklers, portable extinguishers (appropriate to the flammable hazard in the area) and automated fire extinguishers would be provided at strategic locations with clear labelling of the extinguisher type.
- Plant equipment at hot temperatures that can pose risk to workers would be identified and protected to prevent accidental contact. Training on handling, hazard due to contact with hot surfaces would be provided; PPEs (gloves, insulated clothing would be used)

- Training would be provided with training for first aid, firefighting procedures and emergency response procedure
- Safe assembly area would be identified, and evacuation of the premises would be practised regularly through mock drills.
- A near miss and accident reporting system would be followed and corrective measures would be taken to avoid / minimize near miss incidents.
- Safety measures in the form of Dos and Don'ts would be displayed at strategic locations.
- Safety audits would be conducted periodically as per the regulatory requirements.
- Firefighting system would be tested periodically; andAll hydrants monitor and valves would be visually inspected every month.
- Monitoring of occupational hazards in the working environment designed and implemented by accredited professionals as part of an Occupational health and safety monitoring program.

With implementation of the precautionary and the mitigation measures mentioned above impacts on occupational health and safety would be low.

Flood Risk Assessment

In order to assess the impact on drainage and hydrology during operation of the project, Flood Risk Assessment (FRA) was conducted to assess the potential of flooding at the site and the study area and understand the risks associated with flood related inundations throughout the project life cycle.

The flood vulnerability map indicates the area is vulnerable to get submerged in case of a 50-year return period flood. Therefore, UMPL would carry out substantial filling and levelling works to bring the average existing ground level to 7.76 m above msl. However, raising the site has the potential to cause inundation of the surrounding area. The design has taken into consideration to construct peripheral drain considering the rainfall intensity to be 110 mm/hour which incorporates extreme events of precipitation due to climate change. The designed drain can adequately divert the run-off generated from the outer catchment and from the plant site and channelize the flow towards the river to avoid the potential inundation.

Climate Change Assessment

Bangladesh being one of the most vulnerable regions, considering its low-lying alluvial plain, has undergone numerous impacts such as coastal flooding, scarcity of water resources, inundation, riverbank erosion etc. due to climate change. Climate change assessment for historical period (1985 to 2014) and future projections (2015 to 2050) in terms of its annual mean cycle, trends and climatology of precipitation, maximum temperature, minimum temperature, sea level rise along with extreme precipitation events particularly the intensity and frequency of very heavy and extremely heavy precipitation have been analysed over the project location in Meghnaghat.

The results of the assessment indicate that the projected mean annual precipitation decreases as compared to historical precipitation ranging by 2%. Projected increased mean annual temperature is around 31.3 °C. Mean Sea level rise is also found to be significantly increasing in future projections mainly towards the northern part of Bay of Bengal ranging between 1.6 mm to 3 mm. "The intensity and frequency of very heavy (>29.1 mm at 95th percentile) and extremely heavy precipitation events (>60.9 mm at 99th percentile) are projected to increase during summer monsoon season (June to September). Very heavy precipitation is projected to occur for 1409 times while extremely heavy precipitation event is projected to occur for 338 times between 2015 to 2050 (36 years). A large variation in magnitude for all the climatic parameters studied is observed to have increasing trend towards the future period exposing the project site to climate change associated risk in future especially hydrological disasters.

Cumulative Impact Assessment

Cumulative impact has been assessed on water resource and quality and ambient air considering major industries located within 5 km area of influence of the proposed power plant. The cumulative impact assessment on ambient air shows that the incremental concentration of NO_2 is predicted to be 0.8 µg/cum (annual) at about 4.5 km from the boundary of UMPL and the maximum NO_2 concentration is predicted to be about 3.4 µg/cum (annual) in the southern side of UMPL, in and around Meghnaghat industrial Area. Cumulative water resource assessment indicated that there would be no stress on the main water resource of Meghna river considering existing withdrawals by the industries as well as future demands for the proposed industries. From the load-based (mass balance) analysis of the pollutants, it may be seen that, post discharge of treated wastewater from the proposed industries would have insignificant impact on the water quality of Meghna river. It is envisaged that there would be positive impact on the socio-economic conditions in the AOI due to proposed developments leading to potential growth of auxiliary business opportunities, development, approach to improved healthcare and education facilities, improvement in physical infrastructure and peripheral development in various sectors as a part of CSR by the industries.

Green House Gas Emission

The predictive quantification of GHGs emissions from the proposed project during the construction & operation phases is based on United States Environmental Protection Agency's "Greenhouse Gas Inventories, 2018", "The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol)" developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The annual estimated GHG emissions during the 36-month construction phase and the operation phase of the project, would be in the tune of 2,896 tonnes of CO_2 equivalent and 1,727,452 tonnes of CO_2 equivalent per annum respectively.

Environmental and Social Management Plan

A comprehensive Environmental and Social Management Plan (ESMP) is prepared to minimize or mitigate adverse environmental impacts identified during the E&S risk and impact assessment conducted for the pre-construction, construction and operational stages. The ESMP outlines mitigation and monitoring requirements that would ensure compliance with the GoB environmental laws and regulations and comply with the Environmental and Social standards and guidelines of the AIIB, DEG and SCB. The ESMP takes into consideration each of the impacts identified in the impact assessment of the ESIA. It establishes the management measures required to deal with the impacts and also describe the roles and responsibilities of the various responsible agencies for implementation. UMPL will take the overall responsibility of E&S management system during the project life cycle. The Contractor would be responsible for implementation of ESMP and procedures of UMPL under the supervision of UMPL. All the basic environmental management services and environmental amenities installation and commissioning would be included contractually in Contractor's scope in case of lumpsum turnkey contract. To attain the Sustainable Business Goals, green technologies has been considered, which includes installation and use of Solar Photo-voltaic (PV) Panels and Rainwater Harvesting Structures to reuse the accumulated rainwater. Corporate Social Responsibility plan would be prepared by UMPL.

Environmental Monitoring

The Environmental Monitoring, which is an integral part of the ESMP, would be undertaken during the construction phase for different parameters including air and water quality, drinking water and noise level would be observed on periodic basis as per the ESMP. The periodic monitoring would be carried out during the operation phase for ambient air quality, stack emission monitoring, noise level, raw and treated water, indoor air quality and work zone noise. The Occupational and Community Health Safety would be monitored during both construction and operation phases.

Budgetary Estimate for implementation of ESMP

Budget for ESMP implantation for construction phase would be allocated by EPC contractor and UMPL separately. The CAPEX for implementation of the mitigation measures is estimated to be approximately 4,29,13,000 BDT and the OPEX is about 2,30,00,000 BDT (excluding the cost of testing of dredged material @20,000 BDT per cum of dredged material).

Risk Assessment

Hazard Identification (HAZID) identifies process and non-process hazards affecting the project execution and operational stage, for each of which safeguards have been proposed. Based on the results of quantitative risk assessment, it is observed that the area around LNG pipeline falls in the category of intolerable risk zone, while other events are likely to pose risks that are well within the tolerable risk zone. It is imperative to adopt appropriate mitigation and conduct awareness programme to raise awareness among the nearby community regarding the consequences from events related to natural gas pipeline.

Emergency Management Plan and Disaster Management Plan

Emergency response plan and disaster impact assessment would be formulated based on the outcome of the Environmental Impact Assessment based on detailed design. The Disaster Management Plan (DMP) provides only an overview of that applicable at UMPL level. To ensure proper formulation and implementation of emergency action, a Disaster Management Committee would be constituted and the district civil administrator (District Magistrate or Deputy Commissioner) may be the Chairman of this Committee. The aim of Emergency Action Plan is to identify areas, population and structures likely to be affected due to a catastrophic event of accident. The action plan would also include preventive action, notification, warning procedures and co-ordination among various relief authorities. COVID management plan is also in place to deal with the ongoing pandemic situation.

Stakeholder Assessment and Disclosure

The ESIA and LRP, along with their Executive Summaries in Bangla are available at the project site and online at https://umplbd.com/esia-lrp/.

The Stakeholder Engagement Plan details the undertaken and planned community outreach. During the preparation of the ESIA and LRP, consultations with project-affected people and communities, government agencies and other stakeholders were carried out. The communities expressed their views of the project with the main points listed below:

- Overall positive approach towards the project
- Expectation of CSR activities for development of the adjacent masjid complex.
- Concerns about the pollution arising from the proposed project activities and the deteriorating effects on the living conditions.

The primary purpose of the future stakeholder engagement activities will be to continue making project-related information available in an inclusive and understandable manner. Relevant project related information including the existence and function of the Grievance Redress Mechanism (GRM) is made available to the affected people and workers.

The public disclosure process of UMPL in relation to ESIA and LRP was completed during the period March-May 2022 to explain key social and environmental risks, anticipated impacts & their mitigation measures for various stakeholders including Project Affected Households, fishermen and other community people. During the process, UMPL also received the concerns and feedbacks from the stakeholders. A total of 14 Focus Group Discussions (FGD) were organized with different stakeholder groups. The major issues which emerged from the discussions include livelihood options, improvement of physical infrastructure, issues related to waterlogging in the area adjacent to the plant, concerns related to increase in noise level in the long term period and Grievance Redressal Mechanism developed by UMPL for the Project.

Grievance Redressal Mechanism

Project-affected members of the communities and workers can file their concerns and grievances for free and without any fear of reprisal through the GRM. The mechanism is a significant pillar of the stakeholder engagement process as it creates opportunities for the project proponent and communities to identify problems and determine solutions together. The GRM is in place since the inception of the project till its life. UMPL, has set up a two-level approach for addressing grievances.

The **Level I Grievance Redressal Committee (GRC)** would comprise of the Chairman of Pirojpur Union Parishad, UMPL key staff and female representative of the Pirozpur community. The **level -1 GRC** would address complaints within 15 working days from the day the complaint is lodged. In case the issue is not resolved at this stage or in case the complainant is not satisfied with the resolution as provided by the **level -1 GRC**, the issue would then be forwarded to the Chief Grievance Officer based at the **Corporate Office (Level II)**. The **level-II, GRC** comprises of the Chief Grievance Officer (identified by the Company), Director (Human Resource & Administration), and Director (Operation). The grievance at this stage would be closed within 10 working days of referral.

If the grievance/ complaint is not resolved at GRC Level or the complainant is not satisfied with the solution provided by GRC, the complainant will have the option to approach Court of Law. A separate GRM is established for workers to address workplace complaints and concerns. Contact details of the GRC are listed below:

Sr. No.	Member	Role	Contact Number
Permanent Committee			
1.	General Manager Site	Chairperson & Head of the Grievance Redressal Committee	01787690851
3.	Deputy Manager Site	Chief Grievance Officer of UMPL	01713205320
4.	Deputy Manager Admin	Member	01713205315
5.	Deputy Manager-EHS	Member	01713205295
6.	Deputy Manager- Social Development	Member	01713205310
7	Female Employee-UMPL	Member	01750106441
Additional Member for Community Grievance			
1	Chairman Pirojpur union	Community Representative	01682806020
2	Pirojpur Union Member of Dudhghata Village	Community Representative	01836853006
3	Female Member of Dudhghata Village	Community Representative	01814074010
Additional Member for contractor or contract Employee			
1	Contractor Representative	TBC	

AIIB's Project-affected People's Mechanism (PPM) applies to this Project. The PPM has been established by AIIB to provide an opportunity for an independent and impartial review of submissions from Project-affected people who believe they have been or are likely to be adversely affected by AIIB's failure to implement the ESP in situations when their concerns cannot be addressed satisfactorily through the Project-level GRM or the processes of AIIB's Management. Information on AIIB's PPM is available at: https://www.aiib.org/en/policies-strategies/operational-policies/policyon-theproject-affected-mechanism.html

Conclusion and Recommendations

The ESIA study carried out for the proposed Unique Meghnaghat 600MW CCPP suggests that majority of the environmental and social impacts ranges from medium to low scale which can be minimised within acceptable levels through implementation of the recommended mitigation measures as specified in the ESMP. It may be concluded that the proposed Natural Gas based Combined Cycle Power Plant would have minimal impacts if the suggested mitigation measures are properly implemented throughout the project life cycle. It is also recommended that the ESMP be effectively monitored in order to identify any alterations in the predicted impacts and take appropriate actions to mitigate any unexpected adverse residual impacts to the extent possible during the operational lifecycle of the plant. Also, in the event of any emergency, major accidents and natural and man-made disasters, effective deployment of Emergency Response Plan (ERP) in a very short period of time in a pre-determined sequence would be able to prevent loss of lives and property.

1 Introduction

Unique Meghnaghat Power Limited (UMPL), a Joint Venture Company constituted by the consortium comprising Unique Hotel & Resorts Limited (UHRL), GE Capital Global Energy Investments BV and Strategic Finance Limited (SFL), has been incorporated in the year 2018 for development of 600-Megawatt (MW) Gas/RLNG based Combined Cycle Power Plant (CCPP) project with net output 588.31 MW (As per power purchase agreement constructed capacity is 584 MW, however EPC contractor has guaranteed 588.31 MW) at Dudhghata Mauza in Pirojpur Union of Sonargaon Upazila under Narayanganj District, Bangladesh. The consortium of UHRL, GE and SFL has been selected by Bangladesh Power Development Board (BPDB), Government of Bangladesh (GoB) through Unsolicited Proposal (USP) basis. The proposed site is located in 21.07 acres of land to the South-west of the Dhaka-Chittagong Highway and right bank of branch channel of Meghna River.

The GoB has adopted a strategy for the development of the power sector which envisages private participation in the sector. As part of that strategy, the GoB has decided that some new power generation capacity would be installed and operated by the private sector. In line with this strategy, the GoB has selected the Consortium, for setting up the new greenfield 588.31MW Combined Cycle Power Plant on Build, Own and Operate (“BOO”) basis under the GoB’s Independent Power Producer (IPP) program. The LoI (Letter of Intent) was issued by BPDB on 25th June 2018. Corresponding agreements like Power Purchase Agreement (PPA) with BPDB, Gas Supply Agreement (GSA) with Titas Gas Transmission and Distribution Company Limited (TGTDCL), Implementation Agreement (IA) with Power Division, Ministry of Power, Energy and Mineral Resources (MPEMR), GoB and Power Grid Company of Bangladesh (PGCB) have also been executed.

According to the Bangladesh Environment Conservation Rules 1997 (ECR), power plants come under red category and requires Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) approval prior to start of construction activities at site. With respect to the same, UMPL had applied for IEE approval to Department of Environment (DoE), Bangladesh and site clearance was obtained vide Memo No. 19-29585 dated 01/10/2019 valid through 30/09/2020. UMPL also submitted the EIA report to DoE and received the Environmental Clearance Certificate (ECC) on 19.07.2020 (Memo No: 22.02.6700.140.72.065.19-09).

This project is expected to be funded by Asian Infrastructure Investment Bank (AIIB), DEG, and Standard Chartered Bank (SCB). As per the requirement for project funding by multilateral funding agency, Environmental and Social Impact Assessment Study needs to be carried out as per the applicable reference framework issued by various funding agencies.

UMPL has commissioned AECOM India Private Limited (hereinafter referred as ‘’AECOM’’) to carryout IEE Study, EIA study and ESIA study of the proposed project. The Environmental and Social Impact Assessment (ESIA) study is undertaken in line with the applicable policy framework of AIIB, DEG and SCB with the objective of assessment of the major environmental and social (E&S) impacts arising due to the proposed project activity during its construction and operation phases within the area of influence, recommending the possible mitigation measures for any adverse impacts, management and monitoring plan to evaluate the effectiveness of the mitigation measures as a part of the Environmental and Social Management Plan (ESMP). This Executive Summary presents salient features of the project, the main findings and the conclusions of the Environmental and Social Impact Assessment (ESIA). The ESIA report underwent several rounds of revision following comments from the Lenders and the draft final ESIA was published for disclosure on March 26, 2022 online at the website of UMPL and the Lenders. Hard copies of the draft final ESIA Report were made available at Union Parishad and UMPL site Office for the stakeholders. After addressing the comments received from various stakeholders following 90 days of disclosure period, the present version of ESIA report was finalised. This version of ESIA Report takes into account all the comments of the stakeholders for this project. The Executive Summary of final ESIA would be available at UMPL website https://umplbd.com.

1.1 Need For the Project

As of 2019, around 88% of the total population (92% of urban population and 67% of rural population) of Bangladesh had access to electricity (including off-grid electricity), with largest energy consumers being industries and residential sector, followed by the commercial and agricultural sector. However, consistent and quality supply of power is still faraway, as issues like high system losses, delays in completion of new plants, low plant efficiency, and erratic power supply have attributed deficit in supply to cater to the current demand.

According to the Seventh Five-Year Plan formulated by the Government of Bangladesh, the average GDP growth rate from 2016 to 2020 is expected to reach 7.4%. As per the Power System Master Plan 2016, Bangladesh would become a member of the upper-middle-income economies in the 2020s and would get close to the high-income economies by 2041, if the projected economic development is achieved as projected. Demand for electricity rises as income rises and as people desire a better quality of life. During 2000 and 2007, the overall demand for electricity has risen by about 10 per cent annually. Demands from residential and commercial consumption have risen more rapidly than those from industrial and other sectors. With an average 12% rate of growth, generation would double in about every six years. That means that by 2021, the need for gross generation would be four times the present demand. In December 2009, the installed capacity of power plants was 5,803 MW and the de-rated capacity was 5,250 MW. In these circumstances, the Vision 2021 figures, i.e. 15,357 MW of power generation by 2015 and 20,000 MW by 2021 are the minimum that would be accomplished.

The GoB has given highest priority to power sector development in the country and has committed to making electricity available to all citizens by 2021. According to Power System Master Plan (PSMP), the government has set a target to increase installed electricity generation capacity to 24,000 MW by 2021 and 40,000 MW by 2030. To realize these targets, the GoB since 2011 has undertaken the implementation of reforms in the power sector, including significant development programs for participation of the private sector of which this Project constitutes one of the important parts.

1.2 Brief Description of the Project

Unique Meghnaghat Power Limited (UMPL) intends to develop a 600MW (net output 588.31 MW gas based combined cycle power plant (CCPP) project at Dudhghata Mauza in Pirojpur Union of Sonargaon Upazila under Narayanganj District, Bangladesh. The area of the project site is 21.07 acres and this land is 1.46 km away from Dhaka-Chittagong Highway, 38km away from Dhaka International Airport and on the right bank of the Channel of River Meghna. The proposed power plant is around 30 km from the capital city of Dhaka and well connected through road and river network. The Project Location Map in presented in ***Figure 1.1*** below.

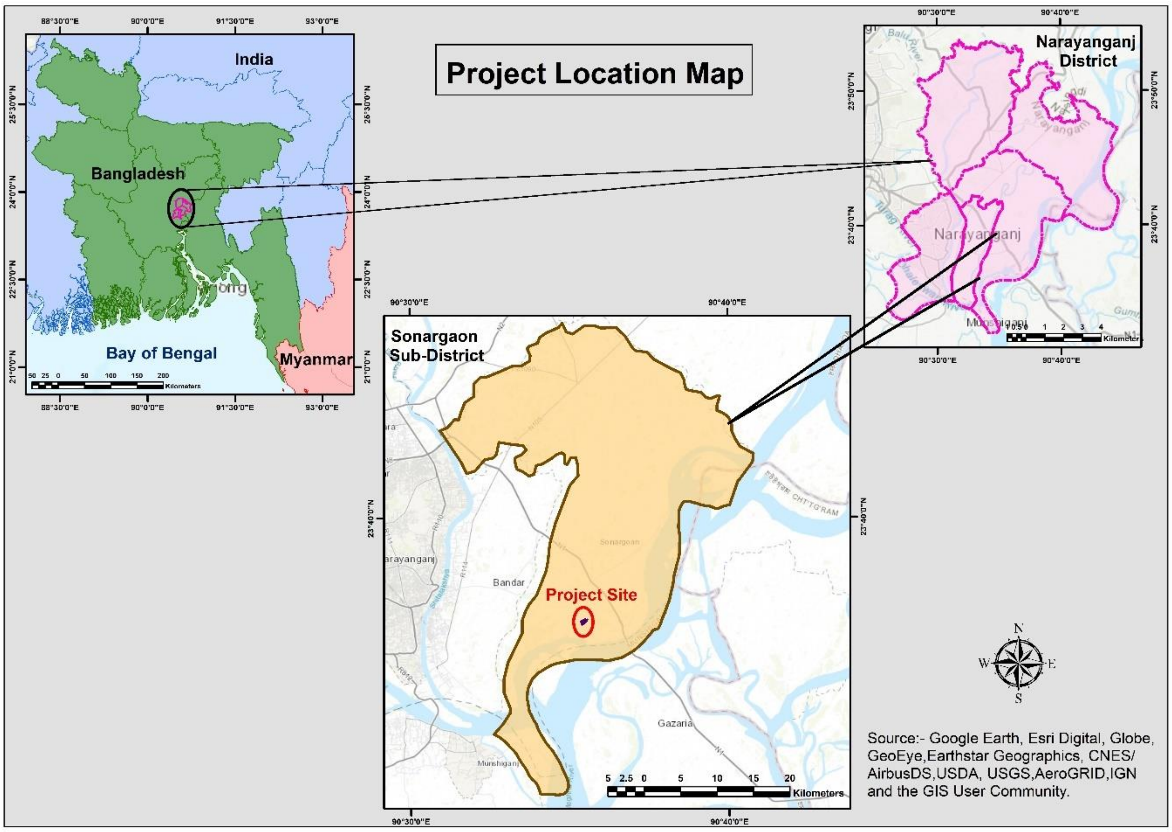


Figure 1.1: Project Location

Main components of this combined Cycle power plant include one (1) GE 9HA.01 Gas Turbine Generator, one (1) Heat Recovery Steam Generator and one (1) Steam Turbine Generator from General Electric (GE). Apart from these units, water intake pump house, induced draft cooling tower, one un-insulated HRSG stack, switchyard, temporary river jetties (for material transport during construction phase and transport of heavy equipment) would be constructed. One 400 kV single circuit transmission line for power evacuation and a 20-inch diameter subsurface pipeline for gas supply across the river would also be constructed as component of this project.

A total of 21.07 acres of single crop agricultural land has been directly procured from the local villages for setting up the project. Water for the power plant operation would be sourced from Meghna branch channel. Natural gas would be supplied by Titas Gas Transmission and Distribution Company Limited, Bangladesh from nearby valve station located on the other side of Meghna branch channel. Also, power generated from the proposed power plant would be evacuated to the nearest proposed substation of Power Grid Company of Bangladesh (PGCB) on the other side Meghna Brach Channel through 400kV single circuit overhead line.

Total estimated cost of the project is 43680 million Bangladeshi Taka (3 approx. 515.7 million USD) and it is expected to be funded by DEG, Asian Infrastructure Investment Bank (AIIB) and Standard Chartered Bank (SCB).

1.3 Brief Description of the Project Proponent and Share Holder

Unique Meghnaghat Power Limited (UMPL) has been duly incorporated under the Laws of People Republic of Bangladesh in the year 2018 as a Limited Company to develop, design, finance, build, own, operate and maintain the 600 MW CCPP in Meghnaghat area of Bangladesh. The documents regarding incorporation of UMPL is presented in Appendix A.

UMPL is a joint venture company of Unique Hotel and Resorts Limited with 510% ownership which is a Sister Concern of Unique Group and GE Capital Global Energy Investment BV with 20% ownership and Strategic Finance Limited with 29% ownership. Project contractual structure is presented in ***Figure 1.2***

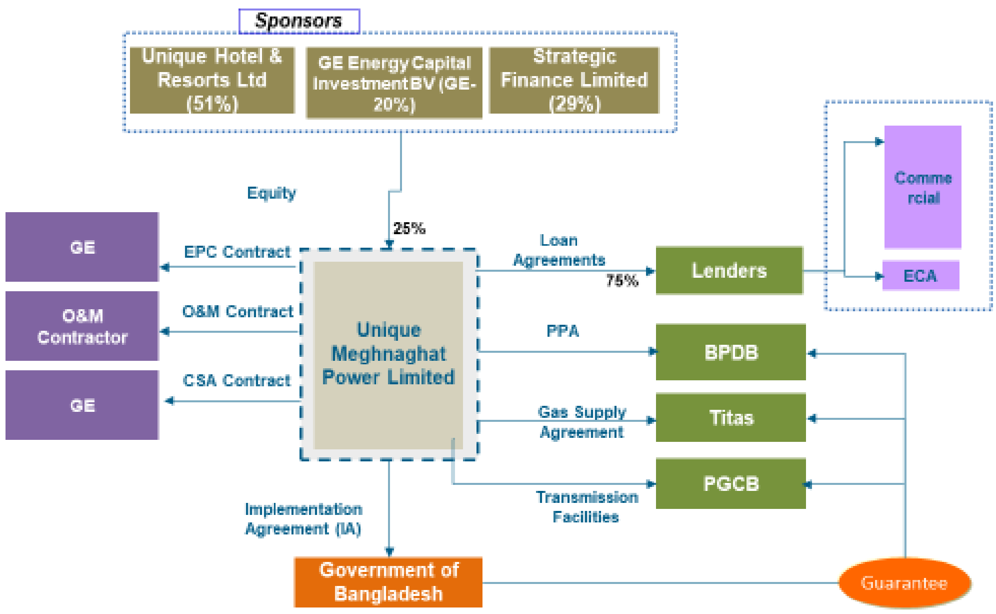


Figure 1.2: Project Contractual Structure

1.3.1 Unique Hotel and Resorts Limited

Unique Hotel and Resort limited is subsidiary of Unique Group. The Unique Group (UG), a business conglomerate in Bangladesh, began its operation in 1982. Earlier UG was engaged for exporting human resources and then pioneered skill development. Afterwards they expanded to business like luxury hotel in the private sector of Bangladesh.

In due course, the Group diversified into various areas like hospitality, real estate, construction & infrastructure development, power sector, telecommunication, stock brokerage, bank, insurance, financial institution, Agro-based business, education, ceramic industry, international trade, media & publications and economic zones. Recently

Unique Group has started to develop a Special Economic Zone (SEZ) namely Sonargaon Economic Zone near Meghna River, Narayanganj, Bangladesh.

Unique Hotel & Resorts Limited (UHRL), an enterprise of Unique Group, played a pioneering role in the country's luxury hotel business. Incorporated on November 28, 2000, the Unique Hotel & Resorts Limited got the Certificate of Commencement of Business in the Brand name "The Westin Dhaka" on July 01, 2007. Since then, it has been maintaining consistent growth with innovation & valued services and has been the leading luxury hotel chain in Bangladesh.

Unique Hotel & Resorts Ltd. Is a Public Limited Company listed with Dhaka Stock Exchange and Chittagong Stock Exchange on 14 June 2012 and 5 June 2012 respectively. The address of the registered office of the company is Plot # 01, CWN (B), Road # 45, Gulshan-2, Dhaka-1212. Corporate head office of the Company is at Borak Mehnur, 51/B, Kemal Ataturk Avenue, Banani, Dhaka.

1.3.2 GE Capital Global Energy Investment BV (GE)

GE Capital Global Energy Investment BV is a Netherlands based wholly owned subsidiary of General Electric (GE). General Electric (GE) is an American multinational conglomerate incorporated in New York City and headquartered in Boston. As of 2018, the company operates in the following segments: aviation, healthcare, power, renewable energy, digital industry, additive manufacturing, venture capital and finance and lighting.

In 2018, GE ranked among the Fortune 500 as the 18th-largest firm in the U.S. by gross revenue. In 2011, GE ranked among the Fortune 20 as the 14th-most profitable company.

1.3.3 Strategic Finance Limited

Strategic Finance Limited (SFL) is an investment bank offering full-fledged merchant banking operation under the license from Bangladesh Securities and Exchange Commission. The primary focus of SFL is on Investment Banking services as well as Strategic Investment in power and infrastructure sector with high growth potentials. SFL provides solutions in managing initial public offerings (IPO), rights issues, private equity placements, capital restructuring, placement of corporate bonds, loan syndication, underwriting and portfolio management.

1.4 Objective of ESIA Study

The objective of this study is to provide details of examination and assessment of the major environmental and social impacts arising due to the proposed project activity during its construction and operation phase within the area of influence. The study would also focus on recommending the possible mitigation measures for any adverse impacts. Management plan and monitoring plan to evaluate the effectiveness of the mitigation measures would be suggested as a part of Environment & Social Management Plan (ESMP). The specific objectives of this Study are to:

- To facilitate UMPL to assess the concerned risks of the project from concept to commissioning and operational life as a part of its overall corporate objective and integrate the findings with the environmental and social management systems of the Company
- Integrate the findings and recommendations of ESIA study, into the basic design & engineering aspects of the proposed Power Plant and its associated facility, their proper implementation and operation over the life of the project
- To enable the Lenders Group, assess the key financing risks of the project including adequacy of proper management measures for mitigation of various environmental and social risks, ensuring proper implementation and monitoring of the mitigated risks so as to minimise any residual impacts of the project under the applicable framework of legislations, guidelines and standards of DoE, Bangladesh as well as Multi-lateral Financial Institutions.

1.5 Scope of the ESIA Study

The scope of the Environment and Social Impact Assessment study considers the impact due to the proposed development of UMPL's 600 MW (net output 588.31 MW) CCPP on physical, biological and socio-economic environment of the surrounding areas in line with reference framework of multilateral funding agency. The area falling within 5 km radius from the proposed site has been considered as the Area of Influence (AoI) for conducting this study. The scope of the Environmental and Social Impact Assessment study includes the following:

- Establishing the prevailing environmental and socio-economic conditions of the study area by characterizing baseline environmental scenario through primary and secondary environmental and socio-economic data collection.
- Assessing environmental and socio-economic impacts arising out of the proposed activities during pre-construction, construction and operation of the CCPP in and around the proposed site.
- Assessing the Cumulative Impacts due to operation of UMPL Gas-based Combined Cycle Power Plant in Meghnaghat Industrial Area.
- Recommending appropriate preventive and mitigation measures vis-à-vis each anticipated impact to eliminate or minimize pollution.
- Identifying and formulating Environmental and Social Management Plans (ESMP) in terms of good practices that may help in abating adverse environmental or socio-economic impacts due to the project.
- Preparing a Disaster Management Plan (DMP) based on Risk Assessment/ studies.
- Preparation of Grievance Redressal Mechanism
- Green House Gas Estimation
- Flood Risk Assessment
- Livelihood Restoration Plan
- Conducting stakeholders' consultation along with formulation of the Stakeholder Engagement Plan

This E&S Impact Assessment report is prepared in accordance with Environmental and Social Framework of AIIB, IFC Performance Standard and EHS guideline for Thermal Power Plant as well as relevant environmental regulations of Bangladesh such as Environmental Conservation Rules 1997 and Environmental Conservation Act of 1995.

1.6 Approach and Methodology for study

Based on the above Scope of Work, the ESIA study has been carried out using a systematic process which can predict and evaluate impacts that may arise from the project on various environmental aspects e.g., physical environment, biological environment and socio-economic environment. Based on the evaluation of impact, mitigation measures have been identified and management plan have been prepared through which the project can avoid, minimise, mitigate and compensate the adverse impact and enhance positive impact on surrounding environment. Entire E&S Impact Assessment methodology is presented in ***Figure 1.3.***

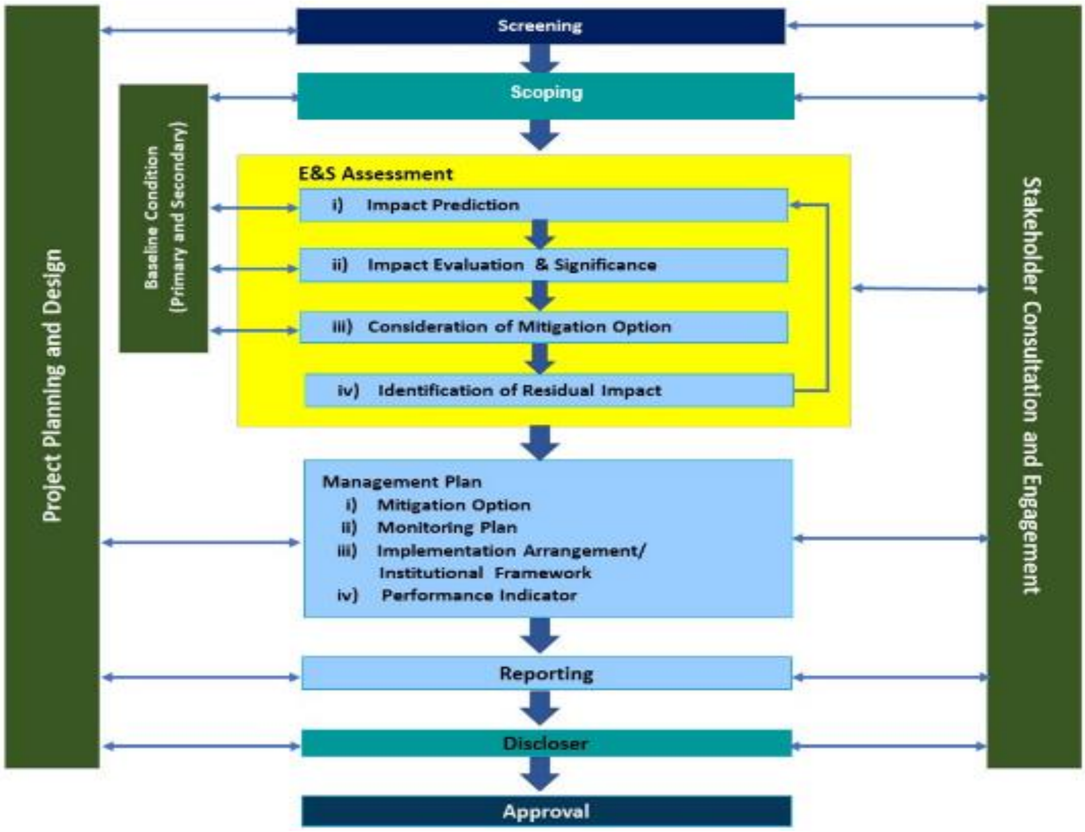


Figure 1.3: ESIA Approach

1.6.1 Screening

At the Inception stage of the E&S Impact Assessment study, preliminary project information was collected during kick off meeting with UMPL and evaluated to determine the legal and other requirements that would be applicable to the project. This stage has been utilised for developing a preliminary level description of the project.

1.6.2 Scoping

Scoping stage has been utilised to identify the Area of Influence of the project, interaction between the gas based (clean fuel) thermal power project and sensitive receptors located within the Area of Influence and impacts that may arise due to this interaction and significance of the impacts largely contained within the vicinity. For this study, an area of 5 km radius around the project boundary has been considered as the Area of Influence as major impacts arising from the project activities are likely to be confined within 5 km radius. Apart from that reference framework of multilateral funding agency for ESIA study has also been considered to outline the scope of the study. Different receptors and probable impacts on each receptor due to project activities is presented in ***Table 1.1.***

Table 1.1: Identified Aspects and Probable Impacts

Sl. No.	Aspects	Impact
Environment		
1	Land Resource	Change in land use and land cover
2	Air Shed	Changes in air quality due to emission of • Gaseous pollutants (e.g. NO_x, So_x, etc.) • Particulate matter (e.g. PM_{10} and $PM_{2.5}$)
3	Ambient Noise	Changes in ambient Noise levels due to plant construction and operation
4	Surface Water Quantity & Quality	• Impact on river morphology and stress on water resource due to withdrawal of surface water

Sl. No.	Aspects	Impact
		• Changes in physical, chemical or biological quality of Meghna River due to effluent discharge
5	Ground water Quality	Impact on ground water quality due to effluent discharge and dumping of hazardous and non-hazardous waste
6	Soil/Land Quality	Impact on physical and chemical properties of soil due to effluent discharge and dumping of hazardous and non-hazardous waste
7	Sediment Quality	Impact on physical and chemical properties of sediment and benthic organisms due to effluent discharge and dumping of hazardous and non-hazardous waste
8	Drainage	Changes in drainage pattern, localised submergence and flooding due to filling up of project site, blocking of drainage channel
9	Climate Change	Emission of Greenhouse gases (CO_2, CH_4, and N_2O);
10	Geology	Impact on the geological formation of the site and AOI
11	Aesthetics	Impact on the visual & aesthetical disposition of the project site and its surroundings
Ecology		
12	Terrestrial Ecology	Impact on flora and fauna due to plant construction and operation activities
13	Aquatic Ecology	Impact on aquatic ecology and fish production due to effluent discharge and water withdrawal
Social/Socio-Economic		
14	Social/Community Cohesion	Any social/ conflicts due to workers from outside or due to project related activities.
15	Economy and livelihood	Impact on livelihood due to land purchase, approach restriction of fisherman community, reduction in fish production
16	Social and Cultural Structures	Physical disturbance on cultural and religious resources, Intra and inter-ethnic conflict.
17	Infrastructure and Services	Pressure on existing rural infrastructure or services including road network, transportation; water, sanitation, waste handling facilities etc.
18	Vulnerable Groups	Impact on livelihood, community networks, displacement induced impacts
Community Health and Safety aspect		
19	Dust and noise discomfort	Impact on community health due to generation of noise and dust from the construction activities and during the operation of the plant
20	Transmission of infectious disease due to migrant labour	Potential chances of spreading vector borne and infectious diseases from the migrant labourers
21	Potential accidental events from traffic movements on road	Impact on community health & safety due to chances of accidents from increased traffic movement on road, especially during construction

1.6.3 Baseline Data Collection

Main objective of the baseline data generation is to assess the Impact that may arise from different phases (pre-construction, construction, operation) of the project based on the existing condition. Baseline data was collected for different environmental and social aspect e.g., physical environment, ecological environment and socio-economic environment, cultural environment etc.

Physical environment parameters e.g., micrometeorology, air quality sample, groundwater quality sample, surface water quality sample, noise, soil sample, sediment sample were collected during post monsoon season (October 2019 to November 2019) in presence of environmental experts of AECOM. Local laboratory (EQMS) has been involved in collection and analysis of primary samples from the study area. Since the project area is on the fringe of Meghnaghat Industrial Area, influence of industrial activities was observed on the baseline environment of the project site and its surroundings. In order to assess the seasonal variation of the environmental attributes in the study area, second season monitoring was carried out during June 2020 by the local laboratory Mitra S.K. Bangladesh (Pvt.) Ltd.

Apart from that, ecological assessment has been carried out and phytoplankton, zooplankton, benthos and primary productivity sample has been collected by terrestrial and aquatic ecological expert of AECOM.

Social experts have been involved in assessment of socio-economic condition of the landowners whose land has been directly purchased for the project and other communities present within the area of influence. Primary sample socio economic questionnaire survey has been carried out by AECOM social expert among the landowners and community consultation has been conducted among the other community member to assess the baseline socio economic condition.

1.6.4 Impact Assessment and Management

Impact has been identified by superimposing project description on the baseline condition of the project area. Impact assessment has four steps e.g. Impact Prediction, Impact Evaluation, Mitigation Measures Identification and Residual Impact Evaluation.

Impact Prediction: In this step Impacts in the study area arising from the project and associated facility have been predicted.

Impact Evaluation: Significance of predicted impact has been evaluated considering magnitude, likelihood, scale, sensitivity of the impact on the receptors.

Mitigation Measures Identification: Suitable mitigation measures have been suggested to mitigate any adverse impact due to the project activities.

Residual Impact Evaluation: Evaluation of the environmental impacts predicted to remain after the application of mitigation measures suggested in the ESIA study

1.6.5 Reporting and Disclosure

The ESIA report has been prepared based on finding of the entire assessment. The report would also be disclosed for comments and observations from all the stakeholders.

1.7 Structure of ESIA Report

The overall contents of the ESIA report have been prepared as per the available reference framework of multilateral funding agency. The report consists of executive summary followed by twelve chapters, Conclusion & Recommendation. The Appendices are presented in Volume II in a separate report. The content of the report is briefly described in ***Table 1.2***.

Table 1.2: Structure of ESIA report

Chapter No	Chapter Title	Description
	Executive Summary	This chapter includes brief summary of ESIA report
1	Introduction	This chapter discuss introduction about the project, project background, Scope and objective of ESIA study, Methodology of ESIA study.
2	Policy, Legal and Administrative Framework	This Chapter evaluates various national and international rules and regulations, guidelines, framework, policies related to Environmental and Social Impact Assessment of proposed power development project.
3.	Project Description	This section describes the proposed project and its various components, technology, resource requirement and evaluates alternative to the proposed project.
4.	Baseline Environmental condition	This Chapter outlined baseline physical, biological and socio-economic conditions of the study area and established prevailing environmental condition.
5	Impact Assessment and Mitigation Measures	This section predicts and assesses likely impacts of the projects on physical, biological and socio-economic environment in the study area. It also outlined probable mitigation measures to mitigate predicted impacts.
6	Greenhouse Gas Emission	This chapter presents the methodology for quantification of greenhouse gas (GHG) and estimation of the same, followed by assessment of impact due to emission of GHG and suggestion of measures to mitigate the emission.
7	Flood Risk Assessment	This Chapter delineates the study on flood risk vulnerability of the site.
8	Climate Change Assessment	This chapter describes the climate change issues that could likely be faced by the project

Chapter No	Chapter Title	Description
9	Environmental and Social Management Plan	This section deals with mitigation measures to be taken during the project implementation period to mitigate any adverse environmental and social impacts.
10	Hazard identification and Consequence Analysis	This chapter includes identification of different hazards associated with project activity and carried out consequence analysis for specific accidental events.
11	Emergency management plan and Disaster management	This includes Emergency and Disaster Management Plan to deal with any unforeseen natural or manmade calamity.
12	Stakeholder Assessment and Discloser	This Chapter summarises comments received from project affected people during stakeholder consultations and describes planned information disclosure measures and process for carrying out stakeholder consultation.
13	Grievance Redressal Mechanism	This chapter formulates the Grievance Redressal Mechanism.
14	Conclusion and Recommendation	This includes conclusion and recommendation.

1.8 Assumption and Limitation

This ESIA study is based on certain scientific principles and professional judgment to certain facts with resultant subjective interpretation. Professional judgment expressed herein is based on the available data and information and other constraints related to pandemic (Covid-19) restrictions which has been prevailing since March 2020.

This report has been developed based on the project related information provided by Unique Meghnaghat Power Limited with the assumption that the information gathered is representative for the proposed 600-Megawatt (MW) gas based combined cycle power plant (CCPP) project and other available site surrounding information of similar projects within the study area defined. If information to the contrary is discovered or any additional project activities which is under planning or construction has been found out at a later stage and which can have any specific influence on the proposed project environmental settings individually or cumulatively, the findings in this ESIA may need to be modified accordingly. The impact assessment for the proposed Project is based on the project configuration as described in Project Description in Chapter No. 3.

No hydrodynamic modelling has been undertaken for assessing the impacts of the proposed water intake channel as detailed design & engineering of the same has not been finalised during the preparation of the report. The associated impacts on livelihood of fishermen docking their boats adjoining the proposed water intake channel also could not be assessed.

1.9 ESIA Team

The AECOM India Limited has constituted a team of various experts to carry out the ESIA study. The details of team members are given in following ***Table 1.3.***

Table 1.3: ESIA TEAM

Sl. No.	Name	Area of Specialization
1.	Chetan Zaveri	Project Director
2.	Avijit Sarkar	Team Lead and Project Manager
3.	Anindya Basu	Environmental Expert
4	Nilanjan Das	Social Expert
5.	Souvik Basu	Social Expert
6.	Debleena Mitra Sinha	Risk Assessment and General Environmental Expert
7.	Aziz Hasan	Water Quality, Noise Modelling Expert
8.	Mainak Majumder	Terrestrial Ecology Expert
9.	Dr. Sudin Pal	Aquatic Expert
10.	Swagata Mukherjee	Air Quality, Air pollution dispersion Modelling
11.	Bidyabati Soraism	Climate Change expert
12.	Moumita Dey	GIS Expert
13.	Moudipta Banerjee	Team Member

2 Policy, Legal and Administrative Framework

2.1 Introduction

The Govt. of Bangladesh (GoB) has specified regulations, policies and guidelines to protect the environment. To address the environmental and social risks of any project and its associated components, and to protect and conserve the environment from any adverse impacts, regulations and authorization processes have been formulated by GoB. International Lenders also have their own set of policies for compliance, applicable to any project funded by them. In this project, the requirements of the Asian Infrastructure Investment Bank (AIIB) ESS Policy, DEG Sustainability Policy, IFC Performance Standard, General EHS guideline, EHS guideline for Thermal Power Plant & Associated Facilityand Equator Principles 4 would be used along with all the requirement of the GoB.

This Section focuses on the administrative framework under the purview of which the Project falls and the ESIA study has been governed, namely:

- Bangladesh national and local policy, legal and institutional framework.
- AIIB ESS Guideline.
- DEG Sustainability Guideline.
- IFC Performance Standards and EHS Guidelines.
- Equator Principles 4; and
- IFC / EBRD Standards for Worker's Accommodation

2.2 Policy, Regulation and Guidelines of Bangladesh

2.2.1 Industrial Policy 1999

The Industrial Policy 1999 is considered as one of the most comprehensive policy of Bangladesh, which sought to give private industrial sector a dominant export orientation by means of attracting FDI in export and domestic market-oriented industries and a pivotal role in ensuring the following:

- Encourage and develop competitive strength of import substituting industries for catering to a growing domestic market.
- Encourage direct foreign investments and investments by public and private sector,
- Develop new indigenous technology and expand production based on domestic raw materials, and
- Promote infrastructure development and environmentally sound industrial development
- Encourage balanced industrial development through regional dispersal of the industrial growth throughout the country and rehabilitation of sick industries.

This policy is applicable for the proposed project as this project is an industrial development and involves foreign investments through Multi-lateral Funding Agencies.

2.2.2 Power Policy 1995

The Power Policy 1995 establishes the requirements in the Power Sector for long term planning and implementation of Power projects, sets criteria for policy statement on the demand forecast, investment terms, fuels and technologies, load management, institutional issues, private sector participation, technology transfer and research programme, environmental policy and legal issues; and forms an integral part of the Energy Policy.

The proposed project is a gas-based power plant, aiming to produce 600 MW electricity. Being under Power sector, the policy would be applicable for the proposed project.

2.2.3 Energy Policy 1996

The Energy Policy formulated in 1996 highlights the necessity of carrying out Environmental Impact Assessment for any new energy development project to remove any impacts which may hinder optimal utilization of energy for sustainable socio-economic growth and sets requirements for utilization of energy for sustainable economic growth, supply to different zones of the country, and development of indigenous energy source and environmentally sustainable energy development programmes.

As the proposed project would produce electricity, so the requirements of sustainable utilization of energy for socio-economic growth needs to be formulated according to the policy and the impacts induced by the proposed project, needs to be assessed and proper mitigation to combat the pollution needs to be suggested.

2.2.4 Environmental Policy of Bangladesh, 2018

Bangladesh is extremely vulnerable to Climate Change and has been considered as one of the most affected countries among the 10 countries all over the world. To combat with the challenge of Climate Change in Bangladesh, a Climate Change trust Fund has been established in 2010. Bangladesh is determined to comply with the clauses of Paris Agreement. The Government of Bangladesh has framed a comprehensive development plan - the Bangladesh Delta Plan (BDP 2100), focusing on economic growth, environmental conservation, and enhanced climate resilience. Few objectives of National Environment Policy of Bangladesh, 2018 are to achieve Sustainable Development Goals of 2030, scientific and efficient uses of Natural resources, preparation of adaptation and mitigation plans on climate change, reduce recycle and reuse of resources, implementation of Polluter's Pay Principle.

The National Environmental Policy 1992 has been modified and amended to National environmental Policy 2018, by addressing the potential risks of Climate Change, effect of different kind of natural disasters and depletion of Natural resources and also to achieve Sustainable Development Goals.

2.2.5 Power System Master Plan, 2016

The Power System Master Plan (PSMP) 2016 is prepared in aiming at formulating a comprehensive energy and power development plan up to the year 2041.

The master plan focuses on five key points

1. Enhancement of imported energy infrastructure and its flexible operation.
2. Efficient development and utilization of domestic natural resources (gas and coal).
3. Construction of a robust, high-quality power network.
4. Maximization of green energy and promotion of its introduction.
5. Improvement of human resources and mechanisms related to the stable supply of energy.

2.2.6 National 3R Strategy for Waste Management

The three R's – reduce, reuse and recycle – all help to cut down on the amount of waste we throw away. They conserve natural resources, landfill space and energy. Plus, the three R's save land and money communities must use to dispose of waste in landfills.

The main objective of this 3R strategy is to delineate ways and means of achieving national 3R goals through providing a uniform guideline for all stakeholders. Specific objectives of this strategy are to:

- address the key issues and challenges of waste management acting as a barrier for promotion of 3R in the country.
- define the roles of various actors to promote 3R in the country; and
- guide the creation of enabling conditions for success regarding implementation of 3R in the country.

Priority sectors include municipal solid waste, industrial waste, biomedical waste, institutional and commercial waste and agricultural waste

The policy would be applicable to the project since the project will generate waste (solid waste, e-waste etc) during construction, operation and decommissioning.

The project is required to raise public awareness through IEC for implementation of the waste strategy and behavioural changes with respect to long term environmental management.

Other strategy includes inventory of hazardous waste generation, reuse, recovery and recycling of hazardous waste etc.

2.2.7 Bangladesh Climate Change strategy and Action Plan 2009

The Government of Bangladesh's Vision is to eradicate poverty and achieve economic and social well-being for all the people through a pro-poor Climate Change Strategy, which prioritises adaptation and disaster risk reduction, and also addresses low carbon development, mitigation, technology transfer and the provision of adequate finance.

Sections I to V of the action plan provide an overview of different adaptation strategies and briefly outline mitigation issues.

Sections VI to VII specifies the need for capacity and resilience of the country to meet the challenge of climate change over the next 20-25 years.

The Climate Change Action Plan is built on six pillars:

1. food security, social protection and health,
2. comprehensive disaster management,
3. infrastructure,
4. research and knowledge management,
5. mitigation and low carbon development, and
6. capacity building and institutional strengthening.

The key environmental and social (E&S) policies and regulations, which are relevant to proposed 600 MW CCPP project of UMPL are described in the following ***Table 2.1.***

Table 2.1: List of applicable environmental policies in Bangladesh

Policies	Key aspects	Applicability
National Environment Policy, 2018	• To adopt corrective measures in phases in industries that causes pollution. • To conduct EIA for all new public & private industrial developments. • To prohibit the formation of any industry that cause environmental pollution and/or introduction of environmentally sound substitutes and to prevent wastage from the industries by sustainable use of raw materials.	The proposed project is new development, so it needs to conduct EIA according to the policy. In the operational and construction phase the corrective measures would be adopted to mitigate pollution, according to this policy.
National Environment Management Action Plan, 1995	• To identify important environmental issues as well as essential actions to stop or reduce the rate of environmental degradation which would improve the natural and built-up environment of Bangladesh. • Conservation of biodiversity and promotion of sustainable development in association with improvement in the quality of life of the people of Bangladesh	During various phase of the proposed project the environmental components like air, water, land is likely to be adversely impacted. According to this policy, the detail of pollution sources, would be assessed and technology, which would lead to efficient use of resources and waste minimization would be suggested. The policy would also encourage sustainable development and biodiversity conservation, during the life cycle of the project.
National Conservation Strategy, 1992	• It is mandatory for all industries to carry out EIA and adopt pollution prevention and control technologies. • Prohibit import of hazardous or toxic materials/wastes as raw materials for the industries in Bangladesh. • Promulgation of environmentally sound technology.	The policy would be applicable to the project, as under this policy all new industries need to carry out EIA and adopt pollution prevention and control technologies and other requirement.

Policies	Key aspects	Applicability
	• Minimization of dependence on imported technology and machinery to enhance sustainable local skills and resources.	

2.2.8 Other Policy Relevant to Environment

Additional environmental and social policies of Bangladesh, their key features and applicability to the proposed project are detailed in ***Table 2.2*** below.

Table 2.2: Environmental and Social Policy of Bangladesh

Policy	Key Aspects	Applicability to Project
National Land use Policy, 2001	This policy identifies all the constraints associated with several land uses including agriculture, fishery and livestock, housing, forestry, industrialization, railways and roads, tea and rubber	Applicable, as Land use data shows that the major land use at the project site is agricultural land, followed by river and settlements.
Industrial Policy 1991	The Industrial Policy of 1991 contains the following clauses in respect of environmental protection • To conserve ecological balance and prevent pollution during industrialization • To take effective steps for pollution control and conservation of environment during industrialization	This is applicable since the proposed project is required to conserve ecological balance and prevent pollution as per Regulatory requirements and Multi-lateral Funding Agencies' guidelines and standards.
National Fisheries Policy, 1998	This Policy emphasises on the preservation, management and exploitation of fisheries resources in inland open water and sea including cultivation and management of fish.	This is applicable for the proposed project as the raw water would be drawn from Meghna River channel and treated effluent would be discharged into the same water body. The construction raw materials like filling earth, power equipment would be also transported to the site through the same waterbody and fuel would be transported underneath the river in pipeline during operation phase.
Water Policy, 1999	This Policy emphasises on protection and enhancement of water resources and quality and regulate discharge of pollutants including untreated agricultural and industrial effluent. It also promotes local community engagement in all water sector development to enhance sanitation, hygiene and potability of the water resources. Restoration and enhancement of water resources.	This is applicable for the proposed project as total raw water for the proposed project including water for cooling towers, heat exchanger, condenser etc would be withdrawn from Meghna River channel and treated wastewater would be let into the river channel; hence protection and enhancement of the water resource and quality is of utmost priority for UMPL.

2.2.9 Environmental and Social Related Legislation in Bangladesh

The key E&S Acts and Regulations establishing statutory compliance requirements for environmental protection and conservation; and social safeguards in Bangladesh are outlined in the following sub-sections:

2.2.9.1 Environmental Conservation Act 1995 and subsequent amendments

The provisions of the Act authorize the Director General (DG) of Department of Environment to undertake any activity he deems fit and necessary to conserve and enhance the quality of environment and to control, prevent and mitigate pollution and currently it is the main legislative document relating to environmental protection in Bangladesh. The main objectives of ECA'95 are:

- Conservation and improvement of environment, and
- Control and mitigation of pollution of environment.

The main strategies of the act can be summarized as:

- Declaration of ecologically critical areas.
- Obtaining Environmental Clearance Certificate.
- Regulation of development activities from environmental perspective.
- Regulation in respect of vehicles emitting smoke harmful for the environment.

- Promulgation of standards for quality of air, water, noise and soil for different areas for different purposes.
- Promulgation of standard limit for discharging and emitting waste.
- Formulation of environmental guidelines relating to control and mitigation of environmental pollution, conservation and improvement of environment.

The regulation would be applicable in the proposed project. In every phase of the project, the requirement of the regulation would be met, as per the requirement of the Act. The project needs to obtain environmental clearance, under this regulation. During the various project phases, the emission standard would be met according to the specification of the regulation. The guidelines to control pollution arising from the proposed project, would be formulated according to the law.

2.2.9.2 Environmental Conservation Rule 1997 and subsequent amendments

The Environment Conservation Rules, 1997 are the first set of rules promulgated under the Environment Conservation Act, 1995. These Rules provide for, inter alia, the following:

- The national Environmental Quality Standards (EQS) for ambient air, surface water, groundwater, drinking water, industrial effluents, emissions, noise and vehicular exhaust.
- Categorization of industries, development projects and other activities based on actual (for existing industries/development projects/activities) and anticipated (for proposed industries/development projects/activities) pollution load.
- Procedure for obtaining environmental clearance.
- Requirement for undertaking IEE and EIA as well as formulating EMP according to categories of industries/development projects/activities.
- Procedure for damage-claim by persons affected or likely to be affected due to polluting activities or activities causing hindrance to normal civic life.

Depending upon location, size and severity of pollution load, projects/activities have been classified in ECR, 1997 into three categories:

1. Green: Industries/development projects/activities are considered relatively pollution-free and therefore, they do not require an environmental clearance certificate from the DOE and no environmental study.
2. Orange: Industries/development projects/activities under this category fall into two sub-categories. Orange "A" is less polluting and Orange "B" is moderately polluting. These projects are required to submit general information. A process flow diagram and schematic diagrams of waste treatment facilities along with their application is submitted to DOE for obtaining environmental site clearance and environmental clearance.
3. Red: Industries/development projects/activities which may cause 'significantly adverse' environmental impacts are categorized as 'red' and are required to submit an EIA report. It would be noted that they might obtain an environmental site clearance based on an IEE report, and subsequently submit an EIA report for obtaining environmental clearance along with other necessary papers.

Corresponding category related to power plants and associated facility are as under: Schedule-1, Red Category (Item 6: power plants; Item 64: includes construction / replacement / extension of natural gas pipelines). For red category project, it would require two-steps assessment procedure, firstly an Initial Environmental Examination (IEE) for site clearance, and secondly, a full Environmental Impact Assessment (EIA) for technical clearance.

UMPL had applied for IEE approval to Department of Environment (DoE), Bangladesh and site clearance was obtained vide Memo No. 19-29585 dated 01/10/2019 with validity till 30/09/2020. Site Clearance was renewed vide Memo No. 21-54203 valid till 30/09/2021. UMPL also submitted the EIA report to DoE and received the Environmental Clearance Certificate (ECC) on 19.07.2020 (Memo No: 22.02.6700.140.72.065.19-09).

2.2.9.3 E-waste management rules 2021

Bangladesh's Department of Environment (DOE) on June 10, 2021, published the Hazardous Waste (e-waste) Management Rules, 2021 under the Bangladesh Environmental Protection Act, 1995.

The E-waste rule covers the products listed in the Schedule (home appliances, monitoring and control equipment, medical equipment, automatic machines, IT and communication equipment), and establishes obligations for manufacturers, assemblers, collectors, sellers, and consumers of the products.

The rule also sets provisions to limit the use of the 10 substances covered by the EU RoHS Directive. This regulation entered in force upon publication.

The main provisions of this regulation are as follows.

- Manufacturers, traders, sellers, transporters, repairers, collection centers, recyclers, dismantlers, etc. of the subject products are required to register with a prescribed form to the DOE. When applying for registration, they shall also submit Waste Electrical and Electronic (WEEE) management plan.
- Registered manufacturers, recyclers, etc. shall obtain environmental clearance in accordance with the Bangladesh Environmental Protection Rules, 1997.
- Manufacturers have to establish individual or joint collection centres and set aside funds for the management of WEEE.
- For fluorescent lamps and mercury incandescent lamps, if they cannot be recycled, they need to be handed over to collection centres for storage and disposal.
- Manufacturers, importers, etc. shall meet the collection targets for WEEE as specified in the Schedule (10% in the first year of the implementation, 20% in the second year, 30% in the third year, 40% in the 4th year, and 50% in the fifth year and thereafter).
- In order to facilitate the proper management of WEEE, the name, address and contact information of the trader or seller as well as the information on the registered collection centre shall be displayed on the product or on the product label, or this information shall be provided to consumers or large consumers.
- Traders, sellers and collectors of WEEE shall receive them from consumers at designated points and transport them to collection centers.

The act also specifies that in case of violation of the provisions of these rules, imprisonment for a maximum period of two years or to a fine of up to two hundred thousand taka shall be levied in accordance with the Bangladesh Environmental Protection Act, 1995. In case of repeat offence, imprisonment for a term ranging from two to ten years or a fine ranging from Taka 200,000 to Taka 1,000,000 or both

2.2.9.4 Environmental court act 2000 and subsequent amendment 2002

An Act to provide for the establishment of environment courts and matters incidental thereto. The Act expedites the establishment of Environment Courts as and where necessary for the trial of offences relating to environmental pollution.

The GoB will establish one or more Environmental Court in each division, constituting of one judge. In consultation with the Supreme Court, the government shall-

- Appoint an officer of the rank of Joint District Judge to dispose of cases only under Environmental laws; and
- If considered necessary, appoint a judge of the rank of the rank of Joint District Judge for a Division, or a specific part of the same. The judge will, in addition to his ordinary functions, dispose cases that fall within the jurisdiction of Environmental Court.
- The Environment Court shall be the competent authority to impose penalty for offences under Section 5A of the Act, and under any other Environmental law, and to pass order for compensation in appropriate cases.
- If a person violates the court order under clause (a) of section 5(2) by repeating or continuing with the offence of which he has been fined, he shall be liable to sentenced with penalty prescribed for that offence, with the penalty not less than that imposed in the first instance of the order

2.2.10 Other Relevant National Legal Instruments for the Project

The primary environmental regulatory agency in Bangladesh is Ministry of Environment, Forest and Climate Change (MoEF), Dhaka. The Power Projects are come under the ambit of Environment Conservation Rules, 1997. Hence, project requires preparation of Environmental Impact Assessment Report and pursuing Environmental Clearance from Department of Environment or Ministry of Environment and Forest. Environmental and safety related host country regulations along with applicability assessment for the proposed Power Project are discussed in ***Table 2.3*** below.

Table 2.3: National Regulation Applicable in Power Project

Sr. No.	Act/Law	Responsible authority	Key features and Applicability
1	The Environment Conservation Act, 1995 and subsequent amendments in 2000 and 2002	Department of Environment, Ministry of Environment, Forest & Climate Change	1. To adopt corrective measures in phases in industries that causes pollution, 2. Conduct EIA for all new public & private industries. Ensure sustainable use of raw materials in the industries to minimize their wastage. 3. To prohibit the formation of any industry that cause environmental pollution and/or introduction of environmentally sound substitutes. The Act is applicable for the project and the project would require EIA to be conducted for obtaining Environmental Clearance of the project. UMPL has conducted EIA study and received the approval on 19.07.2020 (Memo No: 22.02.6700.140.72.065.19-09) to commence construction.
2	National Environmental Management Action Plan, 1995	Ministry of Environment, Forest & Climate Change	1. Promulgation of standards for quality of air, water, noise, and soils for different areas and for different purposes. 2. Promulgation of acceptable limits for discharging and emitting waste. 3. Formulation of environmental guidelines relating to control and mitigation of environmental pollution, conservation and improvement of environment. The Plan is applicable for the project and the project is required to follow standards for air, water and noise quality.
3.	Environment Conservation Rules, 1997 and subsequent amendments in 2002 and 2003	Department of Environment, Ministry of Environment, Forest & Climate Change	1. Provides standards for quality of air, water & sound and acceptable limits for emission/discharges from vehicles and other sources. 2. Categorization of industries, development projects and other activities based on pollution load. The Rule is applicable for the project and the project is required to follow standards for air, water and noise quality.
4.	Water Supply and Sanitation Act, 1996	Ministry of Local Government, Rural Development and Cooperatives	Management and control of water supply and sanitation in urban areas. The Act is applicable for the project and guideline with respect to Water and Sanitation to be followed.
5.	The Protection and Conservation of Fish Act 1950 and subsequent amendments in 1982	Ministry of Fishery	To provide for the protection and conservation of fishes in Bangladesh. The act is applicable for the project. The project site is just beside the Channel of Meghna River and activities such as jetty construction, vessel transport would be done. So, impact due to construction and transportation, if any, needs to be assessed under this act.
6.	Natural Water Bodies Protection Act 2000	Rajdhani Unnayan Kartipakkha/ Town Development Authority/ Municipalities	The playground, open space, park and the character of water bodies i.e., rivers, canals, tanks, or floodplains of Mega city, Divisional Town and District Town's municipal areas shall not be changed without approval of concerned ministry. The act is applicable for the project. The project site is just beside the Meghna River and jetty construction, vessel transport would be done.
7.	The Vehicle Act, 1927; The Motor Vehicles Ordinance, 1983; The Bengal Motor Vehicle Rules, 1940	Bangladesh Road Transport Authority (BRTA)	Controlling Exhaust emission; Vehicular air and noise; Road safety. For transportation of officials and workers, cars and mini truck would be used. So, the act is applicable for the project.
8.	Noise Pollution (Control) Rules, 2006	Ministry of Environment, Forests & Climate Change	This Act sets rules for prevention of noise pollution and enforce standards for noise levels. Since the proposed project involves high noise generating activities during both construction and operation phase; hence the rule is applicable.
9	Ozone Depleting Substances (Control) Rules, 2004	Ministry of Environment, Forests & Climate Change	This Rule put ban on the use of Ozone depleting substances and phasing out of Ozone depleting substances. Since there is a potential for generation of ODS, hence the rule is applicable.
10.	Water Act, 2013	National Water Resources Council	The Water Act 2013 regulates all forms of water within the territory of Bangladesh and declares the same as the national property of the Government of Bangladesh. The Act regulates withdrawal of surface water and abstraction of groundwater through introduction of permit/license requirement for large scale surface or groundwater abstraction The proposed project is situated at the bank of Meghna River, and the withdrawn of the surface water would be regulated by this Act.

Sr. No.	Act/Law	Responsible authority	Key features and Applicability
			In addition, a recent judgement from High Court of Bangladesh gave the verdict, in response to a public litigation, that deals with encroachment of river. As the project is situated in the bank of Meghna, hence the decision of the verdict would be triggered to prevent any encroachment to the river. In line with this, Bank of Bangladesh is also discouraged not to provide loans to those business entities, which comes under the illegal encroachment of water bodies.
11	Bangladesh Water Rules, 2018	National Water Resources Council	Bangladesh Water Rules, 2018 have been formulated under the Bangladesh Water Act, 2013 issuing directives for regulation of use of water resource and conservation of water. It is imperative to obtain Clearance/license for use of water for various purposes including for industrial use with submission of fees as per the provisions laid down in the Water Rules 2018. It is also imperative to abide by other directives under this Rule for drawl & use of water. UMPL would obtain necessary Clearance/license for drawl & use of water from Meghna River from designated Authority and would also adhere to provisions laid down in Bangladesh Water Rules, 2018
12	Natural Gas Safety Rules 1991	Bangladesh Energy Regulatory Commission	The Rules encompass aspects of design and construction of gas pipelines including selection of materials; specifications for pipeline crossings of other infrastructure such as railways; testing and commissioning of pipelines; Pipeline operation and maintenance; and reporting of accidents. The Rules also include stipulations as to the separation distances between pipelines and public properties and thoroughfares. The rules have been amended in 2003. The natural gas pipeline would be planned and designed as per requirements of the Bangladesh Natural Gas Safety Rules 1991
13	Petroleum Act 2016	Bangladesh Energy Regulatory Commission	This act has set provisions dealing with import, storage, transportation, production, refining of petroleum and other inflammable substances and reuse of such substances through recycling. The petroleum Bill 2016 has the provision of giving legal coverage to the activities carried out under the Petroleum Act of 1934 and for continuation of the actions taken. For the proposed project, use of petroleum products like HSD would be guided by the provisions of this Act and the license for storage of HSD will be required.
14	Bangladesh Energy Regulatory Commission Act 2003 (Amended 2005)	Ministry of Power, Energy and Mineral Resources	The Act makes provisions for the establishment of an independent and impartial regulatory commission for the energy sector. The commission is, inter alia, to determine the energy efficiency of institutions regulated under the Act, and to monitor and verify institutions' energy use through energy audits. It is also required to ensure the efficient use of energy at a generation, transmission and distribution level. Provisions under this Act would be applicable for this project encompassing aspects of generation & transmission of energy.
15	Fire Prevention & Extinction Act, 2003 and Fire Prevention and Extinction Rules 2014		The Fire Prevention and Extinction Act 2003 supplemented by the Fire Prevention and Extinction Rules 2014 enumerates that owner of the building shall have to apply for occupancy certificate of the building at the end of the construction. These enable the authority to inspect the building, to examine whether the owner met all the requirements of the building code for the public safety or not. UMPL would comply with relevant provisions under this Act.
16	Electricity Act, 2018	Bangladesh Power Development Board	This Act relates to the supply and use of electrical energy, provisions for obtaining a license to supply energy and to put down or place electrical supply lines for the transmission of energy. The Electricity Act, 2018 aims to repeal and re-enact the Electricity Act, 1910 with modification for developing and reforming the sectors of power generation, transmission, supply and distribution and for better service delivery to consumers and meeting the increasing demand for electricity. The act specifies that (section 12) If any damage, harm or inconvenience is caused during civil work under this Act, the licensee shall, liable to provide compensation to the affected person or the owner of the land affected for acquiring land for construction of electricity towers. In Section 13 specifies that for the purpose of laying power supply lines or doing civil works under this Act, the licensee shall reserve the right of way over the land and the space above or underground. However, the landowner shall be informed of the intent in writing before laying of power supply lines and doing civil works within a reasonable time. The Act also specifies that If acquisition of land is required for establishment of power generation plant or sub-station, it shall be

Sr. No.	Act/Law	Responsible authority	Key features and Applicability
			deemed to have been necessary for public interest and the existing laws and regulations on acquisition of land shall have to be followed. This Act would be applicable and would be complied by UMPL.
17	Electricity Rules 2018 and its subsequent amendments	Bangladesh Power Development Board	
18	The Acquisition and Requisition of Immovable Property Act, 2017	Govt of Bangladesh	This law is applicable for acquisition of immovable property for any project by any Govt Authority or department. The Government of Bangladesh have enacted a new land acquisition law titled The Acquisition and Requisition of Immovable Property Act (APIPA), 2017 replacing the 1982 Ordinance depending on the need and requirements of the day. The ARIPA 2017 requires that compensation be paid for (i) land and assets permanently acquired (including standing crops, trees, houses); and (ii) any other damages caused by such acquisition. The act also says that religious places, graves or crematoriums can be taken into acquisition. Provided that, if it essential in public purpose or public interest, by relocation and rebuilding, in the own money of the requiring persons or organizations. The amount of compensation to be awarded Deputy Commissioner will take into consideration- (a) the market value of the property at the date of publication of the notice (b) the damage that may be sustained by the person interested, by reason of the taking of any standing crops or trees which may be on the property at the time of the making of the joint list; (c) the damage that may be sustained by the person interested by reason of severing such property from his other property; (d) the damage that may be sustained by the person interested by reason of the acquisition injuriously affecting his other properties, movable or immovable, in any other manner, or his earnings; and (e) if in consequence of the acquisition of the property, the person interested is likely to be compelled to change his residence or place of business, the reasonable expenses, if any, incidental to such change. According to the law, affected persons will get additional 200% of assessed value for land and additional 100% for structures, trees, crops and other assets. The Act says in spite of any compensation provided under the law; necessary steps may be taken to rehabilitate evicted persons due to acquisition. The act also provides for an appointment of arbitrator. The affected landowners have a provision of filing arbitration case and a right to be heard by the arbitrator if any entitled person is not agreeable with the calculation of the cost of compensation. The new law has provision for resettlement off those who will be displaced from homestead with living structures due to the project. The act recognizes the Bargadars and pays compensations for the loss of standing crops being cultivated at the time of land acquisition. This Act, however, is not applicable for the project as no government led acquisition or expropriation has been undertaken for the project. However, this Act provides an important guidance to the compensation amounts and the minimum entitlements to be provided to the affected households as a part of resettlement planning However, g buyer and willing seller' process

The project would engage workers during construction phase and operation phase. Hence, the project would have to conform with the labour laws of Bangladesh, for occupational and health related rules. The outline of the regulatory provisions is given in ***Table 2.4*** below:

Table 2.4: Occupational Health & Safety Laws

Sr. No.	Act/Law	Key features and Applicability
1.	Fatal Accidents Act. 1855	Provide compensation to families for loss occasioned by the death of a person caused by actionable wrong. In this project, workers would be engaged during construction as well as operation phase. Hence this Act would be applicable.
2.	Bangladesh Labour Act. 2006	An Act relating to employment of workers, relation between workers and employers, determination of minimum rates of wages, payment of wages, compensation for injuries to workers during working hours, formation of trade unions, raising and settlement of industrial disputes, health, safety, welfare and working conditions and environment of workers.

Sr. No.	Act/Law	Key features and Applicability
		The project would engage workers during construction phase and operation phase. Hence Bangladesh Labour Act. 2006 would be applicable.
3.	Public Health Emergency Provisions Ordinance, 1994	Calls for special provisions about public health. In case of emergency, it is necessary to make special provisions for preventing the spread of disease, safeguarding the public health, and providing adequate medical service, and other services essential to the health of respective communities and workers during construction-related work. The Law is applicable and necessary guideline must be fulfilled during project life cycle.

2.2.11 Administrative Set up Relevant to Environment in Bangladesh

In Bangladesh, the Ministry of Environment, Forest and Climate Change (MoEF) is accountable for supervision of all environmental associated matters relating to National Environmental Policy and regulatory issues. Under the supervision of MoEF the following organizations act as implementing agencies as well as govern the technical matter relevant to environmental issues.

- Bangladesh Climate Change Trust.
- Department of Environment (DOE).
- Forest Department (FD).
- Bangladesh National Herbarium (BNH).
- Bangladesh Forest Industries Development Corporation (BFIDC) and
- Bangladesh Forest Research Institute (BFRI)

Under the administrative framework there are some other agencies who would govern the environmental and social functions connected to the proposed Project, namely:

- Ministry of Land: Land reform and Land Acquisition Directorate.
- Ministry of Water Resources: Bangladesh Water Development Board.
- Ministry of Agriculture; and
- Local Government Engineering Department (LGED).

2.2.11.1 Department of Environment

The Department of Environment (DoE) was established in 1989 under the Environment Pollution Control Ordinance, 1977 and functions under the Environment Conservation Act (ECA) in 1995. With the formation of the new Ministry of Environment and Forests, in 1989, both the departments were transferred to this new Ministry. The DoE has been placed under the MoEF as its technical wing and is statutorily responsible for the implementation of the Environment Conservation Act, 1995. The principal activities of the DoE are:

- Defining and evaluating EIA/ESIA and issuing environmental clearance permits and providing other regulatory approval to factories and industries for operation.
- The department regulates pollution by monitoring pollution sources, ensuring mitigation of this pollution.
- Taking direct action to prevent environmental degradation and also, fine polluting industries.
- Declaring Ecologically Critical Areas (ECAs) and protected areas in association with Forest Department.
- Preparing the Quality Standards for different environmental factors and physico-chemical factors of waste products.

2.2.11.2 Status of Project Approval from DoE

UMPL received the approved Site Clearance Certificate from DoE, Bangladesh with Environmental Compliance conditions stipulated. The Site Clearance was granted on 01 October 2019 and is valid till 30 September 2020. This clearance was granted post submission of Initial Environmental Examination (IEE) report which was prepared in June 2019. Site Clearance was renewed vide Memo No. 21-54203 with validity till 30/09/2021 (Appendix B)

The Environmental Impact Assessment (EIA) Report was completed in January 2020 and submitted to DOE for approval to commence construction and grant of Environmental Clearance Certificate for the proposed 600 MW RLNG-based Combined Cycle Power Plant. UMPL received the Environmental Clearance Certificate (ECC) on 19.07.2020 (Memo No: 22.02.6700.140.72.065.19-09). The copy of the ECC is presented in ***Appendix C.***

2.3 Relevant International Treaty and Convention

Bangladesh has ratified to about 30 international treaties and conventions related to environment. The relevant international treaties and conventions related to the Project and their status are given in ***Table 2.5*** below.

Table 2.5: International Treaties and Conventions relevant to the project

Sr. No.	Environment related international convention and Treaties	Status
1	Convention on International Trade in Endangered Species of Wild Fauna and flora (Washington, 1973.) ("CITES Convention")	18.02.82 (ratified)
2	Kyoto protocol to the United Nations Framework Convention on Climate Change	21.8.2001 (approached)
3	Montreal Protocol on Substances that Deplete the Ozone Layer (Montreal 1987.)	02.08.90 31.10.90 (approached) (entry into force)
4	Montreal Amendment of the Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal, 1997	27.7.2001 (Accepted) 26.10.2001 (Entry into force)
5	Vienna Convention for the Protection of the Ozone Layer (Vienna, 1985.)	02.08.90 (approached) and 31.10.90 (entry into force)
6	Copenhagen Amendment to the Montreal protocol on Substances that Deplete the Ozone Layer, Copenhagen, 1992	27.11.2000 (accepted) and 26.2.2001 (entry into force)
7	London Amendment to the Montreal Protocol on substances that Deplete the Ozone Layer (London, 1990)	18.03.94 (approached) 16.06.94 (entry into force)
8	United Nations Framework Convention on Climate Change, (New York, 1992.)	09.06.92 (signed) and 15.04.94 (ratified)
9	Convention on Biological Diversity, (Rio De Janeiro, 1992.)	05.06.92 (signed) and 03.05.94 (ratified)
10	Convention on persistent Organic Pollutants, Stockholm	23.5.2001 (signed) and 12.03.2007 (ratified
11	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel, 1989.)	01.04.93 (approached)

Source: Department of Environment, Bangladesh

2.4 International Safeguard Requirement of Multilateral Funding Agency

The proposed 600 MW Combined Cycle Power Plant of Unique Meghnaghat Power Limited would receive financing sources and financial support from multi-lateral financial institutions, such as AIIB, EPFIs and IFC as well as from the export credit agencies of the countries where major equipment for the Project would be sourced. This support from multi-lateral financial institutions/ export credit agencies is also linked w1ith adherence to international best practices and environmental and social safeguard requirements of the lenders. The following sub-sections outline the key environmental and social requirements of the IFC, EPFIs and the AIIB, applicable to the Project.

2.4.1 AIIB Environmental and Social Framework

The Asian Infrastructure Investment Bank (AIIB) sets Environmental and Social Policy (ESP) under the Environmental and Social Framework (ESF), 2016, amended in 2019 and it is applicable for each Project funded by the Bank. As part of its vision provided in the ESF, AIIB has established the following:

- The Bank requires the integration of environmental and social sustainability in the identification, preparation, and implementation of the Project, which in turns become part of its decision-making process.
- The Bank requires meaningful consultation of Stakeholders by its Clients throughout the Project life cycle.

- The Bank supports its clients to identify potential gender-specific opportunities as well as gender-specific adverse risks and impacts under their Projects and to develop mitigation measures to avoid or reduce such impacts and risks.
- The Bank recognizes the important role played by workers and their representatives in the development process and their contribution to sustainable economic growth. Thus, protection should be provided to workers on their rights and working conditions, and avoidance of forced, harmful or exploitative forms of labour.
- The Bank recognizes that protecting and conserving biodiversity, sustainably managing terrestrial and aquatic natural resources and maintaining core ecological functions and services are fundamental to sustainable development.

The ESP also defines the roles and responsibilities between AIIB and its Clients and ensure they are complied with to secure AIIB financing.

The Bank requires each proposed Project to be assigned one of the following four categories:

- **Category A:** A Project is categorized A if it is likely to have significant adverse environmental and social impacts that are irreversible, cumulative, diverse or unprecedented. These impacts may affect an area larger than the sites or facilities subject to physical works and may be temporary or permanent in nature.
- **Category B**: A Project is categorized B when: it has a limited number of potentially adverse environmental and social impacts; the impacts are not unprecedented; few if any of them are irreversible or cumulative; they are limited to the Project area; and can be successfully managed using good practice in an operational setting.
- **Category C:** A Project is categorized C when it is likely to have minimal or no adverse environmental and social impacts.
- **Category FI:** A Project is categorized FI if the financing structure involves the provision of funds to or through a financial intermediary (FI) for the Project, whereby the Bank delegates to the FI the decision-making on the use of the Bank funds, including the selection, appraisal, approval and monitoring of Bank-financed sub-project.

Further the AIIB requires compliance applicable to the Project, for identification and management of environmental and social risks and impacts. The three Environmental and Social Standards (ESS) are:

AIIB ESS 1: Environmental and Social Assessment and Management

AIIB ESS 2: Involuntary Resettlement and

AIIB ESS 3: Indigenous Peoples

2.4.2 DEG Guideline for Environmental and Social Sustainability

DEG considers protection of environment including compliance with applicable social standards, and the sustainable use of natural resources as the fundamental factors in the process of an ecological, economic and social development for the benefit of the people. DEG Guideline for Environmental and Social Sustainability comprise of the following principles:

- Environmental and social sustainability encompasses the protection of people's lives and health, the economic basis of their livelihood and their ecological, social and cultural environment as well as the sustainable use of natural resources.
- Attention to environmental protection and sustainable use of resources as well as adherence to social principles.
- Compliance with international environmental and social standards as well as environmentally relevant safety, health and technical standards in production and products.
- DEG supports the implementation and advancement of environmental protection and international social standards in its partner countries.
- Consideration of the ecological and social interests of people affected by the impact of projects co-financed by DEG; and
- These principles are also a benchmark for DEG itself and it applies high ecological and social standards to its own organisation and business activities.

Apart from the above, DEG mostly consider IFC PS standards for their project evaluation. Requirement of IFC PS standards is presented in following section.

2.4.3 IFC Performance Standard

The Performance Standards (PS) (January 2012) established by IFC stipulates that the Project would meet certain requirements throughout the life cycle of an investment by IFC or other relevant financial institution such as DEG or commercial banks, which are signatory to the Equator Principles, 2006. A brief description of the Performance standards and its applicability to the proposed project is provided in ***Table 2.6*** below.

Table 2.6: IFC Performance Standards

Performance Standards	Specific Areas	Key features and Applicability
Performance Standard 1	Assessment and Management of Environmental and Social Risks and Impacts	The PS 1 requires Social and Environmental Assessment and Management Systems for managing social and environmental performance throughout the life cycle of this Project and runs through all subsequent PSs. The social and environmental performance is a continuous process to be initiated by the management and would involve communication between the organisation, its workers and local communities directly affected by the Project. The PS 1 is applicable for the project because it would require carrying out regular assessment of the potential social and environmental risks and impacts and consistently try to mitigate and manage the impacts on an ongoing basis.
Performance Standard 2	Labour and Working Conditions	The economic growth through employment creation and income generation is recognised along with protecting the basic rights of workers. PS 2 is guided by the various conventions of International Labour Organisation (ILO) and outlines the minimum requirements of working conditions, protection to the workforce (including issues of child and forced labour) and ensuring occupational health and safety of both its ‘employees’ as well as ‘nonemployees’ working through contractors. PS 2 is applicable for this proposed project because it would be required to conduct its activities in a manner in accordance with the four core labour standards (child labour, forced labour, non-discrimination, and freedom of association and collective bargaining) and address the areas such as working conditions and terms of employment, retrenchment, and occupational health and safety issues.
Performance Standard 3	Resource Efficiency and Pollution Prevention	PS 3 outline a project level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices PS3 is applicable for the project because due to the project activities the ambient environmental conditions would be altered. Measurement of ambient conditions and application of technically and financially feasible resources with pollution prevention principles and techniques to avoid or to minimize adverse impacts on human health during the entire project lifecycle would be needed.
Performance Standard 4	Community Health, Safety and Security	PS 4 concentrates on the responsibility that must be undertaken by the client to avoid or minimize the risks and impacts to the community’s health, safety and security that may arise from project activities. PS 4 is required for this project to evaluate risks and impacts to the health and safety of the affected community during the Project life cycle and establish measures to avoid, minimize and reduce risks and impacts from the Project.
Performance Standard 5	Land Acquisition and Involuntary Resettlement	PS 5 require a project to consider various processes and systems to avoid /minimise social and economic impacts related to land acquisition and involuntary resettlement. For the proposed project, although, ‘Willing buyer Willing seller’ method has been adopted for procurement of land, approximately 90 landowners have become agriculturally landless and 60-fisherman families & 18 land dependents are envisaged to be impacted due to land procurement. Hence, IPS 5 is applicable for the proposed project.
Performance Standard 6	Biodiversity Conservation and Sustainable Management of Living Natural Resource	PS 6 aims at protecting and conserving biodiversity, maintaining ecosystem services, the variety of life in all its forms, including genetic, species and ecosystem diversity and its ability to change and evolve, is fundamental to sustainable development. The project Site would be evaluated under PS 6 to confirm whether the land is natural, modified or critical and based on that, a conservation plan would be prepared if required to conserve the biodiversity.

Performance Standards	Specific Areas	Key features and Applicability
Performance Standard 7	Indigenous Peoples	PS 7 acknowledges the possibility of vulnerability of indigenous people owing to their culture, beliefs, institutions and living standards, and that it may further get compromised by one or other project activity throughout the life cycle of the project. This PS delineates the requirement of avoiding / minimizing adverse impacts on indigenous people in a project area, respecting the local culture and customs, fostering good relationship and ensuring that development benefits are provided to improve their standard of living and livelihoods. However, no indigenous people are residing in and around the project area; hence PS 7 is not applicable for the present project.
Performance Standard 8	Cultural Heritage	PS 8 aims to protect the irreplaceable cultural heritage and to guide clients on protecting cultural heritage in the course of their business operations. In addition, the requirements of this PS on a project's use of cultural heritage are based in part on standards set by the Convention on Biological Diversity. However, as per ESIA report, no buildings and structures of cultural, archaeological and religious significance is located in and around the project area; hence PS 8 is not applicable.

Source: IFC Performance Standard, January 2012

2.4.3.1 IFC Project Categorisation

IFC uses a system of environmental and social categorisation to review the extent of environmental and social impacts of a project to specify IFC's institutional requirements. The IFC categories are:

- **Category A Projects:** Projects with potential significant adverse social or environmental impacts that are diverse, irreversible or unprecedented.
- **Category B Projects:** Projects with potential limited adverse social or environmental impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures.
- **Category C Projects:** Projects with minimal or no adverse social or environmental impacts, including certain financial intermediary (FI) projects with minimal or no adverse risks.

Category FI Projects: All FI projects excluding those that are Category C projects. Project activities involving investments in Financial Institutions (FIs) or through delivery mechanisms involving financial intermediation. This category is further divided into:

- **FI–1:** when an FI's existing or proposed portfolio includes or is expected to include substantial financial exposure to business/project activities with potential significant adverse environmental or social risks or impacts that are diverse, irreversible, or unprecedented.
- **FI–2:** when an FI's existing or proposed portfolio is comprised of, or is expected to be comprised of, business/project activities that have potential limited adverse environmental or social risks or impacts that are few in number, generally site-specific, largely reversible, and readily addressed through mitigation measures; or includes a very limited number of business activities with potential significant adverse environmental or social risks or impacts that are diverse, irreversible, or unprecedented.
- **FI–3:** when an FI's existing or proposed portfolio includes financial exposure to business/project activities that predominantly have minimal or no adverse environmental or social impacts.

2.4.3.2 IFC General EHS Guideline

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

Effective management of environmental, health, and safety (EHS) issues entails the inclusion of EHS considerations into corporate-and facility-level business processes in an organized, hierarchical approach that includes the following steps:

- Identifying EHS project hazards and associated risks as early as possible in the facility development or project cycle, including the incorporation of EHS considerations into the site selection process, product design process, engineering planning process for capital requests, engineering work orders, facility modification authorizations, or layout and process change plans.
- Involving EHS professionals, who have the experience, competence, and training necessary to assess and manage EHS impacts and risks and carry out specialized environmental management functions including the preparation of project or activity-specific plans and procedures that incorporate the technical recommendations presented in this document that are relevant to the project.
- Understanding the likelihood and magnitude of EHS risks, based on:
- a) The nature of the project activities, such as whether the project will generate significant quantities of emissions or effluents or involve hazardous materials or processes.
- b) The potential consequences to workers, communities, or the environment if hazards are not adequately managed, which may depend on the proximity of project activities to the people or environmental resources on which they depend.
- Prioritizing risk management strategies with the objective of achieving an overall reduction of risk to human health and the environment, focusing on the prevention of irreversible and/or significant impacts.
- Favouring strategies that eliminate the cause of the hazard at its source, for example, by selecting less hazardous materials or processes that avoid the need for EHS controls.
- When impact avoidance is not feasible, incorporating engineering and management controls to reduce or minimize the possibility and magnitude of undesired consequences, for example, with the application of pollution controls to reduce the levels of emitted contaminants to workers or environments.
- Preparing workers and nearby communities to respond to accidents, including providing technical and financial resources to effectively and safely control such events, and restoring workplace and community environments to a safe and healthy condition.
- Improving EHS performance through a combination of ongoing monitoring of facility performance and effective accountability.

The Environmental, Health, and Safety (EHS) General Guidelines (April 30, 2007) will be applicable for this Project.

IFC Thermal Power Plant Guideline

IFC's Sector specific EHS Guidelines for Thermal Power Plants (December 19, 2008) will apply for the project. This guideline includes information relevant to combustion processes fuelled by gaseous, liquid and solid fossil fuels and biomass and designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type (except for solid waste which is covered under a separate Guideline for Waste Management Facilities), with a total rated heat input capacity above 50-Megawatt thermal input (MWth) on Higher Heating Value (HHV) basis. It applies to boilers, reciprocating engines, and combustion turbines in new and existing facilities. Emissions guidelines applicable to facilities with a total heat input capacity of less than 50 MWth are presented in Section 1.1 of the General EHS Guidelines. Depending on the characteristics of the project and its associated activities (i.e., fuel sourcing and evacuation of generated electricity), readers should also consult the EHS Guidelines for Electric Power Transmission and Distribution. Any revision of this guidelines after finalisation would be followed for this project.

The development of an environmental assessment (EA) for a thermal power project should take into account any government energy and/or environmental policy or strategy including strategic aspects such as energy efficiency improvements in existing power generation, transmission, and distribution systems, demand side management, project siting, fuel choice, technology choice, and environmental performance.

The other relevant EHS guidelines related to the project is provided in ***Table 2.7:***

Table 2.7: Other relevant IFC EHS Guidelines

<table>
<tr><th>IFC EHS Guidelines*</th><th>Key Guidelines</th><th>Applicability</th></tr>
<tr><td>IFC EHS Guidelines for Gas Distribution Systems</td><td>

Prescribes recommendations for the common impacts arising from the project in the General EHS Guidelines.
The common impacts include noise and vibration caused by various HDD activities (diesel driven hydraulic drill drive and electricity generator, electrically driven spoil treatment plant for mechanical separation of solids from working fluid) and from handling of hazardous materials and waste which includes oil spills associated with heavy equipment operation and fuelling activities.
Recommends the use of guided / directional drilling for distribution pipeline installation, this reduces both terrestrial and aquatic habitats impact.
This industry specific guidelines suggests that the rights-of-way should avoid critical habitat, fish spawning habitat and critical fish over-wintering habitat, wherever possible and also use of existing utility and transport corridors.
Major recommended measures related to leakages in gas distribution systems leading to air emissions are as follows –

Gas pipelines and pipeline components should meet international standards or structural integrity and operational performance.
For underground application, it should be ensured that ferrous metal pipelines should be treated with cathodic protection technique for corrosion prevention. An alternative recommendation to this is polyethylene pipe.
Testing of pipelines for pressure specifications, presence of leak and corrosion detection should be undertaken prior to commissioning.
Pipelines, valves, and other component infrastructure should be regularly maintained, and provision of adequate ventilation and gas detection / alarm equipment in station buildings or vaults.

</td><td>The gas requirement would be supplied by Petro Bangla through Titas Gas Transmission and Distribution company using subsurface pipeline across the river by using Horizontal Directional Drilling (HDD). The use of HDD technique would reduce the impacts on both terrestrial and aquatic habitats. The project must integrate the IFC EHS Guidelines for Gas Distribution Systems</td></tr>
<tr><td>IFC EHS Guidelines for Electric Power Transmission and Distribution</td><td>The guidelines recommend the measures to prevent and control impacts to terrestrial habitats during construction and maintenance of the right-of-way:

The construction activities should avoid critical habitat and land clearing through the use of existing utilities and transport corridors for transmission and distribution, existing roads and tracks for approach roads and use of the existing vegetation whenever possible.
Scheduling activities to avoid the breeding, nestling and other sensitive seasons mainly for critically endangered or endangered wildlife species.
Regular maintenance of vegetation within the rights-of-way by controlling vegetation through checking the growth of tall trees and plant growth and implementation of integrated vegetation management approach (IVM) and to check ignition of bushes to avoid disruption to overhead power lines and towers.
Observing manufacturer machinery and equipment guidelines, procedures with regard to noise, and oil spill prevention and emergency response.
Electrocution can be avoided by 1.5 meter (60-inch) spacing between energized components and grounded hardware or, where spacing is not feasible, covering energized parts and hardware; installation of visibility enhancement objects such as marker balls, bird deterrents, or diverters.

Recommendations to manage the electric and magnetic field forces emitted by and surrounding any electrical device includes –

Evaluating potential exposure to the public against the reference levels developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)
Avoiding installation of transmission lines or other high voltage equipment above or adjacent to residential properties or other locations intended for highly frequent human occupancy (schools or offices)
In case the EMF levels are confirmed or expected to be above the recommended exposure limits, application of engineering techniques should be considered
</td><td>The project must integrate the IFC EHS Guidelines for Electric Power Transmission and Distribution while transmission of power through 400 kV Single Circuit Transmission Line to the nearest proposed grid substation of PGCB.</td></tr>
</table>

IFC EHS Guidelines*	Key Guidelines	Applicability
	The guidelines provide specification for the various hazardous materials (polychlorinated biphenyls (PCB), sulphur hexafluoride, fuels and wood preservatives) in use • Management of PCB includes replacement of electrical equipment containing PCB and disposal should involve facilities capable of safely transporting and disposing of hazardous waste containing PCB. In case of leakages appropriate removal and / or remediation measures should be implemented. • Use of alternatives to wooden poles by the cost and benefit studies. Landfill facilities should be capable of handling wastes that may have chemical leaching properties. • Pesticide use should be established as part of an Integrated Pest Management (IPM) strategy and a documented Pest Management Plan (PMP).	
IFC EHS Guidelines for Construction Materials Extraction	The recommendation for the major EHS issues associated with construction materials extraction that occur during the operational, construction, and decommissioning phases includes: • Dust emissions from drilling activities, processing equipment should be adequately controlled through dust extractors, collectors, filters and wet processing, or water spraying. • Adoption of mobile and fixed-belt transport and conveyors and limiting the drop height of falling materials. • Usage of electrically driven machines should be considered and fixing the speed limit for trucks. Adoption of sound barriers or noise containments. • Installation of sediment traps along water drainages, including fascines, silt fences, and vegetation traps. • Hazardous and non-hazardous waste management plans should be developed and adopted during the design and planning phase. Impacts associated with specific chemical and / or physical properties of extracted materials should be considered during the design phase, and impacts from waste rock impurities should be adequately controlled and mitigated by covering waste disposals with noncontaminated soil • During construction it should be ensured that the ecological niches be preserved and protected as far as possible.	The project would follow the IFC EHS Guidelines for Construction Materials Extraction during the construction phase.

Source:

** IFC EHS Guidelines for Gas Distribution Systems, April 2007*

IFC EHS Guidelines for Electric Power Transmission and Distribution, April 2007

IFC EHS Guidelines for Construction Materials Extraction, April 2007

2.4.4 Equator Principles 2020

The Equator Principle Financial Institutions (EPFI) provide Project Finance and Project-Related Corporate Loans to Projects that meet the requirements of Principles 1-10. The ten requirements of the Equator Principle Financial Institutions (EPFIs) correspond to the following parameters:

- **Principle 1 (Review and Categorisation):** When a Project is proposed for financing, this stage involves internal environmental and social review and due diligence, categorisation based on the magnitude of its potential environmental and social risks and impacts. Such screening is based on the environmental and social categorisation process of the International Finance Corporation (IFC). The categories are:

  Category A – Projects with potential significant adverse environmental and social risks and/or impacts that are diverse, irreversible or unprecedented.

  Category B – Projects with potential limited adverse environmental and social risks and/or impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures; and

  Category C – Projects with minimal or no adverse environmental and social risks and/or impacts.

  This principle has been duly incorporated in the report and the project categorisation has been done in Section 2.5 of the report.

- **Principle 2 (Environmental and Social Assessment):** For all Category A and Category B projects, the EPFI would require the client to conduct an Environmental & Social Impact Assessment (ESIA) process to address the relevant environmental and social risks and impacts of the proposed project. Human Rights impact assessment and climate change risk assessment are required to be addressed as part of the ESIA or other Assessment, included in the Assessment Documentation. Climate Change Risk Assessment would be required for Category A & Category B projects.

  Since this is a Category A project, the ESIA addresses all the environmental & social risks and impacts of the proposed project. In line with requirement of EP4, Climate Change Risk Assessment (CCRA) has been undertaken for the proposed project as the combined annual Scope 1 & 2 emissions are greater than 1,00,000 tonnes of CO_2 equivalent. The findings of the study are presented in **Appendix Q.** In the same line of requirement of Principle 2, Human Right Impact Assessment has been carried out and presented in ***Appendix R***.

- **Principle 3 (Applicable Environmental and Social Standards):** The Assessment process should address compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues followed by compliance with International Funding Agencies Environmental and Social Standards.

  The ESIA report duly complies with the requirements of Principle 3.

- **Principle 4 (Environmental and Social Management System and Equator Principles Action Plan):** For all Category A and Category B Projects, the EPFI would require the client to develop or maintain an Environmental and Social Management System (ESMS) which is further developed into an Environmental and Social Management Plan (ESMP); Where the applicable standards are not met to the EPFI's satisfaction, an Equator Principles Action Plan (EPAP) would be prepared to outline gaps and commitments to meet EPFI requirements in line with the applicable standards.

  An ESMP has been prepared based on environmental & social impact assessment. Also, as understood, an independent third-party ESDD has also been carried out based on which an ESAP has been prepared.

- **Principle 5 (Stakeholder Engagement):** For all Category A and Category B Projects, the EPFI would require the client to demonstrate effective Stakeholder Engagement as an ongoing process in a structured and culturally appropriate manner with affected communities and, where relevant, other stakeholders through an informed Consultation and Participation process to identify, assess and mitigate any social risks and impacts which may impact the decision-making process.

  A project specific Stakeholder Engagement Plan, in compliance with the requirement of Principle 5, has been prepared and provided in ***Appendix P.***

- **Principle 6 (Grievance Mechanism):** For all Category A and, as appropriate, Category B projects, the EPFI would require the client, as part of the ESMS, to establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance. The client would inform the affected communities about the mechanism in the course of the Stakeholder Engagement process.

  A project specific Grievance Redressal Mechanism has been designed in compliance with Principle 6 and the same is presented in Chapter 11 of this report.

- **Principle 7 (Independent Review):** A) Project Finance: For all Category A and, as appropriate, Category B projects, an Independent Environmental and Social Consultant, not directly associated with the client, would carry out an Independent Review of the Assessment Documentation including the ESMPs, the ESMS, and the Stakeholder Engagement process documentation in order to assist the E'FI's due diligence, and assess Equator Principles compliance.

  As understood from Client, an independent Environmental & Social Due Diligence (ESDD) by third-party E&S consultant has already been conducted and the ESAP has been formulated.

- **Principle 8 (Covenants):** For all Projects, the client would covenant in the financing documentation to comply with all relevant host country environmental and social laws, regulations and permits in all material respects.

  This ESIA report complies all the E&S requirements as specified above.

- **Principle 9 (Independent Monitoring and Reporting):** Project Finance: To assess project compliance with the Equator Principles and ensure ongoing monitoring and reporting after Financial Closure and over the life of the loan, the EPFI would , for all Category A and, as appropriate, Category B Projects, require the appointment of an Independent Environmental and Social Consultant, or require that the client retain qualified and experienced external experts to verify its monitoring information which would be shared with the EPFI.

Independent E&S monitoring of the ESIA/ESMP and ESAP implementation would be undertaken by third party E&S consultant during implementation stage.

- **Principle 10 (Reporting and Transparency):** For all Category A and, as appropriate, Category B Projects: - The client would ensure that, at a minimum, a summary of the ESIA is approachable and available online; and the client would publicly report GHG emission levels

  This ESIA report includes an executive summary and quantified GHG emissions, both during construction and operation phase of the project in line with requirements of Principle 10. UMPL would publish the same once approved.

2.5 Project Classification and Categorisation

2.5.1 DOE, Ministry of Environment & Forest, Bangladesh

The proposed 600-Megawatt (MW) gas based combined cycle Unique Meghnaghat power plant project is likely to have significant adverse environmental and social impacts that may be irreversible, cumulative, diverse or unprecedented, and the impacts may be short-term or long-term in nature; and may affect an area larger than the site or facilities. An Environmental Impact Assessment (EIA) with subsequent Environmental Management Plan (EMP) has, therefore, been carried out for this project as per the requirement of DOE for obtaining Environmental Clearance.

Depending upon location, size and severity of pollution loads, projects/ activities have been classified in the ECR, 1997 into four categories: Green, Orange A, Orange B and Red, respectively, to nil, minor, medium and severe impacts on important environmental components (IECs).

As per the Schedule-1 of the ECR 1997, corresponding category related to power plants fall under Red Category for the following component:

- Item 6: power plants

2.5.2 Project Classification as per AIIB ESS, IFC PS

The classification of the proposed project as per AIIB's Project Categorization criteria, IFC's Environmental and Social Performance Standards is presented below

Project Classification as per AIIB ESS	Project is categorized as 'A', as it is likely to have significant adverse environmental and social impacts that are irreversible, cumulative, diverse or unprecedented.
Applicability of AIIB ESS	1. ***AIIB ESS 1: Environmental and Social Assessment and Management*** is applicable for the proposed project as the project is required to ensure their Environmental and Social assessment and management measures are proportional to project risks and impact 2. ***AIIB ESS 2: Involuntary Resettlement*** is applicable for the project. Although the project land is procured by 'willing buyer and willing seller' method, there are 90 landowners who have become agriculturally landless. Apart from that 60-fisherman family and 18 land dependents have also been impacted due to land procurement. Safeguard requirement regarding indigenous people would not be applicable to present project as primary survey and FGD carried out by AECOM confirm that none of the project affected people belongs to indigenous people category. Primary data shows that all belong to Bengali Muslim population. Apart from that, as per Population and Housing Census 2011, indigenous people are not present with in the AOI.
Project Classification as per IFC	The proposed project is anticipated to usher some irreversible environmental and social impacts and categorised as A as per IFC's Environmental and Social Screening Criteria
Project Classification as per Equator Principles 2020	The proposed project falls under Category A as per Equator Principles 2020 as it is envisaged to have potential significant adverse environmental and social risks and/or impacts that are diverse, irreversible or unprecedented.
Project Classification as per AIIB ESS, IFC PS	The categorization of the proposed project based on the **The applicable Environmental and Social Standards (ESS) of AIIB:** 1. ***AIIB ESS 1: Environmental and Social Assessment and Management*** is applicable for the proposed project as it the project is required to ensure their Environmental and Social assessment and management measures are proportional to project risks and impact are implemented

2. ***AIIB ESS 2: Involuntary Resettlement*** is applicable for the project as despite the project land is procured by willing buyer and willing seller method, there are 90 landowners who have become agriculturally landless. Apart from that 60-fisherman family and 18 land dependents have also been impacted due to land procurement.

IFC's Environmental and Social Screening Criteria: *Category A*

As the proposed project is anticipated to usher some irreversible environmental and social impacts.

Equator Principles 2020 Categorization: *Category A*

The proposed project is envisaged to cause diverse, irreversible or unprecedented effects.

2.5.3 Applicable National and International Environmental Standards

The project would comply with Bangladesh environmental, health and safety laws, GoB Environmental Conservation Rule 1997, World Bank Group Guidelines, and World Bank Group requirements regarding air emissions 2008. Therefore, the EHS standards as specified in ECR 1997 and its subsequent amendments along with the IFC EHS guidelines (General and Thermal Power Plant specific) for air quality, surface and ground water quality, ambient noise levels, emissions and effluent discharge would be applicable for the project. During the design, construction, and operation of the project, the project proponent would apply pollution prevention and control technologies and practices consistent with international good practice, according to the standards of World Bank Group's Environment, Health and Safety Guidelines. For this project the IFC EHS Guidelines are recommended.

The relevant environmental standards of GoB (national) and international standards for thermal power plant (IFC/WB, WHO etc) as applicable for the proposed Project are presented in the following tables. The project has been designed to comply with national/International norms, whichever is more stringent.

Table 2.8: Air Emission Standards/ Guidelines

Parameter	Unit	Bangladesh*	IFC**
PM_{10}	mg/Nm^3	150	50 (liquid fuel)
		-	N/A (natural gas)
SO_2		- (1)	Use less than 0.5% sulphur fuel (liquid fuel)
		-	N/A (natural gas)
NO_x	mg/Nm^3	30 ppm	51 (25 ppm) – natural gas
Dry Gas, Excess	%		15 (natural gas)

(1) In Bangladesh, SO_2 concentration in gas emissions is not regulated by law, except regulations concerning stack heights.
** Schedule 11 (Standards for Gaseous Emission from Industries or Projects) of the Environmental Conservation Rules, 1997.*
*** Emission Guidelines for Combustion Turbines, WB/IFC EHS Guidelines for Thermal Power Plants, 2008.*

Table 2.9: Ambient Air Quality Standards/ Guidelines

Parameters	Bangladesh		WHO Guideline values	
	24 hourly ($\mu g/m^3$)/8 hourly ($\mu g/m^3$)	Annual ($\mu g/m^3$)	24 hourly ($\mu g/m^3$)/8 hourly ($\mu g/m^3$)	Annual ($\mu g/m^3$)
SPM*	200	-	-	-
PM_{10}	150	50	50 (guideline)	20 (guideline)
$PM_{2.5}$	65	15	25 (guideline)	10 (guideline)
SO_2	365	80	20 (guideline)	--
NO_x	-	100		
NO_2	-	-	NO_2 200 (1 hourly) (guideline)	NO_2 40 (guideline)
CO*	10,000	-	10,000	-
Ozone	157		100	-
Lead	-	0.5	-	-

** SPM, CO, Ozone concentrations and standards are 8-hourly only.*

*** The Bangladesh National Ambient Air Quality Standards have been taken from the Environmental Conservation Rules, 1997 which was amended on [1]9th July 2005 vide S.R.O. No. 220-Law/2005.*

**** WHO Ambient Air Quality Guideline Values (2005 and 2000), which are also being referred in the World Bank and IFC's General EHS Guidelines (2007)*

Table 2.10: Effluent Standards/ Guidelines

Parameter	Unit	Bangladesh*	IFC**
pH	-	6-9	6-9
Total Suspended Solids (TSS)	mg/l	150	50
Oil and grease	mg/l	10	10
BOD5 at 20°C	mg/l	50	-
Chromium (total)	mg/l	0.5	0.5
Copper	mg/l	0.5	0.5
Iron	mg/l	2.0	1.0
Zinc	mg/l	5.0	1.0
Lead	mg/l	0.1	0.5
Cadmium	mg/l	0.5	0.1
Mercury	mg/l	0.01	0.005
Arsenic	mg/l	0.2	0.5
Temperature increases at the edge of the mixing zone	°C	400C (Summer) 450C (Winter)	Site specific requirement to be established by the EA.
Ammonical Nitrogen (as elementary N)	mg/l	50	
Ammonia (as free ammonia)	mg/l	5	
Boron	mg/l	2	
Cadmium	mg/l	0.50	
Chloride	mg/l	600	
COD	mg/l	200	
Chromium (as hexavalent Cr)	mg/l	0.1	
Dissolved Oxygen (DO)	mg/l	4.5-8	
Electro-conductivity (EC)	micromho/cm	1200	
Total Dissolved Solids	mg/l	2100	
Fluoride (as F)	mg/l	2	
Sulphide (as S)	mg/l	1	
Total Kjeldahl Nitrogen (as N)	mg/l	100	
Manganese (as Mn)	mg/l	5	
Nickel (as Ni)	mg/l	1.0	
Nitrate (as elementary N)	mg/l	10.0	
Phenolic Compounds (as C_6H_5OH)	mg/l	1.0	
Dissolved Phosphorus (as P)	mg/l	8	
Selenium (as Se)	mg/l	0.05	
Total Dissolved Solids	mg/l	2100	
Cyanide (as Cn)	mg/l	0.1	

** Schedule 10 (Standards for Waste from Industrial Units or Projects Waste) of the Environmental Conservation Rules, 1997.*

*** Effluent Guidelines, IFC EHS Guidelines for Thermal Power Plants, 2008.*

Table 2.11: Standards for Sewage Discharge

Parameter	Unit	Standard Limit (Bangladesh)*	WB Guideline Values**
BOD	mg/l	40	30
Nitrate	mg/l	250	-
Phosphate	mg/l	35	-
Suspended Solid	mg/l	100	50
Temperature	°C	30	-
Coliform	No./100 ml	1000	400
pH	-	-	6-9
COD	mg/l	-	125
Oil & Grease	mg/l	-	10
Total Nitrogen	mg/l	-	10
Total Phosphorus	mg/l	-	2

** Schedule 9 (Standards for Sewage Discharge) of the Environmental Conservation Rules, 1997*

*** Guideline Values for treated Sanitary sewage Discharge, IFC's General EHS Guidelines (2007)*

Table 2.12: Noise Level Standards/ Guidelines

Category of Area/ Receptor	Bangladesh		WHO** and IFC***	
	Day [dB(A)] 6.00 am -10 .00 pm	Night [dB(A)] 10.00 pm – 6.00 am	Day [dB(A)] 7.00 am – 10.00 pm	Night [dB(A)] 10.00 pm – 7.00 am
Silent Zone	50	40	55	45
Residential Area	55	45	55	45
Mixed Area	60	50	-	-
Commercial Area	70	60	70	70
Industrial Area	75	70	70	70

**The Bangladesh National Ambient Noise Standards have been taken from Schedule 4 (Standards for Sound) of the Environmental Conservation Rules, 1997 amended on September 7, 2006.*

*** Guidelines values are for noise levels measured out of doors. Source: Guidelines for Community Noise, World Health Organization (WHO), 1999.*

**** As per IFC EHS noise level guidelines, Noise impacts should not exceed the levels presented in the above table or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.*

In addition to the above, working noise limits for which noise protection PPE is to be provided to workers would be 85 dB(A) for an exposure duration of 8 hours per day. For every 3 dB(A) increase in sound levels, the 'allowed' exposure period or duration should be reduced by 50 percent (The American Conference of Governmental Industrial Hygienists (ACGIH), 2006). The norms related to Industrial area would be applicable within the proposed UMPL Plant boundary, whereas beyond the Plant boundary, where there are human receptors in community settlements, the Residential area norms would be desirable.

Drinking water standard specified in Schedule 3 of the Bangladesh Environment Conservation Rules, 1997 and WHO drinking water guidelines is provided in ***Table 2.13***

Table 2.13: Drinking water Standards/ Guidelines

Parameter	Unit	Bangladesh Standard*	WHO guidelines
Aluminium (Al)	mg/L	0.2	Not considered
Ammonia	mg/L	0.5	Not considered
Arsenic (As)	mg/L	0.05	0.01
Barium (Ba)	mg/L	0.01	1.3
Cadmium (Cd)	mg/L	0.005	0.003
Calcium (Ca)	mg/L	75	--

Parameter	Unit	Bangladesh Standard*	WHO guidelines
Chloride	mg/L	150-600	Not considered
Colour	Hazen	15	
Copper (Cu)	mg/L	1.0	2
Cr (Total)	mg/L	0.05	0.05
Fluoride	mg/L	1.0	1.5
Hardness	mg/L	200-500	--
Iron (Fe)	mg/L	0.3-1	Not considered
Magnesium (Mg)	mg/L	30-35	--
Manganese (Mn)	mg/L	0.1	Not considered
Nickel (Ni)	mg/L	0.1	0.07
Nitrogen (Nitrate)	mg/L	10.0	50
Odour	Odourless	Odourless	--
Sulphate	mg/L	400	Not considered
Zinc (Zn)	mg/L	5.0	Not considered
Boron (B)	mg/L	-	2.4
Phosphorus (P)	mg/L	-	--
Lead (Pb)	mg/L	-	0.01
Mercury (Hg)	mg/L	-	0.006
pH value	-		Not considered
Total Dissolved Solids (as TDS)	mg/l	1000	---
Benzene	mg/L	0.01	0.01
BOD, 5 days, 20 ^{0}C	mg/L	0.2	--
Chlorinated alkanes carbon tetrachloride	mg/l	0.01	0.004
1.1 dichloroethylene	mg/l	0.001	0.03
1.2 dichloroethylene	mg/l	0.03	0.05
tetrachloroethylene	mg/l	0.03	0.04
trichloroethylene	mg/l	0.09	20 (P)
Chlorinated phenols - pentachlorophen–l - 2.4.6 trichlorophenol	mg/L	0.03	0.2 (C)
Chlorine (residual)	mg/L	0.2	0.5 – 1.5
Chloroform	mg/L	0.09	0.3
Chromium (hexavalent)	mg/L	0.05	0.05
COD	mg/L	4	--
Coliform (faecal)	n/100 ml	0	--
Coliform (total)	n/100 ml	0	Absent
Cyanide	mg/L	0.1	--
Detergents	mg/L	0.2	--
DO	mg/L	6	--
Kjeldahl Nitrogen (total)	mg/L	1	--
Nitrite	mg/L	□1	3
Oil and grease	mg/L	0.01	--
Phenolic compounds	mg/L	0.002	--
Phosphate	mg/L	6	--
Potassium	mg/L	12	--
Radioactive materials (gross alpha activity)	Bq/l	0.01	--
Radioactive materials (gross beta activity)	Bq/l	0.1	--
Selenium	mg/l	0.01	0.04
Silver	mg/L	0.02	--

Parameter	Unit	Bangladesh Standard*	WHO guidelines
Sodium	mg/L	200	40
Suspended particulate matters	mg/L	10	--
Sulphide	mg/L	0	--
Temperature	^{0}C	20-30	--
Tin	mg/l	2	--
Turbidity	NTU	4	0–3 - 1.0

2.6 Applicable IFC / EBRD Standards for Worker's Accommodation

The relevant IFC / EBRD Standards for worker's accommodation addresses the processes and standards that should be applied to establish, maintain and improve the worker-management relationship, to promote fair treatment, non-discrimination and equal opportunity of workers, and to promote safe and healthy working conditions of workers. The planning and assessing requirements for workers' accommodation is carried out in three stages:

1. **Assessing the need for workers' accommodation:** This includes guidelines to approach the local housing and labour markets and the potential effects the building of new facilities may have on the surrounding communities by considering a comprehensive assessment of the availability of workforce and existing housing. The measures to mitigate adverse impacts should be identified and included in the relevant action plans.
2. **Assessing impacts of workers' accommodation on communities:** This assessment is relevant to both the construction phase (or other accommodation) and operation phase. The construction of workers' accommodation and its Impacts on communities should be managed in the same way as for construction of the project itself. The impact of the presence of workers with different lifestyles or cultural backgrounds on the host community and also the transmission of disease due to the influx needs to be assessed and managed.
3. **Types of workers' accommodation:** Depending on the type of project, specific attention should be given to either providing single workers' accommodation or family accommodation. As per the benchmark practices, the family of the workers should be also accommodated, particularly when workers are sourced from outside.

The relevant applicable standards for management of workers' accommodation are presented in ***Table 2.14***

Table 2.14: IFC / EBRD Standards for and management of Workers' Accommodation

Guidelines	Key Points of Guidelines
Standards for Workers' Accommodation	
National / Local Standards	Under this guideline the general relevant construction standards to be followed for building labour accommodations includes standards for building construction, housing and public housing, general health, safety and security, fire safety and electricity, plumbing and for water and sanitation.
General living facilities	The living facilities should be maintained to avoid safety hazards and to protect workers from diseases and/or illness resulting from humidity, bad/stagnant water (or lack of water), cold, spread of fungus, proliferation of insects or rodents, as well as to maintain a good level of morale. Under the general living facilities, the guideline specifies – 1. The provision of adequate drainage facilities to protect labours from potential diseases arising from stagnant water. 2. The accommodation facility should have proper heating, air-conditioning and ventilation as per the appropriate climatic condition with the provision of window area more than 5% to 10% of the floor area. 3. Potable water facility should be present with the quality maintained as per the provisions specified to meet local or WHO drinking water standards. 4. Wastewater treatment and effluent discharge as well as solid waste treatment and disposal must comply with local or World Bank effluent discharge standards and should be adequately designed to prevent contamination of any water body, this will subsequently ensure hygiene and avoid the spread of infections and diseases, the proliferation of mosquitoes, flies, rodents, and other pest vectors.
Room/dormitory facilities	The guidelines recommend following certain benchmark facilities which include – proper ventilation facilities and ensuring overcrowding is avoided, the rooms should be built with easily cleanable flooring material which are to be cleaned at regular intervals and there should be provision of separated sanitary facilities for men and women. As per the benchmark there should be a minimum space of 1 m between the beds and triple deck bunks are prohibited. The benchmark states the density standards to be expressed either in terms of minimal volume per resident or of minimal floor space with the usual standards ranges from 10 to 12.5 cubic metres (volume) or 4 to 5.5 square metres (surface).

Guidelines	Key Points of Guidelines
Sanitary and toilet facilities	As per the benchmark practices mention–d - the sanitary and toilet facilities are to be constructed with materials that are easily cleanable and cleaned at regular intervals to ensure maintenance of personal hygiene and to prevent contamination and the spread of diseases. It should be ensured that sanitary and toilet facilities are not shared between men and women, except in family accommodation. An adequate number of toilets should be provided to workers which would be easily approachable. The standards range for toilets and showers are from 1 unit to 15 persons to 1 unit per 6 persons. For urinals, usual standards are 1 unit to 15 persons.
Canteen, cooking and laundry facilities	Good standards of hygiene in canteen/dining halls and cooking facilities are crucial. Adequate canteen, cooking and laundry facilities and equipment should also be provided. When caterers are contracted to manage kitchens and canteens, special attention should be paid so that adequate reporting and monitoring mechanisms are in place. When workers can individually cook their meals, they should be provided with a space separate from the sleeping areas. Facilities must be kept in a clean and sanitary condition. In addition to this, canteen, kitchen, cooking and laundry floors, ceilings and walls should be made of easily cleanable materials.
Standards for nutrition and food safety	The WHO 5** keys to safer food or an equivalent process should be implemented. It should be ensured that the food provided to the workers contains an appropriate level of nutrition value and also considers religious/cultural backgrounds
Medical facilities	Adequate first aid kits with trained staffs should be made available. Where possible and depending on the medical infrastructures existing in the community, other medical facilities are provided (nurse rooms, dental care, minor surgery).
Leisure, social and telecommunication facilities	Accommodation should include basic collective social/rest spaces to workers with standards range from providing workers multi-purpose halls to providing designated areas for radio, TV and cinemas. Provision of dedicated places for religious observance if the context warrants.
Managing Workers' Accommodation	
Management and staff	As per the benchmarks provided in the guidance, if the facility is being managed by a contractor, as is often the case, the expected housing and management standards should be specified in the relevant contract, and mechanisms to ensure that those standards are implemented should be set up. As part of this process, the accommodation manager (or contractor) should have a duty to monitor the application of the accommodation standards and to report frequently on their implementation to the client.
Charging fees for accommodation and services	As per the guidelines, any charges should be transparent, discussed during recruitment and specified in workers' contracts. The charges levied on the workers, should be such as to leave workers with sufficient income and should never lead to a worker becoming indebted to an employer.
Health and safety on site	The company or body in charge of managing the workers' accommodation should have the prime responsibility for ensuring workers' physical well-being and integrity. This involves making sure that the facilities are kept in good condition (ensuring that sanitary standards or fire regulations are respected for instance) and that adequate health and safety plans and standards are designed and implemented.
Security of workers' accommodation	As per the guidelines a security plan including clear measures to protect workers against theft and attack is implemented. Particular attention should be paid to the safety and security of women workers. Security staff should have a good understanding about the importance of respecting workers' rights and the rights of the communities.
Workers' rights, rules and regulations on workers' accommodation	The guideline recognizes the freedoms and human rights of workers and the accommodation should have non-discriminatory and reasonable rules and regulations prepared on consultation with the workers' representatives. As per the best management practices, workers' gender and religious, cultural and social backgrounds should be respected. In particular, workers should be provided with the possibility of celebrating religious holidays and observances. The workers should be made aware of their rights and obligations, and it should be ensured that restriction of workers' freedom of movement to and from the site be limited and duly justified.
Consultation and grievance mechanisms	All residents should be made aware of any rules governing the accommodation and the consequences of breaking such rules. As per the best practices a mechanism for workers' consultation should be designed and implemented, and also to set up a review committee to include representatives elected by workers. Processes should be implemented to allow consultation between site management and the resident workers for smooth running of an accommodation site. In cases of serious offences including serious physical or mental abuse, there should be provision of mechanisms to ensure full cooperation with the police authority (where adequate).
Management of community relations	As per the guidelines, the workers' living facilities can have various ongoing impacts on adjacent communities. To manage these impacts, a thorough community relations management plan should be designed, which would contain processes to implement the findings of the preliminary community impact assessment and to identify, manage, mitigate or enhance ongoing impacts of the workers' accommodation on the surrounding communities.

Source:

** Workers' accommodation: processes and standards. A guidance Note by IFC and the EBRD*

*** World Health Organization, Food Safety: www.who.int/foodsafety/publications/consumer/en/5keys_en.pdf*

3 Project Description

The Project Description sets out the scope of the Project features and activities, with particular reference to the aspects which have the potential to impact the physical, biological and socio-economic environment. Details of the Project facilities' design characteristics, as well as planned and unplanned Project activities, are provided in the subsequent sections based on the detailed Project Feasibility Report prepared by Tractebel in May 2019. The proposed 600 MW RLNG based Combined Cycle Power Plant (CCPP) project would be developed on Build, Own and Operate (BOO) basis for 22 years term with a construction period for 3 years for net output 588.31 MW. However, the EPC Contractor has pitched for a life of minimum 30 years. Power plant would consist of heavy duty, advanced class gas turbines, matching heat recovery steam generator (HRSG), steam turbine generator with all integral auxiliary equipment. The preferred unit configuration for the project would consist of a power block of 600 MW with HRSG, one steam turbine and two generators.

Gas would be supplied by Petro Bangla through Titas Gas Transmission and Distribution company by using subsurface pipeline. Power would be evacuated through 400 kV Single Circuit Transmission Line to the nearest proposed grid substation of PGCB.

3.1 Project Location

The proposed project site for 600MW gas fired Combined Cycle Power Plant (CCPP) by UMPL is located in Dudhghata Mouza of Pirojpur Union, Sonargaon Upazila, Narayanganj District, Bangladesh. Regional setting map of the project site is presented in ***Figure 3.1.*** The site is about 1.46 km from Dhaka-Chattogram highway to the south-west, about 3.49 km south-west of the Sonargaon Upazila headquarter and about 3.28 km away from Mograpara bus stand by road. The distance from Dhaka zero point to project site is approximately 27.3 kilometres.

The project site is situated on the right bank of the branch channel of Meghna River. The geographical location of the proposed project site lies between 23'37'4"57"N; 90'35'19"23"E and 23'36'53"20"N; 90'35'34"55"E. Project site on satellite imagery is presented in ***Figure 3.1.*** A total of 21.07 acres land has been purchased from Dudhghata Mouza. The detail of land is presented in ***Table 3.1*** and the project location on revenue map is presented in ***Figure 3.2.***

Table 3.1: Details of the project land

District	Upazila	Mouza	Khatian (/Record of rights (RS)	Daag/Plot Number (RS2)	Type of land	Total Area (acres)
Narayanganj	Sonargaon	Dudhghata	201,68,322,302,142,366,107,107,37,400,40,20,205,03,265,330,298,347,111,359,65,179,316,175,50,41,124,309,349,381,347,381,60,350,213,31,346,60,155,144,01,227,309,15,09,97,41,309,174,175,33,363,391,340,372,206,285,340,145,380,352,309	725,726,727,728,729,730,731,732,733,734,735,736,737,738,739,740,741,742,743,744,745,746,747,748,749,750,751,752,753,754,755,756,757,758,759,770,771,772,773,774,775,776,777,778,779,780,781,782,783,784,785,786,787,788,789,790,791,792,793,794,795,796,797,798,799,800,801,802,803,804,805,806,807,808,809,810,811,812,813,814,815,816,817,818,819,820,821.	Agricultural land and Fellow Land	21

Source: Detailed Project Feasibility Report

[2] *Revenue survey*

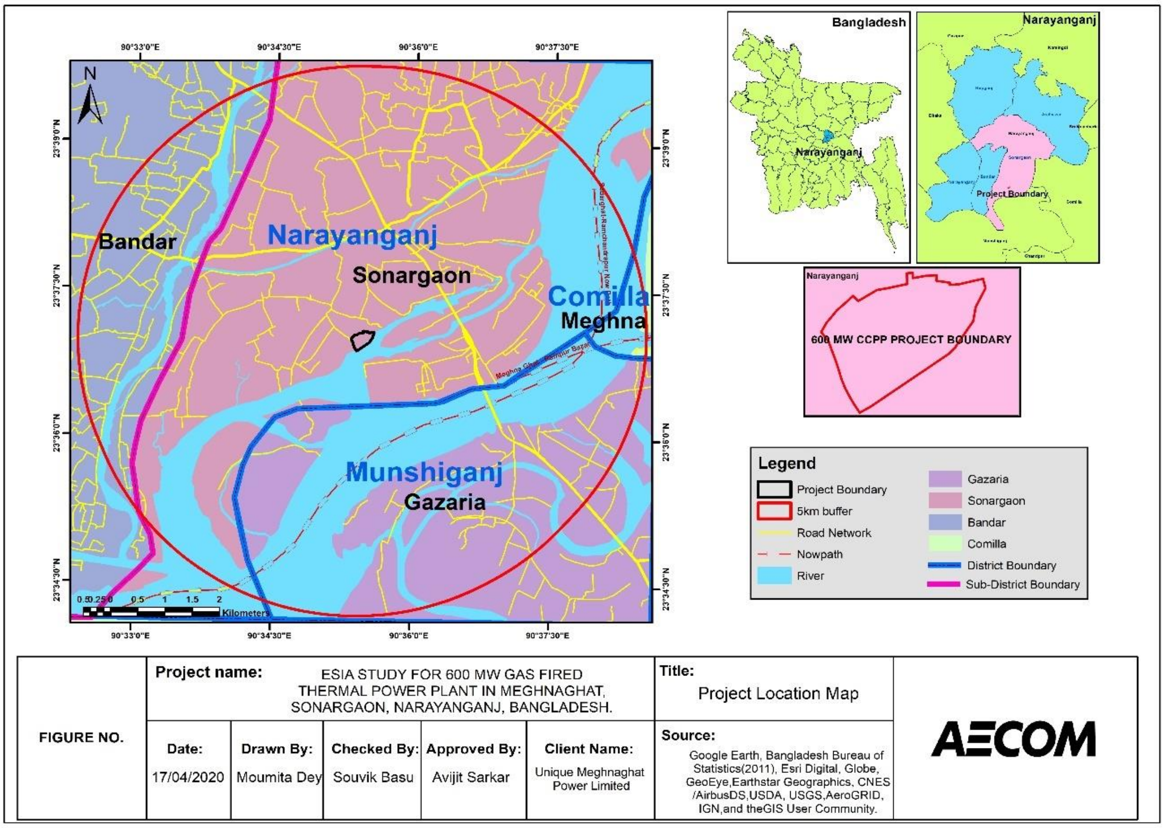


Figure 3.1: Regional Setting Map

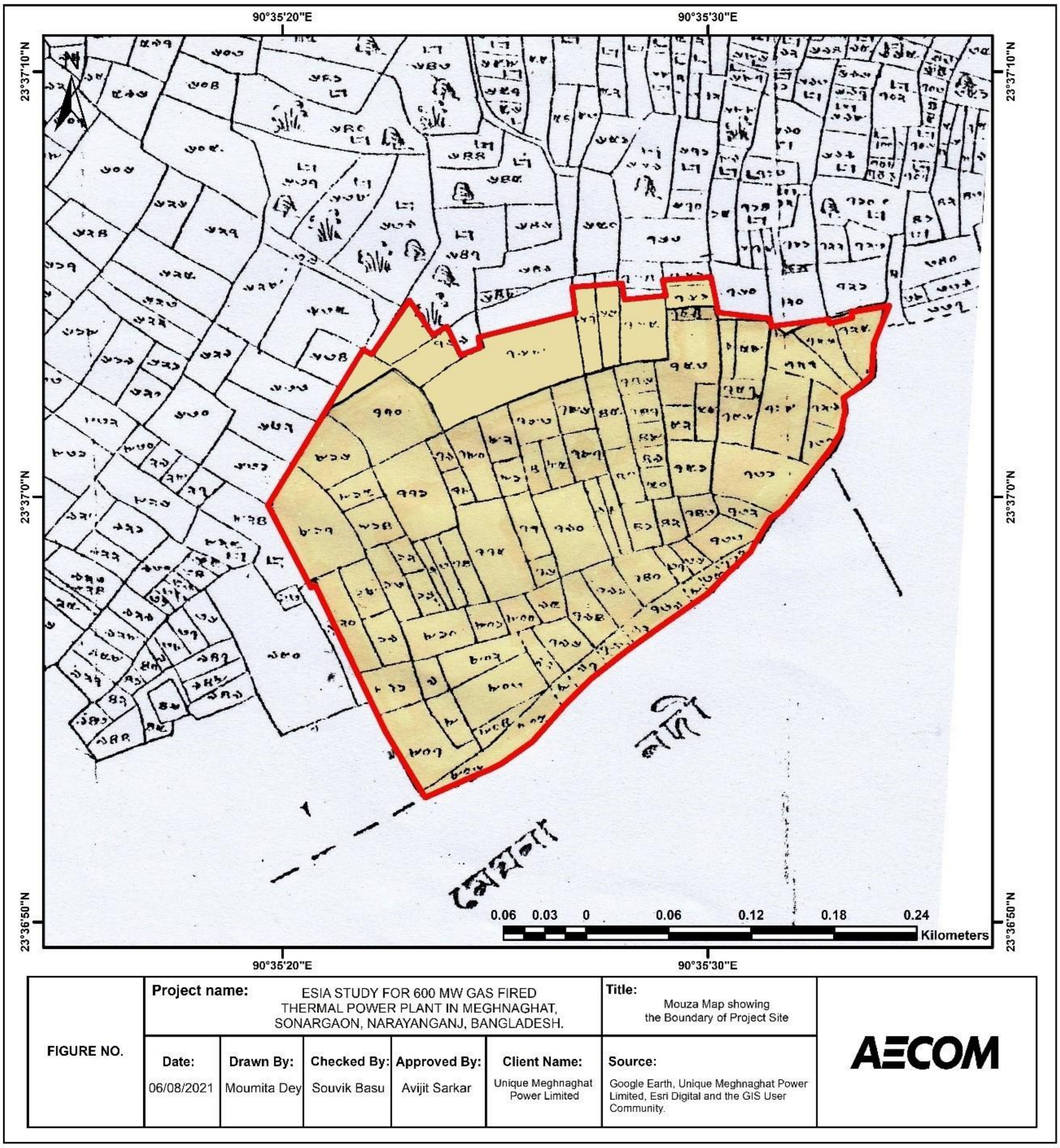


Figure 3.2: Project Location on Revenue Map

The project also consists of two temporary jetties (operational during construction period only), transmission line, water intake channel, gas pipeline and the construction camp with treated sewage pipeline (operational during construction period only). The location of these project components & the Associated facility and their terminal coordinates are presented in ***Figure 3.3.***

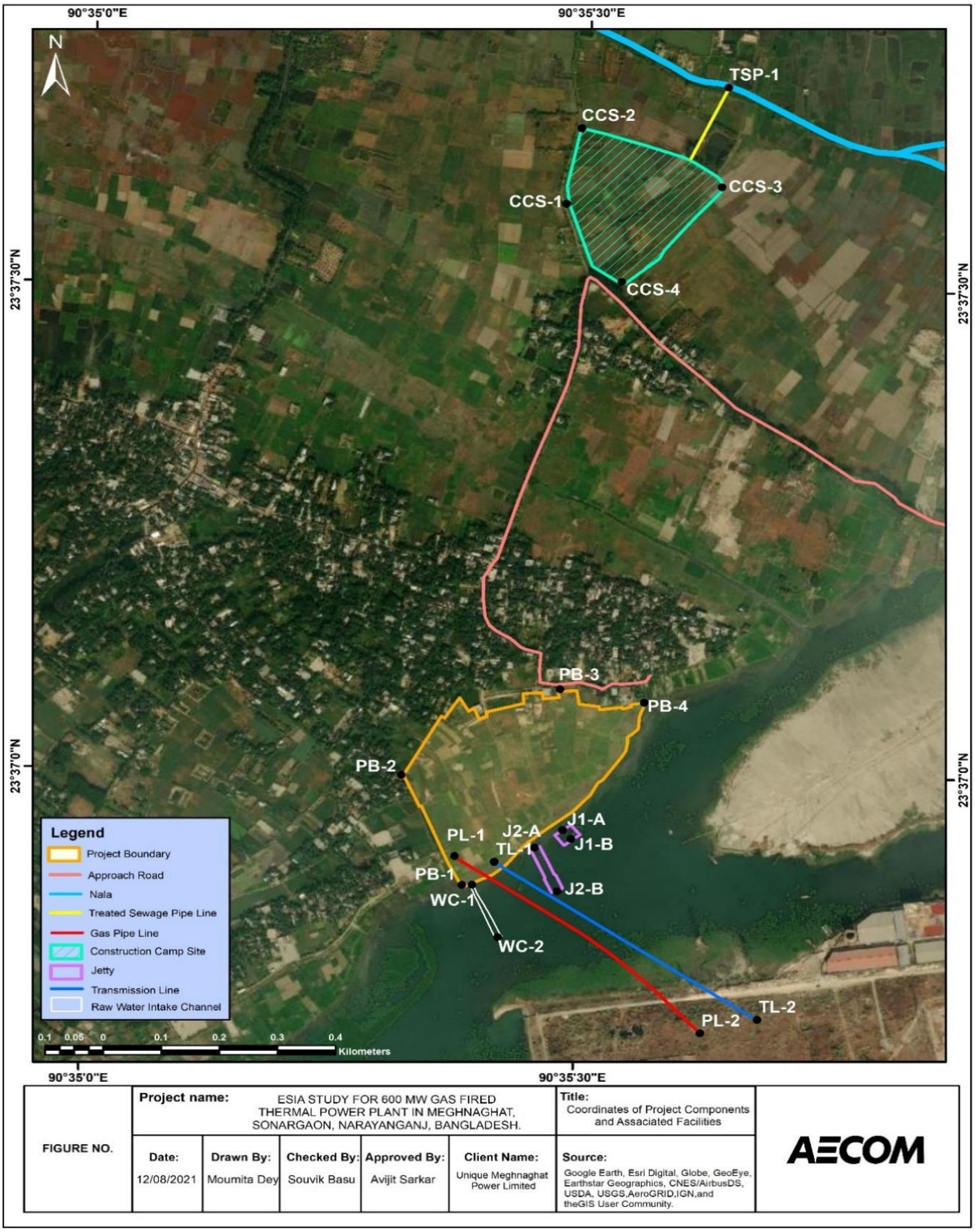


Figure 3.3: Project Location of Project components

Table 3.2: Coordinates of Project components

Sr. No.	Name	Representation	Latitude	Longitude
1	Construction Camp Site	CCS-1	23° 37' 35.149" N	90° 35' 28.957" E
2	Construction Camp Site	CCS-2	23° 37' 39.831" N	90° 35' 29.779" E
3	Construction Camp Site	CCS-3	23° 37' 36.312" N	90° 35' 38.367" E
4	Construction Camp Site	CCS-4	23° 37' 30.379" N	90° 35' 32.400" E
5	Project Boundary	PB-1	23°'36' 53."36" N	90°'35' 23."58" E

Sr. No.	Name	Representation	Latitude	Longitude
6	Project Boundary	PB-2	23°'36' 59."73" N	90°'35' 19."69" E
7	Project Boundary	PB-3	23°'37' 5."05" N	90°'35' 29."98" E
8	Project Boundary	PB-4	23°'37' 4."51" N	90°'35' 34."19" E
9	Jetty_1	J1-A	23°'36' 56."72" N	90°'35' 28."58" E
10	Jetty_1	J1-B	23°'36' 56."09" N	90°'35' 29."61" E
11	Jetty_1	J1-C	23°'36' 56."51" N	90°'35' 30."13" E
12	Jetty_1	J1-D	23°'36' 55."67" N	90°'35' 29."63" E
13	Jetty_2	J2-A	23°'36' 55."68" N	90°'35' 27."97" E
14	Jetty_2	J2-B	23°'36' 55."07" N	90°'35' 28."01" E
15	Jetty_2	J2-C	23°'36' 52."57" N	90°'35' 29."83" E
16	Jetty_2	J2-D	23°'36' 52."91" N	90°'35' 28."72" E
17	Transmission Line	TL-1	23°'36' 54."98" N	90°'35' 25."92" E
18	Transmission Line	TL-2	23°'36' 44."87" N	90°'35' 41."18" E
19	Gas Pipeline	PL-1	23°'36' 54."17" N	90°'35' 22."74" E
20	Gas Pipeline	PL-2	23°'36' 44."10" N	90°'35' 37."64" E
21	Water Channel	WC-1	23°'36' 53."62" N	90°'35' 23."72" E
22	Water Channel	WC-2	23°'36' 49."47" N	90°'35' 25."93" E
23	Treated sewage pipeline	TSP -1	23° 37' 42.478" N	90° 35' 38.666" E

3.2 Site Accessibility

The Dhaka-Chittagong highway is the arterial road for the project site and the Meghnaghat Industrial Area. The approach road to the site is a village metal road connecting Dhaka-Chittagong Highway to Dudhghata More. Proposed construction labour camp site is located just beside this road before reaching Dudhghata More.

The road is maintained by the Local Government Engineering Department (LGED), Govt. of Bangladesh. The project intends to use the existing road of length 780m for carrying construction materials and ferrying personnel from the campsite/laydown area to the project site. For heavy equipment & machinery for plant erection, UMPL would use the waterway as main means of transportation.

Initially, based on letter dated 19 Sept. 2019 from local Member of Parliament to Ministry of Local Government Engineering Department (LGED) of the Government of Bangladesh, LGED had planned to execute road widening from 2.5-3 m to 5 m for welfare of local villagers.

Before execution of the work by LGED, land survey was carried out by govt surveyor to identify the available ROW of the road and additional land requirement and based on the survey, LGED had marked the proposed ROW of the road. After marking the ROW, it was found that exiting structures/trees of roadside residence were coming within the proposed ROW and needed to be removed before widening. Additionally, roadside residents also claimed that not only structure, but additional land was also belonging to them, and they needed compensation for that in addition to compensation of damaged structures. Though LGED has claimed that existing ROW of the road is wider than the actual paved surface of the road and as local community who resided along the road had encroached the ROW of the road, they have no provision to pay any compensation on ground of additional land requirements and structure damage.

To resolve this conflict between LGED and affected persons and remove obstruction in road widening activity, local Member of Parliament (MP) verbally requested UMPL to pay compensation to the affected households as UMPL would also get benefited from road widening activity.

Reportedly, after detailed deliberation in UMPL Management, they decided to help affected persons by paying off their losses for widening of the road as UMPL was also planning to use this road for transportation of construction materials and workers from the laydown area to plant site and it would help them in the future to accommodate increase in traffic due to the project. UMPL management decided to pay this amount to the affected persons under their corporate social responsibility.

However, as suggested by lenders in the latter stage of the project, this approach road was considered as an associated facility of the proposed power plant and UMPL had to pay compensation to the impacted household due to road widening as per the market price. Based on this understanding, AECOM had commissioned a fresh assessment of the approach road widening issue. It was found from the assessment (digital survey of land parcel and household survey and focus group discussion) that in few stretches of the road, private land was also used for widening of the road.

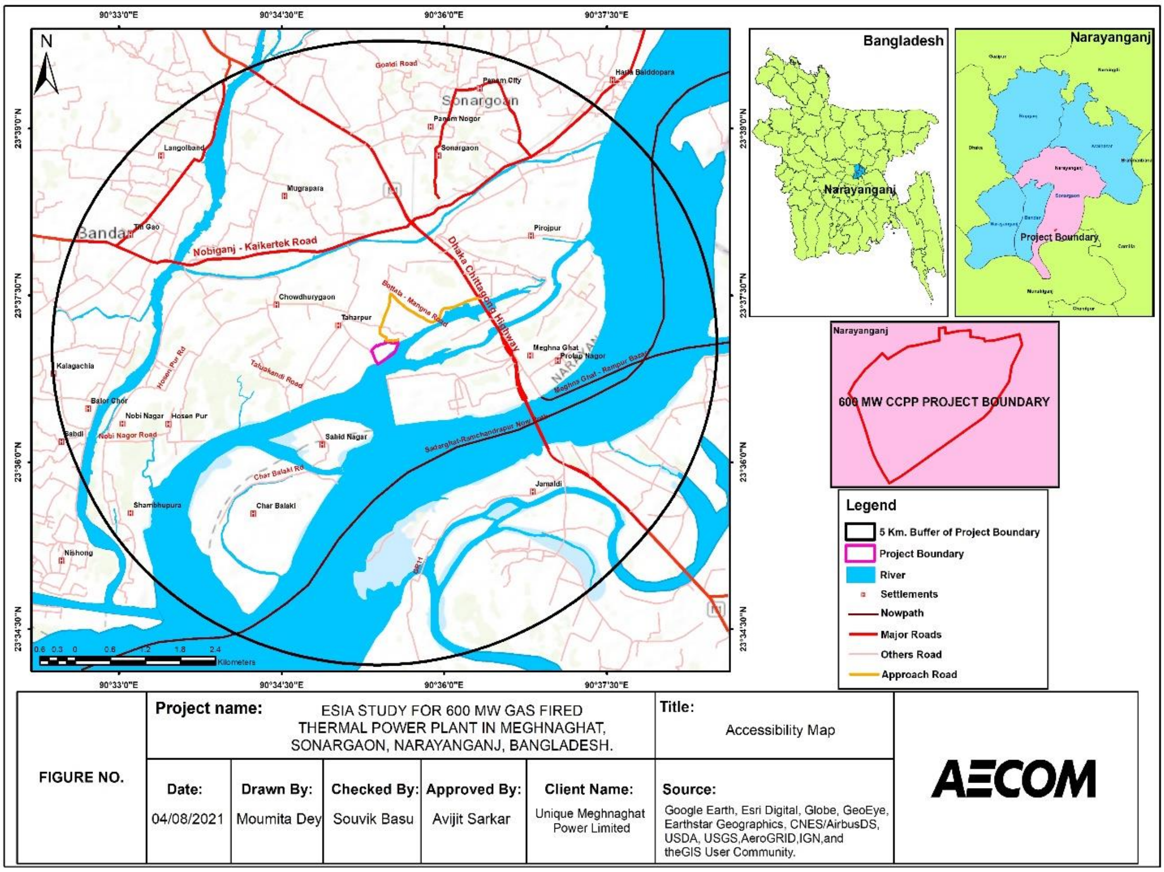


Figure 3.4: Accessibility map of Meghnaghat Area

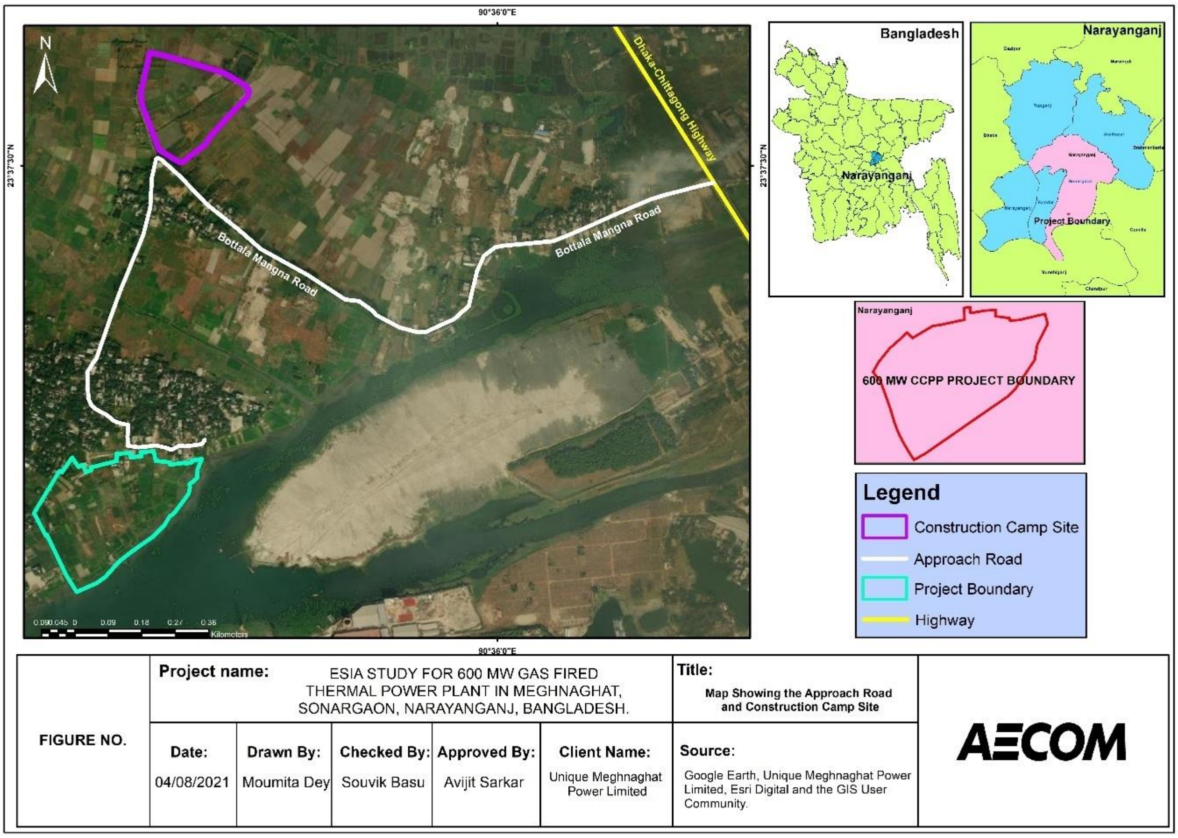


Figure 3.5: Accessibility Map of the Project Site and Construction Camp Site

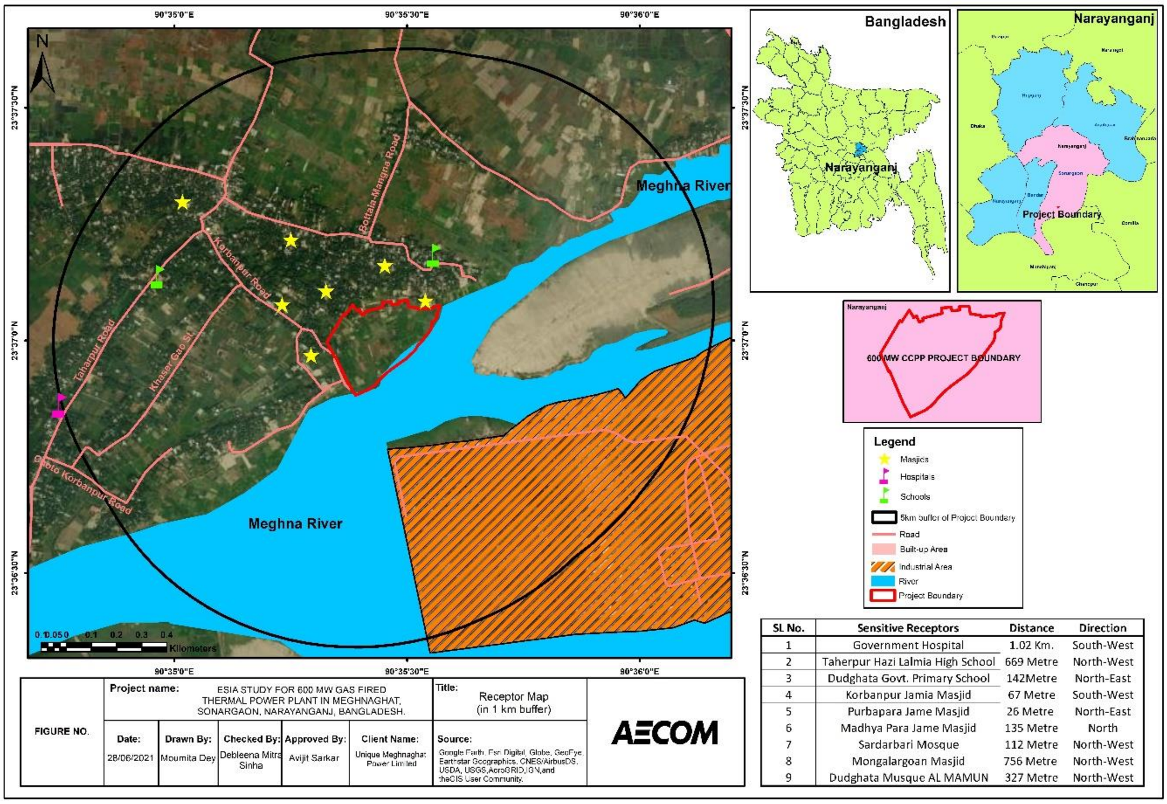
3.3 Key Features of the Site and Surroundings

Proposed site is located in agricultural land and surrounded by habitation area of Dudhghata Mouza. Details of surrounding features of the proposed project site are as follows:

- **North-** Settlement area of Dudhghata Madhyapara; Madhyapara Jame Masjid, Purbapara Jame Masjid, Dudhghata Government High School
- **South-** Branch Channel of Meghna River.
- **East-** Settlement area of Dudhgahta Purba para.
- **West-** Agricultural land and settlement of Dudhghata Dakshinpara; Taharpur Hazi Lalmia High School, Sardarbari Mosque

Dudhghata Purbopara Jame mosque is located adjacent to the northeastern boundary of the proposed site. Dudhghata Govt. Primary School, a Govt. primary school is located 142 m north-east (NE) of the project site. Dudhghata Madhyapara Jame Mosque and Korbanpur Jamia Mosque are located at 135m North and 67m south-west of the proposed project site respectively. Dudhghata More is the main market area of the Dudhghata mouza which is located about 250 meters away in the north of the site. One archaeological site (Panam City) is located 4.50 km NE of the proposed site. No protected area, reserve forest, hills and defence installation are present within the 5km radius of the project site.

Proposed site is located in the fringe of Meghnaghat Industrial Area. Two power plants of Summit Power and Orion Power is located 460 meters and 750 meters respectively from the proposed site on other side of the Meghna Branch Channel. Apart from that there are various industries like cement plant, food processing, paper & pulp, sugar mill, ship building etc. operational within Meghnaghat Industrial area. Sonargaon Economic Zone is located 2.37 km from the project site in the north direction. The details of sensitive features located within 1 km and 5 km from the site are given in Figure 3.6 and Figure 3.6 respectively. Primary survey and FGD carried out by AECOM confirm that none of the project affected people belongs to indigenous people category. Primary data shows that they are Bengali Muslim. Also, as per Population and Housing Census 2011, indigenous people are not present within the AOI.



SL No.	Sensitive Receptors	Distance	Direction
1	Government Hospital	1.02 Km.	South-West
2	Taherpur Hazi Lalmia High School	669 Metre	North-West
3	Dudghata Govt. Primary School	142Metre	North-East
4	Korbanpur Jamia Masjid	67 Metre	South-West
5	Purbapara Jame Masjid	26 Metre	North-East
6	Madhya Para Jame Masjid	135 Metre	North
7	Sardarbari Mosque	112 Metre	North-West
8	Mongalargoan Masjid	756 Metre	North-West
9	Dudghata Musque AL MAMUN	327 Metre	North-West

Figure 3.6: Environmental Settings Map showing sensitive features (upto 1 km)

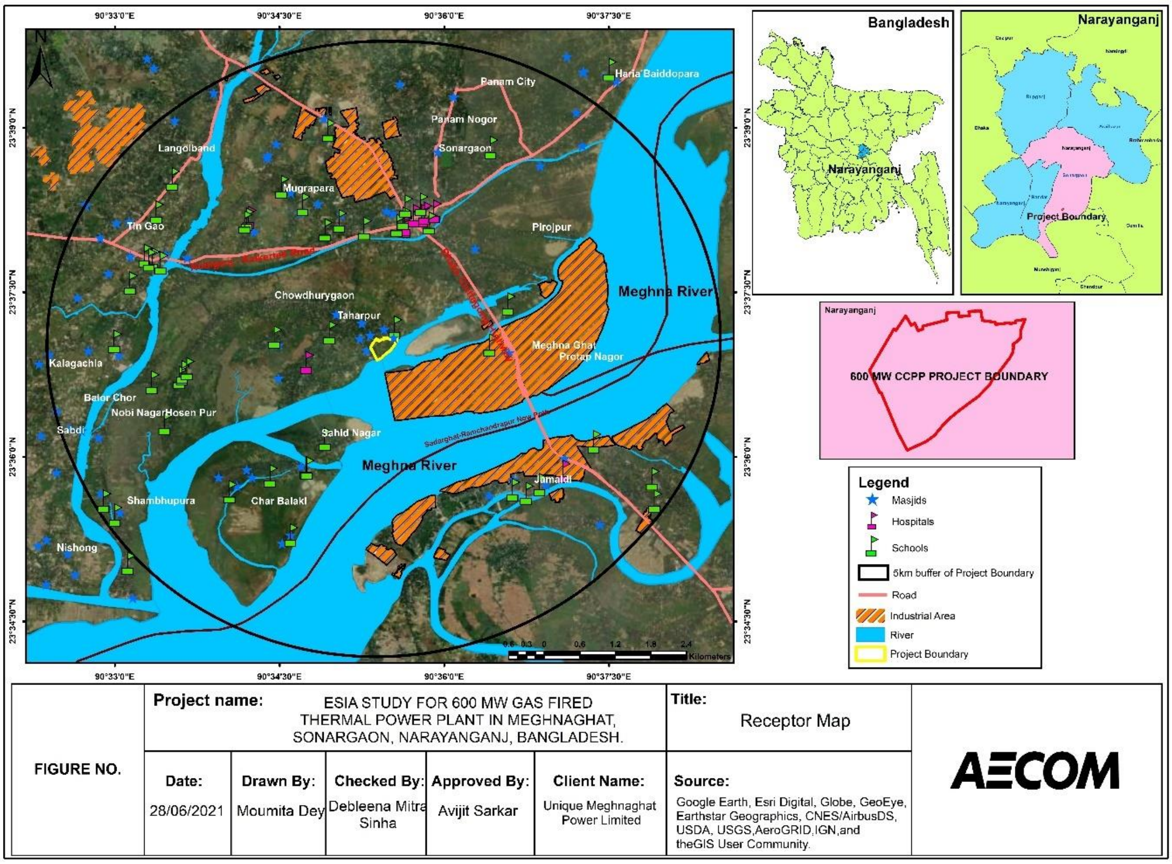


Figure 3.7: Environmental Settings Map showing sensitive features (up to 5 km)

3.4 Plant Configuration

The Power Plant would be designed for optimum efficiency, availability and reliability using advanced class gas turbines of state-of-art technology. Gas turbines with high open and combined cycle efficiencies, low environmental emissions and proven performance record would be installed.

The plant would have one (1) module of combined cycle units to have a gross output of around 600 MW at site conditions. The plant would run on Re-gasified LNG (RLNG) from Petrobangla through Titas Gas Transmission and Distribution Company Limited (TGTDCL). The distance between power plant and grid substation is approximately 800 meters and the evacuation voltage would be 400 kv Power would be evacuated through 400 kV Single Circuit Transmission Line to the nearest proposed grid substation of PGCB. A subsurface pipeline of 20-inch diameter subsurface pipeline for gas supply from PGCB across the river would also be constructed as a part of this project. Raw water for the plant would be drawn from Meghna Channel to Raw Water Pump House, located inside plant, through an intake channel and fore bay. All these are part of the project and are designated as project components. The Construction camp or the laydown area which would be set up on the leased land from Hamdard laboratories and the treated sewage pipeline from the laydown area would also be project components. With the same rationale. the two temporary jetties for conveyance of construction materials & Equipment are also considered as project components. The movement of men & material between the site & the laydown area is dependent on the Approach Road and it is considered as an Associated facility of this project. The project components and its ancillary/associated facility are presented in the table.

Sl. No.	Project Component & its ancillary/associated facility	Major Activity
1	Construction Camp Site and Treated Sewage pipeline	12 acres of land has been procured from the Hamdard Laboratory (WAQF) (3 years lease), which was initially agricultural land but has been set by UMPL as a construction camp. The area would comprise of office structures, residential area with different category of accommodation, warehouse (Class A and Class B) and seven open storage yards. The area will be decommissioned on completion of construction phase and handed over to the Hamdard Laboratory without restoration (as per agreement).
2	Jetties	Two (2) temporary river jetties would be constructed by UMPL during the construction phase. Jetty 1 with area 810 m^2, would be used for conveying raw materials and Jetty 2 with 735 m^2 area, to be constructed for receipt of heavy equipment & machinery. Decommissioning of jetties will be carried out on completion of construction phase.
3	Transmission towers (Tower A & B)	A 400 KV line would evacuate power through Tower A, proposed to be located within the plant boundary of UMPL. The 400-kV transmission line from Tower A would then cross Meghna Branch Channel and evacuate electricity to PGCB's 400 KV substation through Tower B, which would be located on the land of BIWTA.
4	Gas pipeline	A 20-inch diameter subsurface pipeline is proposed for gas supply. The gas pipeline would be laid underground beneath the river by using Horizontal Directional Drilling (HDD) with adequate cathodic protection and designs based on soil resistivity. The pipeline would surface out within the plant boundary at one side and TGTDL valve station on the other side.
5	Water intake pump and pump house	The raw water requirement for the plant is 676.22 cum/hr which would be drawn from the Meghna River. It is proposed that one (1) working and one (1) standby raw water pumps of capacity 750-900 m^3/hr would be housed in a pump house located adjacent to the river. Each pump would have primary filtration (a set of trash rack and rake and travelling screens) units to remove debris. Outlet of each raw water pump would be provided with one motor butterfly valve.
6.	Approach Road	The Approach Road is the road connecting Dhaka-Chittagong Highway to Purbapara Ghat which passes by the Plant and is proposed to be used for movement of men & materials between the site and the Construction camp/Laydown area.

The plant would be designed for optimum availability and reliability. Selection criteria of the gas and steam turbine units would be guided by the unit availability, minimum maintenance and downtime requirement of the machines. All balance of plant (BOP) equipment would be of proven performance with high availability and reliability. BOP systems would be provided with capacity to improve availability of the modules/ station.

Annual plant load factor is envisaged as 84.6% with a minimum availability of 90%. The parameters of the main plant have been reviewed keeping in view the international trend during the past few years, feedback from international operating plants, commercial competitiveness etc. Based on the data gathered from the units of the proposed size, which are in operation, plant load factor as 84.6% with a minimum availability of 90% is considered achievable.

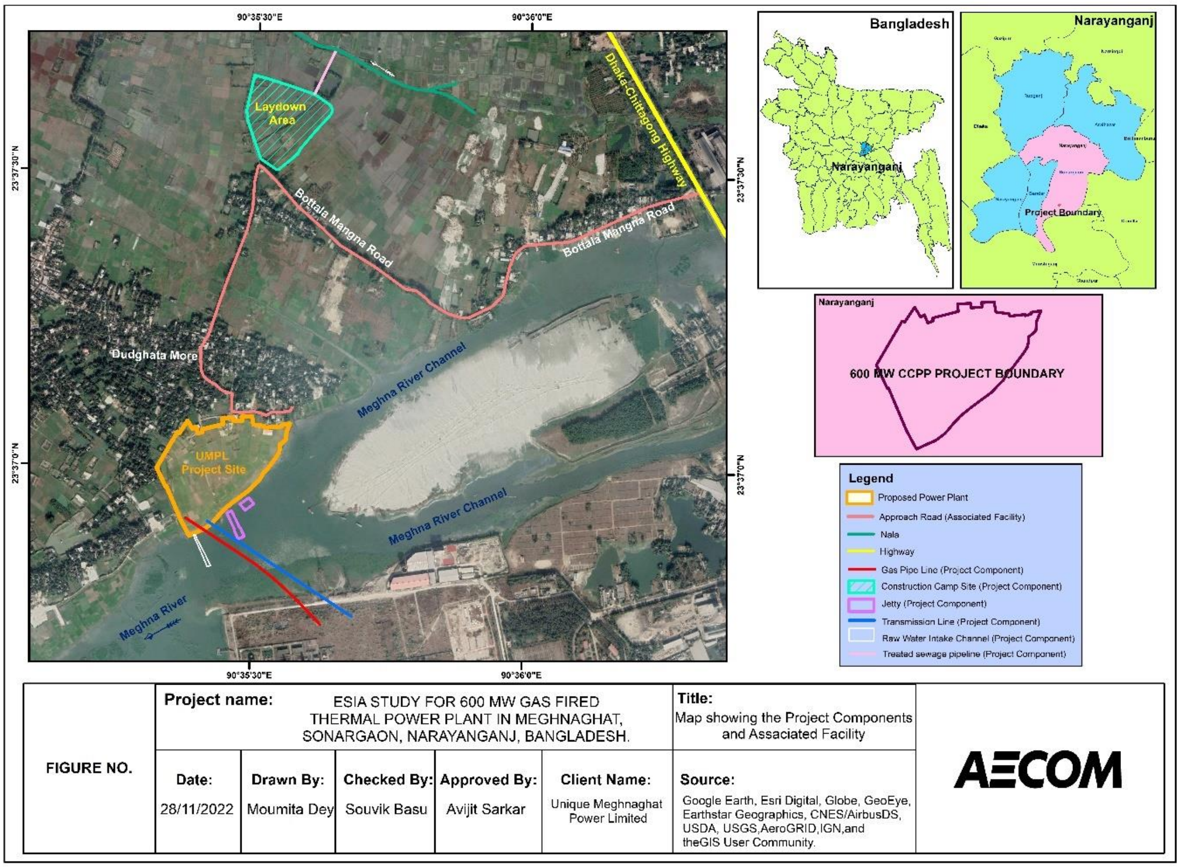


Figure 3.8: Project components and associated facility

3.5 Plant Layout

All buildings and structures would be located according to the General Layout given in Appendix D, which consists of main block area and auxiliary area. The main block would be composed of gas turbine hall, HRSG, steam turbine hall, main transformer, and HV unit auxiliary transformer. The auxiliary area would include boiler make-up water treatment plant, industrial wastewater treatment plant, chemical dosing room, mechanical draft counter flow cooling tower, C.W. pump house, mechanical accelerated clarifier, raw water intake pump house, comprehensive water pump house, service & firefighting water basin, raw water basin and potable water basin, filter and sanitary wastewater treatment plant. The proposed project site encompasses a total area of 21.07 acres.

3.5.1 Gas Turbine

The function of the Gas Turbine and Generator (GTG) is to generate the electrical power and to provide heat source to the Heat Recovery Steam Generator (HRSG). The gas turbine would be of single flow open cycle type allowing continuous operation at the rated output at site conditions. The entire turbine casing would be heat insulated in such a manner to allow easy removal and replacement for overhaul and inspection. The dedicated GTG control system would have facility of complete operation from the Local Control Cubicle and from the Central Control Room (CCR).

3.5.2 Heat Recovery Steam Generator

The function of the Heat Recovery Steam Generator (HRSG) is to generate steam using the exhaust gas from the gas turbine to feed the Steam Turbine.

The HRSGs are located at the downstream of Gas Turbine. The exhaust gas from Gas Turbine flows into HRSG through duct via diverter damper. The HRSG is of the unfired, triple pressure, reheat, horizontal gas flow type with natural circulation in the evaporator zones, matching the exhaust gas energy available.

The HRSG is manufactured by General Electric. HRSG is Horizontal type with triple pressure system, with reheat, no burners. It consists of inlet gas duct, outlet gas duct, main stack, HP/IP/LP boiler drums, and auxiliaries, such as LP recirculation pumps, blow down tank. The HRSG height is about 39 m and 14 m in width approximately and the elevation of stack top is 75 m. The specifications would be HP steam rating 400 t/h, pressure 165 Bar and temperature 600 (°C) and exhaust flue gas temperature 91.4 (°C)

3.5.3 Steam Turbine

The function of STG Plant is to generate the electrical power by admitting the steam from the Heat Recovery Steam Generators (HRSG) in order to supply the power to the Grid system.

The HP-steam supplied by the HRSG is admitted to the HP-turbine through one HP-stop valve and one HP-control valve. From the HP-exhaust side the cold reheat steam enters the re-heater via a power assisted check valve. The hot reheat steam is admitted to the IP-turbine by two IP-stop and two IP-control valves. At the LP-section the LP-steam supply is admitted through a stop and a control valve. From the LP-turbine exhaust the expanded steam flows into the condenser. The ST-A650 steam turbine manufactured by General Electrics. Water cooled condenser would be used.

3.5.4 Feed Water System

The feedwater system delivers feedwater from low pressure drum to the HRSG economizer inlet header and supplies spray water of HP steam system, HP bypass system and reheat steam system.

Feedwater pumps would be motor driven with constant speed and the water flow to the HRSG would be controlled by control valve. The pumps would be horizontal, centrifugal, multi-stage; diffuser or volute type, with impellers arranged in series specially designed for feedwater pumping piping service.

Each pump would be provided with isolating valves on the suction and discharge sides and also a non-return valve on the pump discharge. Each pump suction would be provided with arrangements to automatically recirculate water back to the LP drum for protection of pumps low and no-load conditions.

3.5.5 Condensate System

Low pressure (LP) turbine exhaust steam comes to Condenser where it is condensed to saturate liquid conditions and accumulated into Condenser Hot well. The Condensate System delivers this condensate from the condenser to the LP steam drum of HRSG via the condensate extraction pumps.

The condensate is chemically treated by injecting ammonia and hydrazine to adjust the pH level, scavenge residual oxygen and thus minimize corrosion.

The condensate system also provides water to various desuperheater, attemperator and makeup water to miscellaneous systems. Between the condenser hot well and the LP drum, the condensate flows sequentially through the following equipment:

- Condensate pumps
- Gland Steam Condenser
- LP economizer

3.5.6 Closed Cooling Water System

The functions of the closed loop cooling water system is to supply make-up water for demineralised cooling water for gas turbine oil coolers, gas turbine generator, hydrogen coolers, steam turbine oil coolers, steam turbine generator air coolers, pumps, steam and water samplers, air compressors, and any other equipment requiring cooling water and to reject the waste heat to the auxiliary cooling water (primary side – cold) via the closed cooling water coolers. The total make-up water requirement for closed cooling water system is estimated as 580.32 cum/hr.

Two (2) x 100% capacity closed cooling water pumps for both units are arranged upstream of two (2) x 100% capacity closed cooling water coolers in the secondary circuit. The closed cooling water pumps and coolers are located in Closed Cooling Water Pump House.

The system distributes the demineralised cooling water to the coolers of various equipment which are located in the Steam Turbine area, BFP station, air compressor room, HRSG area, Gas turbine area as the following:

- GT generator hydrogen coolers
- GT lube oil coolers
- ST generator air coolers
- ST lube oil coolers
- HP/IP boiler feed water pumps
- HRSG CPH recirculation pumps
- Air compressor coolers
- Sampling system

3.5.7 Plant Water System

The plant water requirement would be drawn from the Meghna River by 2 X 100% capacity raw water make-up pumps located in the intake water pump house. Capacity of each raw water pump would be around 750-900 cum/hr. The raw water requirement for the plant is 676.22 cum/hr. The Intake water pump house would be built nearer to the Meghna River. It is proposed to provide buried pipeline of carbon steel construction from Intake water pump house to the Clarifier. The pipelines would be protected against corrosion using suitable internal coating and external coating and wrapping.

The plant water system would be designed to supply cooling water make-up based on cycle of concentration as 6 and other consumptive water requirement for the plant. A closed cooling water system employing Induced draft-cooling tower (IDCT) has been envisaged for each proposed unit to minimize the plant water intake requirement. One stand by cell has been considered for each cooling tower.

The raw water from Meghna River would be clarified in a clarifier and stored in an intermediate water tank. The clarified water from this intermediate tank is transferred to filtered water storage tanks via Pressure Sand Filters. The filtered water would meet the following requirements:

1. Cooling towers make up water would be provided from filtered water storage tanks to the cold-water channel of cooling water channel by Cooling tower make-up pumps.
2. Demineralised (DM) water supply pumps would draw water from filtered water storage tank to the DM Plant. Demineralised water system would consist of one working and one standby system comprising cation exchanger, degasser, anion exchanger and mixed bed units along with associated regeneration system and effluent neutralization & disposal system. The DM water would be stored in two outdoor storage tanks, each having capacity for 48 hours storage. DM water transfer pumps would be provided to transfer DM water from the DM water storage tank to condenser hotwell through condensate storage tank and to other DM water consumption units.
3. Potable water would be stored in potable water overhead tank through potable water supply pumps and supplied to the consumers from the overhead tank.
4. HVAC water would cater to the water requirement of HVAC system. HVAC make up pumps would draw water from filtered water storage tanks
5. Service water would be supplied throughout the plant from the filtered water storage tank through service water pumps.

3.5.8 Natural Gas System

The natural gas would be supplied by Titas Gas Transmission and Distribution Company Limited (TGTDCL), which is at a distance of approximately 700 m from the site located across the Meghna Branch Channel. Available pressure at the area would be in the range of 150-175 psig. A subsurface pipeline would be laid under the riverbed using horizontal directional drilling (HDD). Chemical composition of Gas to be delivered to the facility is shown in ***Table 3.3.***

Table 3.3: Chemical Composition of Gas

Constituent	Minimum Percent by Volume	Maximum Percent by Volume
Methane (CH_4)	85.0	100.0

Constituent	Minimum Percent by Volume	Maximum Percent by Volume
Ethane (C_2H_6)	0	6.0
Propane (C_3H_8)	0	5.0
Butane (C_4H_{10})	0	3.0
Pentane (C_5H_{12}) and higher	0	2.0
Hydrogen Sulphide (H_2S)	0	0.0
Carbon dioxide (CO_2)	0	2.0
Nitrogen	0	3.0
Oxygen(O_2)	0	5.0
Total Sulphur Content	0	10 mg/cum

Source: Unique Meghnaghat Power Limited

3.5.9 Electrical Plant and System Requirement

A 400kV Gas Insulated Switchyard (GIS) has been envisaged for evacuation of power, import of power for start-up / shut down / station auxiliary power through Unit Transformers for the proposed power plant. This switchyard as shown in the Plant Layout would be located in an area separate from the main powerhouse building and would be surrounded by a chain link fence. The switchyard for the proposed power plant would also be gravel filled. This switchyard would have the following feeders with Two Mains Bus Scheme with a coupler bay.

- Gas Turbine Generator Transformer #1 Feeder
- Steam Turbine Generator Transformer #1 Feeder
- Line Feeder Bay for connectivity with nearest PGCB grid substation.

For evacuation of power through the above outgoing line feeders, 400 kV single circuit transmission lines would be established by the EPC contractor between the proposed power plant and the PGCB's nearest grid sub-station.

3.5.10 Power Evacuation and Off Take

The proposed transmission towers would transmit electricity generated from the proposed 600 MW CCPP through a 400 kV Single Circuit (S/C) transmission line. Tower A would be located within the site and Tower B would be located on the other side of Meghna Branch Channel. A 400-kV grid sub-station belonging to PGCB would be located around 800 m from the project site on the other side of Meghna Branch Channel. The heights of the proposed Towers A & B are 60 m each. The evacuation and off-take would be the responsibility of PGCB; UMPL would be liable to provide approach to PGCB to their site for operation and maintenance. The details of transmission towers and 400 kV substation of PGCB has been elucidated in Section 3.8.6.

3.5.11 Emergency DG set

In order to cater to the safe shutdown of the plant under emergency conditions like total power failure, diesel generating (DG) set of capacity 1260 kW would be installed for feeding vital applications like battery chargers, emergency lighting, essential air conditioning/ventilation and all auxiliaries necessary for barring operation of main turbines. Low sulphur High Speed Diesel (HSD) would be required for running the emergency DG set and would be stored in a day tank of approximate capacity 20 KL. The storage arrangements would include secondary containment and shade. Requisite License under Petroleum Act 2016 for storage of HSD would be obtained from Chief Inspector of Explosives.

3.5.12 Effluent Treatment Plant and Sewage Treatment Plant

The liquid effluents would be collected and treated / recycled generally as per the following:

- Effluents from GT, ST, HRSG, Transformer areas and other areas, which may contain oil traces, would be sent to oil / water separator. The oil would be pumped out periodically and trucked offsite for disposal. The treated water would be directed to guard pond.

- The clarifier sludge generated in pre-treatment would be further thickened and dried in thickener and filter press and drying bed. The dry sludge from the sludge drying bed would be manually sent through truck for offsite disposal and the recovered water from the sludge would be re-routed to the Effluent treatment plant.
- The quenched HRSG Blow down water would be discharged to cooling tower basin for recycling and sent to Common Monitoring Basin (CMB).
- Demineralization regeneration wastes are directed to the neutralization basin. The basin is sized to contain regenerations volumes of the ion exchangers. The pH of collected wastewater is adjusted on a batch basis where the self-neutralizing tendencies of the exchanger regeneration acidic and alkaline wastes are enhanced by mixing. The neutralized water would be transferred to Guard Pond.
- Treated effluents would be collected in the common monitoring basin for final monitoring. Final effluent would be monitored for temperature, pH, TSS, oil and grease, total residual chlorine, chromium (total), copper, iron, zinc, lead, cadmium, mercury and arsenic and subsequently would be partially used for plantation works and the balance flow would be routed to the Meghna Channel.
- STP would be installed for treatment of domestic wastewater generated from the plant area. The treated wastewater would also be directed to the CMB, where final monitoring would be carried out before re-use and discharge to Meghna Channel. Underground pipeline would carry the treated effluent to the Storm water basin located at the south-eastern periphery of the plant beside the green area, from where it would be discharged to Meghna Channel.
- This is closed loop recirculation system. The warm water would be recirculated through cooling tower. Treated fresh water is added in the cold well whereas blowdown from the cooling tower is discharged through CMB after COC of 6. The design temperature of final outlet is 31.5 °C, which is within the stipulated limit of temperature of discharge water, i.e., 40°C, as per ECR 1997. Also, the outlet temperature is within 3° C of the river water temperature, which is around 28.5°C – 29.5 °C as per design data and between 31.2°C – 33.5°C as per the monitored baseline data and is compliant with IFC EHS Guidelines.

The tentative quality of the treated effluent discharged from the plant would be as presented in ***Table 3.4***

Table 3.4: Tentative quality of the final effluent discharged from the plant through CMB

Sl. No	Parameters	Tentative quality	Stipulated Limit as per Schedule 10 of ECR 1997 for discharge to Inland Surface Water	IFC Standards
1	Total suspended solids	<50 mg/L	150 mg/L	50 mg/L
2	pH	6.0-9.0	6.0-9.0	6-9
3	Oil and Grease	<10 mg/L	10 mg/L	10 mg/L
4	BOD	<10 mg/L	50 mg/L	30 mg/L
5	COD	<125 mg/L	200 mg/L	125 mg/L
6	E-coli Bacterium	Not to be detected	-	-

Source: UMPL and IFC EHS Guideline

All the parameters are observed to be well within the stipulated limits as mentioned in Schedule 9 and 10 of ECR 1997 and IFC guidelines. Compliance to the prescribed standards would be ascertained by monitoring of outlet of CMB. Flow diagram of Wastewater Treatment is presented in the ***Figure 3.9*** below.

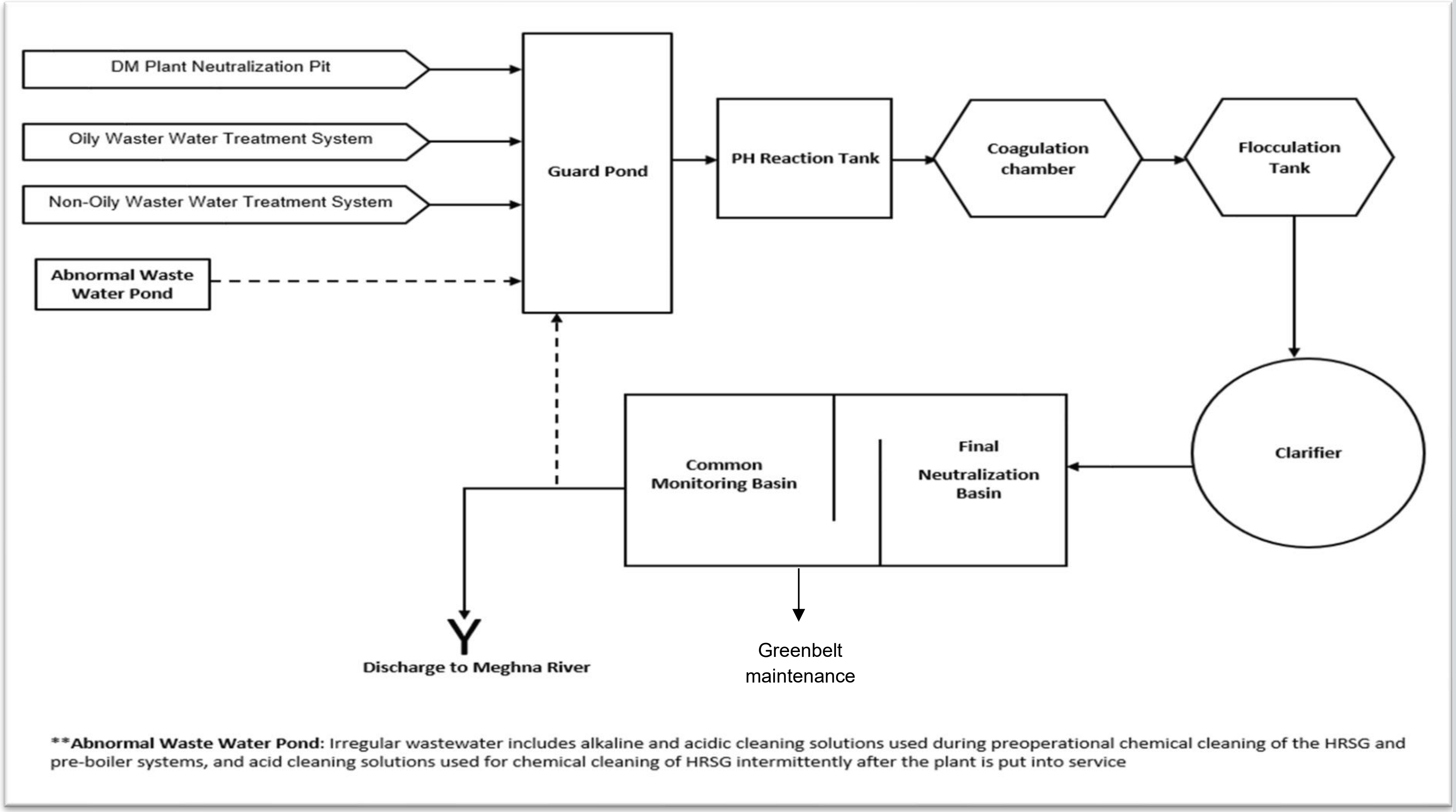


Figure 3.9: Flow Diagram of Wastewater Treatment

3.5.13 Stack

One un-insulated HRSG stack having height of 75m (diameter 7.4 m) above top surface of the HRSG foundation would be provided. The HRSG stack would be made of carbon steel. The HRSG is equipped with an approach door located for convenient access in the base section, drain, connecting ductwork with expansion joint, approach platforms and vertical ladders with enclosing safety cage to the platform level. Aviation warning lights would be provided to each stack of HRSG. At the mouth of stack, a deflector ring of stainless steel of adequate external diameter is arranged to prevent down flow of gases on the outside of the stack at extreme low loads. Natural gas performance is based on operation with a Dry Low NOx combustion system without gas turbine diluent injection for NOx controls.

A bypass stack would be provided to divert the flue gases from the HRSG to the bypass stack to allow the plant to operate in simple cycle mode. This would also allow the HRSG to be inspected, repaired, or have maintenance to be done while it is isolated completely from the gas turbine. The bypass stack and diverter system permit, power to be generated by the gas turbine even when the steam turbine cycle is down for a scheduled or unscheduled shut down, keeping the plant functional and avoiding potential power outages. The bypass stack would have a height of 60 m t and a diameter of 7.3 m.

3.5.14 Control System

3.5.14.1 Plant DCS System

The complete control, indication, annunciation and supervision of the electrical systems for the proposed power plant would be performed from the monitor through plant DCS for main power plant and 400 kV system. Necessary 'online' dynamic graphics would be provided. Necessary command signals, feedback signals and measurement signals would be wired up from various equipment through transducers and interposing relays to the plant DCS system. It would be possible to display and control any electrical system up to 400 V switchgear level on the monitor of the plant DCS system.

Entire mimic from 400V switchgear level to 400 kV system would be available on the monitor itself. Release of auto synchronization command for Generator would be achieved from DCS monitor. Communication interfaces and protocol adaptation would be provided as required.

Synchronization Panel

A hardwired synchronizing panel, unit wise for both generators would be provided. It would consist of all synchronizing equipment viz. double voltmeter, double frequency meter etc., generator selector switch, 'Auto / Manual / Remote' selector switch, dual channel auto-synchronizer and other necessary relays / components. A mimic showing associated circuit for synchronization of generators would be provided in this panel. This synchronization panel would be suitably interfaced with Plant DCS.

Disturbance Recorder

A microprocessor-based disturbance recorder for 400 kV switchyard equipment's would be in the main control building of the proposed power plant and this would record pre-fault as well as post-fault data, which are of use in analysing fault for recommending remedial measures.

3.5.15 Pollution Monitoring and Control Measures

Primary impact on environment due to installation of a power plant comes from the combustion of fuel and discharge of chemicals and effluents from the plant through wastewater. The following pollution control measures proposed to be adopted are envisaged for the proposed 600 MW Combined Cycle Power Plant:

3.5.15.1 Air Pollution Control Measures

As Natural Gas is one of the lowest polluting fuels known world-wide, the proposed activity is supposed to need minimum pollution control measures. There would be minimum generation of Particulate Matter and SO_2 due to combustion of natural gas and the only air pollutant of concern would be NOx generated during the combustion process. To ensure proper dispersion and dilution of the off-gas containing mostly NO_x (as air pollutant) into the atmosphere, main stack of 75 m height and bypass stack of 60 m height is proposed with an approximate exit velocity greater than 19 m/s.

Expected Natural Gas analysis available for the study indicated negligible sulphur content, therefore an insignificant quantity of SO_2 would be generated.

Latest combustion technology with low NOx burners with premix burning system would be used in the Gas turbines, which restricts the combustion temperature below 1300° C, considered as the temperature above which NOx are formed. This would ensure that the plant power produce NOx within 25 ppm when firing Natural Gas, which is within IFC/WB emission limit of 51 mg/Nm^3 (25ppm) with 15% O_2, for gas turbine power plants more than 50 MW located in the degraded or non-degraded air shed. The emission of NOx would also adhere to the standard limit of 50 ppm NO_X emission as per ECR 1997.

Continuous Emission Monitoring System (CEMS) has been considered for continuous online monitoring of stack exhaust with crossflow modulated Non-dispersive Infrared (NDIR) detection. CEMS also has inbuilt CO_2 sensor that constantly measures and makes corrections to compensate for CO_2 interference in NOx measurements. An interference compensation detector is also provided that compensates for interference from H_2O during NOx and SO_2 measurement. The output shows concentrations of NOx, SO_2, CO, CO_2, O_2.

3.5.15.2 Control of Noise Pollution Caused by Equipment in Operation

Identified major sources of contributions to noise pollution from the power plant are the Compressors, Gas turbines, Steam turbines, Inlet and Exhaust systems etc. The noise level of all operating equipment would be kept within the prescribed norm of 85 dBA at 1 metre distance from the outline of the equipment at the design stage itself. Individual equipment exceeding these limits would be provided with suitable sound absorption/attenuation/dampening enclosures. Plant operations personnel would be equipped with earplugs and other safety measures.

3.5.15.3 Water Pollution mitigation

The wastewater from De-mineralised Water Plant and other service area would be treated in the neutralising pit and Effluent Treatment Plant to the required degree. The total effluent available after treatment from Effluent Treatment Plant would be utilised partially for plantation and the balance effluent would be routed to the outfall in Meghna Channel. Monitoring of all the parameters as per Schedule 10 (Standards for Waste from Industrial Units or Projects Waste) of Environmental Conservation Rules, 1997 or IFC's Effluent discharge guidelines for thermal power plants 2008, whichever is stringent, would be carried out. Treated effluent conforming to the above-mentioned discharge standards/guidelines would be allowed to be discharged to the Meghna Channel.

Effluent Treatment Plant (ETP)

The plant effluents would be segregated, and their streams would be identified for giving on-line specific treatment to avoid total treatment of the accumulated fluid, which unnecessarily increase the treatment cost. Neutralisation unit would be provided for the effluents emerging from the De-mineralised Water Plant. All effluent would be treated for COD, BOD and pH in the wastewater treatment system before discharge into Central monitoring basin. The final treated effluent from the Effluent Treatment Plant would be monitored for temperature, pH, COD, TSS, oil and grease, total residual chlorine, chromium (total), copper, iron, zinc, lead, cadmium, mercury and arsenic.

Sewage Treatment Plant (STP)

The project site would be provided with suitable sanitary facilities such as WC latrines for workers and permanent staff to maintain proper hygiene. Sewage Treatment Plant would be installed to treat the sanitary wastewater generated within the plant during the operation phase. The sanitary water would be disposed to the CMB after necessary treatment. Before the sewage is sent to CMB, at regular intervals of time it would be tested for BOD, nitrate, phosphate, suspended solid, temperature, coliform and ph.

Central Monitoring Basin (CMB)

The treated effluent from ETP, treated sewage from STP, cooling tower blow-down and dilution water (raw water to reduce TDS concentration) would be combined in a Common Monitoring Basin and provided designed retention time before reuse/final discharge. Prior to discharge, the treated effluent would be monitored for temperature, pH, TSS, oil and grease, total residual chlorine, chromium (total), copper, iron, zinc, lead, cadmium, mercury and arsenic as per Schedule 10 (Standards for Waste from Industrial Units or Projects Waste) of ECR 1997 or IFC's Effluent discharge guidelines for thermal power plants 2008 whichever is stringent. In the event of non-compliance with the desired discharge standard, the effluent from CMB would be rerouted to plant's wastewater treatment system.

Solid Waste Management

Construction and operation of the power plant will lead to generation of solid wastes constituting of hazardous and non-hazardous solid waste. During the construction phase, there would be generation of non-hazardous solid wastes like wooden palette, scrap metal, plastic packaging, rubber wastes, cardboards, bottles of water, cans, plastic bags, food packaging, domestic wastes like food waste, etc. Hazardous wastes like paint cans and used brushes, hazardous chemical waste, used oils and grease from machinery and equipment, used or spent lead-acid batteries, contaminated spill, empty toners/ink cartridge, etc would also be generated.

Wastes would be stored in designated waste storage area, segregated for hazardous and non-hazardous wastes and would be managed as per the Waste Management Plan & Policy[3], in line with applicable National and International standards. For the construction phase, Hazardous Material Handling and Storage Management Procedure has been prepared for handling and management of hazardous waste. The designated area for hazardous waste would be paved and covered, with secondary containment and appropriate signages. Stages of waste management would include the following:

Segregation

- Involves physical separation of waste materials, according to their general physical and chemical characteristics
- Separation of Hazardous wastes (the general hazardous waste, medical/ bio-hazard waste & electronic hazard waste) and non-hazardous wastes (wood/metal, mixed construction waste & domestic waste)
- Allows wastes of a similar type to be combined, simplifying storage, treatment, recycling and disposal arrangements.

Collection and Storage of Waste

The collection of source segregated construction and office waste to be ensured as these materials reach higher prices at recycling/recovery markets than materials from mixed waste.

Waste Minimization

Exploring waste management methods based on the hierarchy principles of source reduction, reuse and recycling.

Source reduction

Source reduction is the process of eliminating or minimizing, as far as possible, the volume and/or toxicity of wastes through use of alternative materials and/or more efficient processes, practices or procedures. Exploration with respect to source reduction techniques like inventory control and management, material substitution, reduction in the consumption of natural resources, reduction in the use of main materials (by improving the storage of materials or the agreement with timely delivery), use of economic designs, light-weight packaging, use of less ecologically toxic materials whenever possible; and improved housekeeping would be carried out.

Reuse

Maximum reuse of the solid wastes would be considered within the plant or by sending wastes back to vendors for reprocessing/reuse. Especially the waste material from piling, demolition, excavation, and concreting activities should be re-used on site as much as reasonably practicable.

Recycling and Energy Recycling

Recycle, especially conversion of waste into usable materials and/or the extraction of energy or materials from waste would be pursued for wastes like paper, cardboard, toner cartridges, packaging materials, aluminium cans, glass and plastic bottles, wood pallets, etc. The discarded materials with an energy value can generate new alternative energy and reduce carbon emissions by substituting fossil fuels.

Treatment

Treatment of solid wastes would be adopted in situations where source reduction, reuse and recycling options cannot be implemented feasibly to minimize the volume or toxic nature of the waste.

[3] *Waste Management Plan (2020) by the EPC Contractor*

Treatment option depends largely on the waste characteristics, financial factors and environmental aspects of the wastes and regulatory obligations. Potential treatment options of waste treatment may be through physical methods (e.g. filtration, solidification); biological methods (e.g. wastewater treatment, composting); thermal methods (e.g. destruction via incineration); and chemical reaction (e.g. neutralization, stabilization, extraction, precipitation). The waste to be generated from the proposed power plant can be used for landfilling adhering to strict designs requirements. Formaldehyde gas cargo waste decomposition can also be used as fuel for power generation.

Disposal

Disposal, as the last stage of waste management would be adopted only when all preceding management methods has been fully evaluated. Disposal of the waste would be done in line with waste characteristics and regulatory requirements.

Transport

M/s Meghna Enterprise have been entrusted for collection and disposal of the wastes from the Plant. Non-hazardous wastes are generally sent to recycling facility. Hazardous wastes would be either sent to destinations for commercial attractive use or disposed in Waste Recycling and disposal facility licensed by the local authority. Transportation of hazardous waste would be done in line with all applicable legal requirements and Waste Manifest would be properly maintained. Covered vehicles would be used for waste transportation to prevent littering of waste on public roads and in public areas.

Waste materials, both hazardous and non-hazardous generated during construction and commissioning in the lay-down area would be initially stored in temporary storage area before reuse/recycling or transport to final disposal location. Contractors would ensure that adequate numbers of on-site containers for sorting and temporary storage of non-hazardous waste are provided in the construction camp & laydown area. Hazardous wastes would be kept in marked and sealed containers. Trained workers will manage the handling and storage of wastes. M/S Meghna Enterprise is responsible for disposal of the wastes from the Laydown area.

During the operation phases, there would be generation of solid waste and municipal waste, as well as minor quantity of hazardous wastes. Solid waste generated would include paper, cartons, bags, boxes, office wastes, etc. along with minor quantity of domestic waste. There would be generation of waste air filters and waste rugs occasionally which need to be properly disposed. During operation phase of the project, around 100 workers would be employed. It is estimated that around 40 kg/day municipal solid waste would be generated. Solid and municipal wastes would be collected, segregated and disposed through local waste management bodies.

Hazardous waste generated during the operation phase of the proposed project would include waste/spent oil, batteries, lighting lamps, E-waste like used and obsolete IT and telecom equipment: electronic and electrical hardware/ components, PC peripherals, faulty/scrap meters and metering equipment, electronic timers; faulty/used electronic and electrical equipment, capacitors i.e. electrolytic capacitors and capacitors containing Polychlorinated Biphenyls and Battery Wastes. During the transportation of hazardous waste, protection against leakages of hazardous gases (e.g. SF_6) should be ensured. UMPL would need to have a proper Waste Management Plan in place for the operation phase that would ensure that wastes are stored in accordance with safety norms in ventilated enclosures with proper signages, handled as per regulatory instructions and disposed through authorised vendors.

3.5.16 Operation and Maintenance

The operation and maintenance of the power plant and all auxiliary facilities would be done by internationally reputed O&M Contractor finalized by the Owner. The Operator would be responsible for following all laws, rules, regulations and safety requirements as per relevant provisions of central and state acts.

On completion of erection and commissioning of the plant, the operation & maintenance functions would be taken over by the O&M Team engaged by the Owner. EPC Contractor would be responsible for the entire warranty period and they would deploy specialized personnel as and when required to the project site.

The plant is envisaged to have high level of automation to minimise manual intervention. Approximately 100 skilled and semi-skilled manpower including engineers, supervisors and workman would be employed by the O&M Contractor for operation and routine maintenance. UMPL would employ their own staffs for the support functions like administration, finance etc. The details of manpower requirement and organogram have been discussed further in section 3.8.9 of this report.

3.5.17 Decommissioning

The design life of the power plant is estimated to be 25 years. If the Power Purchase Agreement, Gas Supply Agreement and the other relevant agreements are not extended or renewed and an alternative economical fuel is available, the power plant may be retrofitted to support power generation through the alternative fuel sources. This option would be possible, provided the required retrofits can meet the new emission rates as per the applicable standards and guidelines.

If retrofitting is not feasible and the operational life of the Power Plant expires, the power plant would be decommissioned according to the requirements of the competent authorities at that time.

3.6 Project Implementation and Schedule

Unique Group would assume overall responsibility for implementation of the project, covering all fronts of activities as well as conflict resolution, drawing necessary expertise and support from implementation consultants on regular basis. UMPL would establish Project Management Systems for close monitoring of the Project for cost, quality, schedule and environment, health & safety.

The Project would be executed on a single turnkey EPC basis. The initial site development and enabling works would be carried out by the Project Company through local contractors. The Project would be executed with a highly experienced team having specifically defined responsibilities. Services of qualified professional consultants would be used for the project. On completion of commissioning of the plant, the operation and maintenance would be taken over by the O&M Team. Owner would engage an internationally reputed O&M Contractor for the O&M activities.

Assuming 9 months' time period for pre-construction activities, all the required statutory and non-statutory clearances were obtained during this period including the financial closure, and the construction period has been estimated as 32 months from the 'zero date' which is reckoned as the date of Notice to Proceed (NTP).

Table 3.5: Project Implementation Schedule

Milestones	Start Date (Months, days)	Finished Date (Months, days)
Construction permit grant (NTP/ Site handover certificate/ Land allocation etc.)	T0 + 0	T0 + 0
Site preparation (Site mobilization to Final Geotech report available)	T0 + 0	T0 + 4,9
System Engineering	T0 + 0,1	T0 + 8
Civil Design	T0 + 0,1	T0 + 17,2
Detail Engineering	T0 + 0,9	T0 + 18,9
Availability of Right of Way and Physical Access for Civil Work for Transmission Line	T0 + 5	
Right of way for gas pipeline Civil Works available		T0 + 12
Construction of Water treatment area	T0 + 4	T0 + 15,9
Design and Construction of AIS 400 KV Switchyard Area	T0 + 4,4	T0 + 15,8
Construction of Control and Admin. Building (Designing & Implementation)	T0 + 5,1	T0 + 18,2
Design and construction of Cooling Tower area	T0 + 6,3	T0 + 18,8
CIRC WATER U/G PIPELINES CIVIL WORKS	T0 + 7,1	T0 + 13,2
Construction of Electrical Building (Designing & Implementation)	T0 + 9,6	T0 + 15,6
Gas fuel supply area Civil work	T0 + 12,1	T0 + 18
Physical Access for Electromechanical Works in 400 kV PGCB's s/s	T0 + 14,6	
Right of way + Physical Access for gas pipeline Mechanical works available		T0 + 15
RoW + Physical Access for Electro Mech works for Transmission Line from Plant Boundary to PCCB's s/s available		T0 + 16
Permit available to take the Raw (River) Water Supply from River and discharge treated effluent and storm water from plant to the river		T0 + 20,9
400kV Back feed available for Transf. energizing and power for pre-Comm and start-up		T0 + 21,7

Milestones	Start Date (Months, days)	Finished Date (Months, days)
Shutdown in the exiting Fuel Gas system at Connection Point of Gas Supplier with permit available for connection		T0 + 22,2
Fuel Gas available to the plant from Gas Supplier through RMS (within plant boundary)		T0 + 24
Owner's O&M personal available for commissioning, performance testing of the plant and Grid available to export power.		T0 + 25,5
Design of Gas Turbine, Steam Turbine and Heat Recovery Steam Generator Plant, Installation and commissioning at site	T0 + 0,1	T0 + 26,2
Mechanical Completion (GTG Circuit breaker & bus duct, Water, Gas, GSUT ST, AIS 400KV, ST, GT & Equipment associated, ST & Equipment associated, etc.)	,	T0 + 26,2
Plant Control System (PCS) Hardware and Software Commissioning at Site	T0 + 1,2	T0 + 26,2
Extension of Existing 400 KV Switchyard and AIS 400 KV delivery to site	T0 + 0,1	T0 + 20,7
Pre-Commissioning test for all plants & equipment's	T0 + 20,1	T0 + 25,2
Plant testing and commissioning of all turbines and plants	T0 + 20,8	T0 + 32

Source: Unique Groupe TKP 1x109HA.01 PROPOSAL – IPS# 1228683 rev 18

Note: As per EPC Contract, NTP is 23rd October 2019 and as per EPC Contract, COD is after 32 months of NTP

3.7 Resource and Utility Requirement

3.7.1 Land Requirement

The total land requirement for setting up of the power plant is 21.07 acres, which houses the power plant and facilities including switchyard and dormitory for 600 MW unit with future provision of another 600 MW Unit. The project land was single cropped agricultural land, being converted into industrial land. The overall land break-up for the power plant is shown in ***Table 3.6*** below.:

Table 3.6: Land Breakdown of the Proposed Power Plant

Structure Name	Area (Square Meter)	Area (Acre)	Percentage (%)
GT Area	8094	2	9.5
ST Area	8094	2	9.5
HRSG Area	6879	1.07	5.1
DM Plant House	3238	0.8	3.8
Raw Water Pump House	1214	0.3	1.4
Water Pre-Treatment Area	2833	0.7	3.3
Wastewater Treatment Area	3642	0.9	4.3
Chemical Dosing Room	1619	0.4	1.9
Cooling Tower	2833	0.7	3.3
CW Pump House	2428	0.6	2.8
Hydrogen Generation Station	2428	0.6	2.8
RMS	2833	0.7	3.3
Administrative Building	3238	0.8	3.8
Warehouse and Workshop	3642	0.9	4.3
Dormitory	3238	0.8	3.8
400 kv Switchyard	11735	2.9	13.8
Green Area	19830	4.9	23.3
Total	87818	21.07	100

Source: Unique Meghnaghat Power Limited

Entire land has been procured by consortium company (SFL-913.64 decimal, Unique Hotel and Resort Limited-1108.16 decimal and SFL+ UHRL-85.56 decimal) from 343 landowner based on 'willing buyer and willing seller' method. After completion of land procurement process, entire land has been transferred to UMPL. Before procurement, 6.79-acre land was already fallow as that has been previously procured by a businessman for setting up an industry. This fallow land has been used by the local community and fisherman to approach the river front. Rest of land was used by the landowners for agriculture purpose. As the entire land is low lying agricultural land, it was not possible to be utilised for agriculture during monsoon. Only during the dry period, landowners used this land for agriculture. Seven residential land parcels were also procured for the project on negotiation basis.

Land price has been negotiated based on the prevailing market price. Payment of land compensation has been made to each of the landowner. It has been revealed during consultation with Sub Register of Land Revenue office in Sonargaon that after land price negotiation, land parcel has been registered in the name of UMPL in presence of both the parties. As per the legal provision of the Govt of Bangladesh, it has been confirmed by the sub register that full and final payment of the land price has been received by all the present landowners who sold their land, before the land registration in the name of UMPL.

Apart from that land is also required for construction camp and lay down area, laying of STP treated water discharge pipeline from construction camp to the discharge point. Total 1200 decimal land (12 acre) in Dudhghata mouza has been taken on 3 years lease from Hamdard Laboratory for construction camp and lay down area. The treated sewage pipeline will be aid along the along of the road and no additional land is required for laying of this pipeline. Extra land is not required for gas pipeline and transmission tower. Gas pipeline would be laid beneath the river & would surface out within the plant boundary at one side and TGTDL valve station on the other side. One of the two transmission towers would be located within the plant boundary and other one would be located within the road on the land of BIWTA, for which requisite permit/license has been obtained.

The area requirement of project components & Associated facility is presented in ***Table 3.7 :***

Table 3.7: Breakdown of area requirement of the project components & Associated facility

Sl. No	Name	Area requirement, acre	Status of the land Procured/leased from	Use of the land
1	Construction Camp Site	12.00	3 years lease from Hamdard Laboratory	To be used as residence cum material laydown area during the construction of the plant and decommissioned once construction phase is over. As per contractual agreement with Hamdard Laboratory, no site restoration is required to be undertaken by UMPL
2	Treated Sewage pipeline	-	The treated sewage pipeline will be laid along the alignment of the road. No additional land is required.	
3	Jetties	0.38	To be set up on UMPL land	To be used during construction phase for receipt of raw materials and equipment including heavy machinery and decommissioned on completion of construction phase
4	Transmission towers (Tower A & B)	-	Tower A would be located within the plant boundary of UMPL, and Tower B would be located on the land of BIWTA, for which requisite permit/license has been obtained.	
5	Gas pipeline	-	Gas pipeline would be laid underground and beneath the river & would surface out within the plant boundary at one side and TGTDL valve station on the other side.	
6	Additional Laydown Area	1.49	Land adjacent to the plant site has been procured on lease during 2021 from local community for 15 months for storage of Construction materials	
7	Approach Road	0.19	The Approach Road is the road connecting Dhaka-Chittagong Highway to Purbapara Ghat which passes by the Plant and is proposed to be used for movement of men & materials between the site and the Construction camp/Laydown area.	

3.7.2 Investment of Land Sell Amount by the Landowner

It has been observed from data collected by the by local sub-contractor of AECOM during socio-economic survey of each landowner carried out during August 2020 that 38% landowners have procured alternate agricultural land which is more than the amount of land they have sold out to UMPL. During consultation it was informed by the landowners that adequate alternative agriculture land is available for procurement within the vicinity of the

Dudhghata village. Further it was found that 7% landowners have invested their money in animal husbandry business. They have bought cows and constructed cattle shed for doing animal husbandry business. 6% landowners have invested the amount in their existing business or bought new autorickshaw or CNG vehicle based on their existing transport business. Only 2% among the landowners distributed their land price amongst their sons and daughters or invested their money for going abroad for job.

Apart from that, 47% of landowners have kept the money received as land price in bank for future investment. They are planning to invest their land sale amount in other ventures. However due to pandemic situation they were unable to invest in any business and waiting for improvement of pandemic situation in Bangladesh, when they can decide on their further course of action for a better utilisation of the money received.

3.7.2.1 Present Status of Willingly Relocated Houses

As per survey and consultation with willingly relocated household owners revealed that out of 7 willingly relocated households, 6 owners have already completed procurement of land and construction of new houses is ongoing. Only one owner is planning to construct his house. Consultations with UMPL following to this has confirmed that proponent will ensure completion of all reconstructed household structures at the soonest.

Table 3.8: Details Investment by Physically willingly relocated house owner

				Details of Land Procurement		House Construction Details		
Sl.	Name	Present Address	Occupation	Land Sold to UMPL	Newly Procured Land	Amount Received from UMPL for Displaced House (In BDT)	Cost of Building of New House (In BDT)	Remarks
1	Md. Jallauddin	Asariarchar, Pirojpur	Business	Land Area -15 Decimal Land Sell Value- 60,00,000 BDT	Land Area -15 Decimal New Land Price- 25,00,000 BDT	10,00,000	10,00,000	Construction Complete
2	Md. Musa Bhuyian	Shohidnagar, Pirojpur	Business	Land Area - 4Decimal Land Sell Value- 24,00,000 BDT	Land Area -12 Decimal New Land Price- 24,00,000 BDT	9,00,000	900000 (Estimated)	Ongoing
3	Md. Sayed Ali Bhuyian	Shohidnagar, Pirojpur	Business	Land Area -1 Decimal Land Sell Value- 6,00,000 BDT	Land Area -5 Decimal New Land Price- 10,00,000 BDT	6,00,000	350000	Construction Complete
4	Md. Ujjwal Bhuyian	Shohidnagar, Pirojpur	Business	Land Area -2 Decimal Land Sell Value- 12,00,000 BDT	Land Area -6 Decimal New Land Price- 12,00,000 BDT	2,80,000	300000	Construction Complete
5	Nure Alam	Dudhghata, Pirojpur	Business	Land Area - 1.5 Decimal Land Sell Value- 6,18,750 BDT	Land Area -4.5 Decimal New Land Price- 9,00,000 BDT	2,90,000	250000 (Estimated)	Ongoing
6	Md. Asadul	Shohidnagar, Pirojpur	Business	Land Area - 1.5 Decimal Land Sell Value- 8,25,000 BDT	Land Area -5 Decimal New Land Price- 6,00,000 BDT	2,90,000	310000	Construction Complete
7	Md. Ismail Hossain Sumon	Dudhghata, Pirojpur	Job	UMPL did not procure any land from him as he is a tenant on this land. Shifted to another house owned by him				

House of Md. Jalal

Md. Musa Bhuiyan

Md. Sayed Ali Bhuiyan

Md. Ujjon Bhuiyan

Md. Ismail Hossain Sumon

Md. Asadul

Nure Alam

Figure 3.10: Accessibility Map of the Project Site and Construction Camp Site

3.7.2.2 Earth Filling

Before sand filling, the elevation of the site varied from 5.0 to 8 m. The land has been developed up to 7.76 m meters in line with present road level located at the north side of the project boundary to avoid flooding. Approximately 566337 cum (20 x 106 CFT) of sand was required for developing the proposed project site land up to the safer level. Sand has been procured from approved vendor M/s Meghna Enterprise under contract agreement Work Order- SFL/OPS/2019/0036 Date- 27/10/2019 and Work Order- SFL/OPS/2020/0057 Date- 01/09/2020 and designated dredging location. The sand is procured from Dakkhin Nayanpur (23°32'21.01"N 90°34'20.84"E) in Bangladesh.

3.7.3 Water Requirement and Source

Raw water will be sourced from Meghna River for the project. The raw water would be treated to produce clarified water for various uses. A raw water intake pump house would be constructed adjacent to the river. Layout of Raw water pump house is presented in the Figure 3.10. Estimated total raw water requirement for the plant is 676.22 m^3/hr for 600 MW, considering recirculation of cooling water system with cooling tower. The raw water after treatment would be stored in the filtered water reservoir having storage capacity for 16 hours. Plant Water Balance diagram is presented in ***Figure 3.11.***

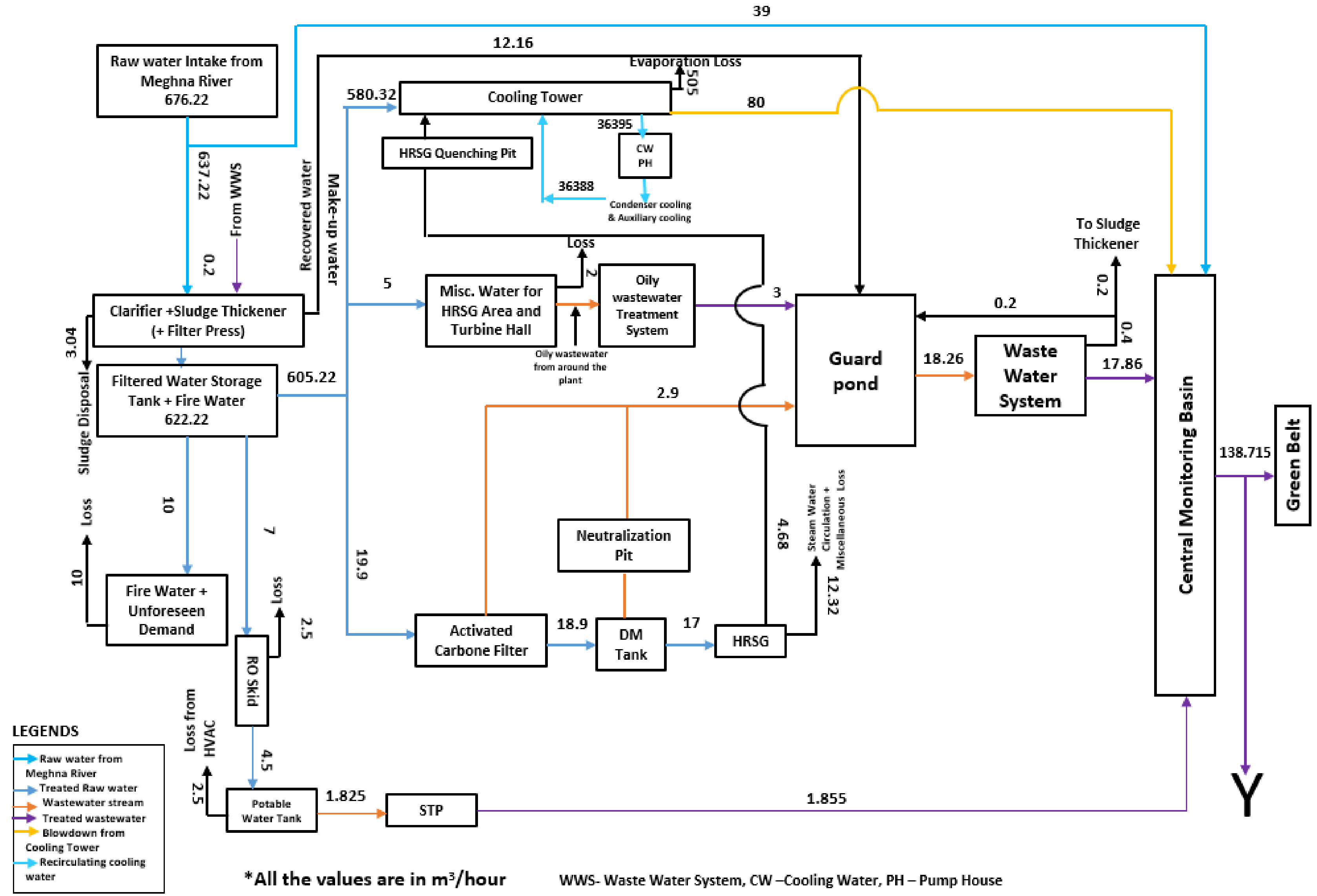


Figure 3.11: Water Balance Diagram (Source: Extracted from Water Balance Diagram dated 10-13-2021 furnished by UMPL)

Raw water for the plant would be drawn from Meghna Channel to Raw Water Pump House, located inside plant, through an intake channel and fore bay. For each raw water pump sump, a set of trash rack and rake and travelling screens would be provided in order to filter out debris etc. One set of stop log would be common for the two pump sumps. Outlet of each raw water pump would be provided with one motor butterfly valve. Water hammer absorbing devices would also be equipped on the raw water pump discharge piping. Raw Water pumps would supply raw water to the Pre-Treatment Plant. It is proposed that Raw water pumps of capacity 750-900 m^3/hr would be installed with 1 working, 1 standby arrangement. A pre-treatment plant will be installed to clarify the raw water. Chemicals such as alum and soda ash will be dosed to the water in flash mixer. The clarified water from the overflow of Clariflocculator will be stored in a twin compartment clarified water reservoir of 2 hours storage capacity and used for Cooling Tower make-up, service water, potable water and input water to the DM Plant. The sludge from the water pre-treatment plant will be treated and disposed of suitably.

During the construction phase, water requirement is mainly for construction purposes, sanitary uses and for drinking. To meet the domestic & potable water requirement during construction phase, two (2) tube wells with motor capacities 15 KW (300 m deep) and 5 KW (100 m deep) have been installed and the permission from Pirojpur Union Parishad for installation of the same is provided in Appendix E. The requirement of groundwater water in the construction site as well as laydown area is in the range of 9-12 cum/day for domestic & potable purposes. The water requirement for construction activities is met from the Meghna River and is about 100 cum/day (peak requirement) for construction site as well as laydown area. The permission for Water Withdrawal from River is presented in ***Appendix F***.

3.7.4 RLNG

Requirement of natural gas would be about 96192 Mscf daily for the proposed project. Required gas would be supplied by TITAS from nearest valve station located at the Meghnaghat. The Gas Supply Agreement (GSA) has been already signed between TITAS Gas Transmission and Distribution Company Limited and Unique Meghnaghat Power Limited.

It is proposed to lay a 20-inch (508 mm) diameter subsurface pipeline for gas supply across the river from nearby valve station located on the other side of the Meghna branch channel. To cross Meghna branch channel pipeline would be laid under the riverbed at a depth of 15.79 m by using Horizontal Directional Drilling. The pipeline alignment route is shown in ***Figure 3.12***

The pipeline would cross the river and enter the plant site as shown in the ***Figure 3.13.*** Necessary License/permit has been obtained from BIWTA for the HDD gas pipeline vide Memo No. 18-11.6758.067.03.540.19 (Unique Meghnaghat Power)/225 dated 04/01/2021 (***Appendix F***).

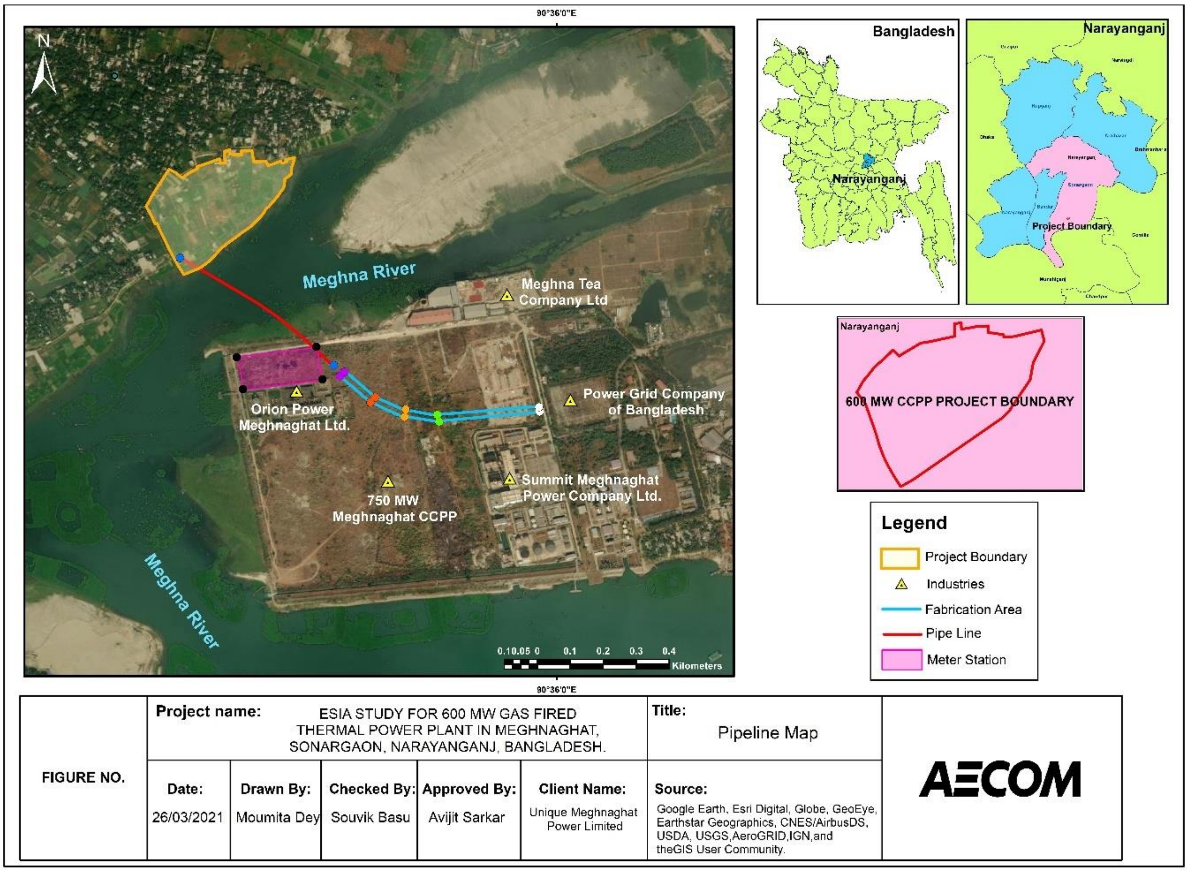


Figure 3.12: General alignment of the Pipeline HDD

The pictorial representation of the underground pipeline is shown in ***Figure 3.13.***

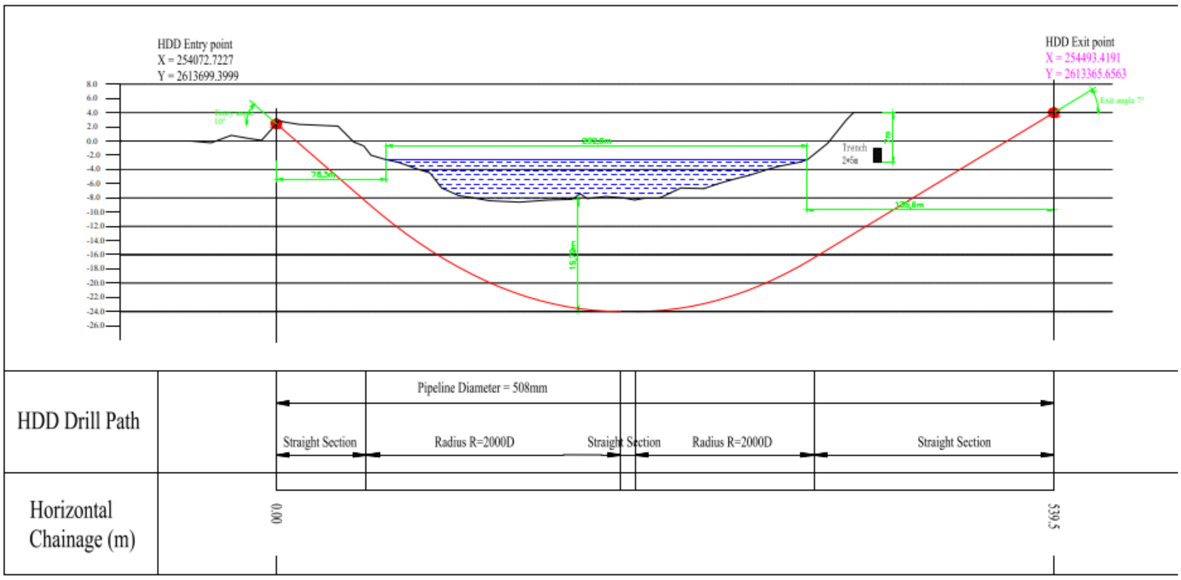


Figure 3.13: Sectional drawing for Meghna river HDD Crossing

(Source: Drawing No. UNQ/00/K/UEP----ADP/SK/001-002 furnished by UMPL)

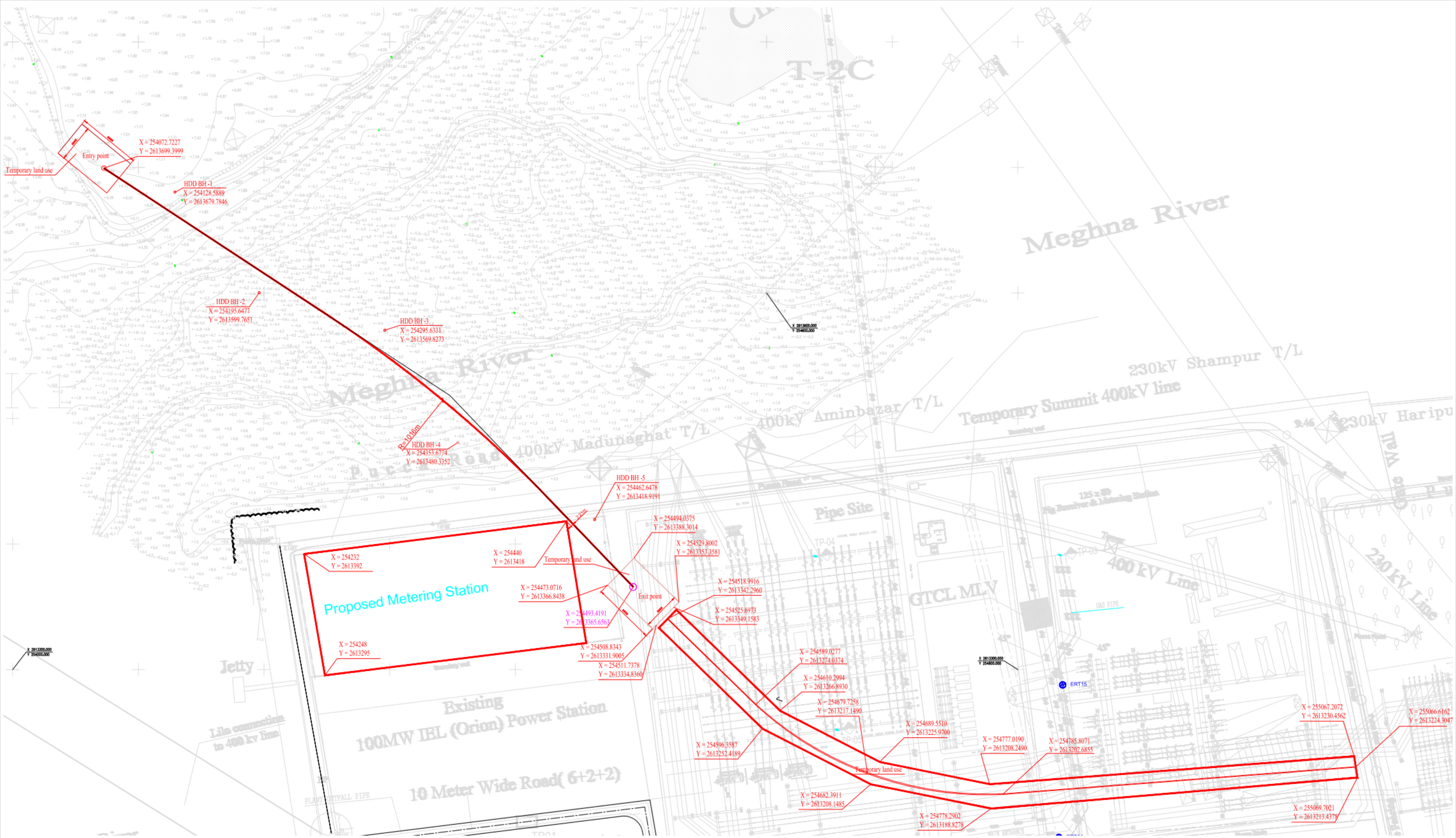


Figure 3.14. Borehole layout for Meghna river HDD Crossing

(Source: Extracted from Drawing No. UNQ/00/K/UEP---ADP/SK/001-005 furnished by UMPL)

3.7.5 Materials Transportation Storage and Handling

All heavy equipment and machineries as well as construction materials will be transported by the river. The major materials and equipment which will be conveyed through river is tabulated in ***Table 3.9:***

Table 3.9. Materials to be conveyed through River

Material Received	Quantity
HRSG Casing Assemblies	19348 (total pcs)
HRSG Inlet Duct Structural Steel	3450 (total pcs)
Lower Turbine Casing Warming Syst	298 (total pcs)
Hazardous gas detection system	119 (total pcs)
HRSG erection frames	1072 (total pcs)
Electrical control system	1 pc
Exhaust Diverter Damper	420 (total pcs)
Gas Tubing Arrangement	1 pc
Gas Turbine - Components	1 pc
Gas Turbine	1 pc
Generator Protection Panel	1 pc
HRSG Anchor Bolt	128 (total pcs)
HRSG Casing Assemblies	3362 (total pcs)
HVB	6 (total pcs)
Stone chips	3000 ton
Sand	2000 ton
Concrete	35000 m^3

Road traffic will be mainly restricted to transport of personnel from the laydown area to the Plant during the Construction phase. During the operation phase, personnel will use the approach road to commute to and from work. River transportation will also be availed as per requirement

The plant operation would require chemicals for water treatment and process requirements. Hazardous material anticipated to be stored during construction and operation include petrol, diesel, welding gas, weld inspection material, radiographic material, paints, cleaning chemicals, DM plant chemicals etc. These materials would be stored in accordance with prescribed safety norms in ventilated enclosures. Safety instructions and signage would be prominently displayed at appropriate points/locations.

3.7.6 River Jetty

UMPL is planning to construct two river jetties for ferrying construction material, equipment, machinery to the site using Meghna Channel. The location of the temporary jetties as well as the coordinates of the nodal points is shown in ***Figure 3.15***

Figure 3.15. Location of the temporary Jetties (marked by Cyan structures)

The Jetties are temporary in nature. The area of the Jetties are 810 sq. m and 735 sq. m. The 810 sq. m jetty, referred as Jetty 1, would be used for conveying sand, stone chop, cement and other construction material. The second Jetty of 735 sq. m, referred as Jetty 2, would be used to transfer heavy equipment & machinery to UMPL site. The timelines of the two Jetties are presented below:

Phase	Jetty 1	Jetty 2
Construction	September 2020	October 2020
Commissioning	November 2020	December 2020
Decommissioning	Before COD	June 2022(approx.) after STG arrives at site

The layout of the two jetties is presented below ***Figure 3.16:***

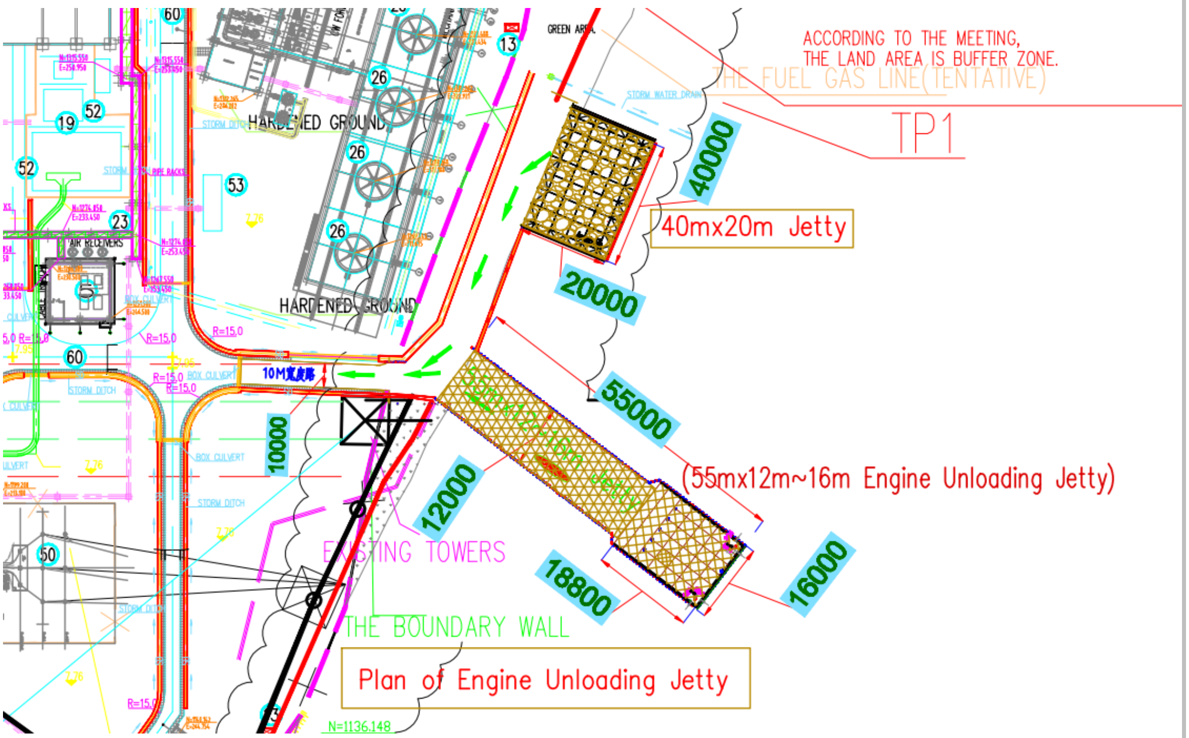


Figure 3.16. Layout showing the Jetties

Meghna River is connected to the main inland river network from Chattogram Port through the Bay-of-Bengal. Imported plant equipment would be transported to the site by this river route. Most of the heavy equipment is expected to be unloaded at Chittagong Port. The river network is the best way to carry construction material and heavy equipment. UMPL has obtained permission from Bangladesh Inland Water Transport Authority vide Licence no 18.11.6758.067.03.540.19 (Unique Meghnaghat Power)/1595 dated 28/08/2019 for use of foreshore waterfront of Meghna River for construction of temporary Jetty (810 Sq. m), water pipeline & pump house and RCC guide wall. Jetty would be operational during the Construction period and would be demolished when the Construction period is over. Design of the temporary Jetty is presented in the ***Figure 3.17, Figure 3.17*** and ***Figure 3.18.***

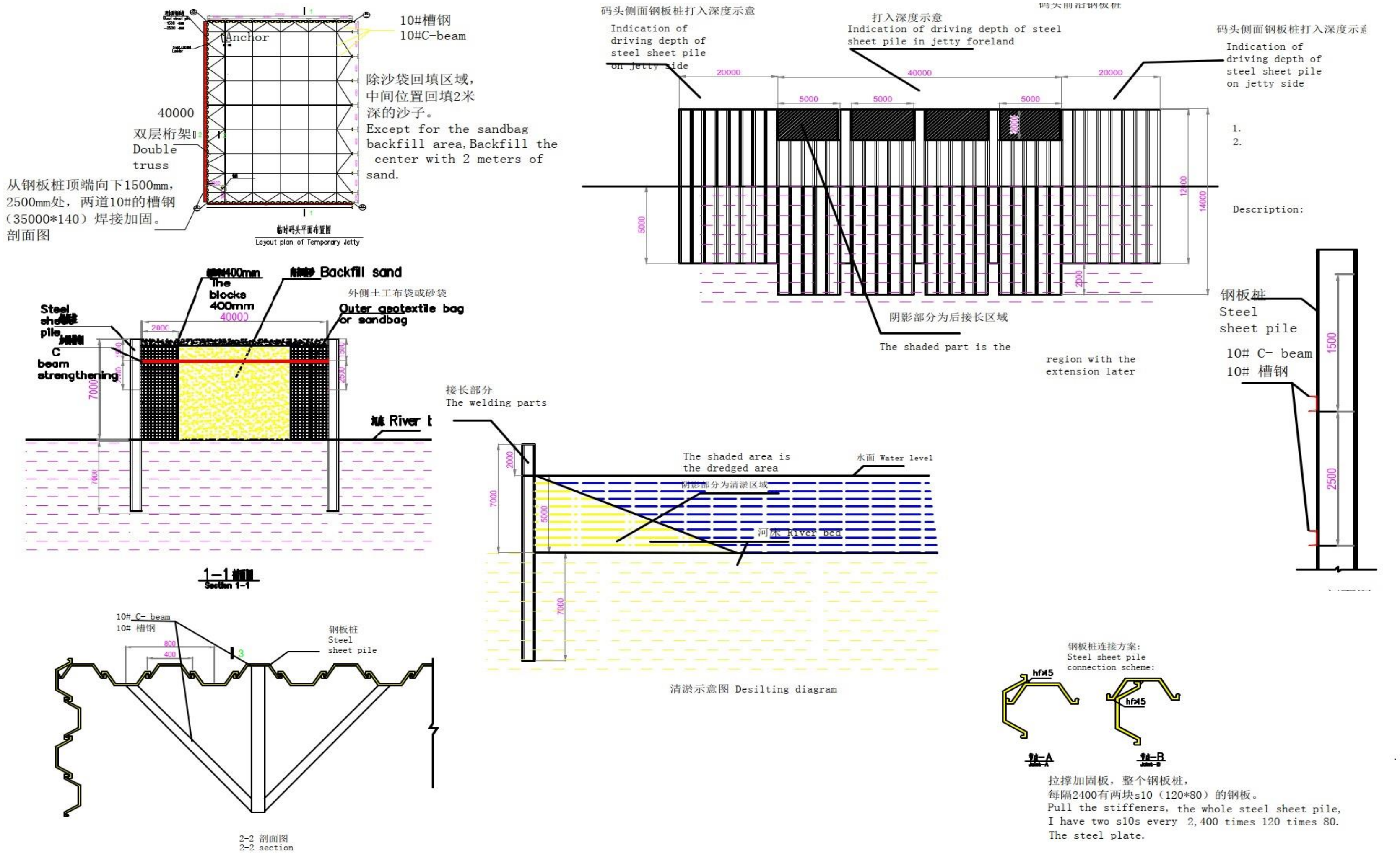


Figure 3.17: Design of Jetty (810 sq. m)

(Source: Temporary Jetty drawings furnished by UMPL)

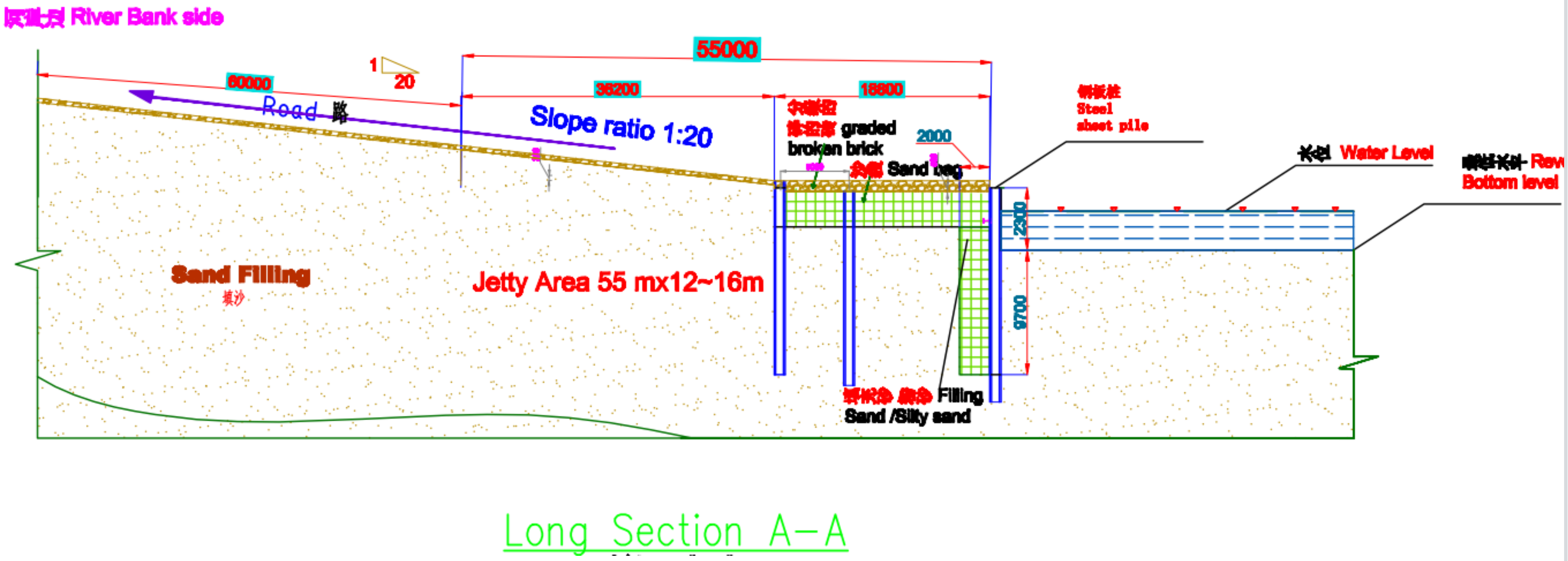


Figure 3.18. Design of Jetty (735 sq. m)

(Source: Temporary Jetty Layout furnished by UMPL)

3.7.7 Transmission Line

A 400 KV line would evacuate the power generated from the plant through a Transmission Tower-A (refer Figure 3.20) proposed within the plant. This 400-kV transmission line from Tower A would cross Meghna Branch Channel and evacuate electricity to PGCB's 400 KV substation. The length of Right of Way (ROW) is 650m & the width is 13m. Vegetation clearing/tree cutting is not envisaged along the ROW. The alignment of proposed 400 kV transmission line is also shown in the figure below. Necessary License/permit has been obtained from BIWTA for the HDD gas pipeline vide Memo No. 18-11.6758.067.03.540.19 (Unique Meghnaghat Power)/225 dated 04/01/2021(Appendix F). The site also has two existing 400 kV transmission towers (Towers 7 & 8) transmitting 400kV Meghnaghat-Amina bazar Line to Transmission Tower (T-6) located on the other bank of Meghna Branch Channel, which ultimately evacuates electricity to the same 400 kV substation of PGCB. As per the MOM between PGCB and UMPL dated 21st November 2019, Towers 7 & 8 located within UMPL site would be undisturbed and the existing 33m wide corridor would be maintained and no structures above ground within this line corridor would be setup. Also, soil would be removed from the tower locations to original ground level to ensure safety of towers inside the proposed plant.

3.7.8 Water Intake Channel

The intake channel connecting Meghna River to RW Pump House fore bay is a 123.8 m long converging channel. The channel width gradually reduces from 11 m at the Meghna River side to 5 m at the fore bay side. The maximum depth at the intake point is (-)5.80 m. The layout of the raw water intake system showing the Raw water pump house, the intake channel is shown in Figure 3.19

3.7.9 Hydrogen Generator Station

In CCPP, air is compressed which then t enters the combustion chamber and mixes with the natural gas. The high temperature flue gas produced from combustion of the mixture of gases drives the Gas Turbine. The flue gas from the Gas Turbine goes to the HRSG for the heat exchange and then passes through the stack to atmosphere. The Gas Turbine is coupled at the Compressor air inlet end via a Load coupling to the Generator Rotor. Mechanical Energy is converted to electrical energy in the Hydrogen cooled generator. The Generator Step up transformer raises the voltage from 15.75 KV to 400 KV. Steam turbine with its HP / IP and dual Flow LP stage converts the Heat Energy to Mechanical Energy and the turbine shaft is coupled to the Hydrogen Cooled Generator rotor. The Mechanical Energy is converted to electrical energy at the generator.

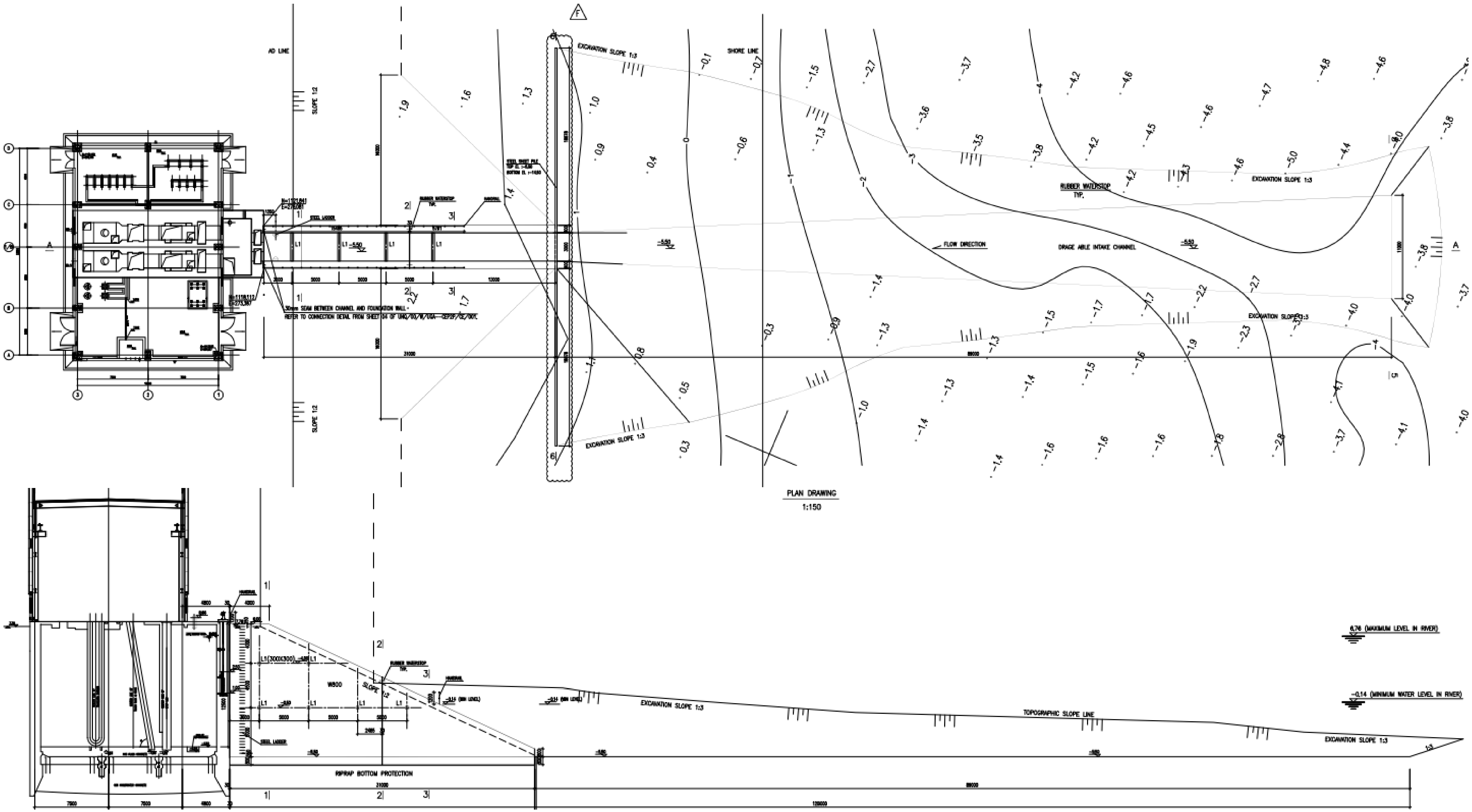


Figure 3.19: Figure showing the raw water intake channel (Extracted from Plan and section drawing of Raw water pump house and intake channel furnished by UMPL)

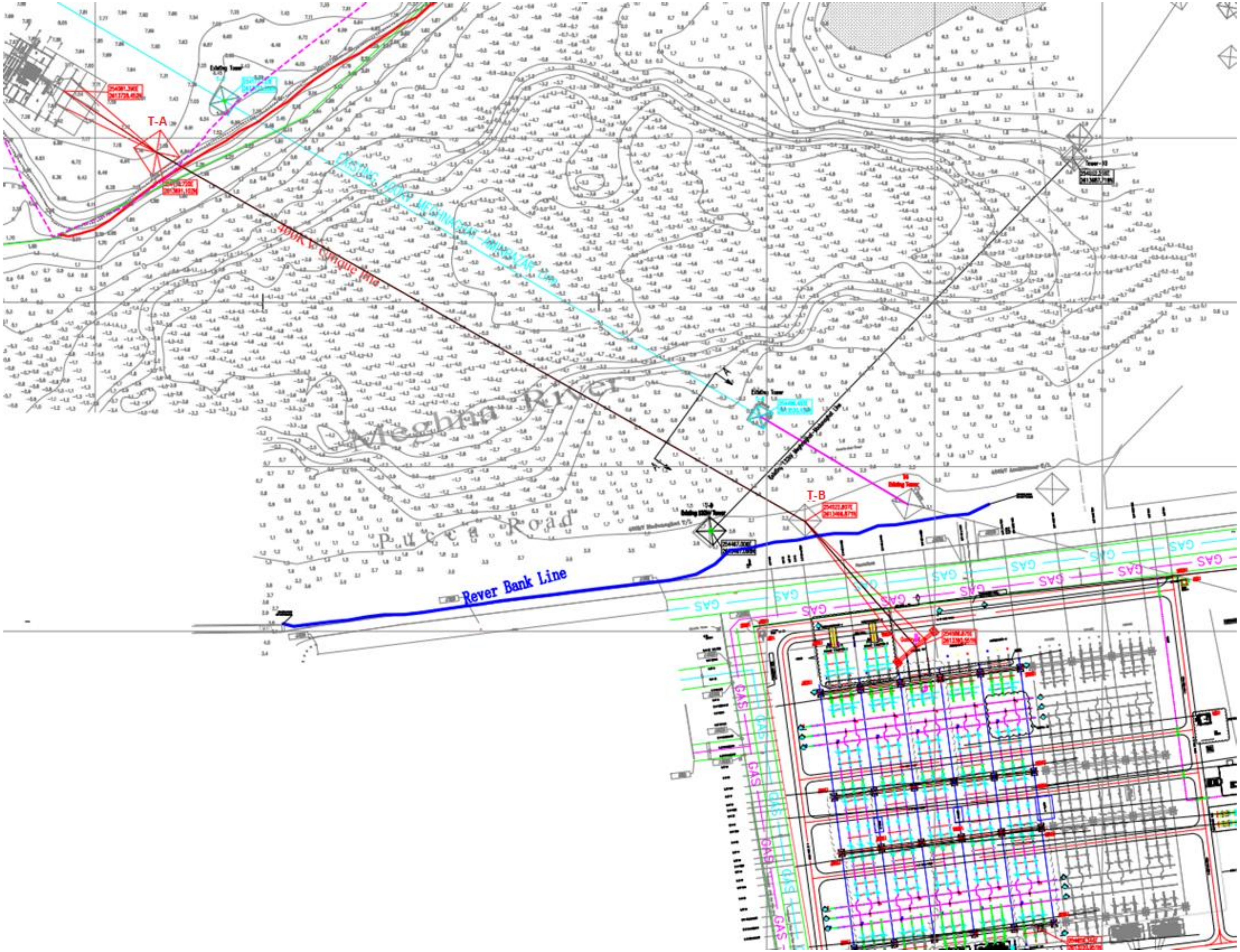


Figure 3.20: Alignment of Transmission Line (Extracted from 400 kV routing layout No FA14931S-D5000-01 dated July 2020 furnished by UMPL)

3.7.10 Construction Camp/Lay down Area

A total of 12 acres land in Dudhghata mouza has been taken on temporary lease for three years from Hamdard Laboratories (WAQF), a Bangladeshi Company. Earlier this land was agricultural land, which was procured by Hamdard laboratories for some other purpose from landowners long back. But due to some reasons they left it vacant and based on the verbal agreement with original landowners, they cultivated this land till UMPL had taken it on lease. As these landowners do not have any legal right on that land, they did not get any compensation from UMPL or Hamdard for impact on their livelihood. However, landowners were informed by Hamdard before start of sand filling by UMPL and they were given sufficient time to harvest their crops prior to the sand-filling activity.

The land was filled up by UMPL by using river sand up to the road level for constructing temporary construction camp site. The figure showing the construction camp/lay down area is given below. The coordinates of lay down area is provided in the Project location.

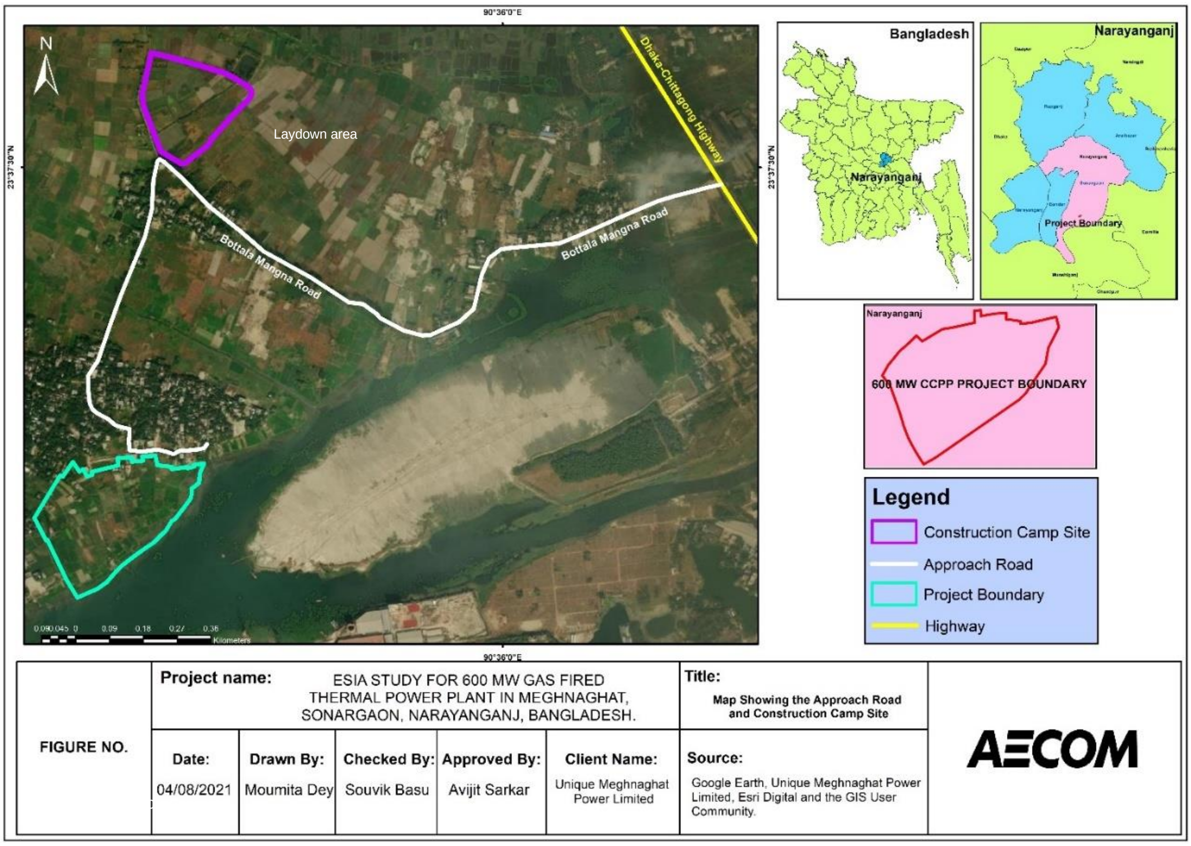


Figure 3.21: Location of Construction Camp/laydown area

The construction camp/laydown area would comprise of the following:

1. Office area consisting of offices of UMPL, GE and NEPC, with sitting arrangements, meeting rooms, coffee room with common facilities like one set of separate gents' washroom (5 toilet-units and 6 wash basins) & ladies' washrooms (4 toilet units and 2 wash basin) and Assembly Point.
2. Living area for UMPL, NEPC and GE with different categories of accommodation, washroom and food preparation area. There would be one basket court and strategically located emergency assembly points.
3. Provision of warehouses comprising of shed warehouse as well as Class A & Class B warehouses.
4. Provision of material storage in open storage yards, with separate entry for the yards

The existing water well on site would be reserved. At present, the STP is under final stage of construction and sewage is being treated through soak pit. Once the STP is commissioned, the sewage will be treated through the modular STP. The STP would consist of Biological Oxidation tank, secondary sedimentation tank, sludge tank and disinfection tank as shown in Figure 3.22. The treated effluent would be stored in a temporary reservoir and used for dust suppression, landscaping, etc and the surplus water would be discharged to a public sewage channel through a 105 m pipeline (NOC for the treated sewage water pipeline is presented in (***Appendix G***). The layout of the Construction camp/laydown ar`ea is presented in the ***Figure 3.23.*** The alignment of the Sewage pipeline, which passes along the road connecting the Laydown area to nearby nala. Treated sewerage pipeline route is presented in ***Figure 3.24.***

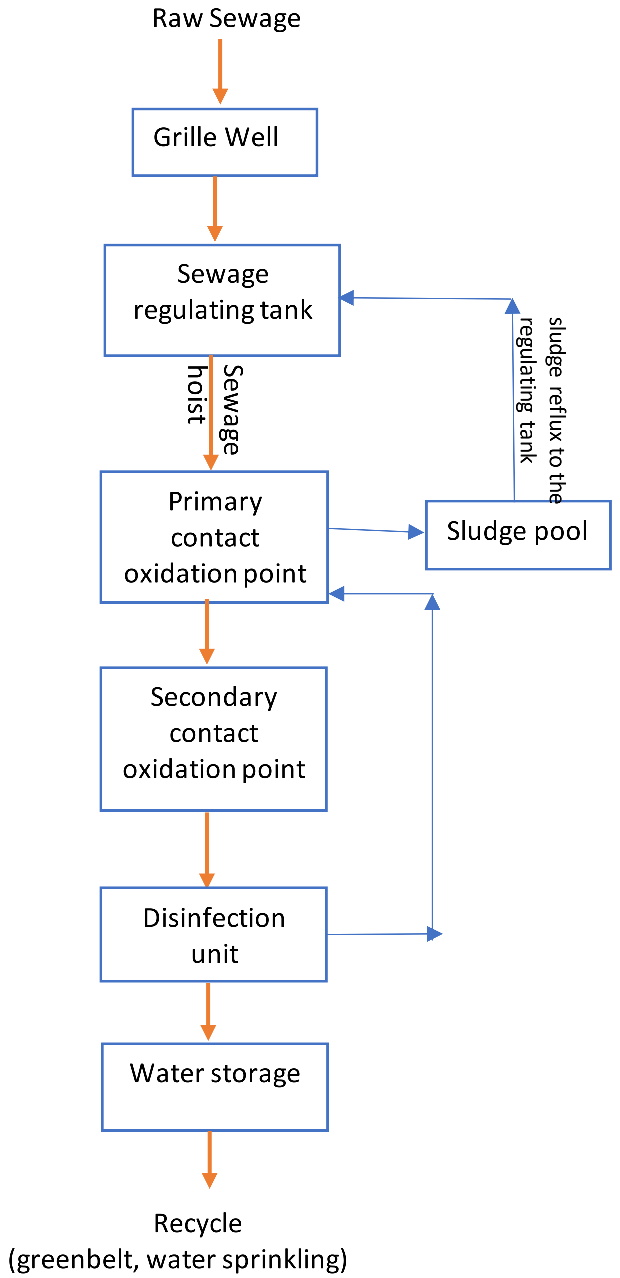


Figure 3.22. Schematic Flow diagram of STP at the construction Camp

(Source: UMPL)

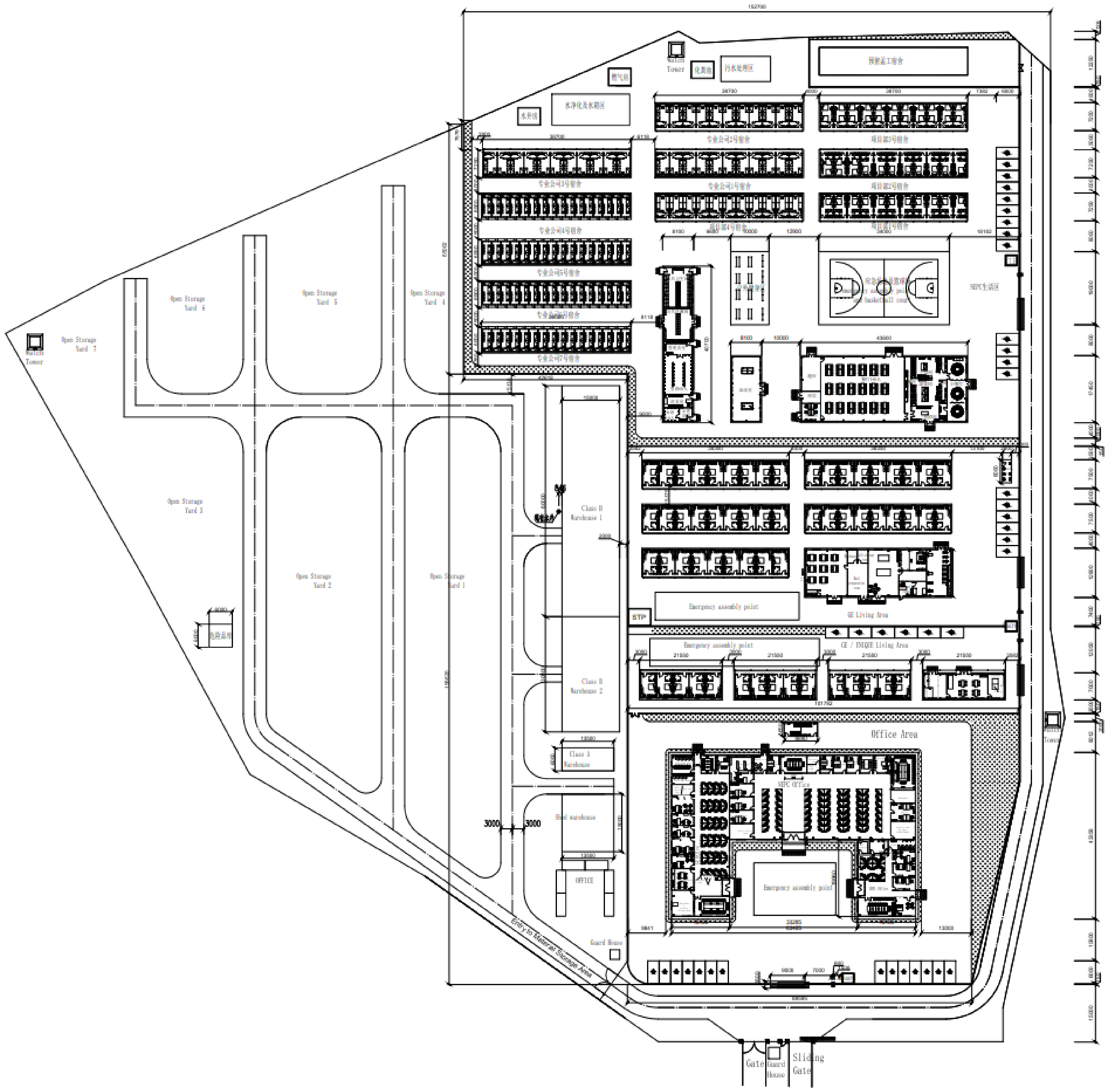


Figure 3.23. Layout of the Construction camp/lay down area

(Source: Extracted from layout shared by UMPL)

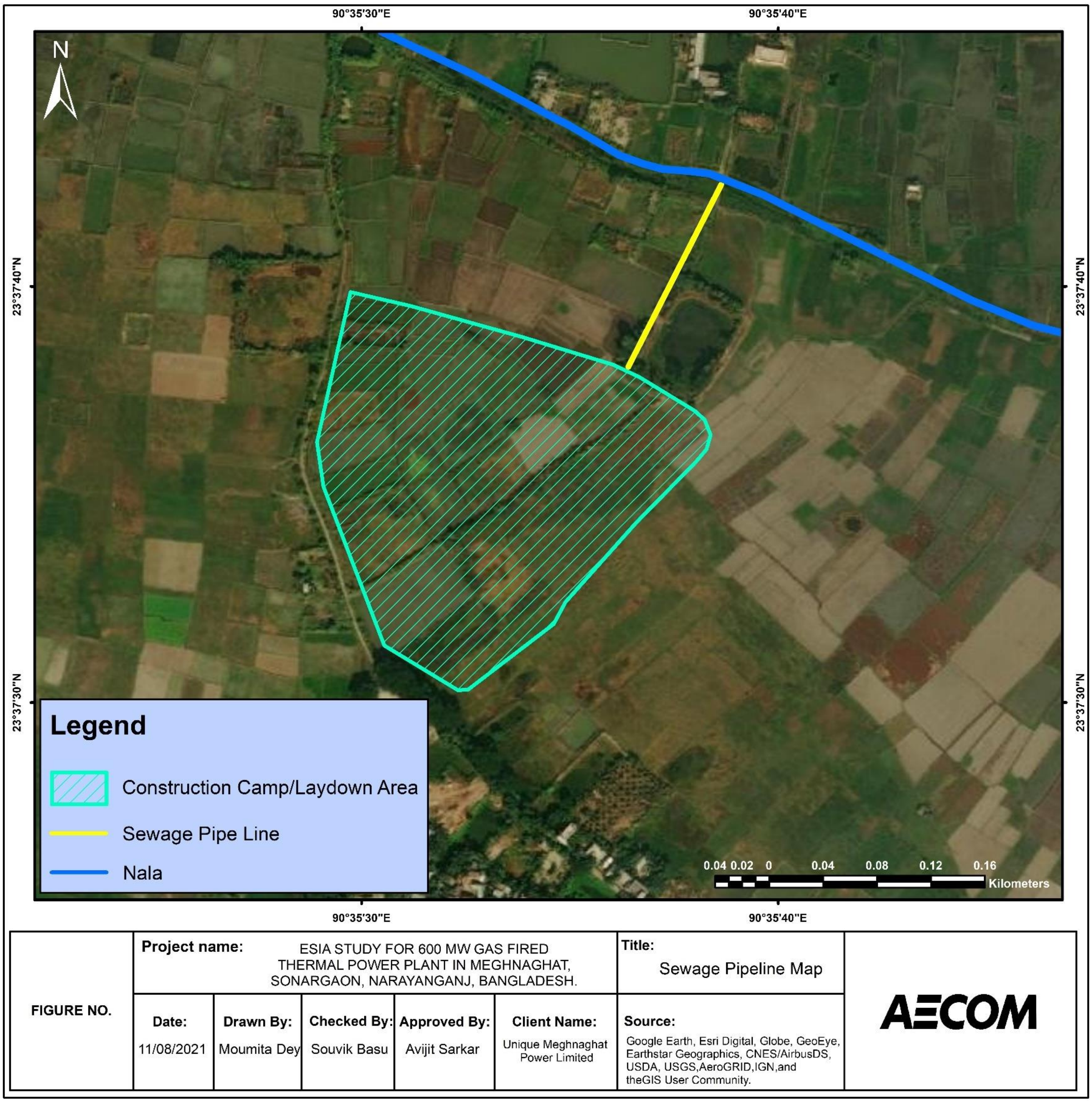


Figure 3.24: Treated Sewage pipeline

3.7.11 Manpower Requirement

During peak construction period approximately 1500 manpower would be required whereas average manpower requirement is 900. Approximately 100 skilled and semi-skilled manpower would be involved during operation phase of the proposed power plant. Manpower (unskilled and semi-skilled) would be hired from local area. Organogram of UMPL is presented in ***Figure 3.25*** below.

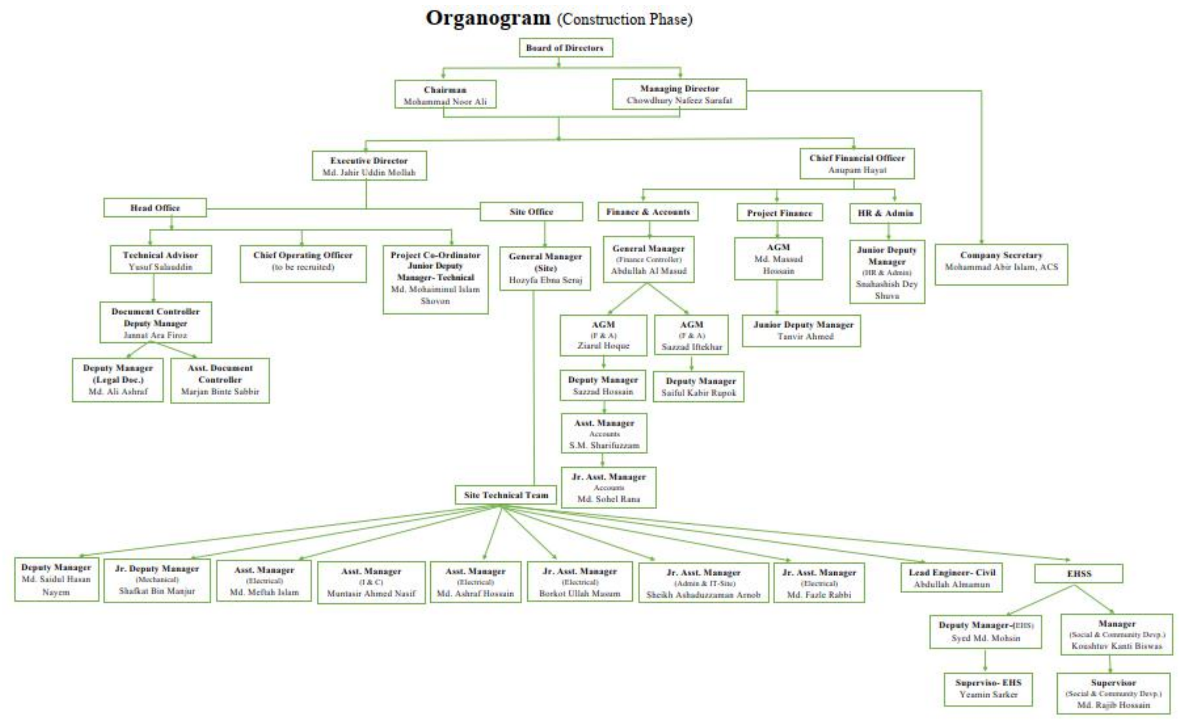


Figure 3.25: UMPL Organogram

Source: UMPL

3.7.12 Cost Estimation

The total project cost estimated as 503 million USD. The breakdown of the project cost is presented in ***Table 3.10:***

Table 3.10: Breakdown of Project Cost

Component	Amount (Million USD)
EPC Cost (incl. taxes)	351
Land, Project Management, Development, Commissioning and Start-up Cost	44
Spare Parts	35
Interest During Construction & Financing Costs	57
Contingency	17
Total	**503**

3.8 Safety Provision

3.8.1 Fire Fighting System

A comprehensive fire detection and protection system is envisaged for the complete power station. This system would generally conform to the recommendations of NFPA – 850. For protection of the plant against fire, the whole plant would be protected by any one or a combination of the following systems:

- Hydrant system (also includes the required number of hydrant pumps electrical motor driven and diesel engine driven).

- Automatic high velocity and medium velocity sprinkler system.
- Portable and mobile chemical extinguishers.
- Inert gas system
- Fire detection and alarm system

Filtered water as supplied to the plant would be used for fire-fighting purposes. Dedicated firewater storage of two hours' fire-fighting requirement would be maintained in the filtered Water Reservoir itself for fire-fighting purpose. It is proposed that there would be fifty-four (54) fire extinguishers placed at designated location within the plant.

The system would be designed as per the applicable Codes and Standards of National Fire Prevention Association (NFPA), USA. Regulations of local statutory authority as applicable would also be followed. The EHS plan delineates provision for one (1) training a year on Fire safety for all personnel working within the premises, apart from Induction training and regular mock drills.

3.8.2 Grounding

All 6.6 kV systems would be low resistance earthed to limit the earth fault current between 300 Amps to 400 Amps for 10 seconds. For this purpose, Neutral Earthing Resistor (NGR) of adequate rating would be connected between neutral point of secondary side winding of all unit transformers and earth. Each NGR unit would be air-cooled and self-supporting type. The enclosure would have a degree of protection of minimum IP 33.

The resistor elements would be made of non-aging stainless steel or equivalent corrosion resistant material having high electrical resistivity and low temperature co-efficient of resistant. All element connections would be bolted type to ensure stable resistance value throughout the working life of the unit.

3.8.3 Lightning Protection

The lightning protection system would be installed for protecting the buildings / structures against lightning discharge. This would be achieved by providing lightning masts on stacks, powerhouse building, towers in switchyard, etc. and connecting them with the earth grid. Over and above, the shielding wires and / or lightning masts would be used to safeguard the equipment of 400 kV switchyard and transformer yard.

3.8.4 Protection of Subsurface Gas Pipeline

UMPL would design, construct, install, commission and test the gas pipeline as per the specification as per Gas Safety Rule 1991 and its amendment (2003) of Bangladesh. It would be gas supplier's property as part of the gas supply network during plant operation. Cathodic protection would be in place for the buried section of the pipeline and the design would be based on soil resistivity.

3.8.5 Health and safety

Construction Phase

The Plant would be in full compliance with relevant health and safety requirements, all related acts, regulations, codes and statutory requirements of the Laws of Bangladesh. Besides the statutory requirements of GoB, the requirements of the Asian Infrastructure Investment Bank (AIIB) ESS policy, DEG Sustainability Policy, IFC Environmental and Social Performance Standards (PS1 to PS8), IFC General EHS guidelines, EHS guideline for thermal power plant and Safeguard Policy Statement (SPS) of Asian Development Bank, World Bank (WB) OP/BP would be applicable. Details regarding the requirements have been mentioned in Chapter 2.

The Construction Contractor would submit a Health and Safety Plan prior to commencing work at Site. The Health and Safety Plan would have method statements, which would include, but not be limited to, working methods, plant utilisation, construction sequence and safety arrangements. The Contractor's key duties would be to:

- Develop and implement the Health and Safety Plan, including rules for management of the construction work.
- Ensure that Sub-Contractors and workers comply with the health and safety plan.
- Monitor the health and safety performance of Sub-Contractors and give directions as appropriate.
- Arrange for competent and adequately resourced Sub-Contractors to carry out the work safety where it is subcontracted.

- Ensure the co-ordination and co-operation of Sub-Contractors.
- Obtain from Sub-Contractors the main findings of their risk assessments, the steps to be taken to control and manage the risks, including method statements for all aspects of the work.
- Ensure that Sub-Contractors and workers have information about risks on Site and that there are co-ordinated arrangements for workers to discuss health and safety and offer advice to the Contractor.
- Ensure that all workers are properly informed, consulted and trained on health and safety issues.
- Ensure that only authorised people are allowed onto the Site; and
- pass information to the Employer for the health and safety file.

Operation Phase

The Company would implement an international standard environment, health and safety (EHS) program in the Plant, which would be in full compliance with relevant health and safety requirements, all related acts, regulations, codes and statutory requirements of the Laws of Bangladesh and multilateral funding agency.

In addition, the Plant aims to be certified to OHSAS and ISO 14001 within 2 years of operation. An offsite accident and emergency response plan to control and mitigate the effects of any catastrophic incidents in above ground installations (AGI) or underground installation (UGI) or road transportation would also be prepared by the project in consultation with the district administration. The offsite emergencies would also be communicated to the local people.

3.9 Analysis of Alternative

The Project has considered alternatives in terms of site location, design and technology options. An analysis of these alternatives has been undertaken for the proposed Project including consideration of a no-Project scenario.

3.9.1 No Project Scenario

The "No Action" means that the Unique Meghnaghat Power Limited decides and agrees not to construct any power plant at the Meghnaghat site or, to be more precise, suspends any ongoing construction activities. As the existing power situation has already entered an alarmingly deficit state with adverse impact on undertaking industrial entrepreneurship and other socio-economic sectors, the proposed power plant project is likely to play a key role in achieving GoB's Power Generation goals and target due to its proposed 588.31584 MW net output. Electricity consumption per capita of Bangladesh was only about 433[4] KWH as of 2019. Sustainable development plan formulated by the Government of Bangladesh has been blocked due to erratic supply of electricity. Bangladesh's energy crisis is not a short-term crisis, and in order to resolve this crisis, the need for new power generation project has become increasingly prominent.

Therefore, the idea of "No Action" or dropping of such a prospective project would not be beneficial for the current power scenario in Bangladesh. The consequences of an undersupply would harm the sustainability of the already existing industrial production in the country as well as impact upon the quality of life of those affected by the power outages. Furthermore, under the zero option, the considerable advantages with the current site vis-à-vis construction of the power plant and power generation and, through it, creation of employment facilities in the proposed project area would be lost.

3.9.2 Site Location Alternative Site Location Alternative

Initially UMPL had selected one land parcel in Badiyer Bazar area of Pirojpur union. Out of total 16 acres, 12 acres of land was already purchased from High Speed Group of Companies during 2015. Rest of the 4 acres of land was to be purchased from the local community. Comparative analysis of the land is presented in Table 3.11 below.

Table 3.11: Site Alternative Analysis

Sr. No.	Site Selection Criteria	Site 1-Badiyer Bazar Area	Site 2-Dudhghata Mouza
1.	Available Land Area	16 acres	21 acres
2.	Land Type	Vacant land and residential land	Agricultural land

[4] *https://en.wikipedia.org/wiki/List_of_countries_by_electricity_consumption*

Sr. No.	Site Selection Criteria	Site 1-Badiyer Bazar Area	Site 2-Dudhghata Mouza
3.	Physical Displacement of Household	Approximately 10 household have to be resettled	Majority of land is agricultural land which has been procured from landowners and 7 household land has been procured and they have been resettled
4.	Approach Road	There is no direct approach road present. UMPL has to construct more than 2 km approach road.	Land parcel is connected Dhaka Chittagong Highways through village road
5.	Gas Pipeline	Aerially site is 4 km away from the nearest gas valve station. Length of gas pipeline would be more	Nearest gas valve station is 500 meters away from the site
6.	Transmission Line	Aerially site is 4 km away in from the nearest substation.	Aerially site is approximately 700 meters away in from the nears substation.
7	Erosion Potential	This site is more prone to river erosion as this is located in meandering position of main Meghna river.	Erosion potential is comparatively less as it is located in Meghna branch channel where flow of water is less than main Meghna River.

Based on the above assessment present site in Dudhghata Mouza has been selected as lesser number of physical displacement of household is required and proximity of gas station & substation.

3.9.3 RLNG route Alternative

It is proposed to lay 20-inch diameter sub-surface pipeline for gas supply across the river from nearby valve station located on the other side of the Meghna branch channel. To cross Meghna branch channel pipeline would be laid under the riverbed by using Horizontal Directional Drilling. However presently UMPL and its design consultant have evaluated the following route options for the pipeline under the river and to the project site

Option 1

The HDD of option 1 is the shortest and exit point is within the plant premise and entry point of HDD is on the other side of Meghna Channel in the metering station of TITAS Gas Transmission and Distribution Company Limited. Alignment of the gas pipeline on google earth is presented in ***Figure 3.26.***

Figure 3.26: Option 1-General alignment of the Pipeline HDD

Note: (The circles indicate terminal points)

Option 2

The HDD route of option 2 is a shorter route and the exit point is in immediate vicinity of the plant, though not within the plant site. This was an initial option and the alignment on google earth is presented in ***Figure 3.27.***

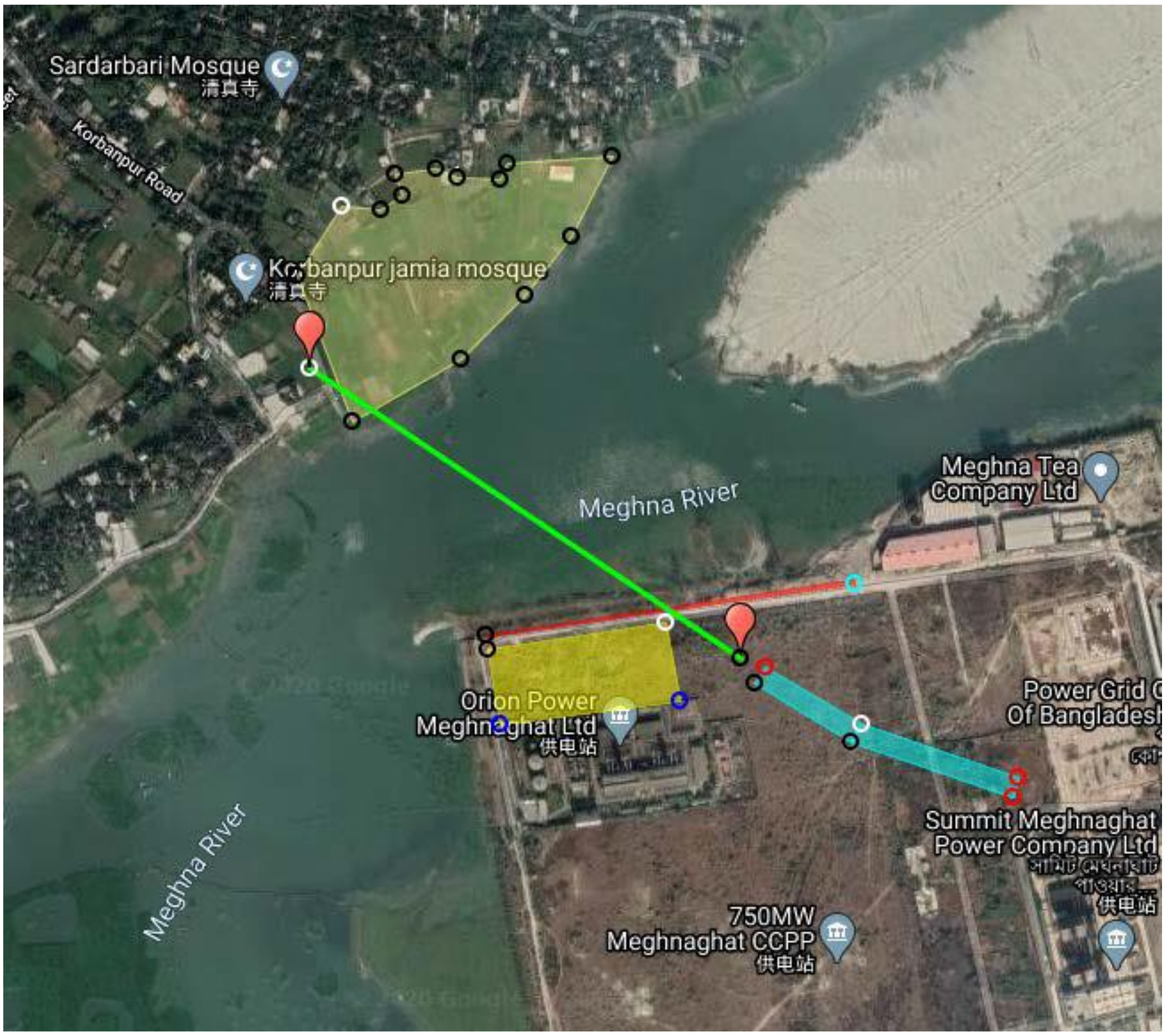


Figure 3.27: Option 2-General alignment of the Pipeline HDD

Note: The circles indicate terminal points

Option 3

The HDD of option 3 have the longest HDD curve and the exit point of the Fuel Gas Pipeline is quite far from the Unique Meghnaghat Power Plant site. This was also an initial option and it requires a longer pipeline to connect to the factory and also requires more land acquisition outside the Plant boundary by UMPL. General alignment on google earth is presented in ***Figure 3.28.***

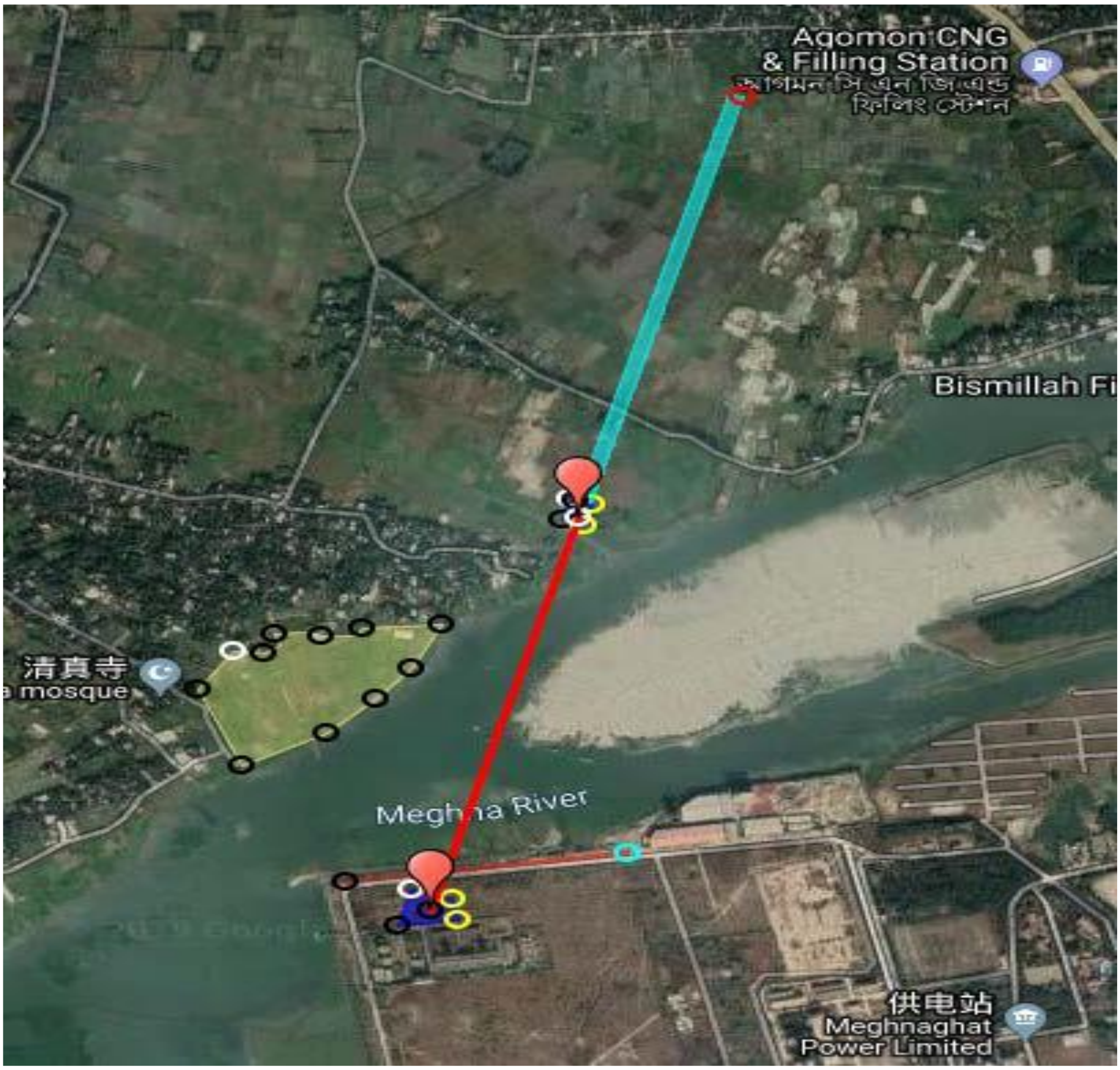


Figure 3.28: Option 3-General Layout of the Pipeline HDD

(The circles indicate terminal points)

Option 4

The length of HDD curve of option 4 is shorter than option 3 but longer than other options. It also has sufficient pipeline prefabrication space and it also needs to consider tie-in section to connect the pipeline to the Unique Meghnaghat Power Plant. General alignment on google earth is presented in ***Figure 3.29.***

Figure 3.29: Option 4-General Layout of the Pipeline HDD

(The circles indicate terminal points)

All the options are presented in the ***Figure 3.30*** for understanding of the different alignments and its associated requirements.

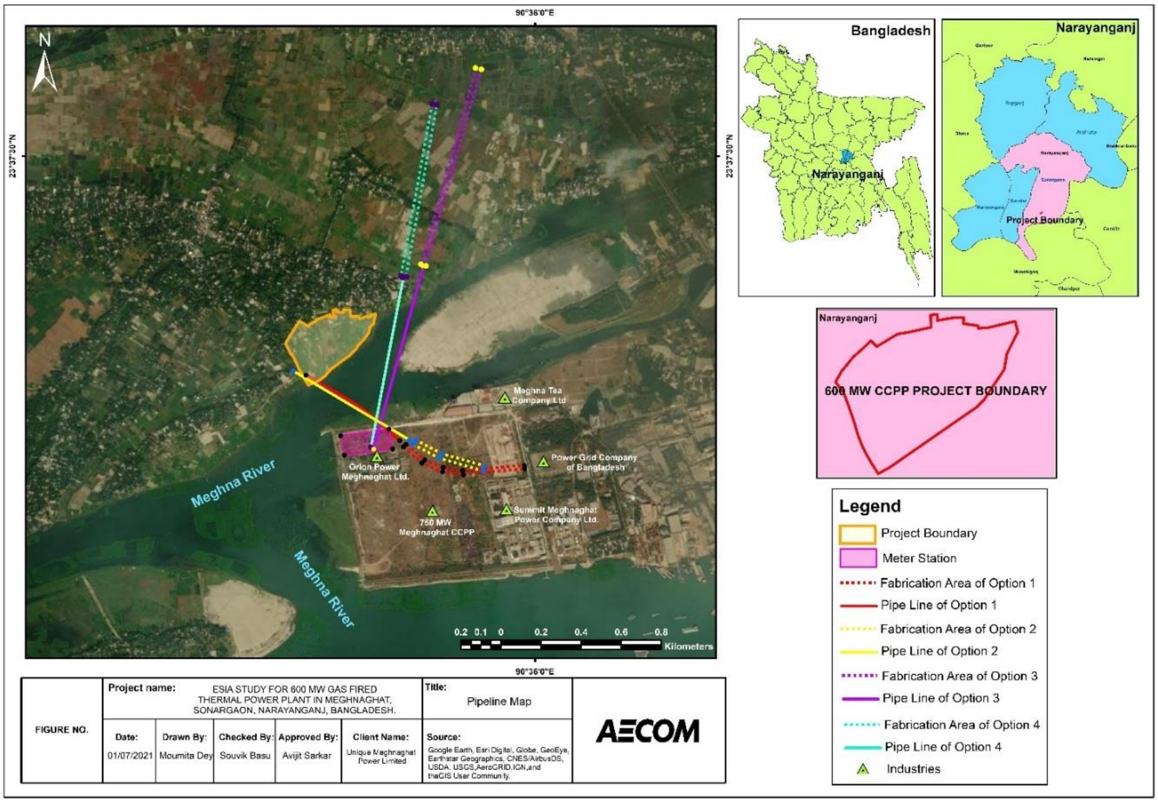


Figure 3.30: General Layout of the Pipeline HDD with the 4 options

(The circles indicate terminal points)

3.9.3.1 Comparison of the Options

Advantages and challenges have been analysed in below ***Table 3.12.***

Table 3.12: Comparison of Options

Aspect	Option 1	Option 2	Option 3	Option 4
Advantages	• The exit point is within the plant site • Additional land procurement is not required. No need for land acquisition	• The pipeline tie-in section for is shortest • Additional permanent land acquisition is very minimum. UMPL only needs to get a smaller quantity of land to ensure the pipe can be connected from exit point to factory.	• HDD length is long enough to ensure deep depth of HDD curve. • Pipeline prefabrication area is long enough to make whole section welding, which would be advantage to the HDD procedure.	• HDD length is long enough to ensure deep depth of HDD curve, which ensure the proper HDD procedure implementation • Pipeline prefabrication area is long enough to make whole section welding which would reduce the risk during pipeline pulling back.
Challenges	-	• Located amid habitation and sensitive receptors (Mosques)	• The pipeline tie-in section is longest; hence the work would take longer time to finish. • More land is to be acquired by UMPL outside the Power Plant boundary • Fuel gas pipeline would be crossing two (2) existing HV Overhead headline and would need necessary clearances from the PGCB & TITAS.	• Tie in point is outside the plant boundary; within the village. The pipeline tie-in section is long, which means that after completing the HDD requires longer pipe length from exit point to the power plant. • Additional permanent land acquisition, which includes a few houses within the village, is required to connect entry point or exit point to power plant. • The HDD exit curve would cross village.

Aspect	Option 1	Option 2	Option 3	Option 4
			• During prefabrication & pulling phase, temporary traffic disruption on Plant approach road (Battala – Mangna Road) may create local issues, which would require intervention from the UMPL.	During construction, the drilling mud oozing from underground, may damage the nearby houses. Moreover, the underground fuel gas pipeline going below the village houses may create a safety hazard. • During prefabrication and pipe pulling there may be temporary traffic disruption and may require Owner's intervention.

Source: Proposal of Fuel Gas Pipeline Routing with Horizontal Directional Drilling (HDD),

Based on the advantages and challenges mentioned above, Options 3 & 4 are not feasible both from social and community health & safety point of view as physical displacement of household and health & safety risk to the community is envisaged. Both these options are also difficult from the point of view of requirement of additional land, pre-fabrication, operation and maintenance.

From social impact point of view, the most feasible alignment is option 1 as it would require less land to be acquired. However, Option 2 is located beside a sensitive receptor (Mosque) and may be potentially dangerous to the sensitive receptor & community in case of hazardous events like gas leakages. From the above comparative analysis, Option 1 is the most convenient option from the point of view of its location within the plant boundary, operation & maintenance and impact on health & safety of the community. Hence, Option 1 alignment has been finalised for gas pipeline. UMPL would implement the management measures for prevention of leakages that has the potential to impact on the Plant assets, environment & resources within the plant and community residing in the immediate vicinity of the plant. Offsite emergency preparedness plan would be in place with immediate deployment facilitation, in case of any untoward incident.

3.9.4 Technological Alternative

Current technology options for large scale generation of base load electricity in Bangladesh are limited to thermal plants utilizing fossil fuels and a large-scale hydro-electrical power generation scheme. The potential for large scale hydro-electrical generation has already been exhausted. Although nuclear and solar energy options as source of electricity are being explored, the country does not have the expertise and infrastructure for large scale generation.

Renewable energy currently attracts significant political and media attention. However, outside of large-scale hydro, the power generation of which has already reached its limiting value in respect of meeting the ever-expanding power deficit in the country, it remains a niche area that does not have the capacity to provide the power delivery at the scale and reliability in view of the existing power deficit scenario. Other renewable energy sources, e.g., biomass production and wind output would still be unable to produce and supply sufficient quantity of power towards meeting the existing demand. Even in countries with a high wind output, the power delivery of a wind turbine over a year rarely exceeds 30%.

Within the scope of fossil fuelled thermal power plant technologies, the considered options have been:

- Coal fired thermal plant.
- Oil or gas fired steam turbine.
- Oil or gas fired open cycle gas turbine.
- Combined Cycle Gas Turbine (CCGT)

Coal fired technology was ruled out for the proposed project due to its high pollution potential including poor emission qualities and flue gas cleaning as well as ash disposal aspects in comparison with the power generation process involving other aforesaid technologies. Oil fired technology was also ruled out when compared with gas-fired technology due to higher emissions of particulates, nitrogen oxides, sulphur dioxide and carbon dioxide from oil-fired technology. In fact, during the project conceptualization, use of oil only as a back-up fuel was also superseded using R-LNG due to low pollution potential of natural gas.

Steam turbine plants, such as the existing thermal blocks built in the 1960s, are only competitive economically when there is a user for the waste heat, such as a very large district heating system.

On the other hand, combined cycle gas turbine using natural gas generate equivalent energy, at the same time emitting much lower concentration of air pollutants and are eco-friendly. Also, the Heat Recovery Steam Generator utilizes the exhaust gas from gas turbine to generate steam for the steam turbine; hence, the technology is more advanced and commercially viable.

From OPEX point of view, it has been found that the operating cost of open cycle gas turbine is $0.062 per kWh, and operating cost of coal, pulverized fuel is $0.05 per kWh, while the OPEX of CCGT is $0.044 per kWh. Thus, the option of CCGT technology is clearly ahead of the other three options considered above as it consumes significantly lesser quantum of natural gas in power generation process.

This is the cleanest conventional energy option based on fossil fuel. A comparative study on emissions of greenhouse gases (GHGs) from various fuel sources reveal that GHG emission from a power plant with combined cycle gas turbine (CCGT) system is significantly lower than that from coal-fired, oil and gas fired steam turbine steam turbine, and oil and gas fired open cycle gas turbine systems which would enable the project to be included in the CDM mechanism of the United Nations Framework Convention on Climate Change (UNFCCC).

Based on the above points, the selection of CCGT technology for the UMPL's proposed 600MW Combined Cycle Power Plant Project appears justified.

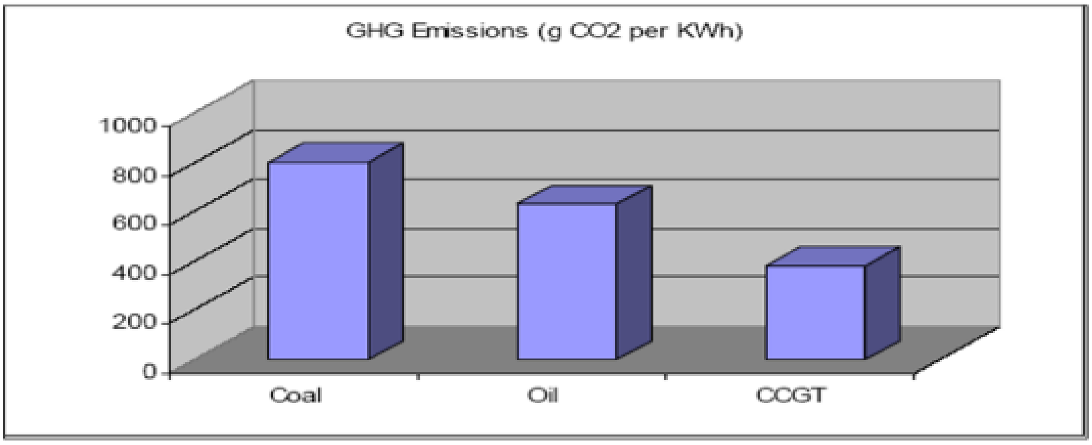


Figure 3.31: Comparison of Green House Gas (GHG) emissions from various power generation options

3.9.5 Fuel Alternative

In this section, an alternative fuel analysis has been done, for the project based on natural gas as the fuel. The main objective of this analysis is to carry out a comparative assessment of the GHG Emissions Potentials of similar 600 MW CCPPs using alternative fuel technologies. The assessment is carried out considering Coal mix, Naphtha and Oil as alternative fuel to LNG or natural gas.

From the project feasibility report, it is understood that LNG requirement for the proposed 600 MW CCPP is 96192 Mscf per day. Based on review of veritable secondary sources of information through desktop research, it is understood that similar capacity Coal-fired Thermal Power Plant would require 7144 tonne of coal mix/day; while Naphtha-based Power Plant of similar capacity would require 812,500 tonne/day. Oil-fired 600 MW Power Plant would require 1247562 gallons oil to generate equivalent power output.

On basis of fuel requirements per day, an estimation of green-house gases emissions, in terms of carbon di-oxide equivalent from each of the power plant (of equivalent capacity) has been carried out, for a whole year, and the result is tabulated below in ***Table 3.13*** and ***Figure 3.32*** below:

Table 3.13: Estimation of Annual GHG Emission in terms of CO_2

Fuel quantity/day	Capacity (MW)	CO_2 (kg/day)	*CH4(kg/day) represented as CO_2 equivalent	**N2O (kg/day) represented as CO_2 equivalent	Total emissions in tonnes of CO_2 equivalent/year
RLNG (96192 Mscf)	600	5236650.16	2072.55	3059.48	1907153
Coal mix (7144 tonne)	600	13464465.50	32561.68	69915.98	4936153.52
Naphtha (812,500 tonne)	600	229521256.25	199887.19	590143.13	83795727
Oil (1247562 gallon)	600	13824185.66	11624.72	34320.59	5046464.41

*Note: *- CH_4 emission is converted to CO_2 equivalent emission using conversion factor (Global warming potential) as 21*
*** -N_2O emission is converted to CO_2 equivalent emission using conversion factor (Global warming potential) as 310*

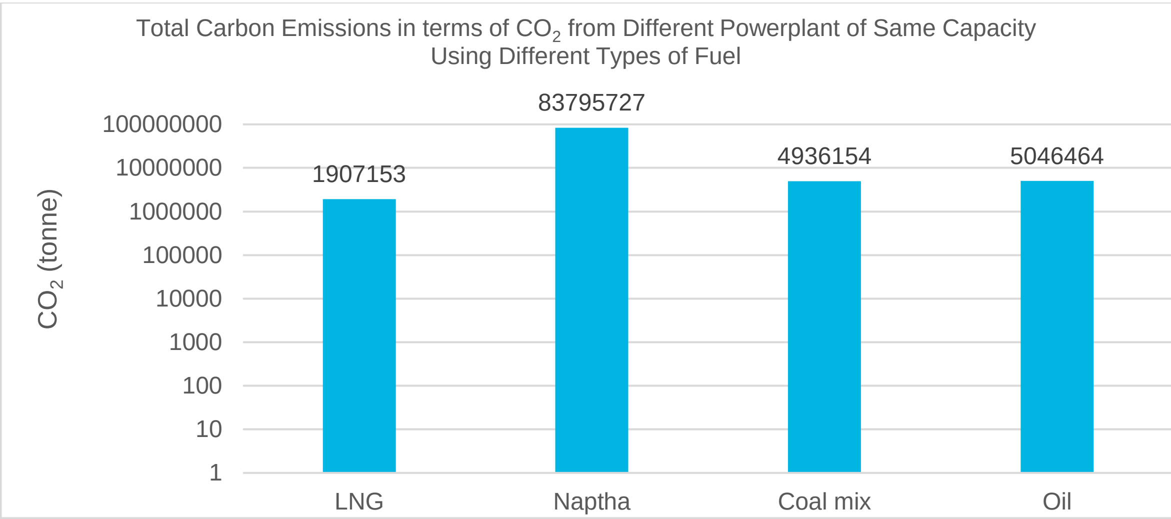


Figure 3.32: Estimation of Annual GHG Emission in terms of CO_2

Figure 3.32 shows total carbon emissions in terms of CO_2 from different power plant of same capacity using different types of Fuel[5]

From the above calculation, it can be concluded that the least GHGs emitting fuel is liquified natural gas (LNG) for the proposed 600 MW power plant with combined cycle technology; to make the process more efficient by using both gas turbine and a steam turbine together to produce up to 50 percent more electricity from the same fuel than a traditional simple-cycle plant. This assessment, therefore, completely justifies selection of LNG as fuel, particularly from GHGs emissions and climate change perspectives.

3.9.6 Cooling Alternative

Two options available for cooling are once through cooling system and induced draft cooling tower. Construction of a cooling tower would have cost implications, but it would reduce the make-up water requirement for the Project as well as limit the quantity of warm water discharge from the project. Once through cooling system would require about 36,000 m^3/hr of cooling water, whereas induced draft cooling system would require only 580 m^3/hr for cooling tower make-up, which is only 1.6% of the once through cooling water demand.

Adverse environmental and social impacts of cooling tower are limited as compared to once through cooling system and therefore, induced draft cooling tower has been considered in the Project design. This would also help in reducing the net make-up water requirement of the plant significantly.

[5] *The amount of CO_2 in this graph along with y axis, shown in logarithmic scale*

3.9.7 Conclusion

The ‘No Project Scenario’ is likely to have a negative effect on opportunities for employment, both directly from the proposed power project and its dependant sectors such as agriculture, industries and manufacturing that require stable power supply in order to operate effectively and be competitive.

The site location is well suited for setting up of power plant with availability of adequate land, water, approach to road, and waterways, fuel source/supply arrangement. Construction laydown and camp areas have also been selected based on the basis of alternative analysis and selection of best suited option.

The project design has considered embedded pollution control systems, which include NOx control, adequate stack height for dispersion of pollutants, use of cleaner primary fuel (natural gas), use of Meghna river water for the Project operations as opposed to ground water, induced draft cooling tower for reducing water requirement and no direct discharge of cooling water into Meghna River.

To conclude, within the available alternatives as site location, technological alternative, fuel options, UMPL has opted for best suited technological option for power generation.

4 Baseline Environmental and Social Condition

4.1 Introduction

The Chapter on Baseline Environmental presents the physico-chemical, biological and socio-economic conditions of the project area and its surroundings. The physico-chemical environment comprises air, water and soil components, the biological environment comprising terrestrial and aquatic ecological status, and socio-economic environment includes demographic features and livelihood status. Attributes of the physical environment like air, water, soil quality and noise level in the surrounding area have been assessed primarily through monitoring and analysis of samples collected from field. Primary surveys were also carried out to record the status of biological environment such as terrestrial ecology (e.g., flora, fauna) and aquatic ecology (e.g. plankton, benthos, fish), in the project area and the same was verified with published information and literatures. The socio-economic environment has been studied through consultations with various stakeholders in the villages within the study area. Additionally, socio-economic data have been obtained from available secondary sources. Information about topography, geology, hydrology, prevailing natural hazards risks like floods, earthquakes etc. have been collected from different available literatures and information from various government departments. The 1st season baseline monitoring studies were carried out from October to November 2019 and the 2nd season baseline monitoring studies were carried in March (part) and June 2020[6].

4.2 Area of Influence (AOI)

Project Site and its surrounding area which would be influenced by the Project activities termed as Area of Influence (AOI). The AOI may include:

- The power plant, gas pipeline, water pipelines and transmission line, which are the main project component and directly managed by the project proponent.
- Surrounding area which may be influenced due to the project developments such as increase of pollution load, if any, increase in traffic on the approach road etc;
- Impacts of the project on the areas immediately adjacent to the project footprint and disturbance on ecological environment would be triggered due to increase of dust, human presence and project related activities. Also, impacts of the project would cover the ecosystem services on which the affected communities depend for their livelihoods.
- Allied facilities on which project depends but that are not funded/managed by the project component or as part of the project.
- Cumulative impacts and risk on surrounding industrial areas or resources used due to the incremental impact by the project and other existing facilities

Considering that the proposed project would be a gas based CCPP and this would be based on closed loop recirculation cooling system, the impacts of the project would be largely contained within the close vicinity of the project site, The area of influence for the present environmental and social impact assessment (ESIA) study is envisaged to be limited to 5 km buffer from the Project site boundary. It has been selected based on the understanding and professional judgement of team of experts that the magnitude of impact is likely to be contained within this influence area. ***Figure 4.1*** shows the study area for the proposed project within 5 km of the site.

[6] The second season monitoring commenced from March, 2020, but had to be suspended due to restrictions imposed on account of COVID-19. The monitoring could be resumed in June, 2020 and conducted for 1 month before onset of monsoon in Bangladesh.

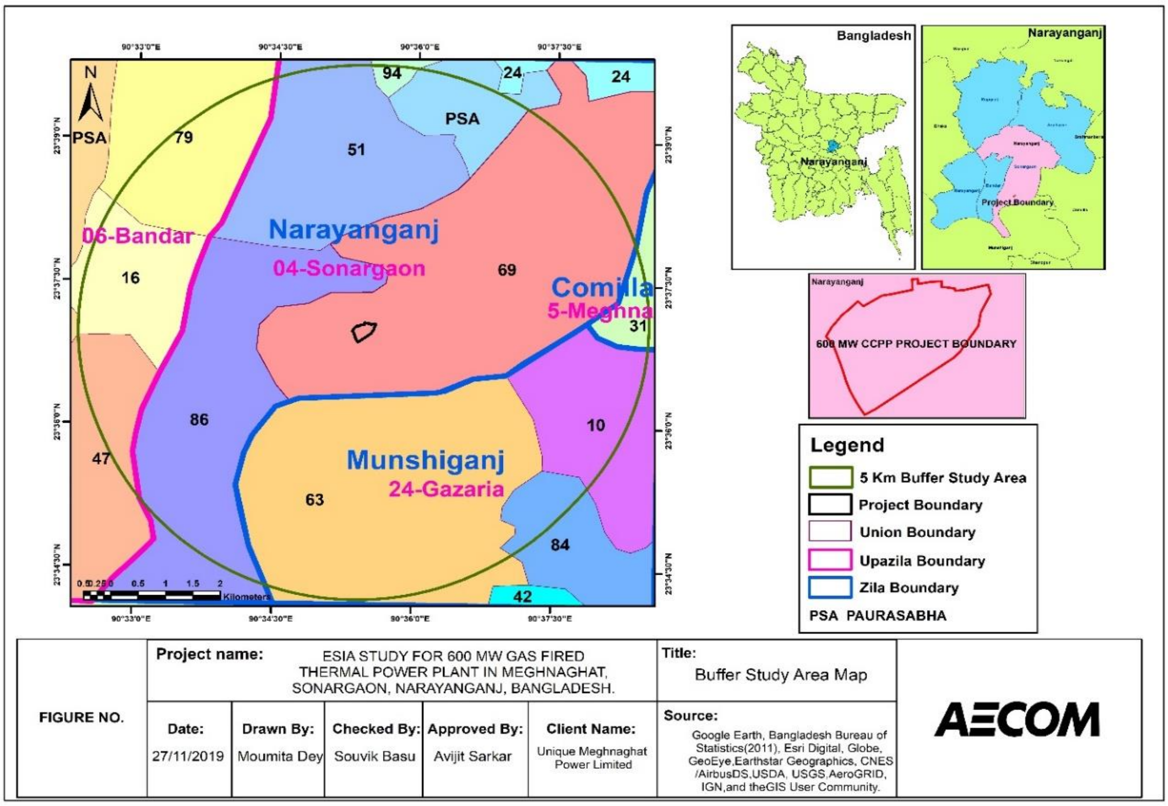


Figure 4.1: Proposed Project Site with Buffer Area within 5km of the Airshed.

4.3 Present Scenario of the AOI

The Project Site and its surrounding area are in Meghnaghat industrial cluster which was mainly developed on a riverine island and along the river side. Meghnaghat Industrial area is divided in two part e.g. Meghnaghat North Industrial Cluster and Meghnaghat South Industrial Cluster. It is evident from the decadal land use change study that agricultural land and wetland has been converted for industrial and urban built-up area. Also, it is noted that the Meghnaghat industrial area is not falling under the Dhaka Metropolitan Development Plan area which would provide a policy framework for the next 20 years to promote sustainable development for the Dhaka Metropolitan Region. The present industrial activities may have cumulative effects on the environmental setting of the area due to their footprints on various environmental attributes. Thus, a glimpse of present industrial area is given below:

Power Plant:

- 100 MW HFO based Power Plant of Orion Group,
- 337 MW Duel Fuel CCPP of Summit Group,
- 450 MW Meghna CCPP of Pendakar Energy;

Shipyard:

- Ananda Shipyard,
- Islampur Shipyard,
- Meghna Shipbuilding & Dockyard,
- T K Shipyard,
- Khan Brother Shipbuilding;

Steel Mill:

- Tanveer Steel Mill

Chemical Industry:

- Meghna Chemicals,
- Meghna Group of Industry,
- Samuda Chemicals;

Paper Mill:

- Basundhara Paper Mill Unit-1 and Unit-2,
- Magura Paper Mill,
- Multi Paper Mill,
- Tanveer Paper Mill;

Cement Plant:

- Tiger Cement Plant Unit 1 and Unit 2,
- Holcim Cement Plant Unit 1 and Unit 2,
- Fresh Cement Plant, Anwar Cement Plant;

Food Processing Unit:

- Meghna Group of Industry,
- Abdul Monem Sugar Refinery;

Textile / RMG Unit:

- Esquire Colour Coating Mill,
- Esquire Approachories

Map of Meghnaghat industrial area is presented in ***Figure 4.2*** below.

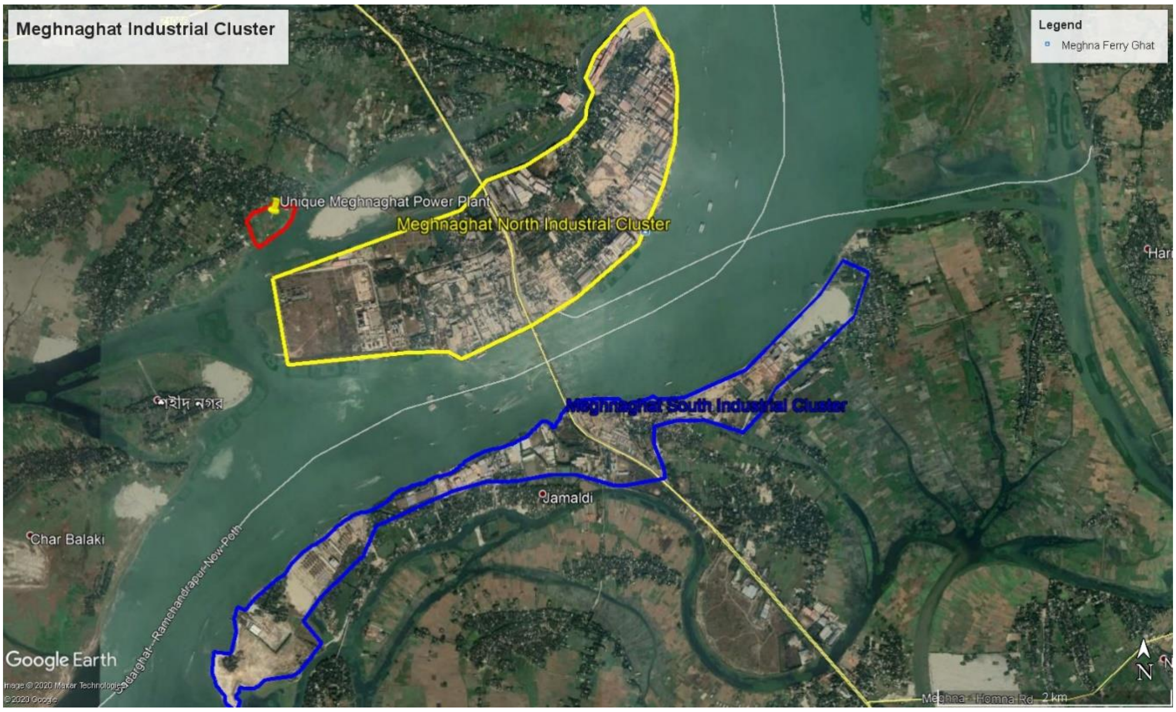


Figure 4.2: Meghnaghat Industrial Area

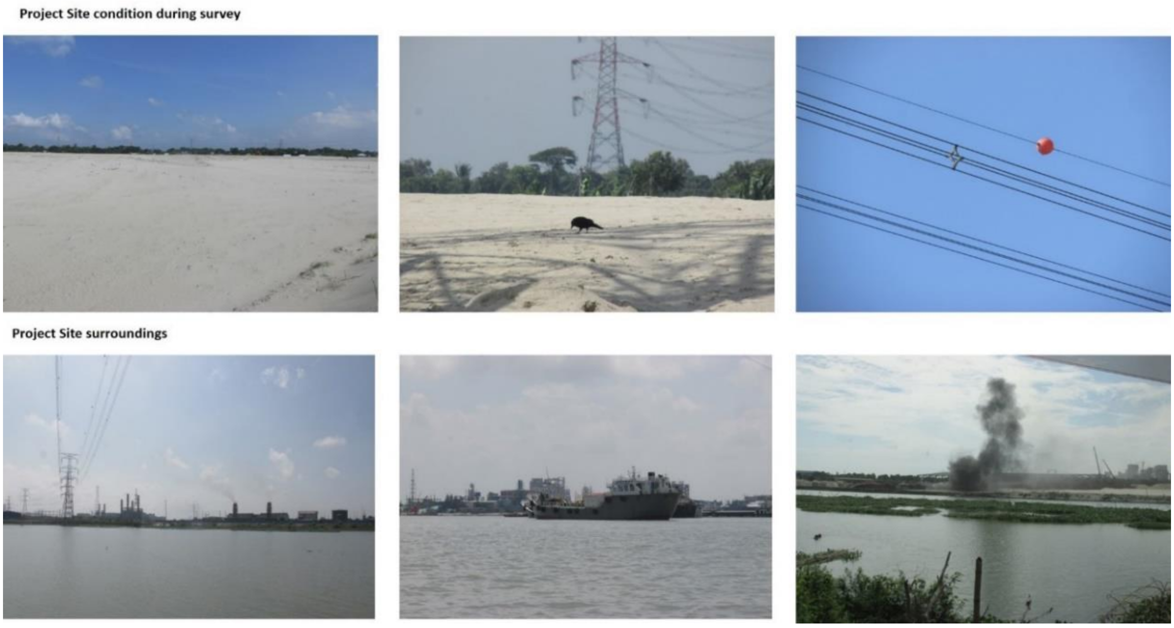


Figure 4.3: Project site condition during survey

4.4 Objective

The primary objective of baseline environmental and social survey is to assess the Impacts of the project during construction, operation and decommissioning phases. The methodology accepted for accumulating the baseline data are as follows:

- The detailed monitoring for environmental and ecological survey was completed during October-November 2019.

- Depending upon the location of project components, associated components and nature of project activities, a 5 km radial zone from the proposed Project location was selected for the baseline studies.
- For baseline environmental data collection survey and sampling was executed for air, water, soil, sediment, noise, traffic and ecology (Terrestrial and Aquatic).
- Reports was collected from different government departments and academic institutes related to environmental survey in the project area. Also, secondary data was collected from different websites, published article, stakeholders and local people.
- Second season monitoring was scheduled to be conducted from March 2020. However, briefly after commencement of monitoring in March 2020, it had to be suspended due to restrictions imposed on account of COVID-19 pandemic. Monitoring was finally restarted in June 2020, when the restrictions were lifted and physio-chemical environmental parameters, i.e., Soil Quality, sediment quality, Ambient air quality, noise quality and Surface & Ground water quality were monitored for the month of June.

4.5 Physical Environment

4.5.1 Land Use/Cover

Land use/cover studies are an essential component in land resource evaluation and environmental studies. The land use study of the proposed project site and study area has been conducted through ground truthing, analysis of satellite imagery and secondary data. At the time of survey, the total project area was already dumped with sand and it was difficult to identify the actual land use. Thus, from the old Google Earth picture the land use of the project area was determined. Before sand filling, the project site was an agricultural land. The previous imagery from Google Earth of project area is depicted in ***Figure 4.4*** and the land use map prepared as per the imagery is presented in ***Figure 4.5.***

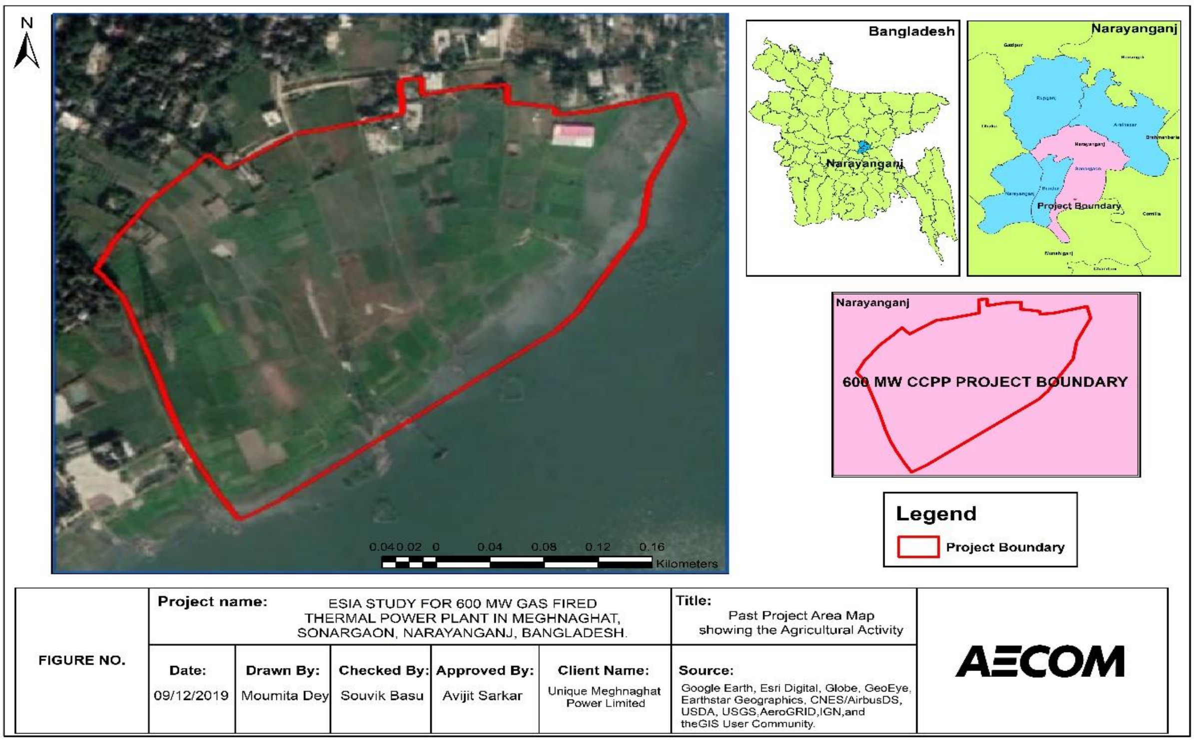


Figure 4.4: Land Use pattern of project area (Satellite Image)

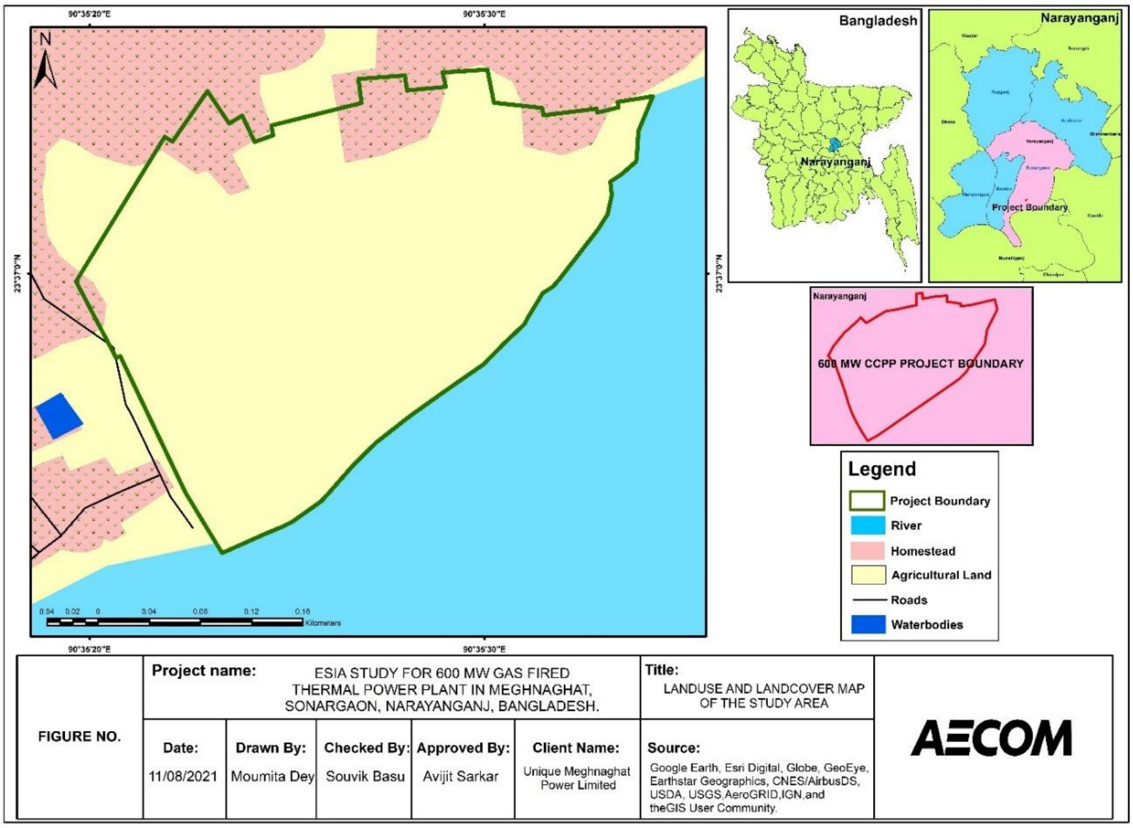


Figure 4.5. Land Use Map of the project area

Land use data of 5km radius of project site is given in ***Figure 4.6*** and ***Figure 4.7.*** The major land use in the study area is agricultural land (39.79%), followed by river (26.59%) and settlements (19.82%) etc.

Proportion of built up land is high near the plant site (within 2 km radius of the site) as the area is mainly industrial. Though there are no declared forest area within 5 km zone however, significant area is covered by trees, mostly rural orchards and other plantations (covered under homestead in the Land use Map). At present the land use of the project site is open land. The entire land has been elevated and developed by sandy material. Earlier, the land was single cropped agricultural land.

Table 4.1: Land Use Details in Study Area

Category	Area within Project Site, Acres	Area within 5 km from Project Boundary, Acres	% Land Use in Study Area
Agricultural Land	19.02	7921.29	37.79
River	0	5572.32	26.59
Homestead	2.05	4154.54	19.82
Waterbodies	0	560.69	2.68
Horticulture	0	79.04	0.38
Industries	0	1803.1	8.60
Barren Land	0	96.33	0.46
Built Up Area	0	699.01	3.39
Major Roads	0	61.75	0.29

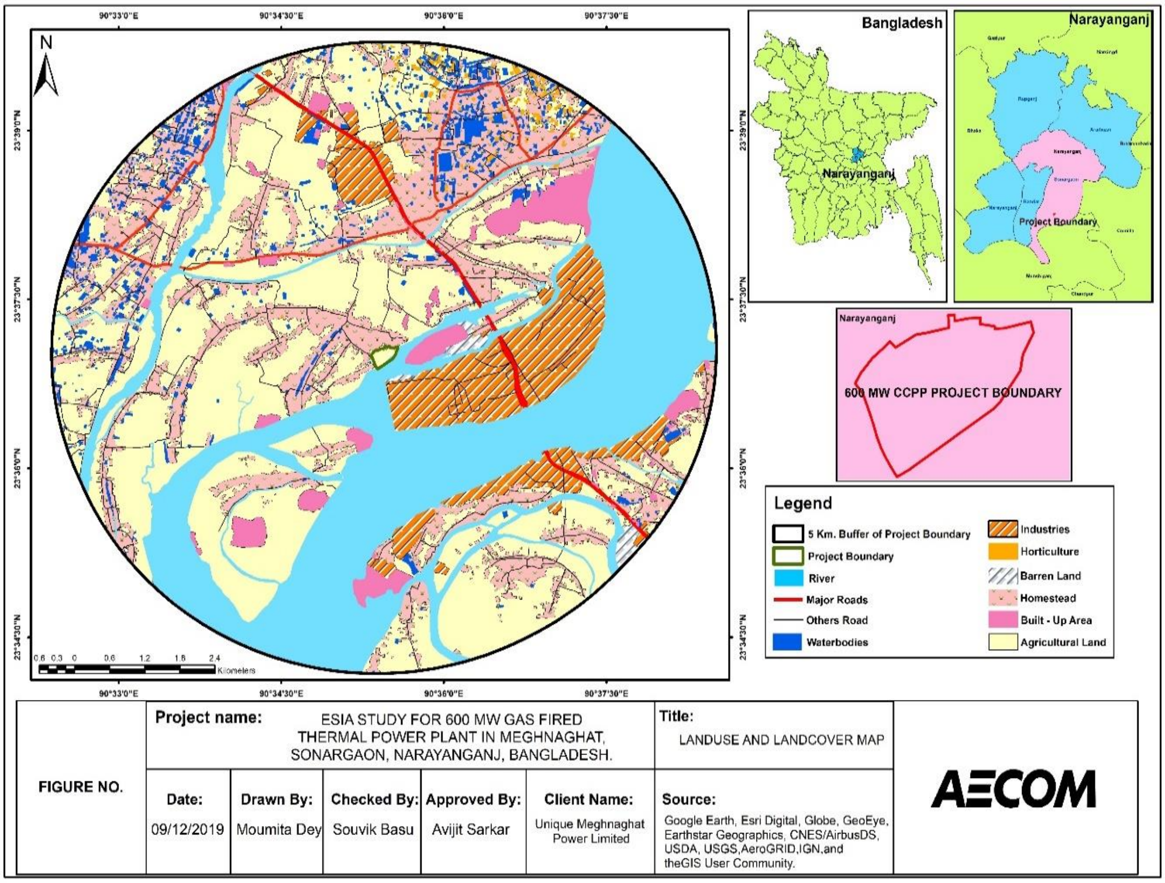


Figure 4.6: Land Use and Land Cover map of the Study Area (5 Km)

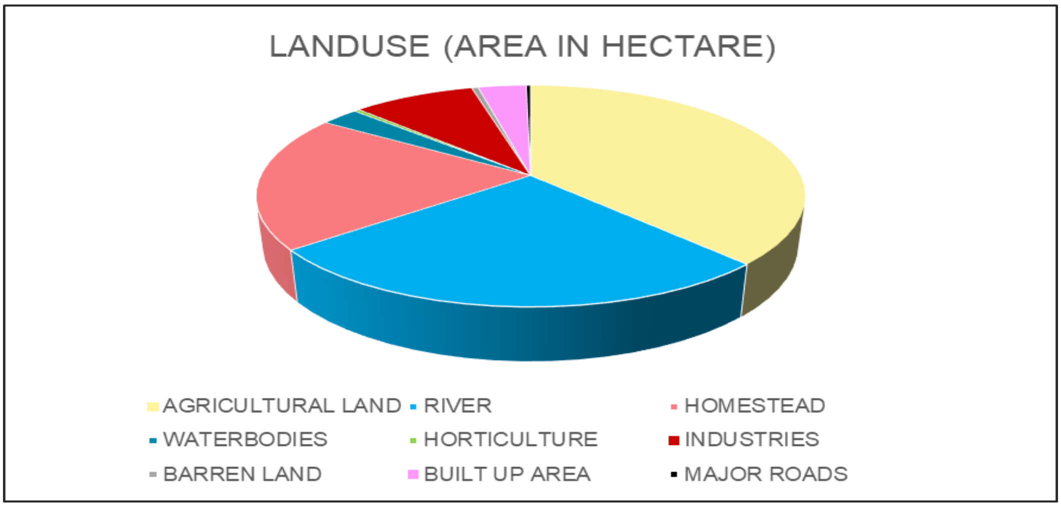


Figure 4.7: Land Use Breakup of the Proposed Study Area (5 km radius)

4.5.2 Topography

The overall landscape of Bangladesh can be divided into three broad categories based on topography, physical features and geological history (Brammer 1996).

- **Hills:** Primarily found along the eastern border of Bangladesh, these areas occupy approximately 18,171 km^2 or 13% of the land surface. They are generally underlain by sandstones, siltstones and shales of Tertiary and Quaternary age;
- **Terraces:** These are isolated tracts of land, primarily found within central northern and north-western Bangladesh which occupy, in total, about 12,085 km^2 or 8% of the total land surface. They are generally

underlain by unconsolidated clays of Tertiary age, which have been uplifted by seismic activity so that their surfaces are several meters higher than the adjoining floodplain; and

- **Floodplain:** Most of the land surface of Bangladesh is floodplain, which is 114, 580 km^2 or 79% approximately of the total land surface. These areas generally comprise of Quaternary sediments which have been deposited over subsurface geological formations by the Ganges, Meghna and Brahmaputra rivers.

The topography of the entire Study Area is generally undulating due to deposition of soil in the delta region. At the site topography is generally undulating and varies between 5-8 m AMSL all over the site.

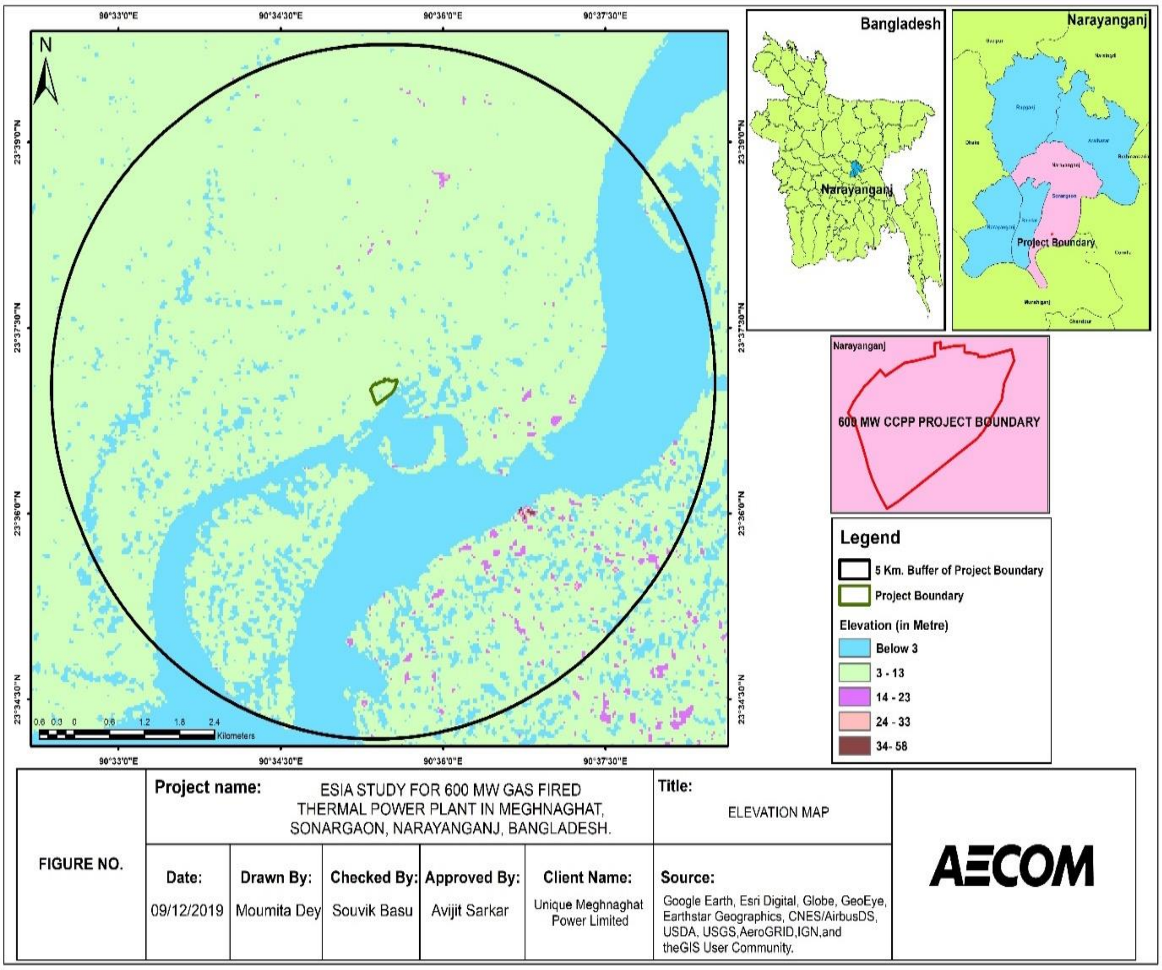


Figure 4.8: Elevation Map of the Proposed Project Site

4.5.3 Geology

The Geology of Bangladesh is affected by its location and Bangladesh is mainly a riverine country. It is the eastern two-thirds of the Ganges and Brahmaputra River delta plain stretching to the north from the Bay of Bengal. According to the Geological Survey of Bangladesh (GSB) map, the study area falls under Alluvial sand, Alluvial silt and Chandina Alluvial geological zones[7]. The geological site setting for the proposed project is as shown in the ***Figure 4.9.***

Alluvial Sand is light to brownish-grey, coarse sand to fine silty sand. Sand is generally surrounded; constitutes channel, bar and levee deposit along rivers and larger tributaries; small and medium-scale cross beds and laminations are common. Brahmaputra River sand ranges in size from coarse to fine; Padma and Meghna River sand is medium to fine. Grain size decreases generally from north to south and away from channels. Brahmaputra sand contains mostly quartz, feldspar, mica, and significant amounts of heavy minerals, indicating that the sands are first-cycle sediments from the Himalaya Mountains and the Shillong Plateau. Ganges sand contains fewer heavy minerals; its composition reflects source areas in the Himalaya Mountains and the Indian Shield. Meghna

[7] Geological Survey of Bangladesh (GSB), 1990, Geological map of Bangladesh. Ministry of Energy and Mineral Resources, Government of the Peoples Republic of Bangladesh.

sand contains quartz rich, reworked sediments from sandy. Tertiary rocks in the fold belt admixed with sediments derived from igneous rocks of the Shillong Plateau. Some coarse sand is found along streams in the Sylhet area. Historic pottery, artefacts, and charcoal found in upper 4-6 m.

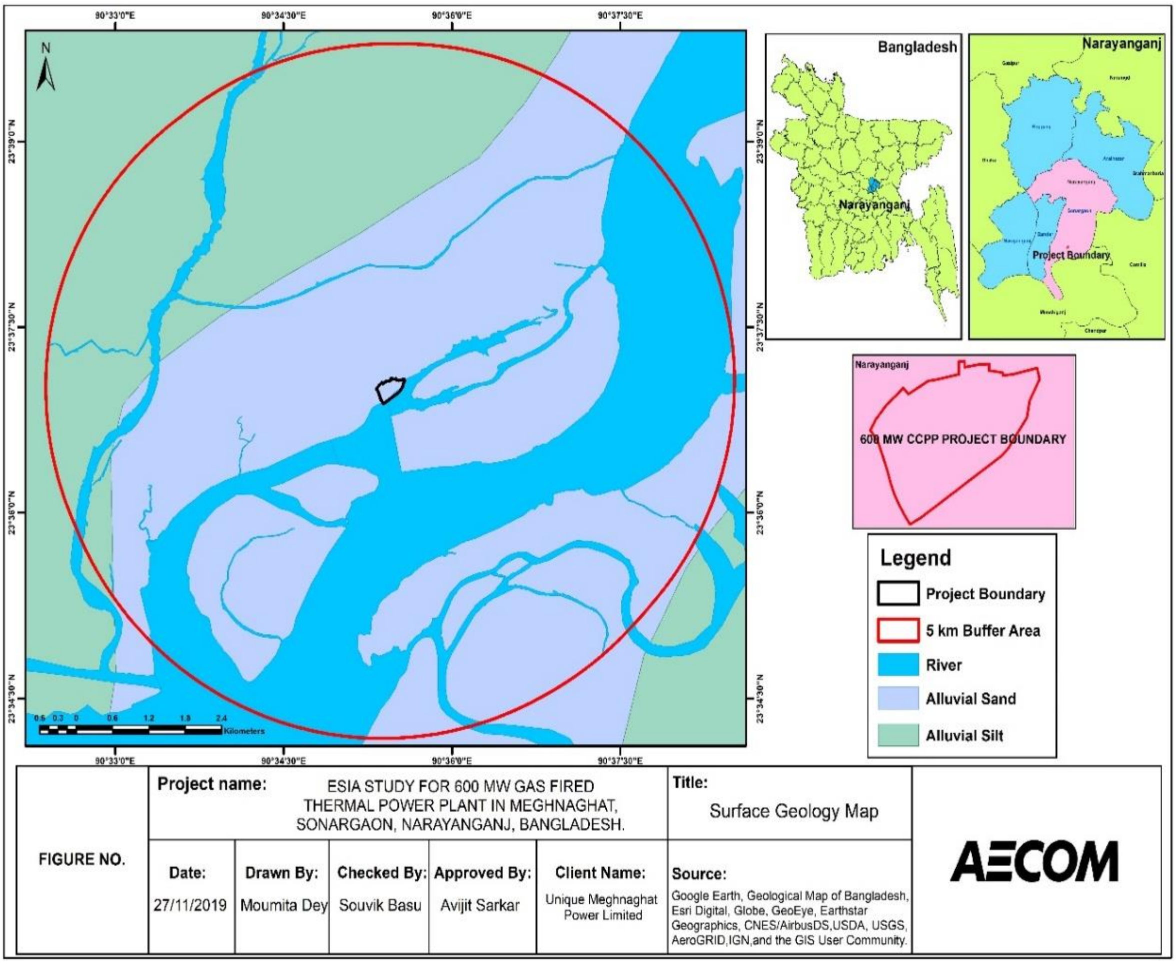


Figure 4.9: Surface Geology Map of the Study Area

4.5.4 Soil Quality of the study area

The Soil Resource Development Institute (SRDI) has identified about 500 soil series in Bangladesh, which is further classified into 23 broad types[8]. The study area falls under the Deep red-brown terrace soils, Non calcareous Alluvium, Non-calcareous dark grey floodplain soils and Non-calcareous grey floodplain (non-saline) soil type.

The major soil families of Sonargaon Upazila are Belabo, Sayek, Kalma, Payati, Khilgaon, Korail, Rajason Savar Bazar Ramapal, Sonatola, Silmond, Tarakanda etc. Dominant land type of Sonargaon upazila is Medium low land (29.2%) followed by low land (17.6), medium high land (12.4%) and high land (5.9%). Rest 34% occupied by settlement, industrial, river and pond. The moisture condition is medium to low. Percentage of upper soil texture of Sonargaon upazila are sandy (1.2%), sandy loam (1.6%), Loamy (28.4%), clayey loam (16%), and clay (17.9%). Soil and land types of Sonargaon Upazila. The project site soil is non-calcareous dark grey floodplain soils as shown in the ***Figure 4.10.***

Non-calcareous dark grey floodplain soils have a cambic B-horizon, non-calcareous dark grey topsoil and subsoil. They occur extensively on the Old Brahmaputra and old Meghna estuarine floodplain. Silt loam and silty clay loam are predominant on the Meghna estuarine floodplain and in the Teesta meander floodplain, whereas silty clays and heavy clays are extensive on the Old Brahmaputra floodplain.

[8] *FAO, Land resources appraisal of Bangladesh for agricultural development, Vol 2, Rome, 1988; FAO/ UNDP, Classification of the soils of Bangladesh, 1986; H Brammer, The Geography of the Soils of Bangladesh, UPL, Dhaka, 1996.*

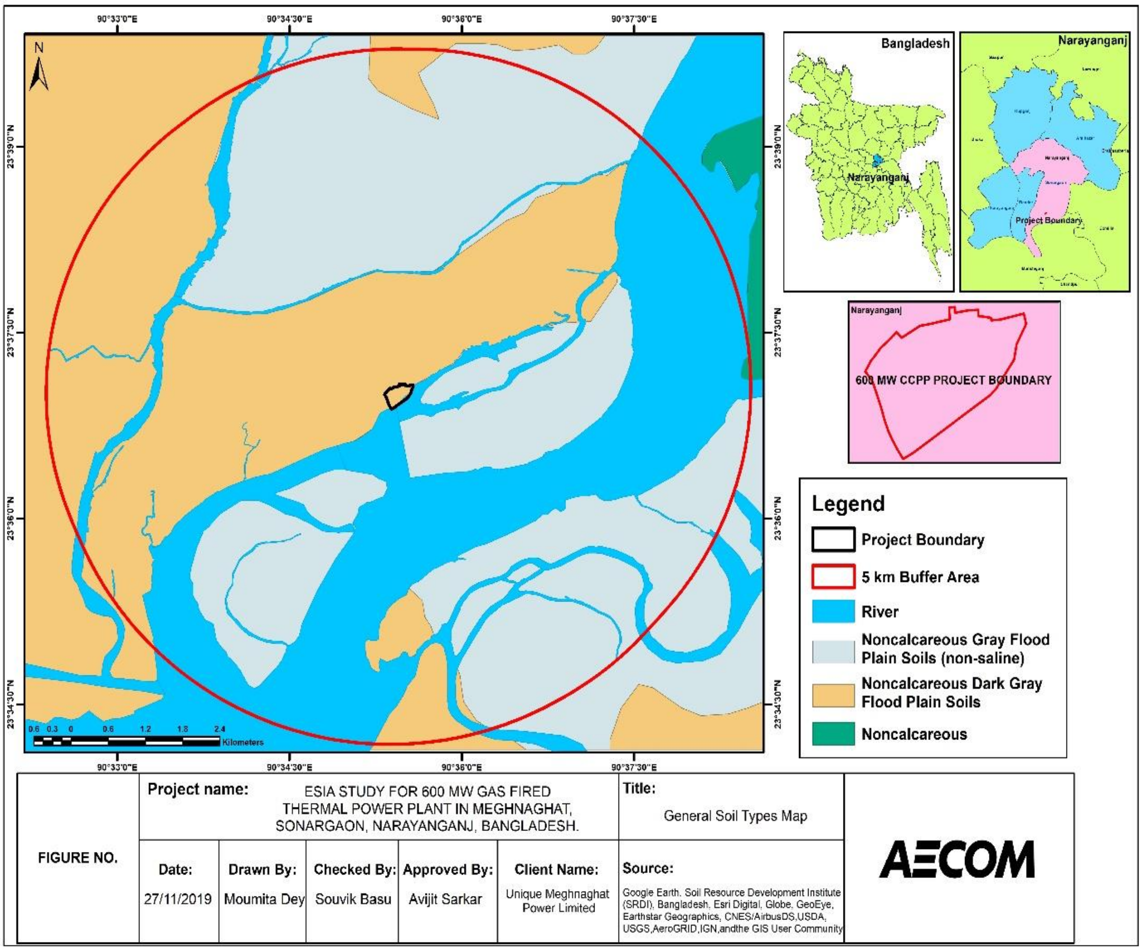


Figure 4.10: General Soil Type Map for the Study Area

Acid Sulphate soils contain sulphide material, which turns extremely acid if exposed to air and occur predominantly on the Chittagong coastal plain and in minor areas of the Ganges tidal floodplain. As it may be seen from ***Figure 4.11*** showing geographical location of various problem soil types including acid sulphate soil in Bangladesh, the project area is free from acid sulphate soil. Hence, the risk of encountering potential acid sulphate soils during construction is improbable.

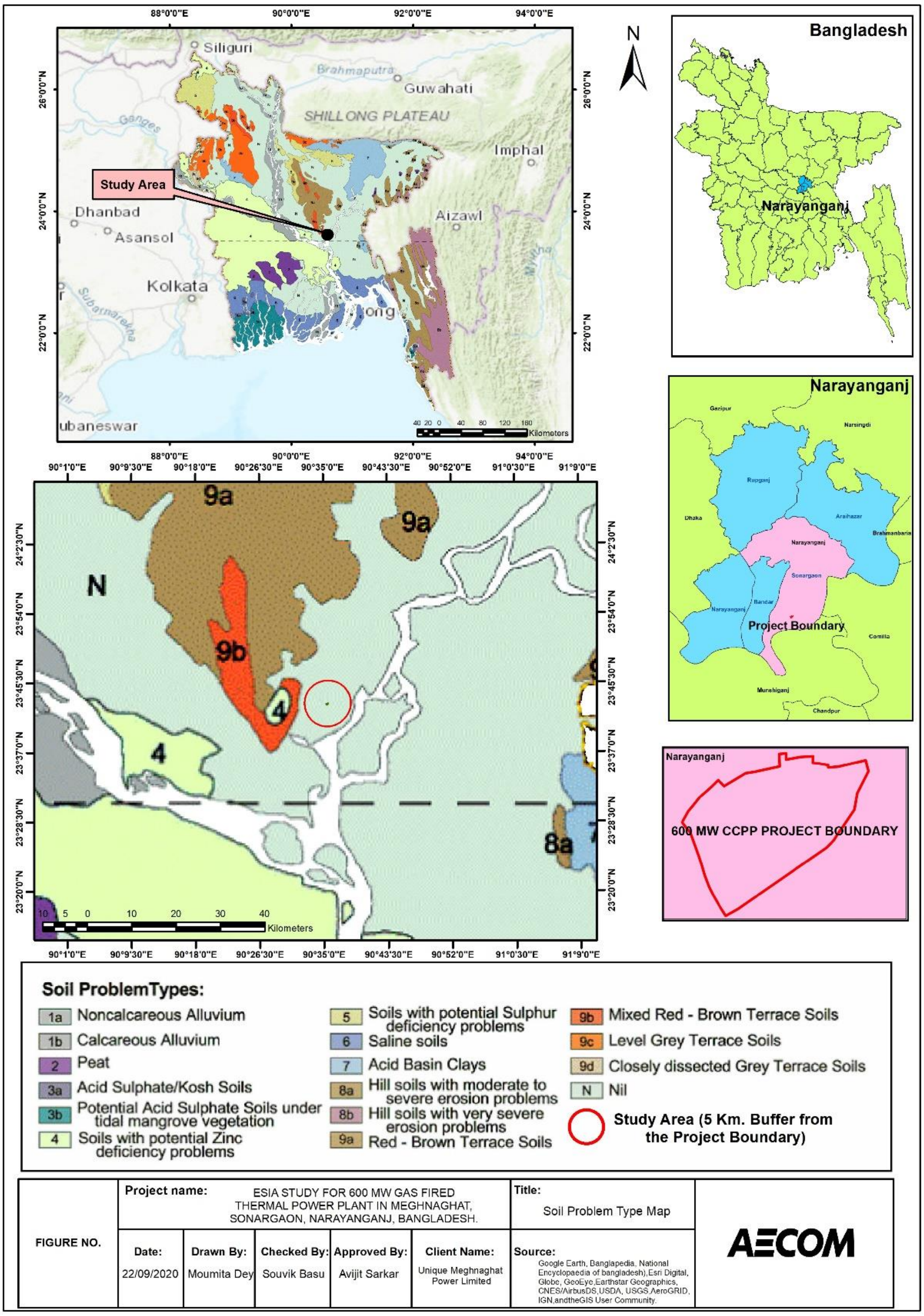


Figure 4.11: Map Showing Different area with various problem soil in Bangladesh

4.5.4.1 Soil quality monitoring

Soil monitoring involves the collection and/or analysis of soil and its associated quality, constituents, and physical status to understand its present characteristics. The soil quality of the study area has been analyzed by collecting and analyzing soil samples from five locations S1 to S5 during October 2019 (Season 1) and June 2020 (Season 2). These sampling locations have been shown below and the details of the sampling locations in and around the study area as depicted in ***Table 4.2.*** Soil sampling locations have been selected based on the contour of the Study area, present land use and is distributed evenly within the study area. The surface soil samples were collected from a depth of 45 cm from the topsoil. Soil samples were collected from three spots at each location and were homogenized. After homogenization the samples were packed in polythene plastic jars. All the samples were sent to the laboratory for analysis.

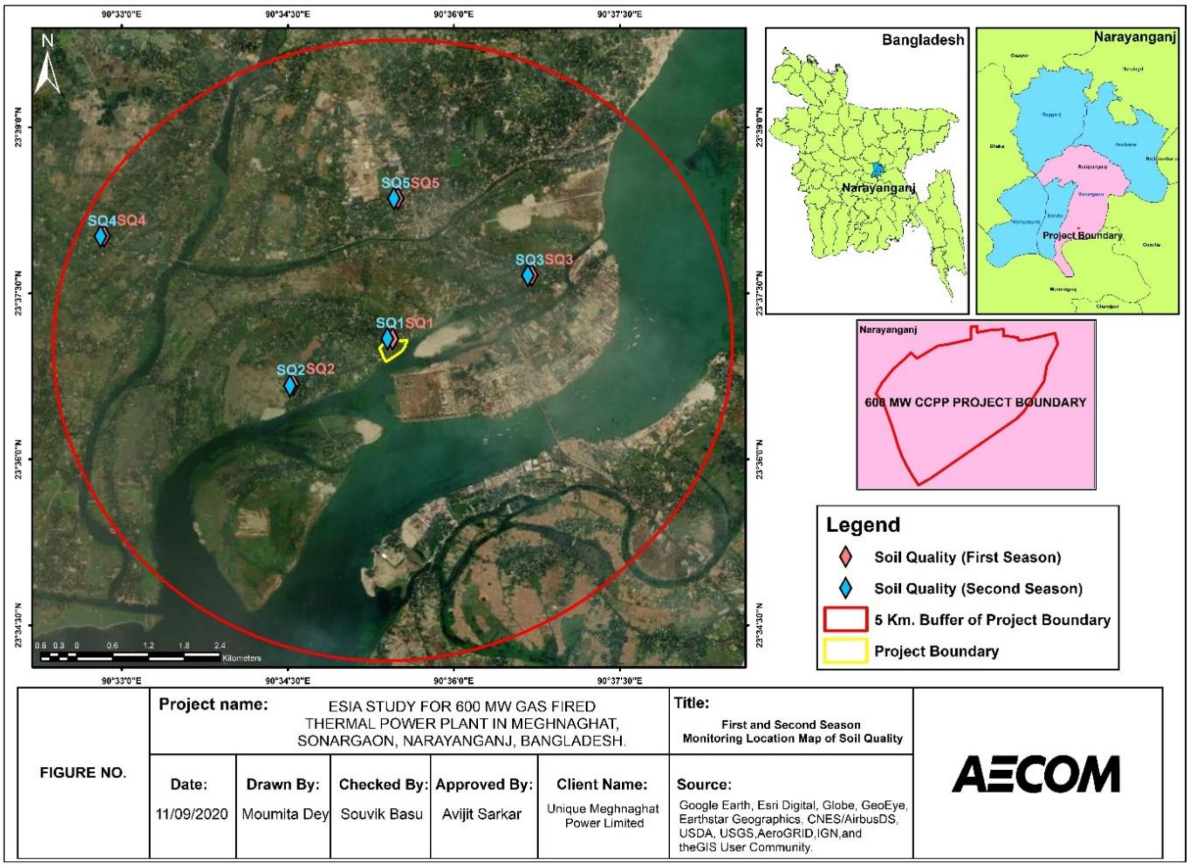


Figure 4.12: Soil Sampling Location Map in the Study Area

Table 4.2: Soil Sampling Locations

Location Code	Co-ordinates	Sampling Location	Distance from Project Boundary	Basis of selection
S1	23°37'5.39"N, 90°35'25.71"E	Dudhghata, Pirojpur, Sonargaon	62.79 metre, N	Sampling location immediately outside of Project Boundary having present land use as vacant land and is Grass Land
S2	23°36'40.59"N, 90°34'31.85"E	Tatuakandi, Pirojpur, Sonargaon	1.50 km, SW	Sampling location South-West from Project Site, which is presently homestead Plantation
S3	23°37'39.94"N, 90°36'40.70"E	Asharia Char, Pirojpur, Sonargaon	2.16 km, NE	Sampling location North-East of the project, which is presently an Agricultural Land
S4	23°38'0.64"N, 90°32'48.48"E	Kusiara, Bandar	4.69 km, NW	Sampling location located west of the project site at the periphery of the study area and is presently an Agricultural Land
S5	23°38'21.42"N, 90°35'27.16"E	Bara Nagar, Mugrapara, Sonargaon	2.36 km, N	Sampling location in the north of the project side in a barren land

There is no national standard in Bangladesh relevant to soil and sediment quality. The classification of pH of soil is presented below ***Table 4.3***. The photographs of soil sampling are presented below.

Table 4.3: Standard Soil Classification

pH	Classification
<4.5	Extremely acidic
4.51-5	Very strong acidic
5.01-5.5	Strongly acidic

pH	Classification
5.51-6	Moderately acidic
6.1-6.5	Slightly acidic
6.51-7.3	Neutral
7.31-7.8	Slightly alkaline
7.81-8.5	Moderately alkaline
8.51-9.00	Strongly alkaline
>9	Very strongly alkaline

Source: http://www.esf.edu/pubprog/brochure/soilph/soilph.htm


S1: Dudhghata, Pirojpur, Sonargaon


S2: Tatuakandi, Pirojpur, Sonargaon


S3: Asharia Char, Pirojpur, Sonargaon


S4: Kusiara, Bandar


S5: Bara Nagar, Mugrapara, Sonargaon

Figure 4.13: Soil sampling pictures

4.5.4.2 Soil monitoring result

The results of analysis of sampled soil in the two seasons is presented below in ***Table 4.4.***

Table 4.4: Soil Quality Monitoring Results in the Study Area

Factors	Unit	S1	S2	S3	S4	S5
Class		Loam & Silt Loam	Silt Loam & clay Loam	Silt Loam & Clay Loam	Silt Loam& clay loam	Loam & clay loam
pH		5.8-5.92	5.7-8.21	6.5-7.41	6.3-8.14	6.1-6.66
Electrical Conductivity	µS/cm	85- 300	153 -300	90-700	254-700	174-700
Cation Exchange Capacity	meq/100g soil	3.868 -13	7.737-18	7.736-14	11.605-19	9.671-16
Alkalinity	ppm	11.71-100	Nil -240(pH<4.3)	47.25-130	165.73-300	39.7-200
Copper	ppm	1.92-2.2	3.74-4.2	3.88-4.1	3.66-3.99	4.04-4.88
Iron	ppm	70-150.12	70-133.68	40-99.17	105.35-120	50-114.26
Manganese	ppm	13.17-14.5	9.87-11.6	11.33-13.6	10.85-12.5	12.16-12.9
Zinc	ppm	1.14-5.3	2.22-6.7	0.58-5.8	1.43-6.1	1.29-6.3
Lead	ppm	BDL-5	BDL-4.5	BDL-5	BDL-6	BDL-5
Cadmium	ppm	BDL	BDL	BDL	BDL	BDL
Nickel	ppm	26.0-26.38	27.25-30.0	28-34.74	30- 31.38	25.0-25.90
Chromium	ppm	27.0-27.84	27.22-30.0	30-33.66	32.85-34	25.44 -27
Sodium	ppm	48-138	88.0-103.5	71-138	264.5-267	103.5-209
Chloride	ppm	70.0 70.15	70.0-105.22	35.07-40	70.15-120	50-105.22
Nitrogen	mg/kg	650-739	414-550	500-633	594-800	600-806
Phosphorous	ppm	2.58-6.9	3.81-16.0	1.64-3.2	3.1-21.27	3.86-8.6
Potassium	ppm	72-74.1	54.6-92.4	74.1-76.9	132.6-140.9	50.7-55.8
Calcium	ppm	1250-2056	1650-1700	1500-2764	2050 - 4046	1750-3652
Magnesium	ppm	240-840	432-630	270-542.4	420-1022.4	210-555.6
Boron	ppm	0.17-1.5	0.21-1.4	0.35-1.2	0.38-1.6	0.17-1.2

pH of the soil varied between 5.7 to 8.21 which indicates the moderately acidic to moderately alkaline characteristic of soil at five (5) sampling locations. Pre-monsoon and Post-monsoon agriculture system and types of crops also play a crucial role in creating & maintaining the pH range at the study area. This possibly have contributed to variation in the pH of the soil during two different seasons of soil quality analysis.

The electrical conductivity varied from 85 µS/cm to 700 µS/cm in all the soil sampling locations whereas cation exchange capacity of the sampled soil ranged from 3.8 – 18 meq/100g.

The macro soil nutrients found in the study area were Nitrogen, Phosphorus, Potassium, Calcium and Magnesium. Nitrogen content of the soil was estimated between 414 kg/mg to 800 kg/mg in the monitoring locations. Level of Phosphorus was found to vary between 1.64 ppm to 21.27 ppm at all locations.

Minor soil nutrients increase fertility, help in reducing the various kinds of diseases of plants, helps in growing nutrient foods for human being etc. In Study area various types of minor soil nutrients have been found at optimum levels which indicate a good quality productive soil. Various sources of minor soil nutrients are presented in **Table 4.5.**

Table 4.5. : Probable sources of Minor soil Nutrients in the study area

Minor Elements of Soil	Source at the Study Area	Minor Elements of Soil	Source at the Study Area
Iron	Parent Rock and Organic Matter (Humus)	Nickel	Sewage, Domestic Wastages and Fertilisers
Sodium	Pesticides and Humus	Chromium	Erosional work of wind from mining sector

Minor Elements of Soil	Source at the Study Area	Minor Elements of Soil	Source at the Study Area
Chloride	weathering of rocks, atmospheric deposition and Rainfall	Manganese	From Acid-forming fertilizers.
Copper	Sewage, Domestic Wastages, Fertilisers, and Pesticides	Cadmium	Parent Rock, Sewage, Sludges and Fertilisers
Zinc	Parent Rocks	Boron	organic matter decomposing in the soil.
Lead	Residential Activities (Painting, E-waste etc)		

The concentrations of copper and zinc were found to be in the range of 1.92 ppm to 4.88 ppm and 0.58 ppm to 6.7 ppm respectively at the sampled locations. Concentration of lead was found to be between 5-6 ppm in all the soil samples. The concentration of iron, sodium & chloride was found to be ranging between 40-150.12 ppm, 40-267 ppm and 35-120 ppm respectively in the monitored samples. Concentrations of Nickel and Chromium were analyzed to be between 25-34.74 ppm and 25.44-34 ppm at the sampled locations. The concentration of Cadmium was found to be in the range of 0.06 to 0.15 ppm while boron was found to be in the range of 0.17-1.6 ppm.

From the analysis, no specific contaminants were found. There is no scope of contamination of virgin soil as the land was primarily an agricultural land. Usually, if the land has a legacy history of industrial use, then only it becomes imperative to conduct a contamination assessment of such soil. During site reconnaissance and consultation with the local farmers, it was understood that pesticides use in the agricultural field are seldom and limited to BCPA approved agricultural pesticides. It is not a general practice to apply pesticides on a regular basis.

From the soil quality analysis, the soil was found to be predominantly silty loam having high NPK and micronutrients. The high nutrient content and presence of stable silt base make it suitable for agriculture.

4.5.5 Sediment Quality Monitoring

Meghnaghat industrial area is a recent development during last 10-15 years. A host of industrial activities like discharge of effluents from industry, spillage and leakage of oil from oil depots vessel, urban discharge etc. stand to impact quality in the rivers. To assess the sediment quality, total five samples were collected, and analysed from Meghna Minor Channel and Meghna River as shown Figure 4.14.The basis of selecting sampling points were for baseline assessment of sediment quality upstream, downstream and near the project site and also understand the impact, if any, on the sediment quality due to discharge from the existing industries. The details of the sampling locations are given in ***Table 4.6.***

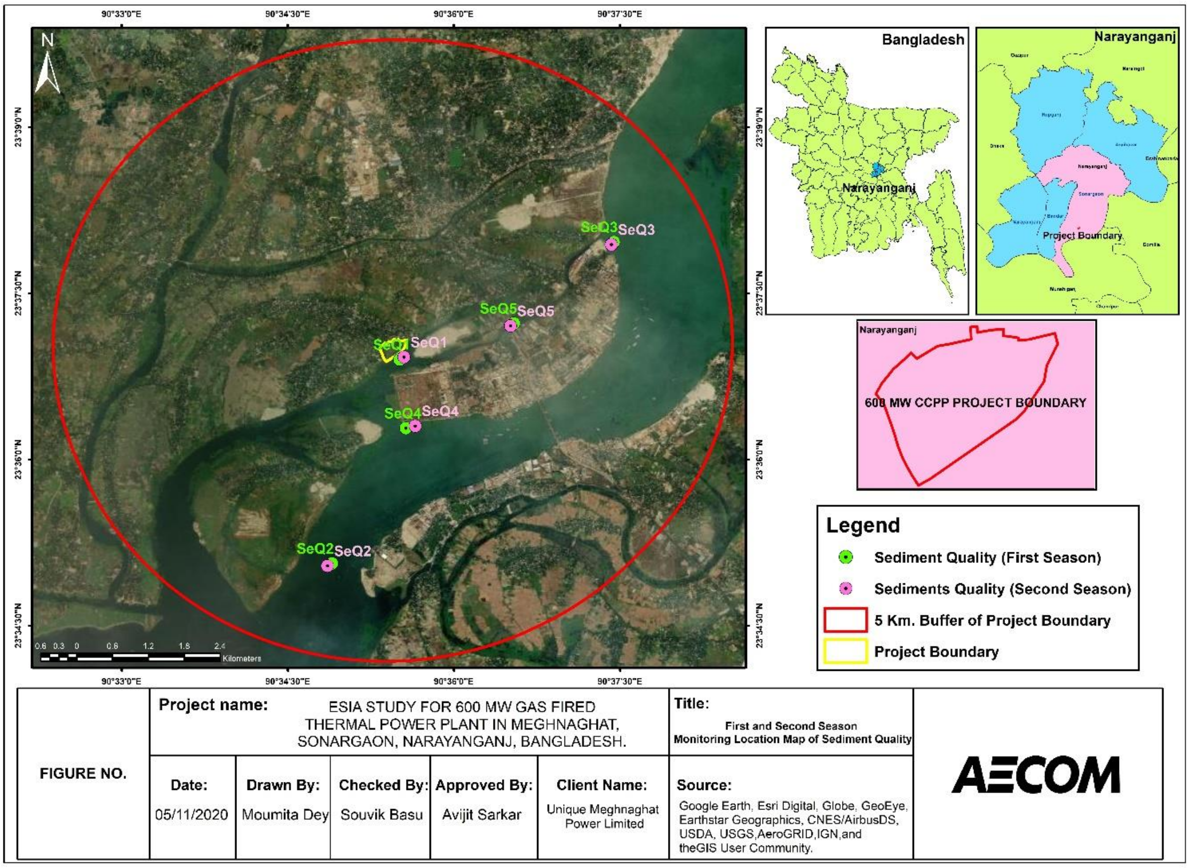


Figure 4.14: First and Second Season Monitoring Location map of the Study Area.

Table 4.6. Sediment Sampling Locations

Location Code	Co-ordinates	Sampling Location	Basis of Selection
SeQ 1	23°36'54.82"N, 90°35'31.21"E	Meghna River	Sample collected from Meghna River Channel in front of Project Site
SeQ 2	23°35'3.00"N, 90°34'52.20"E	Meghna River	Sample collected from downstream of Meghna River, 3.89 km South-West from Project Site, also downstream of Meghnaghat Industrial Area
SeQ 3	23°37'56.44"N, 90°37'25.40"E	Meghna River	Sample collected upstream of Meghna River, 3.53 km North-East from Project Site
SeQ 4	23°36'16.96"N, 90°35'33.98"E	Meghna River	Sample collected on Meghna River, near outlet of Summit Power Plant, 1.48 km South from Project Site
SeQ 5	23°37'12.41"N, 90°36'30.68"E	Meghna River channel	Sample collected from immediate upstream of Meghna River channel, 1.62 km East from Project Site

All the sediment samples were collected from the Meghna River and its side channel by using sediment sampler. The sampling was done from the middle of the width of the stream. At each sampling location, the grab sampling device was set with the jaws cocked open and then lowered until it rested on the sediment. To minimize the effect of turbulence the grab sampler was recovered slowly, which also minimize the loss of sediments during sampling. The samples were packed in Polythene plastic jars. Like soil sampling, from each sampling points three samples were collected and homogenized. The packed samples were sent to the laboratory for further analysis. The photographs of sediment sampling are presented below. The photographs of sediment sampling are presented below.

SeQ1: Sediment Sampling Location 1

SeQ2: Sediment Sampling Location 2

SeQ3: Sediment Sampling Location 3

SeQ4: Sediment Sampling Location 4

SeQ5: Sediment Sampling Location 5

Figure 4.15: Sediment sampling pictures

4.5.5.1 Sediment Quality monitoring

The results of analysis of the sediment collected during first (October 2019) and second (June 2020) season analysis is presented in ***Table 4.7.***

Table 4.7: Sediment Quality Monitoring Results

Parameters	Unit	SeQ1	SeQ2	SeQ 3	SeQ4	SeQ5
Organic Carbon	%	0.5-0.58	0.5-0.7	0.06-0.4	0.5-0.59	0.8-1.02
Copper	ppm	4.69-4.94	3.07-3.74	3.0-5.15	2.05-2.73	2.76-3.11
Iron	ppm	69-118.16	104-120.05	131.44	92-127.21	91-185.05
Manganese	ppm	9.22-10.57	7.89-9.76	10.90-11.08	8.8-12.01	45.23-49.05
Zinc	ppm	0.51-48	0.44-48	0.54-15	0.55-48	2.58-55
Lead	ppm	7.45-8	2.90-7.0	2.06-16	7.0	3.72-8
Cadmium	ppm	BDL	BDL	BDL	BDL	BDL
Nickel	ppm	22-26.24	23.0-26.46	10-23.54	22-24.17	18.49-24
Chromium	ppm	21- 25.70	22.0-25.80	9-23.13	22.0-24.29	19.95-21

Organic Carbon of Sediments at the sampling locations varies from 0.06 to 1.02 %. The concentrations of Copper and Iron ranged from 2.05 ppm to 5.15 ppm and 104 ppm to 185 ppm respectively at the monitoring locations. Manganese content of sediments were analysed between 7 ppm to 49 ppm while Zinc was found to vary between 0.55 ppm to 55 ppm at the five sediment sampling locations. Cadmium was found to be below the detection level while lead was found to be in the range of 2.06-8 ppm. Nickel and Chromium was found to be in the range of 10-26.46 ppm and 9.0-25.8 ppm respectively.

The study area of the proposed project is located at the riverbank of Meghna river, which is one of the largest floodplains of Bangladesh. Meghna river is the one of the largest rivers of Bangladesh and the study area comes under mature cum old stage catchment area of this river when the amount of depleted material in the river is high. During the monsoon, the washed silt from the surrounding area comes and accumulates in the tributaries of the river. The depleted or eroded material, washed silt from surrounding area, remains of dead flora and fauna washed by the water act as major sources of Sediments. The natural phenomena affecting the sediment parameters are rainfall, surface run-off, cyclonic phenomena of Monsoon Climatic zone, flora and fauna in river water etc., while the anthropogenic activities affecting the sediment parameters are Industrial activities, agriculture, sewages, landfilling by sand, construction activity, domestic wastage disposal etc.

4.5.6 River Morphology

The Meghna river originates inside Bangladesh by the joining of the Surma and Kushiyara rivers which are originating from the hilly regions of eastern India. The name is properly applied to a channel of the Old Brahmaputra downstream from Bhairab Bazar, after it receives the Surma (Barak) River. Flowing almost south, the Meghna receives the combined waters of the Padma and Jamuna (the name of the Brahmaputra in Bangladesh) rivers near Chandpur. Down to Chandpur, Meghna is hydrographically referred to as the Upper Meghna and after the Padma joins, it is referred to as the Lower Meghna. Flowing a course of about 260 km it enters the Bay of Bengal by four principal mouths—Tetulia, Shahbazpur, Hatia, and Bamni rivers.

4.5.7 Hydrology and Drainage Pattern

4.5.7.1 Hydrology

The present site is about 30 km North of Chandipur, in the upper Meghna zone. Meghna carries huge amount of water from the precipitation over large area of the Ganga-Brahmaputra-Meghna (GBM) basin. About 80% of the annual rainfall of Bangladesh occurs during monsoon season between June to September.

4.5.7.2 Existing Natural Drainage System in Sonargaon

The proposed project site is drained in River Meghna which flows from East to South West of the study area and controls the entire drainage of the area. However, the entire area lies in the delta region and is drained by several small and large natural drainage features. The Boundary of the Site from East to South West is about by minor channel from Meghna River. The drainage system of 5km radius of the project site are depicted in ***Figure 4.16.***

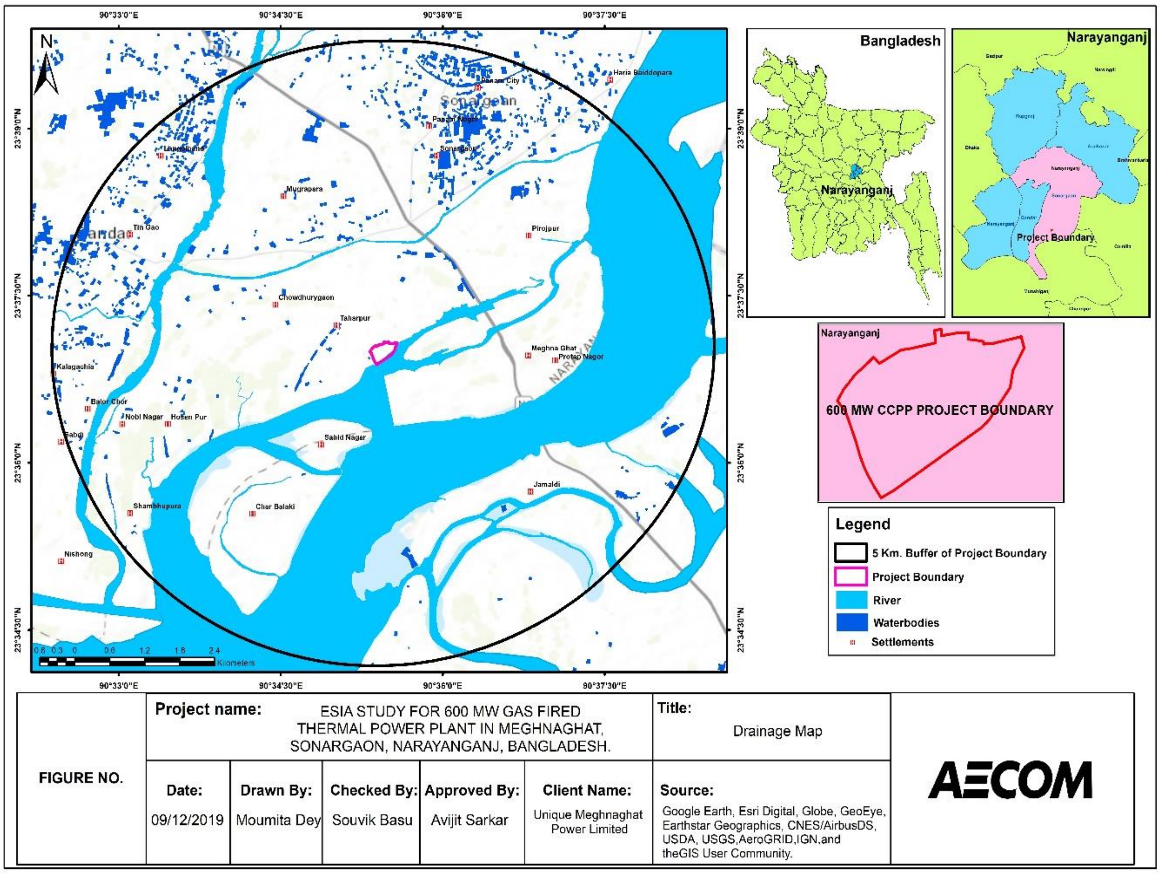


Figure 4.16: Drainage Map of the project area within 5 km radius

4.5.8 Water Source, Use and Quality

To understand the overall baseline water quality characteristics of the surface and groundwater in the Project AOI the water analysis was undertaken. Raw water quality used for design is based on the raw water analysis done on sample collected on 25th April 2020. Water quality assessment has been carried out by analysing different quality parameters of surface and ground water resources within study area. Water samples were collected as grab water sample in a pre-washed 5-litre plastic jerry can and 250 ml sterilized clean PET bottle for complete physio-chemical and bacteriological tests respectively. The Surface and Ground Water Quality samples have been collected and analysed at four locations each, covering entire study area during first & second season of monitoring on October 2019 & June 2020 respectively. The physico-chemical factors, heavy metals and bacteriological parameters have been examined for collected samples and reported in respective sections.

4.5.8.1 Ground Water Availability Status

Groundwater is abundant in Bangladesh with average water table being at a shallow level (1–10 m below the ground surface). About 97% of the population depends on groundwater for potable supplies and is considered to be a reliable source of water for various activities including irrigation (deeper aquifers of depth ranging from 70–100 m), domestic (private tube-wells, penetrating the shallow alluvial aquifers to depths of 10 to 60 m) and industrial purposes (deep tube-wells to avoid high salinity). [9]

As per the Bangladesh Water Development Board, the hydrograph drawn for a time period of 2008 to 2018, for Sonargaon Upazilla (DH082) in Narayanganj District, showed seasonal fluctuation in GWT ranging from 0.52 m to around 5.64 m. The hydrographs of GWT at Narayanganj District, showed a decreasing trend during the dry period (December-February) which reached to the deepest GWTs in the pre-monsoon period (March-May) due to evapotranspiration and inter-basin flow out of the aquifers. This decreasing trend was followed by a rapid increase

[9] *Groundwater Quality: Bangladesh, British Geology Survey, http://nora.nerc.ac.uk/id/eprint/516305/1/Bangladesh.pdf*

in levels during the monsoon period (June-August/September) due to groundwater recharge and then subsequent decrease was observed to take place gradually during the post monsoon period.[10]

Observation from the report published by Bangladesh Water Development Board showed existence of seasonal fluctuations in the ground water table throughout the country. The GWT level dropping to about 6 m below the surface during the dry season and then rising nearly to the ground surface (within 1 m) during the monsoon seasons (July-August). The confined, semi-confined and unconfined aquifers is recharged by major river systems and through rainwater infiltration. The ground water in the study area is closely connected with the Meghna River.

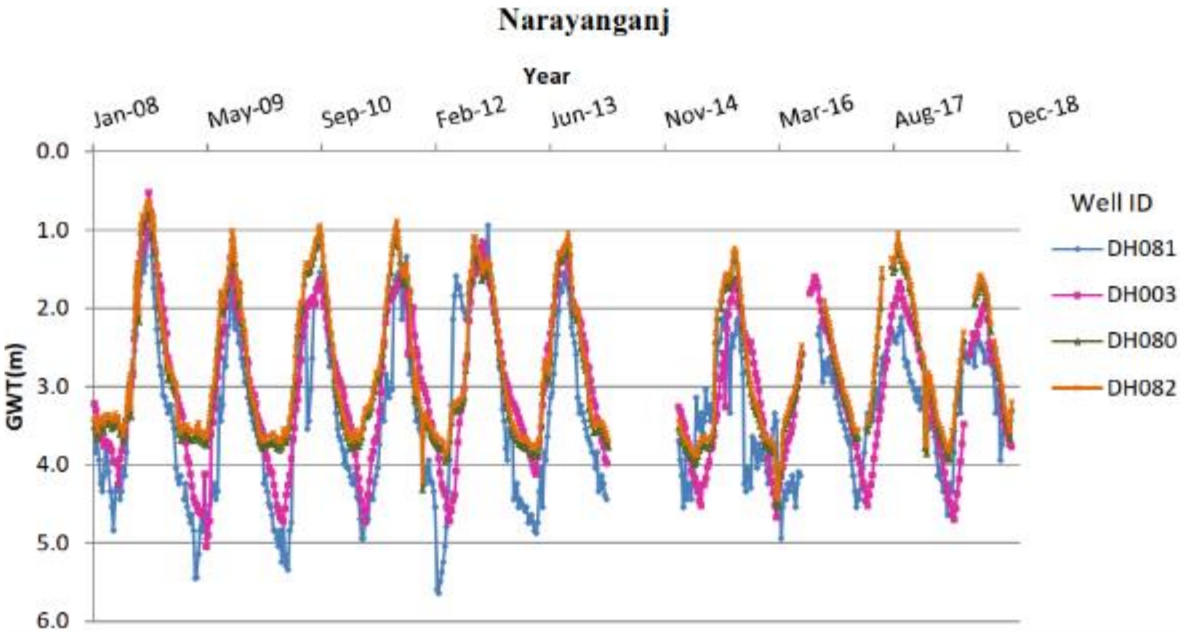


Figure 4.17: Hydrograph for Ground Water Table (GWT) for Narayanganj District (Sonargaon Upazila Well ID: DH082)

Source: Ground Water Table Hydrograph of 38 districts for the year 2008 to 2018, Bangladesh Water Development Board, June 2020

4.5.8.2 Ground Water Quality Monitoring

Primary monitoring of ground water quality was considered important to understand the probable impacts of the proposed project activities on the sub surface aquifers. Map showing ground water sampling locations in the study area is presented in ***Figure 4.18.*** The basis of selecting ground water sampling location was primarily guided by the slope of the area, understanding of local ground water flow regime, understanding of use of ground water in the study area and availability of tube well/bore well for ground water abstraction The details of the sampling location are given in ***Table 4.8.***

[10] *Ground Water Table Hydrograph of 38 districts for the year 2008 to 2018, Bangladesh Water Development Board, June 2020*

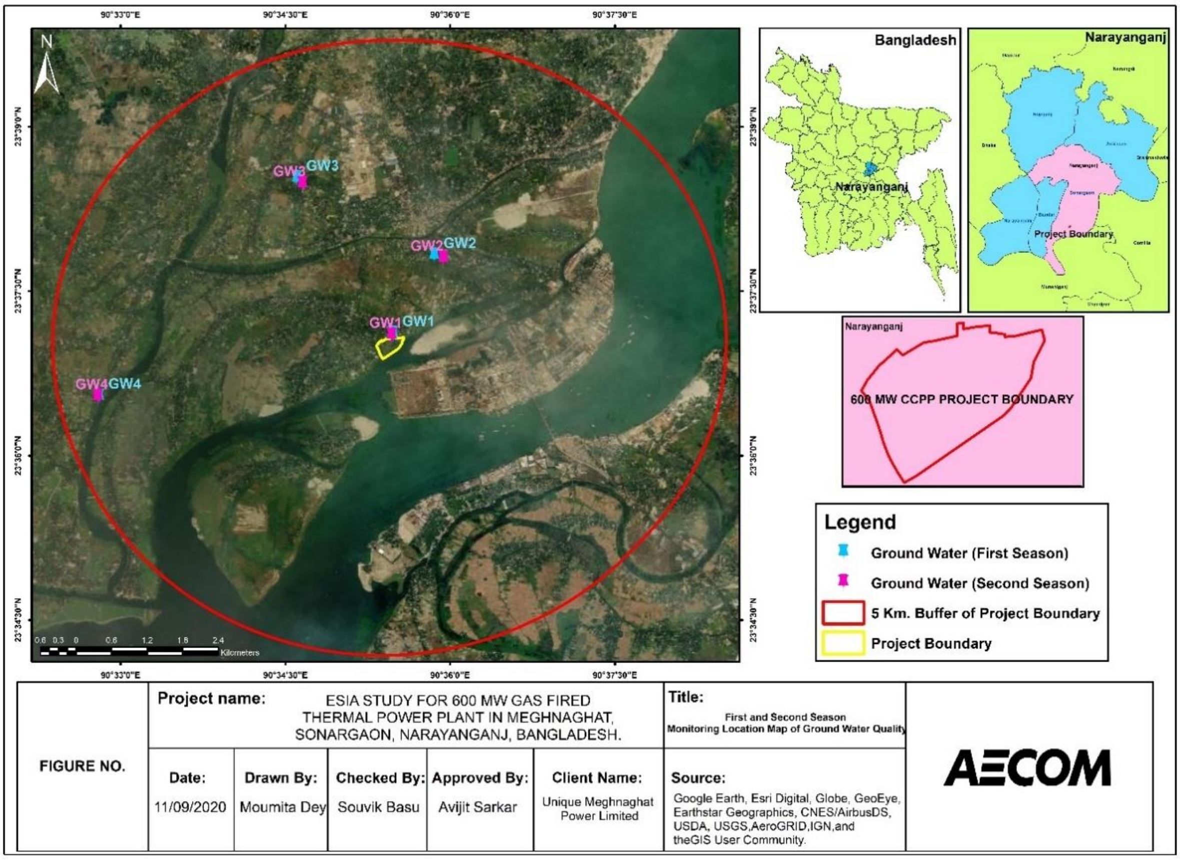


Figure 4.18: Monitoring location for both season

Table 4.8: Ground Water Sampling Locations

Location Code	Co-ordinates	Sampling Location	Basis of selection
GW 1	23°37'5.95"N, 90°35'28.26"E	Bhuiya House, Dudhghata, Sonargaon	Sample collected from boundary of the project site for understanding ground water quality of the project site
GW 2	23°37'48.95"N, 90°35'51.39"E	Molla House, Noyagaon, Sonargaon	Sample collected from northeast of the project site to understand the variation of ground water quality
GW 3	23°38'31.33"N, 90°34'36.32"E	Sultannagar Moor, Kala Dorga, Sonargaon	Sample collected northwest of the site in line with slope profile of the study area
GW 4	23°36'31.91"N, 90°32'47.29"E	Kalabagh Jame Mosque, Shabdi, Bandor	Sample collected from south west of the project site along its periphery from a densely populated Area

All ground water samples have been collected from tube wells. The photographs of sample collection are presented in ***Figure 4.19***

GW1: Bhuiya House, Dudhghata, Sonargaon

GW2: Molla House, Noyagaon, Sonargaon

GW3: Sultannagar Moor, Kala Dorga, Sonargaon

GW4: Kalabagh Jame Mosque, Shabdi, Bandor

Figure 4.19: Groundwater sampling pictures

4.5.8.3 Ground water quality monitoring results

The groundwater quality monitored during the first and second season is presented below ***Table 4.9.***

Table 4.9: Physio-chemical characteristics of Ground Water Sample

Factors	Unit	Bangladesh Standard*	GW1	GW2	GW3	GW4
Alkalinity	mg/L	-	168-186	190-304	228-280	195-334
Aluminium (Al)	mg/L	0.2	0.208	0.08-0.201	0.206	0.238
Ammonia	mg/L	0.5	0.1	0.2	0.1	0.2
Arsenic (As)	mg/L	0.05	0.005	0.006	0.035	0.066
Barium (Ba)	mg/L	0.01	0.054	0.072	0.547	0.090
Cadmium (Cd)	mg/L	0.005	<0.001	<0.001	<0.001	<0.001
Calcium (Ca)	mg/L	75	52-264	35-39	41-51	40-114
Chloride	mg/L	150-600	230-242	31-75	19-60	30-365
Colour	Hazen	15	<1.0	<1.0	<1.0	<1.0
Copper (Cu)	mg/L	1.0	0.05	0.05	0.06	0.05
Cr (Total)	mg/L	0.05	<0.01	<0.01	<0.01	<0.01
Fluoride	mg/L	1.0	0.12-0.59	0.13-0.58	0.12-0.96	0.12-0.37
Hardness	mg/L	200-500	219-300	160-305	188-390	260-543
Iron (Fe)	mg/L	0.3-1	0.44	0.29-0.64	0.24-3.53	0.27-2.91

Factors	Unit	Bangladesh Standard*	GW1	GW2	GW3	GW4
Magnesium (Mg)	mg/L	30-35	21-28	11-18	17-20	14-62
Manganese (Mn)	mg/L	0.1	0.2-1.42	0.1-1.62	0.12-0.23	0.26
Nickel (Ni)	mg/L	0.1	0.05	0.04	0.04	0.06
Nitrogen (Nitrate)	mg/L	10.0	1.3	1.2	2.7-3.6	0.8-3.5
Odour	Odourless	Odourless	Agreeable	Agreeable	Agreeable	Agreeable
Salinity	mg/L	-	0.53-0.65	0.25-0.40	0.28-0.32	0.19-1.04
Sulphate	mg/L	400	1-2.3	1-1.6	1.9-17	1-18
Zinc (Zn)	mg/L	5.0	0.08	0.08	0.08	0.08
Boron (B)	mg/L	-	<0.5	<0.5	<0.5	<0.5
Phosphorus (P)	mg/L	-	< 0.5	< 0.5	< 0.5	< 0.5
Lead (Pb)	mg/L	-	< 0.01	< 0.01	< 0.01	< 0.01
Mercury (Hg)	mg/L	-	< 0.001	< 0.001	< 0.001	< 0.001
pH value	-		6.1-6.35	6.0-6.29	6.2-6.42	5.8-6.90
Total Dissolved Solids (as TDS)	mg/l	1000	550-630	390-570	286-350	220-376
Conductivity			1010-1085	570-686	489-690	440-1006

**Standards for drinking water - Schedule -3 (B) of ECR 1997*

It may be seen from the analysis of water that TDS concentrations ranged between 220 to 550 at the sampling locations. The general trend indicated that TDS is slightly higher in June 2020 due to lesser water recharge during the summer season in contrast to dilution in October 2019 during the post-monsoon period. This is because of the fact that during first season monitoring during October, it was immediately after post monsoon. The area experiences heavy shower leading to ground water recharging and dilution. However, during second season monitoring (June 2020), it was immediately after summer season and ground water recharging could not happen during that period. This have contributed to the higher TDS concentration during June 2020. Electrical conductivity is an indicator of TDS and is a measured of the salinity of the water. In conformity with TDS data, the electrical conductivity is also higher during June. Alkalinity was found in the range of 168 to 334 mg/l. The heavy metals concentrations were found to be within the Bangladesh standards at all monitoring locations except Iron & Manganese which is higher than the prescribed standard in GW4 and which exceeds the standard at all the monitoring locations [11]Manganese occurs naturally in many surface water and groundwater sources and in soils that may erode into these waters. The higher concentrations of Manganese at all the monitoring locations may be attributed to the above-mentioned factors and anthropogenic activity in and around the project site.

4.5.8.4 Surface Water quality monitoring

Primary monitoring of surface water quality is a crucial aspect as raw water for the proposed plant would be sourced from Meghna River and the effluent generated during the proposed project operations are likely to be discharged to Meghna River/Channel after ensuring that it meets prescribed norms. An effort has been made to establish the baseline quality of the existing major watersheds and sub watersheds (comprising the major drainage of the study area) to identify any possible contamination due to any current industrial activities. The map showing surface water sampling locations in the study area is presented in ***Figure 4.20*** and the details of the sampling location are given in ***Table 2.10***. SW1 is considered as representative location for the discharge from the project site while other locations are located upstream and downstream of the site. The photographs of surface water sampling are also presented in ***Figure 4.21.***

[11] https://www.who.int/water_sanitation_health/dwq/chemicals/manganese.pdf (Manganese in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality)

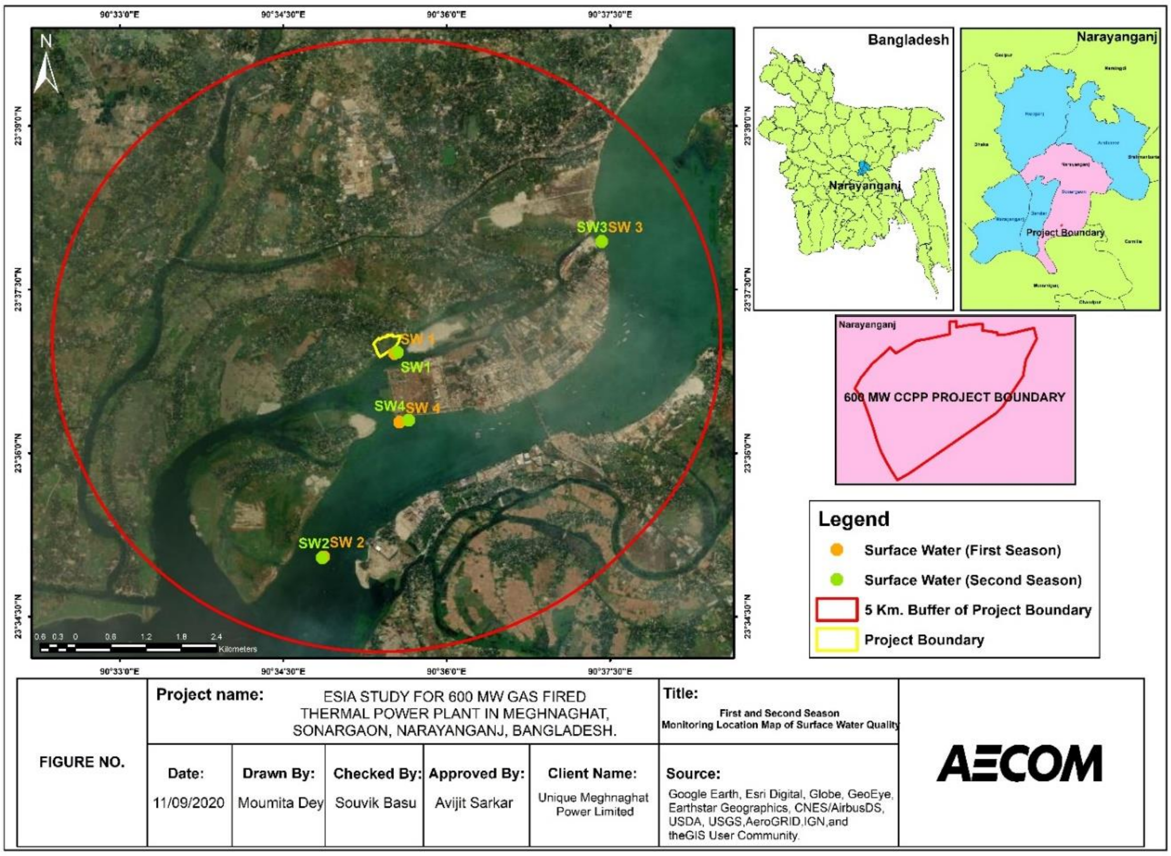


Figure 4.20: Surface water sampling locations in both the seasons

Table 4.10. Ground Water Sampling Locations

Location Code	Co-ordinates	Sampling Location	Basis of selection
SW 1	23°36'54.82"N, 90°35'31.21"E	Meghna River, In front of Project Site	Sample collected from Meghna Channel in front of proposed project site, considered as representative location for discharge from the plant
SW 2	23°35'3.00"N, 90°34'52.20"E	Meghna River (Downstream), 3.89 km South-West from Project Site	Sample collected downstream of the Meghna River, immediate downstream of Meghnaghat Industrial area Downstream of the project site
SW 3	23°37'56.44"N, 90°37'25.40"E	Meghna River (Upstream), 3.53 km North-East from Project Site	Sample collected from Upstream of the project site
SW 4	23°36'16.96"N, 90°35'33.98"E	Meghna River (Near Summit Power Plant), 1.48 km South from Project Site	Sample collected downstream of discharge from Summit Power Plant at the mouth of the creek

Surface Water Sampling Pictures

SW1: Meghna River Minor Channel near project site

SW2: Downstream of Meghna River

SW3: Upstream of Meghna River

SW 4: Confluence of Meghna River and River Channel

Figure 4.21: Surface water sampling pictures

4.5.8.5 Surface Water Monitoring Results

The surface water samples were collected for two seasons and for determining the quality the concentration range obtained for the various analysed parameters are provided in ***Table 4.11***. The monitoring results were compared with Bangladesh standard for drinking water presented in the table.

Table 4.11: Physio-chemical characteristics of Sampled Surface Water

			Sample Location				Bangladesh standards (Best Practice-Based Classification) *					
Parameters	Unit	Bangladesh Standard	SW1	SW2	SW3	SW4	Source of drinking water for supply only After disinfecting	Water usable for Recreational activity	Source of Drinking water for supply after Conventional treatment	Water usable by fisheries	Water usable by Various process And cooling industries	Water Usable for irrigation
pH value	-	6 or above	6.6-7.46	6.2-6.39	6.08-6.3	6.57-6.6	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Temperature	°C	0.2	29.7-32.4	30.8- 31.5	31.2-32.0	32.8-33.5						
Dissolve Oxygen	mg/l	0.5	5.7-5.9	5.2-6.2	5.0-5.6	5.4-6.4	6 or above	5 or more	6 or above	5 or more	5 or more	5 or more
Aluminium (Al)	mg/L	0.05	0.14- 0.302	0.05- 0.292	0.15-0.28	0.08-0.246	---	---	---	---	---	---
Ammonia	mg/L	0.01	0.14	0.23	0.19	0.32	---	---	---	---	---	---
Arsenic (As)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	---	---	---	---	---	---
Barium (Ba)	mg/L	75	<0.05	<0.05	<0.05	<0.05	---	---	---	---	---	---
Cadmium (Cd)	mg/L	4	<0.001	<0.001	<0.001	<0.001	---	---	---	---	---	---
Calcium (Ca)	mg/L	0.2	25-98	9.2-10	8	7.7-8	---	---	---	---	---	---
Chemical Oxygen Demand (COD)	mg/L	150-600	12- 28	40	8-12	56	---	---	---	---	---	---
Biochemical Oxygen Demand (as BOD)	mg/L	0.001	3.2	5	<2.0	<2.0	2 or less	3 or less	6 or less	6 or less	10 or less	10 or less
Chloride	mg/L	0	10-13	10-27	10-17	10-29	---	---	---	---	---	---
Ammonium (NH_4)	mg/L	0	0.15	0.24	0.2	0.34	---	---	---	---	---	---
Coliform (Faecal)	N/100 ml	15	26	80	66	120	---	---	---	---	---	---
Coliform (Total)	N/100 ml	1	40	116	112	248	50 or less	200 or less	5000 or less	---	5000 or less	1000 or less
Colour	Hazen	0.05	1	1.5	1.3	2.1	---	---	---	---	---	---

Parameters	Unit	Bangladesh Standard	Sample Location				Bangladesh standards (Best Practice-Based Classification) *					
			SW1	SW2	SW3	SW4	Source of drinking water for supply only After disinfecting	Water usable for Recreational activity	Source of Drinking water for supply after Conventional treatment	Water usable by fisheries	Water usable by Various process And cooling industries	Water Usable for irrigation
Copper (Cu)	mg/L	1	0.07	0.05	0.03	0.08	---	---	---	---	---	---
Cr (Total)	mg/L	200-500	<0.01	<0.01	<0.01	<0.01	---	---	---	---	---	---
Fluoride	mg/L	0.3-1	0.12-0.15	0.12	0.12	0.12-0.16	---	---	---	---	---	---
Hardness	mg/L	30-35	69-150	54-125	44-112	61-130	---	---	---	---	---	---
Iron (Fe)	mg/L	0.1	0.31-0.43	0.13-0.46	0.57-1.2	0.13-0.63	---	---	---	---	---	---
Magnesium (Mg)	mg/L	0.1	1.8-3	4-7.4	3-5.8	2-10	---	---	---	---	---	---
Manganese (Mn)	mg/L	10	0.03	0.04	0.07	0.07	---	---	---	---	---	---
Nickel (Ni)	mg/L	Odourless	0.07	0.08	0.01	0.01	---	---	---	---	---	---
Nitrogen (Nitrate)	mg/L	400	4	3.2-3.6	3-4.5	0.6-1.5	---	---	---	---	---	---
Odour	Odourless	10	Agreeable	Agreeable	Agreeable	Agreeable	---	---	---	---	---	---
Sulphate	mg/L	1000	1-4.6	1-12	2-5.4	1-9.8	---	---	---	---	---	---
Total Suspended Solid (TSS)	mg/L	10	4.6-11	6	7	9	---	---	---	---	---	---
Total Dissolved Solids (as TDS)	mg/l	5	60-112	40-180	40-88	40-158	---	---	---	---	---	---
Turbidity	NTU		5-7	7.1	8-8.5	11.6	---	---	---	---	---	---
Zinc (Zn)	mg/L		0.08	0.09	0.08	0.08	---	---	---	---	---	---

** Bangladesh Environment Conservation Rules, 1997- Schedule 3 (Standards for inland surface water)*

From the above table, it may be observed that the monitored water samples from Meghna River & Meghna Channel are not suitable for drinking purposes (without adequate treatment) at all sampling locations. As per the above table in both the seasons, it may be seen that the values of faecal Coliform, Total Coliform and COD was found to be in the higher range in all the surface water samples indicating possible sewage contamination. The concentrations of heavy metals such as Aluminium, Barium, Arsenic, Cadmium, Copper, Chromium, Iron, Zinc, Magnesium, Manganese and Nickel were found to be below their corresponding permissible limits, and the same is applicable for concentrations of Ammonia, Chloride, Fluoride, Nitrate and Sulphate at all sampling locations.

4.5.9 Meteorology

Although less than half of Bangladesh lies within the tropics, the presence of the Himalaya Mountain range has created a tropical macroclimate across most of the east Bengal land mass (Rashid, 1991[12] and Brammer, 1996[13]). Four distinct seasons has been identified resulting from this weather pattern, namely:

- Pre-Monsoon Season (March to May): Characterized by the highest temperatures of the year – up to 36°C. Some rainfall may occur, with tropical cyclones occasionally affecting coastal areas.
- Monsoon Season (June to September): Period of highest rainfall (up to 80% of the annual rainfall), humidity and cloud cover. Increased rain and cloud cover generally cause a small reduction in mean daily temperatures.
- Post-Monsoon Season (October to November): Temperature remains hot and humid, though cloud cover decreases in this season. Limited tropical thunderstorms may still occur, particularly in coastal areas; and
- Dry Winter Season (December to February): Coolest time of the year with mean minimum temperatures falling below 10°C in some areas. Reduced humidity and cloud cover. Rainfall is scarce during this season.

Despite the general predictability of the seasons in Bangladesh, local conditions may still vary widely across the country. As such, Bangladesh can be divided into seven climatic zones based on differences in a range of factors including rainfall, temperature, evapo-transpiration and local seasonality (Rashid, 1991). According to the climatic zones of Bangladesh, the study area and project site are in South-central zone (***Figure 4.22***). Long-term Meteorological data for 30 years (1989-2018) was collected from the nearest BMD stations in Dhaka, which is analysed to get the overall micro-climatic conditions of the study area.

12 *Rashid, H. E. (1991). "Geography of Bangladesh". University Press Limited, Dhaka.*

13 *Brammer, H. (1996). "The Geography of the Soils of Bangladesh". University Press Ltd., Dhaka*

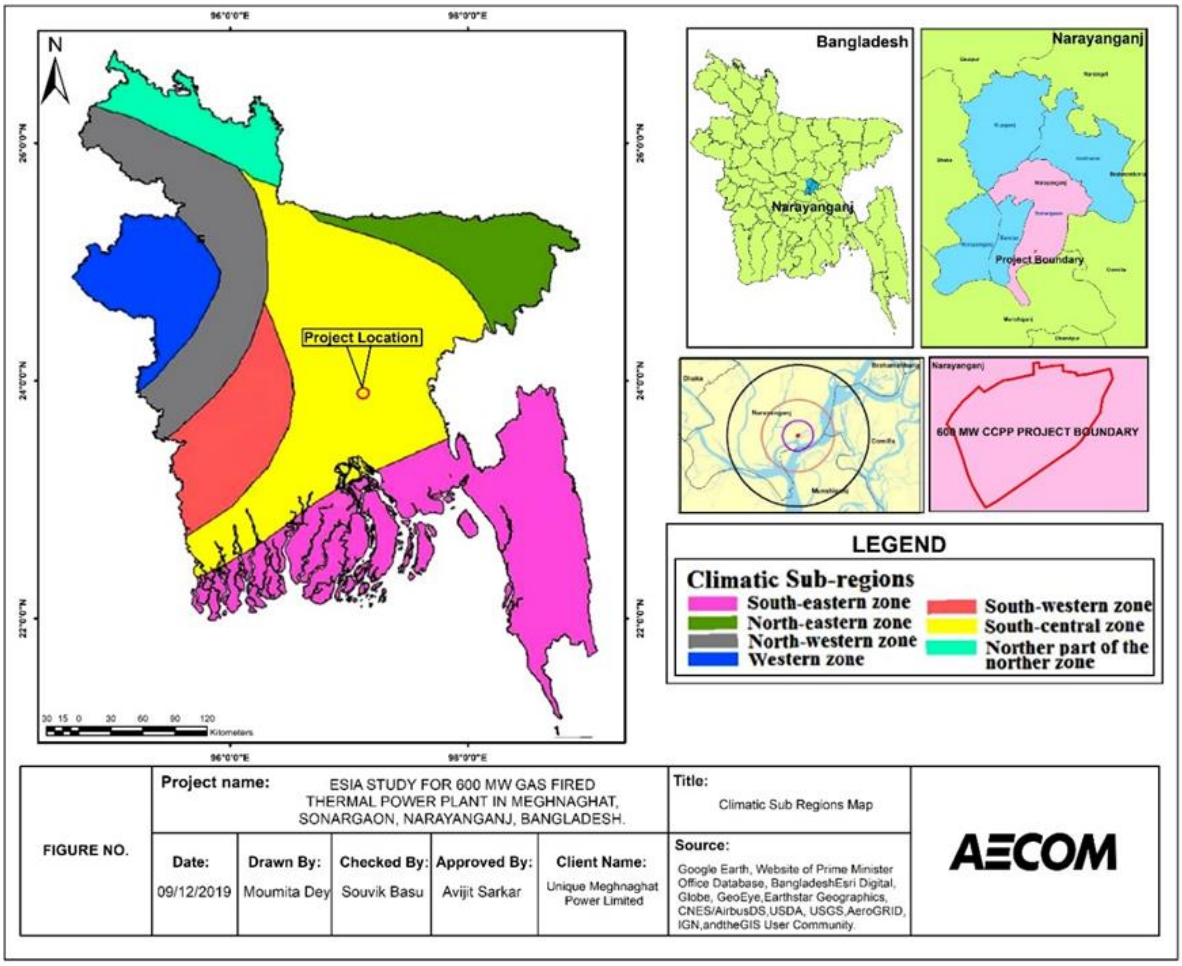
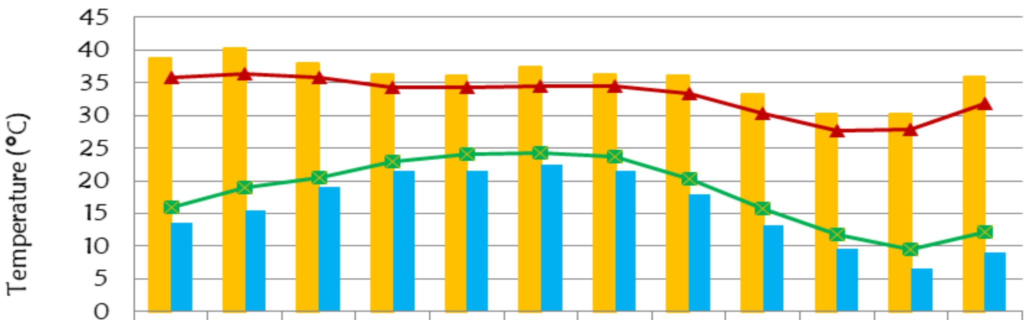


Figure 4.22: Project Site and Study Area Location on Climatic Zones of Bangladesh

4.5.9.1 Temperature

The maximum, minimum and average maximum and minimum temperatures recorded at the Dhaka weather station are presented below in ***Figure 4.23.*** The data analysis of 30 years (1989-2018) shows that monthly maximum temperature varies from 30.2°C to 40.2°C whereas monthly minimum temperature varies from 6.5°C to 22.5°C. The lowest temperature recorded in the past 30 years was in January 1995 (6.5°C). The highest temperature reached 40.2°C in April 2014. Throughout the year, the highest temperatures are generally in March through October, and the lowest temperatures are from December to January.



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Pre-Monsoon			Monsoon				Post-Monsoon		Winter		
Maximum	38.8	40.2	38	36.2	36	37.5	36.2	36	33.2	30.3	30.2	35.9
Minimum	13.5	15.5	19	21.5	21.5	22.5	21.5	18	13.3	9.6	6.5	9.0
Avg Max	35.8	36.4	35.8	34.4	34.3	34.5	34.5	33.3	30.4	27.6	27.8	31.8
Avg Min	16.0	18.9	20.6	22.9	24.1	24.2	23.8	20.2	15.7	11.7	9.4	12.3

Figure 4.23: Monthly Maximum, Minimum and Average Temperatures (1989-2018) of Dhaka Weather Station

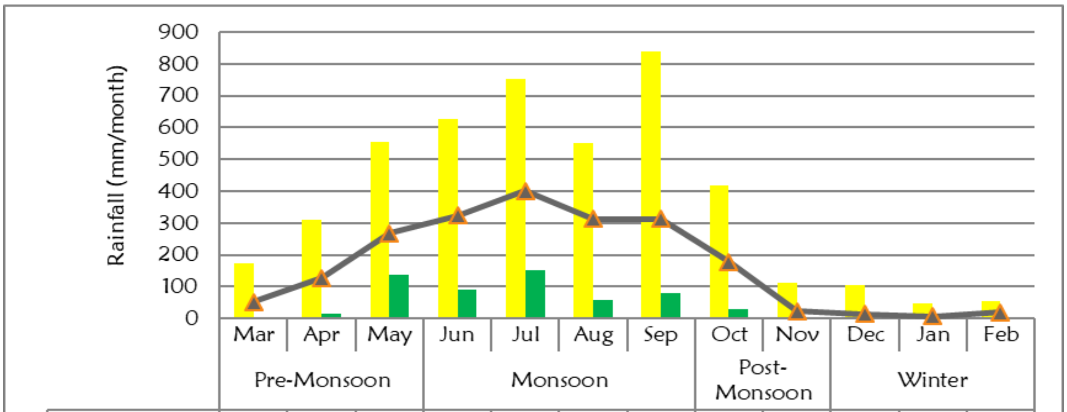
Source: Bangladesh Meteorological Department, Dhaka

4.5.9.2 Rainfall

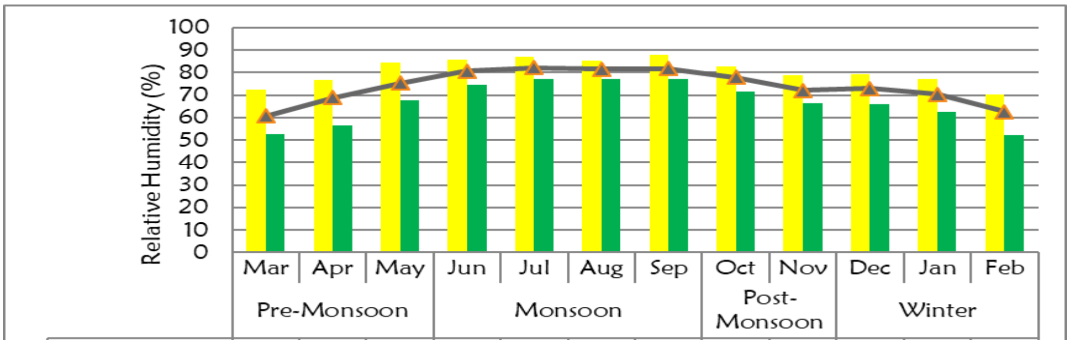
About 80% of the rainfall occurs during six monsoon months (May to October) with June and July getting the maximum rains. Minimum rains are reported during the months of November to February whereas average showering does occur in March, April and November. The last 30 years data of the Dhaka meteorological station shows that the annual average of total rainfall is recorded as 2037.2 mm/year. According to the analysis of the historical data, a monthly maximum of total rainfall occurs in September (839 mm) whereas monthly minimum rainfall was recorded during the winter season. The monthly maximum, minimum and average rainfall of the last 30 years (1989-2018) of Dhaka weather station is shown in ***Figure 4.24.***

4.5.9.3 Humidity

Due to the heavy rainfall and proximity to the Bay of Bengal, the humidity levels in Bangladesh remains high. Average relative humidity in the project area is generally above 75% from May to October. The month of March is the driest with the average relative humidity around 61%. The monthly average relative humidity near the project area varies from 61% to 82% throughout the year. The monthly maximum, minimum and average humidity of the last 30 years (1989-2018) of Dhaka weather station is shown in ***Figure 4.24***.



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Maximum	172	309	556	628	753	552	839	417	112	106	49	56
Minimum	0	14	137	89	153	59	81	30	0	0	0	0
Average	52.6	126.6	267.6	323.4	400.6	312.3	311.9	178.1	23.9	13.4	7.0	19.8



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Maximum	73	77	84	86	87	85	88	83	79	79	77	70
Minimum	53	57	68	75	77	77	77	72	67	66	63	52
Average	61	69	75	81	82	82	82	78	72	73	70	63

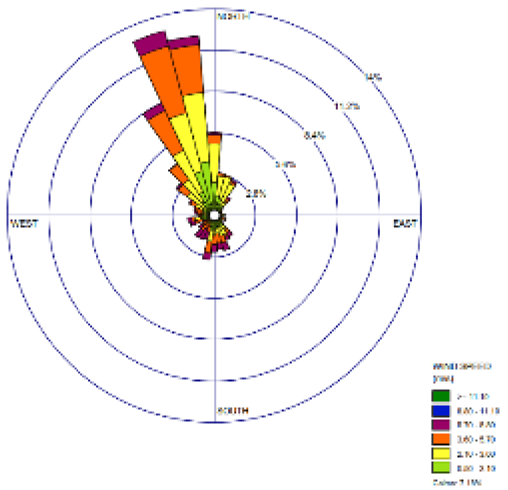
Figure 4.24. Monthly Maximum, Minimum and Average Rainfall & Humidity (1989-2018) of Dhaka Weather Station

Source: Bangladesh Meteorological Department, Dhaka

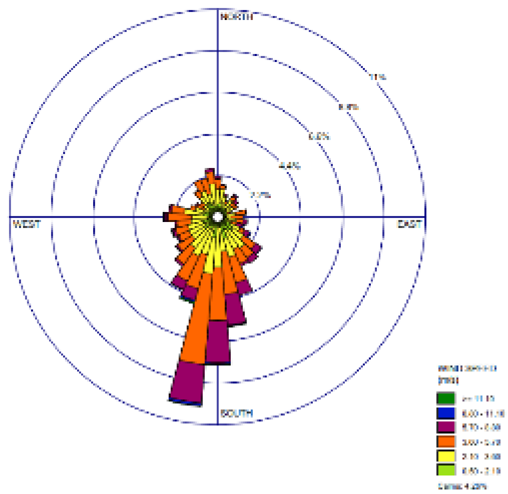
4.5.9.4 Wind Speed and Direction

Wind direction and speed exhibit seasonal variation. Winds are generally moderate during non-monsoon season whereas, during the monsoon season, these are moderate to strong. The average wind speed in the project area is 0.61 m/s. Predominant wind speed varies from 0.50-2.10 m/s which is almost 60.1% of the year.

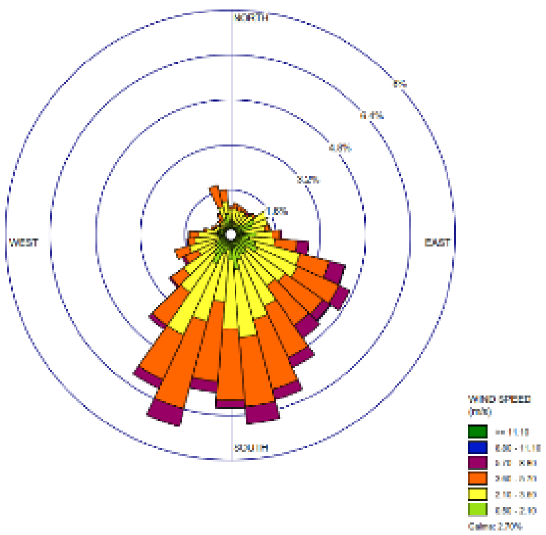
The annual wind rose shows that the predominant wind directions are from South South-West and North North-West. During pre-monsoon (March-May) the predominant wind direction is from South South-west, and during monsoon season (June-September) it is from South, South South-east and South-west whereas during the post-monsoon (October-November) predominant wind direction is also from South-east and south-west and during the winter season (December-February) it is from North-North-west & North-west. The Annual and seasonal Wind-rose is presented in ***Figure 4.25.***



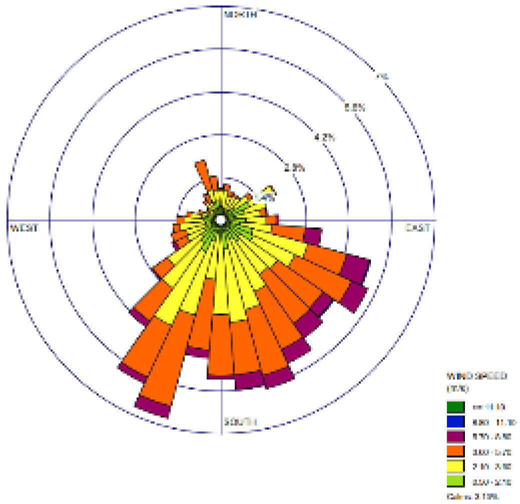
Season-Winter



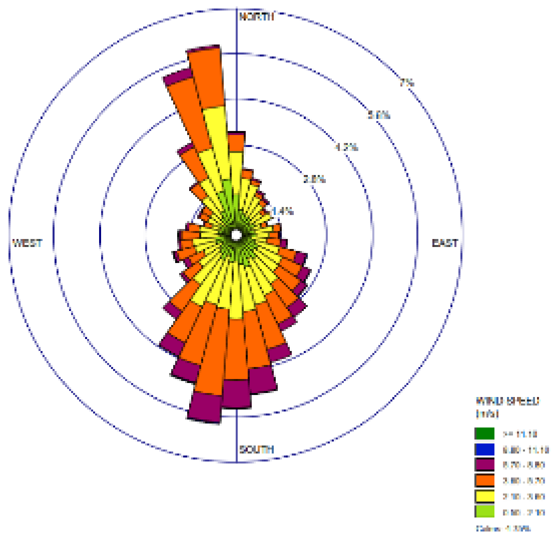
Season- Summer or pre-monsoon



Season-Monsoon



Season-Post monsoon



Annual Windrose

Figure 4.25: Annual and Seasonal Wind Rose of the Project Site

(Source: Processed Meteorological data procured from Envitrans)

4.5.10 Natural Hazards and Risks

4.5.10.1 Cyclone

Natural Hazard are the naturally occurring events like cyclone, earthquake and flood etc. which can become hazardous due to the intervention of human infrastructure. It is not that these events are hazardous but it's the vulnerability of human infrastructure to destruction (risk) that makes such events hazardous. In view of the past natural hazard events in Bangladesh, atmospheric and exogenic hazards risk are high and endogenic hazards risk are relatively low. In Bangladesh Cyclone and flood are major natural hazards. Almost every year overwhelming cyclones hit the Bangladesh. At the time of Cyclone, the winds speed, sometimes reach 250 km/hr or more and 3-10 m high waves. For these types of Cyclone every year extensive damages have happened to life, property and livestock. These cyclones occur in two seasons, April-May and October-November. However, the proposed project Site is in the 'no cyclone risk zone'. In fact, the Site has a no cyclone risk within 10 km of its radius as shown in the ***Figure 4.26.***

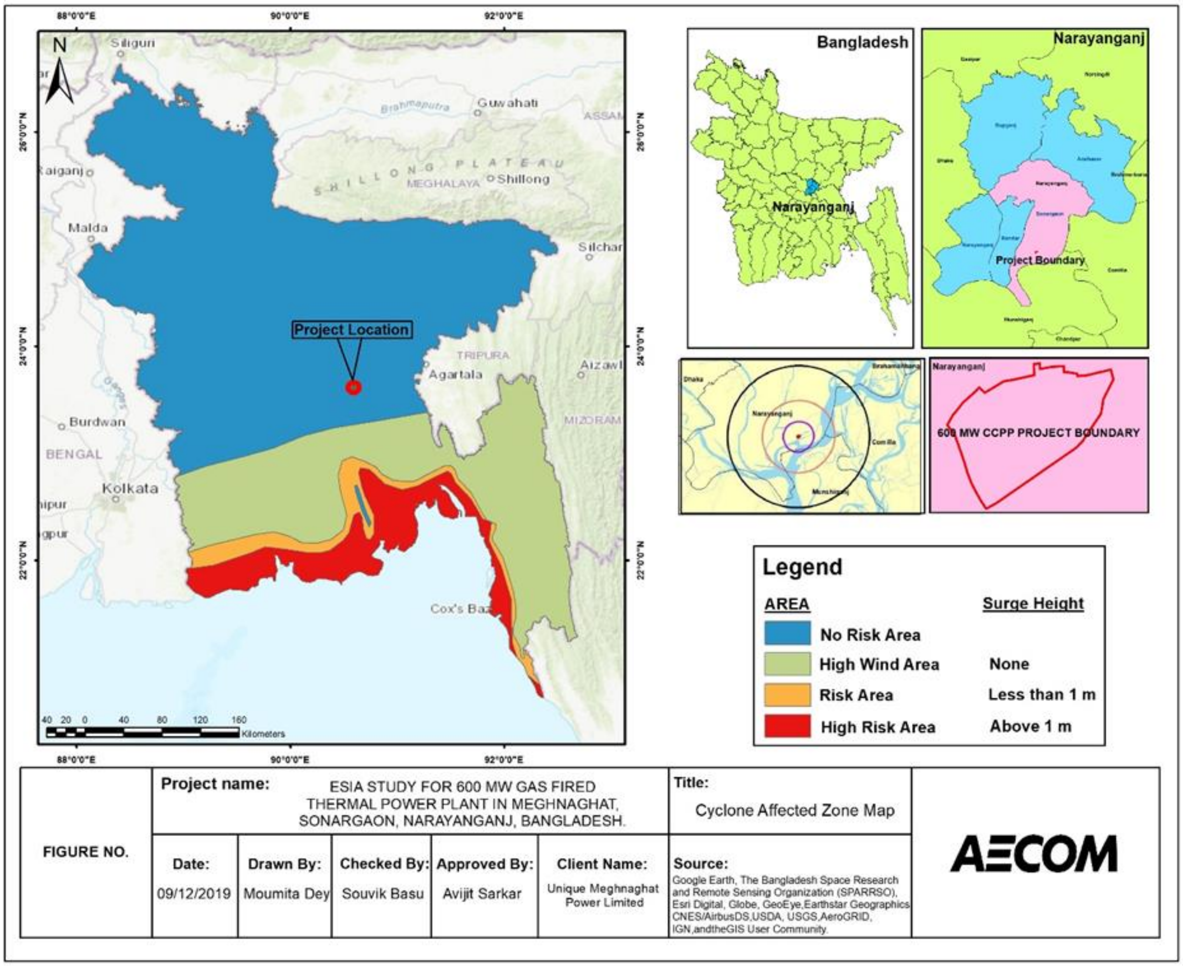


Figure 4.26. Cyclone Affected Zone Map of the Study Area

4.5.10.2 Floods

Bangladesh is situated on the Brahmaputra River Delta and is prone to flooding. Being less than 5 metres above mean sea level, Bangladesh faces the cumulative effects of floods during the monsoon season from June to September. The flood zoning map of the proposed project site (low river flooding zone) and the surrounding project area is as shown in the ***Figure 4.28.***

Ganga-Brahmaputra-Meghna (GBM) Basin is one of the largest river basins (1.7 Million sq. Km) in South East Asia passing through various countries such as India (64%), China (18%), Bangladesh (7%), Bhutan (9%) and Nepal (3%) (BWDB, 2006). Bangladesh is at the confluence of three rivers-Ganga, Brahmaputra and Meghna. Meghna River is one of the most important rivers in Bangladesh and the area of Meghna River basin is more than half of the country's area. Meghna River is divided into two parts-Upper Meghna River and Lower Meghna River. Upper

Meghna River is from Bhairab Bazar (24.0555° N, 90.9802° E) up to Chandpur (23.2321° N, 90.6631° E) and Lower Meghna River is from Chandpur to the end point in the sea. Relevant data of these stations were procured from BDWD for various purposes of this report. These locations along with the project site are shown in the map below:

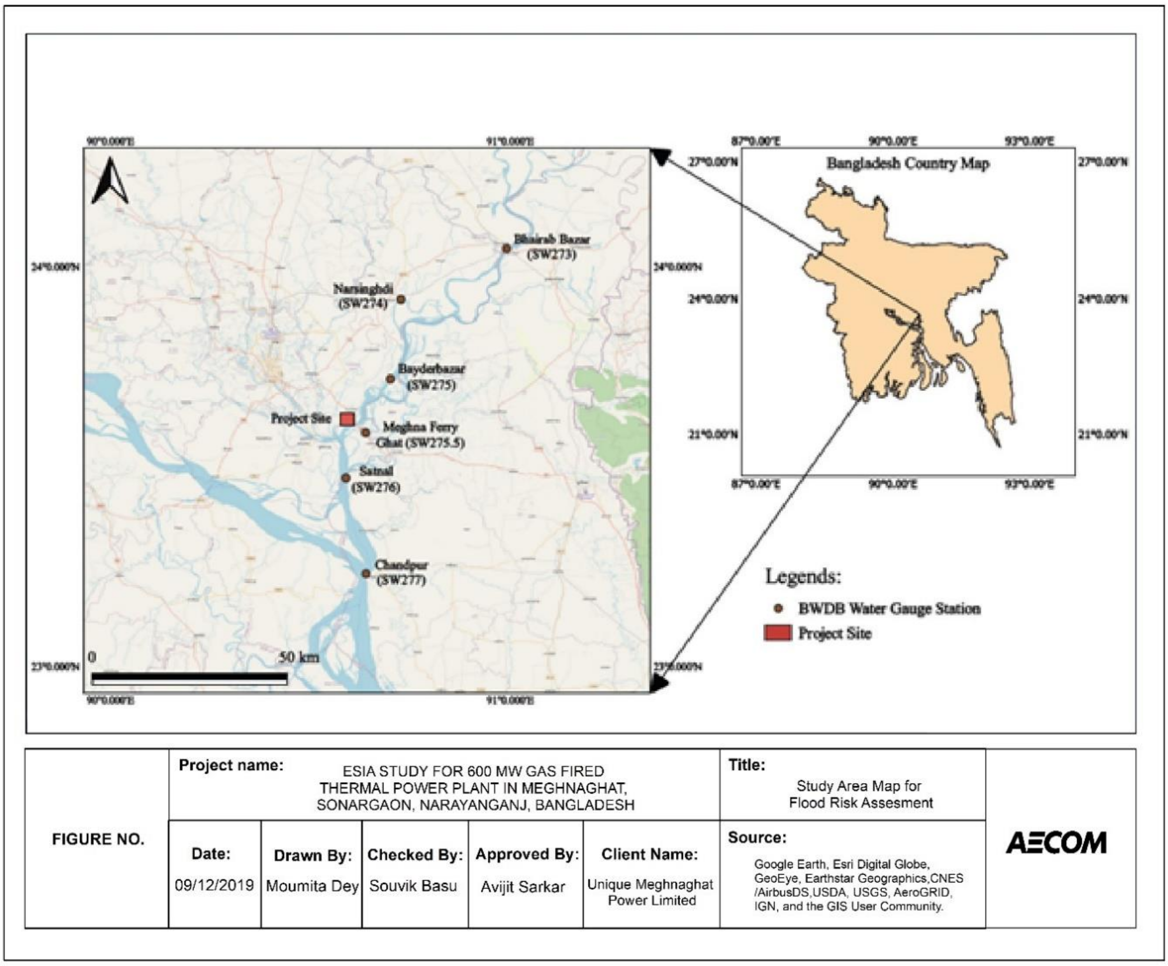


Figure 4.27: Location of River gauge station on Meghna River wrt to the project site

There are four different types of floods encountered in the Bangladesh-Flash floods, river floods, tidal floods and storm surges. However, the upper Meghna River basin is subjected only to flash floods and river floods. Flash floods are restricted to the far eastern and far northern portion of the basin and therefore the study area is mainly subjected to river floods.

The major cause of the monsoon flood is due to the intensity, duration and magnitude of the rainfall in the GBM basin. A comparison of floods in major rivers in 2007 with other major floods of past in 2004, 1998 and 1988 was done. For water level data from one-gauge station in each major river was used for this comparison. Bahadurabad in the Brahmaputra River, Hardinge Bridge in the Ganges River and Bhairab Bazar in the Meghna River were the three well known gauge stations where records of historic flood are available and used in this study (***Table 4.12***). Water level hydrographs of three major rives for floods in 2007, 2004, 1998 and 1988 is depicted in ***Figure 4.29***. It can be found from these hydrographs that floods in major river systems have distinct characteristics and patterns. Comparison was made in terms of danger level, the date of crossing of danger level of falling curve, the date of crossing of danger level of recession curve, the height of peak flood level above local datum (PWD) and the duration of flood above danger level.

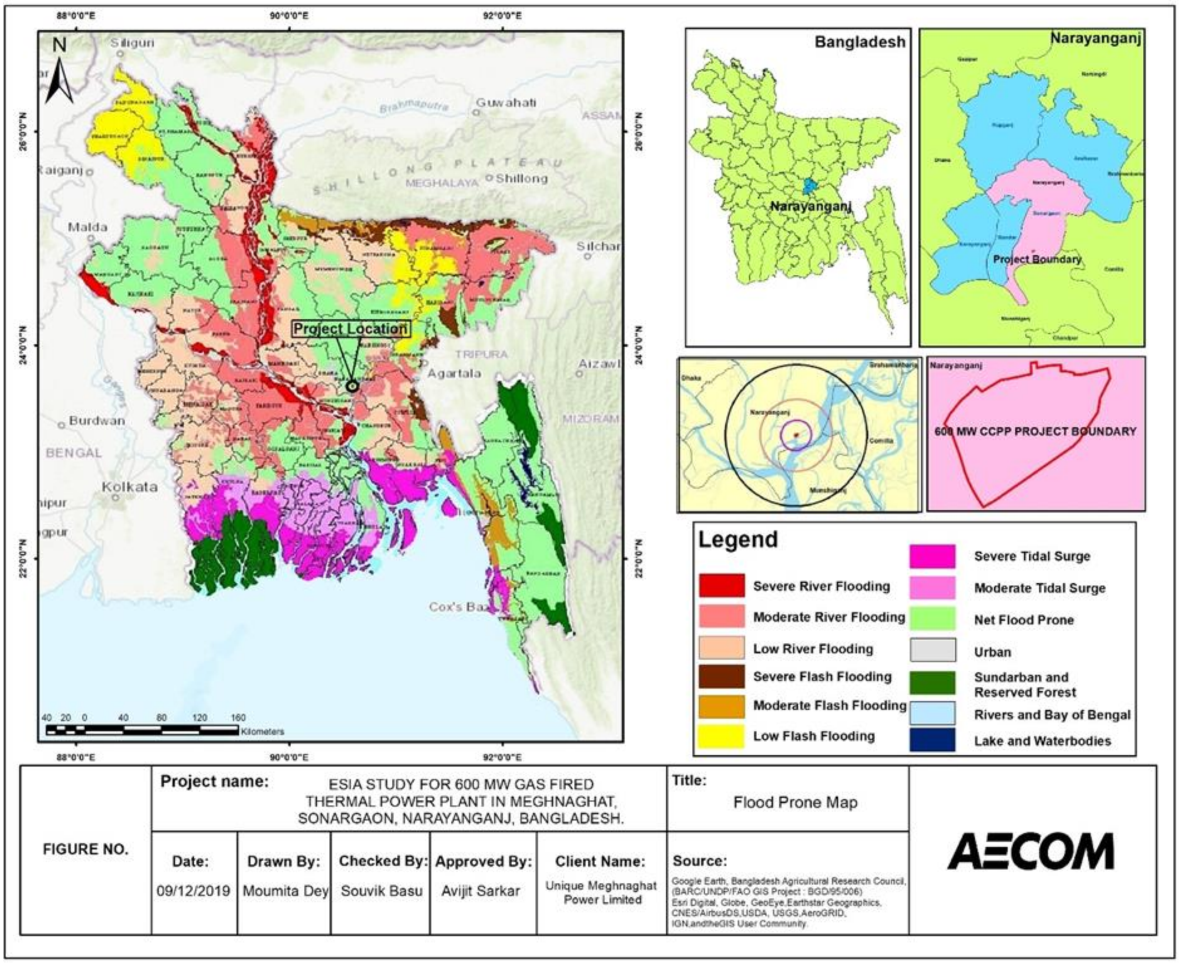


Figure 4.28: Flood Prone map of the Study Area

Table 4.12: Summary of Flood study (2007, 2004, 1998 and 1988) in Major Rivers

Parameter	River	Gauge Station	2007	2004	1998	1988
Danger Level in meters above PWD datum	Brahmaputra	Bahadurabad	19.5	19.5	19.5	19.5
	Ganges	Hardinge Bridge	14.25	14.25	14.25	14.25
	Meghna	Bhairab Bazar	6.25	6.25	6.25	6.25
Date of crossing Danger Level at rising stage	Brahmaputra	Bahadurabad	27.07.07 & 08.09.07	11.07.04	07.07.98	09.07.88 & 24.08.88
	Ganges	Hardinge Bridge	-	-	20.08.98	16.08.88
	Meghna	Bhairab Bazar	30.07.07 & 12.09.07	11.0704	20.07.98	06.07.88 & 14.08.88
Date of crossing Danger Level at falling stage	Brahmaputra	Bahadurabad	06.08.07 & 17.09.07	26.07.04	12.09.98	12.07.88 & 04.09.88
	Ganges	Hardinge Bridge			15.09.98	07.09.88
	Meghna	Bhairab Bazar	21.08.07 & 25.09.07	18.08.04	25.09.98	05.08.88 & 27.09.88
Height of peak flood level in meter above Danger Level	Brahmaputra	Bahadurabad	0.88	0.68	0.87	1.12
	Ganges	Hardinge Bridge			0.94	0.62
	Meghna	Bhairab Bazar	0.69	1.53	1.08	1.41
Duration of flood in days above Danger Level	Brahmaputra	Bahadurabad	21	15	67	16
	Ganges	Hardinge Bridge	0	0	26	23
	Meghna	Bhairab Bazar	37	38	67	75

Source: Islam A.K.M.S., Haque A., Bala S.K. (2008)

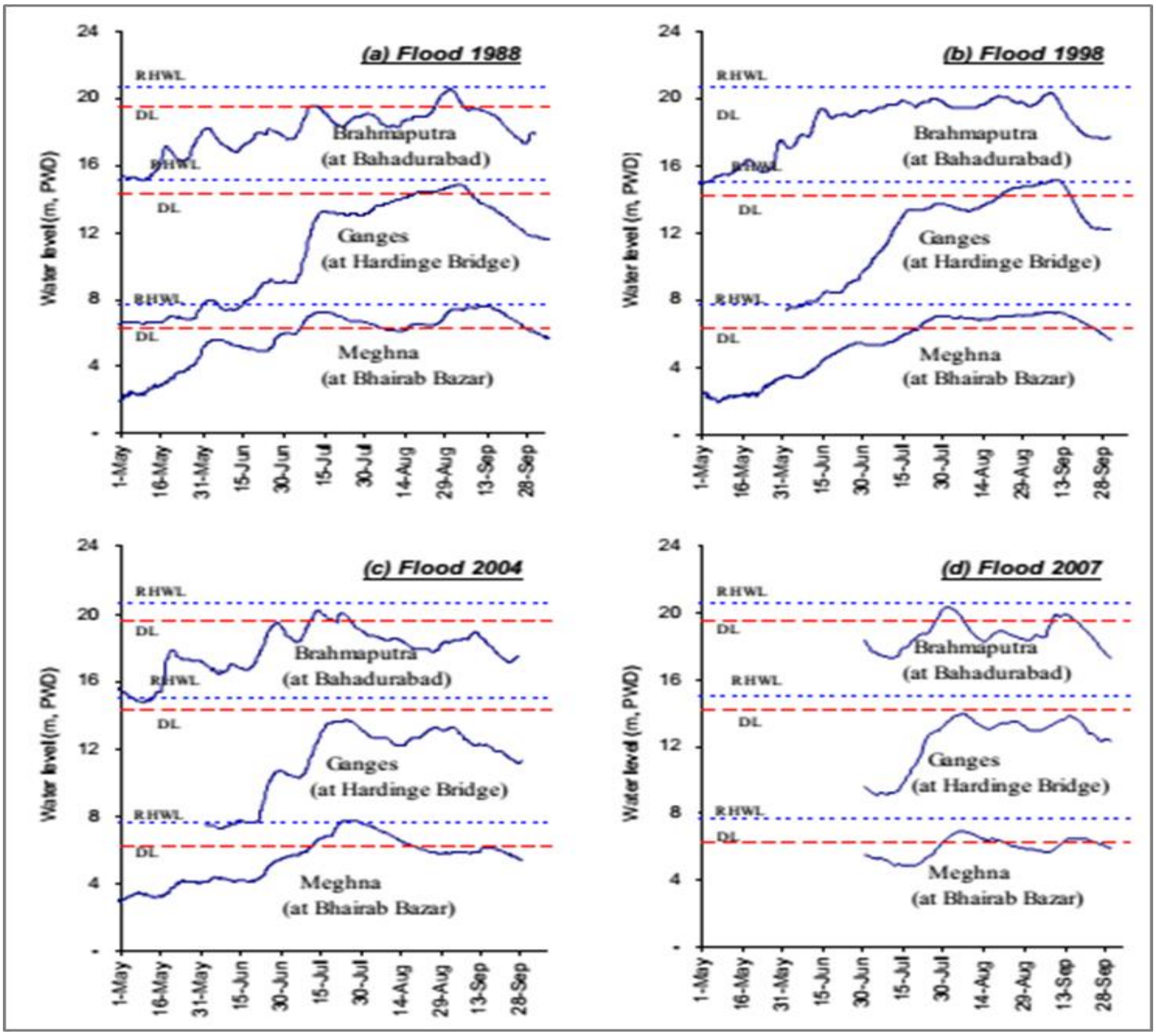


Figure 4.29. Water Level Hydrographs of Major Rivers for Four Major Flooding Years (1988, 1998, 2004 & 2007)

The magnitude of water level above danger level in the Meghna River during 2007 was almost half of it during 2004. The most severe flood in terms of magnitude occurred in this basin during 1988 and 2004. In addition, during 1998 the magnitude of the peak flood in this basin was much higher than that of 2007. In 2007 and 1988, the first flood wave entered Meghna basin in the last week of July. In 1988 and 2007, flood was observed in the Meghna river basin of Bangladesh much earlier (at the beginning of July) than in 2007, while in 1998, the first flood wave was observed in the middle of July. Duration of floods in the Meghna river basin of Bangladesh in 2007 is like that of 2004. Although the long-lasting flood was observed in this basin in 1988 and it was twice the duration of flood in 2007. In 1998, the duration of flood in the Meghna river basin of Bangladesh was less than 1988 but has much higher than in 2007 and 2004. In general, based on the past flood level data, the Meghna River basin is more affected due to flood during the month of July. The magnitude of water level above danger level in the Meghna River during 2007 was almost half of it during 2004. The most severe flood in terms of magnitude occurred in this basin during 1988 and 2004. In addition, during 1998 the magnitude of the peak flood in this basin was much higher than that of 2007. In 2007 and 1988, the first flood wave entered Meghna basin in the last week of July. In 1988 and 2007, flood was observed in the Meghna river basin of Bangladesh much earlier (at the beginning of July) than in 2007, while in 1998, the first flood wave was observed in the middle of July. Duration of floods in the Meghna river basin of Bangladesh in 2007 is like that of 2004. Although the long-lasting flood was observed in this basin in 1988 and it was twice the duration of flood in 2007. In 1998, the duration of flood in the Meghna river basin of Bangladesh was less than 1988 but has much higher than in 2007 and 2004. In general, based on the past flood level data, the Meghna River basin is more affected due to flood during the month of July.

Analysis of water level data and discharge data for the stations of Bhairab Bazar and Meghna Ferry Bridge is done to understand the variation of tidal & non-tidal discharges during 2014-2020, presented in the figure below. It can be seen that the flood flow due to non-tidal flow is higher than the tidal flow, indicating that non-flood flow is critical in the estimation of maximum inundation level in the region.

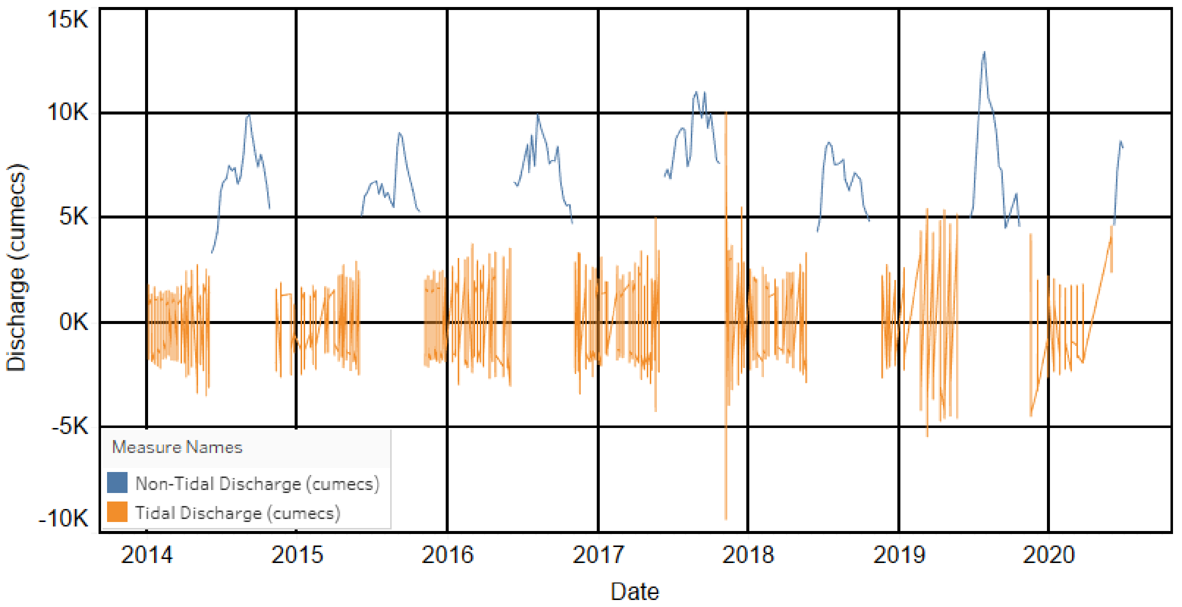


Figure 4.30: Comparison of Tidal vs Non-Tidal Discharge at Bhairab Bazar (2014-2020)

The comparison of water level for tidal flow as well as non-tidal flow in the figure below shows that water levels due to tidal flows varies from 0.1 m to 4 m and the water levels from non-tidal flows varies from 1.6 m to 6.1 m. This indicates that the river is perennial and the water level throughout the year in the river is greater than Mean Sea Level due to the presence of tidal flows.

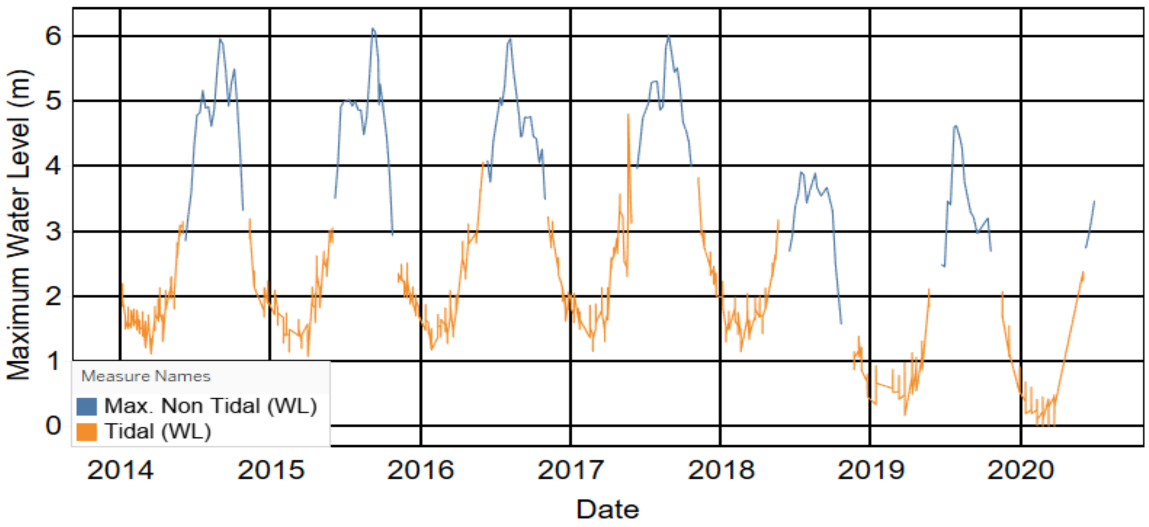


Figure 4.31: Comparison of Tidal and Non-Tidal Water Level at Bhairab Bazar (2014-2020)

Based on water level data obtained for the period 1968-2018 from BWDB for water level stations at Meghna Ferry Bridge (near the project site), it was seen that while minimum water level in the most cases during the entire period from 1968-2020 is around 1 m, maximum water level at Meghna Ferry Bridge during the entire period is 6.76 m for the year 1998.

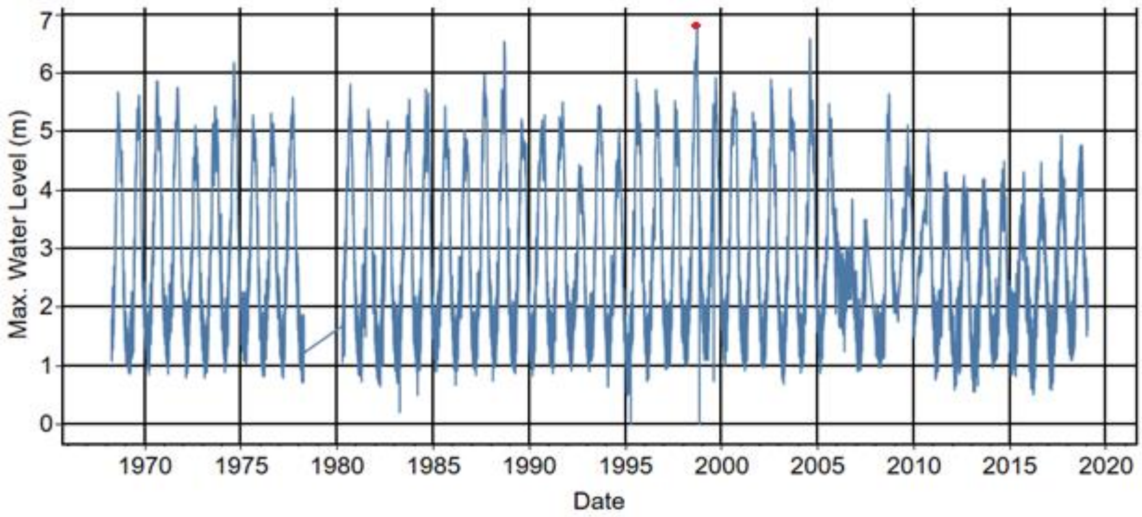


Figure 4.32: Maximum Daily Water Level-Meghna Ferry Bridge (1968-2018)

4.5.10.3 Earthquake

The location of Bangladesh is adjacent to the plate margins of India and Eurasia where earthquake has occurred in the past. The project site is situated at the southern tip of a Pleistocene terrace of the Madhupur Tract. Significant damaging historical earthquakes have occurred in and around Bangladesh and damaging moderate-magnitude earthquake occur every few years. The position of Bangladesh is adjacent to the very active Himalayan subduction plate in the north, moving east, and the westward movement of the Burma deformation produce the potential for earthquakes. Over the past 200 years, at every 30 years intervals, Bangladesh has experienced several large earthquakes. Since 1860, more than 20 light and intermediate major earthquakes, with epicentres in Bangladesh, have been experienced. The flow of the river was diverted because of catastrophic earthquakes in 1762 and 1782. Also, these earthquakes have been partially responsible for the diversion of the Old Brahmaputra River to the Jamuna Channel. Thus, the design of land buildings and land-based structures for this project should be as per of the Bangladesh National Building Code (2006). The location of Bangladesh has been fallen under three seismic zones of which Zone-1 have the least effect, Zone-2 have intermediate effect and Zone-3 have the most severe effect. Project site is in seismic Zone-2 of BNBC with seismic zone coefficient (Z) of 0.15 and depicted in ***Figure 4.30***.

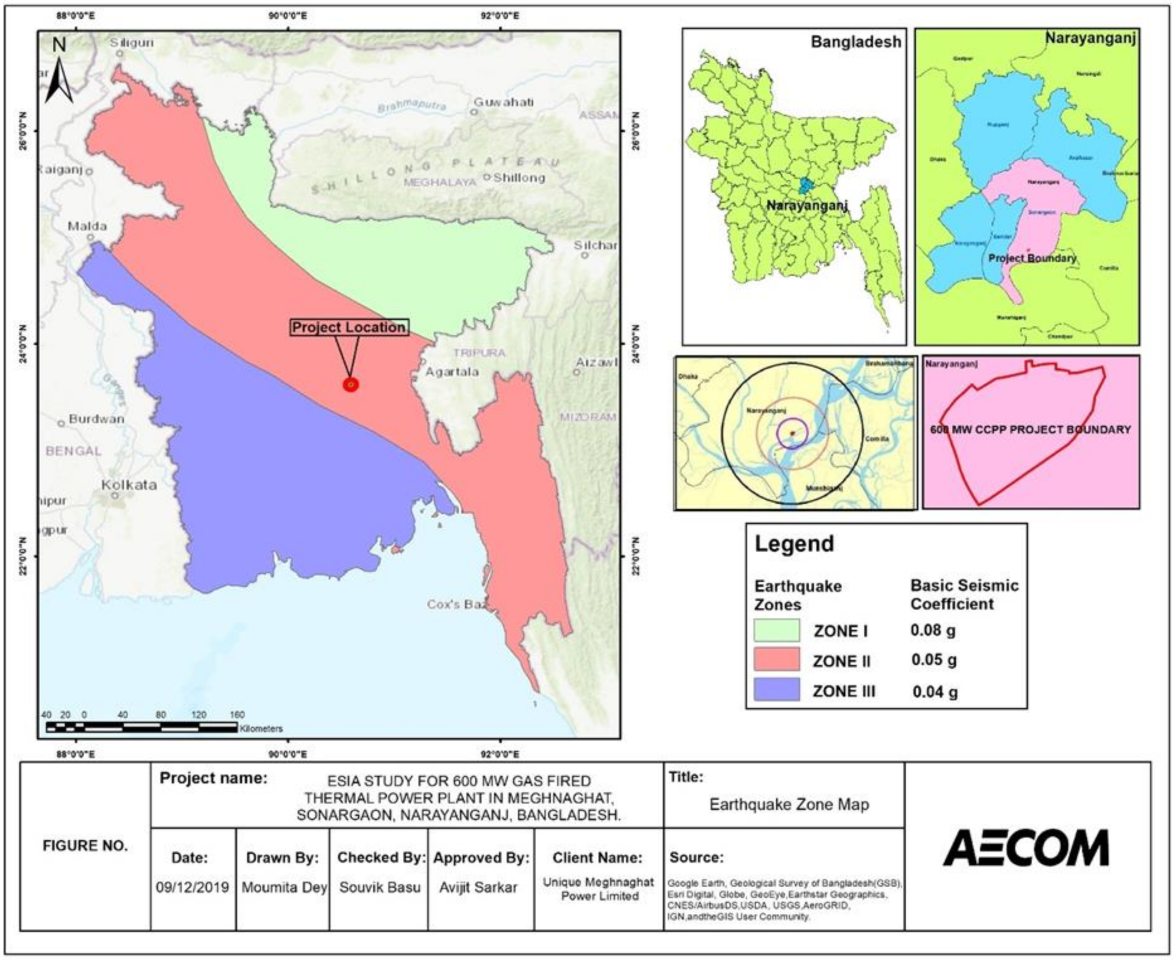


Figure 4.30: Earthquake Zone map of the Study Area

4.5.11 Ambient Air Quality Monitoring

4.5.11.1 Description of the Airshed

Air pollution is a major environmental concern in Bangladesh, especially in the large cities of Dhaka and Chittagong. To understand the present ambient air quality status of the project area and its surroundings, secondary data from Reports[14] of Industries within the study area were examined. It was observed that monitored values of particulate matters are already high in the airshed.

To further establish the existing baseline status, the air quality data from continuous air monitoring station (CAMS) nearest to the project site at Narayanganj (located 8 km west of the project site) was evaluated. A compiled air quality data from 2012 to 2018 was published by the Department of Environment in September 2018, which revealed the air quality of Narayanganj. Annual daily PM_{10} concentration in Narayanganj was recorded to be about 210 µg /m^3. The particulate concentration during dry season (November to April) was observed to be higher. Significant emissions from the megacity of Dhaka may also be another reason contributing to the high PM pollution in Narayanganj during the dry season, as Dhaka lies upwind of Narayanganj.

The graphical presentation of the monthly average, maximum and minimum PM_{10} and $PM_{2.5}$ concentration, show the same trend, recorded during different months of 2018 to 2020 in the Narayanganj CAMS is shown in ***Figure 4.31.***

[14] Environmental and Social Impact Assessment Report of Reliance Meghnaghat 750 MW Combined Cycle Power Plant (October 2017)
Environmental and Social Impact Assessment (ESIA) Report of Summit Narayangonj Power Unit II Limited (October 2015)

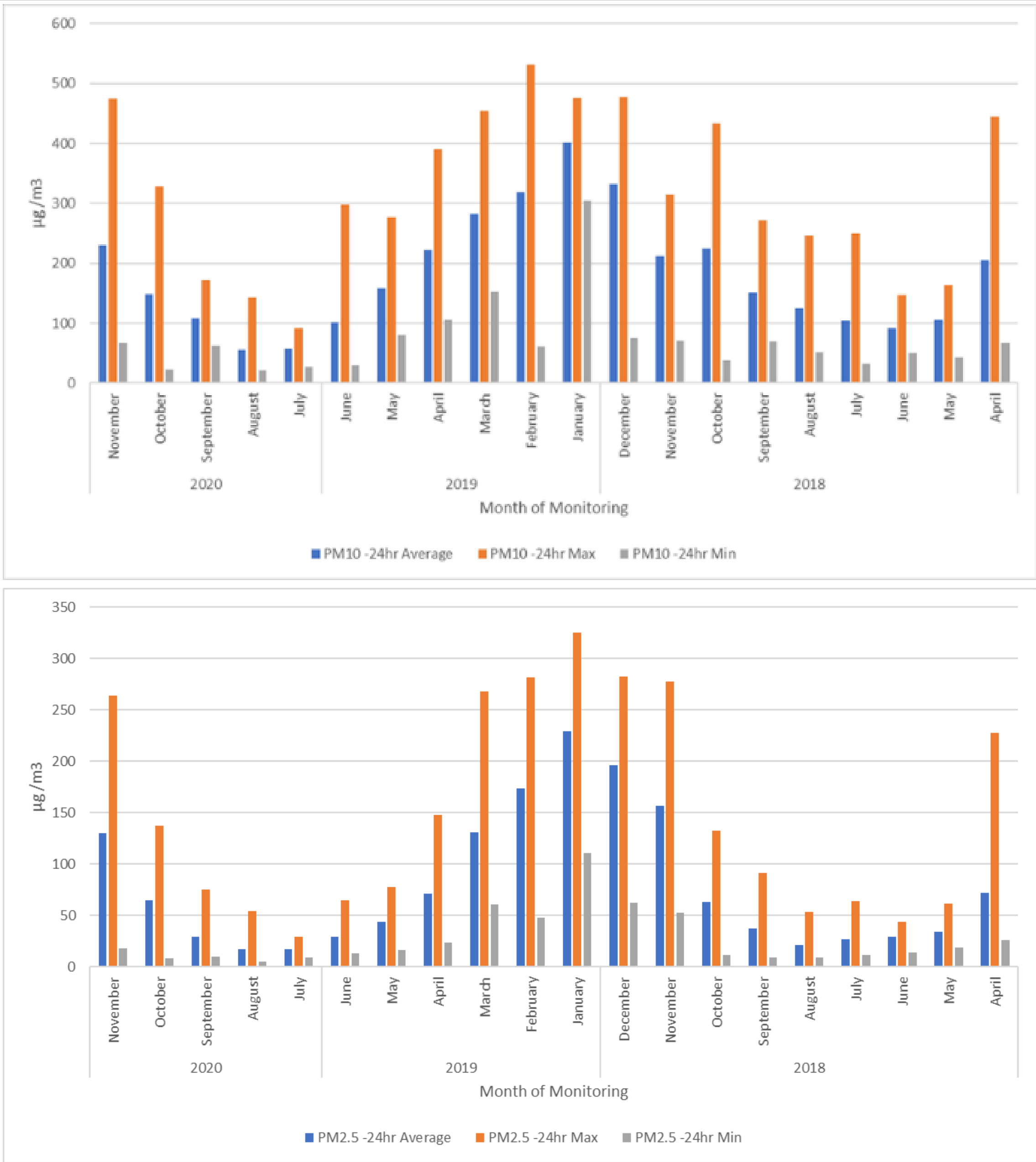


Figure 4.31: Monthly average, maximum and minimum PM_{10} and $PM_{2.5}$ recorded during different months of 2018 to 2020 in the Narayangonj CAMS

During the reported years 2012-2018, high SO_2 and NOx concentration was recorded in dry season (November to April) compared to wet season. Being the largest industrial and business hub near Dhaka, this area is a significant contributor of air pollutants from jute, textile and various other industries, traffic movement, and diesel run water vessels. The trends in SO_2 concentration in Narayanganj was found to be within the acceptable level throughout the year (2012-2018). The NOx concentration was reported as compatible throughout the year except for some days in May to June 2017. The graphical presentation of the monthly average, maximum and minimum SO_2 and NOx recorded during different months of 2018 to 2020 in the Narayangonj CAMS, showing the same trend is presented in ***Figure 4.32.***

Figure 4.32. Monthly average, maximum and minimum SO_2 and NO_X recorded during different months of 2018 to 2020 in the Narayangonj CAMS

In order to understand the present status of ambient air quality in the project area & the AoI, the baseline air monitoring was carried out. The ambient air quality with respect to the study area of 5 km radius from the proposed power unit would form the baseline environmental status, which is being largely contributed by the existing industries, transport & other sources over which the predicted minimal impacts due to the proposed gas based power project can be superimposed to find out the net impacts on the air quality in the Area of Influence. There are several power plants and industries within 5 km study area. At the time of survey, the major sources of air pollution noted in and around the project were road dust, power plant emission, industrial emission, engine vehicles, windblown dust from agricultural lands and exposed earth, and emission from domestic cooking. The Parameters for Air Quality monitoring were Particulate Matter (SPM, PM_{10} and $PM_{2.5}$), Oxides of Nitrogen (NO_X), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Ozone (O_3). The air quality sampling station locations are rural in setting.

The air quality monitoring locations were selected based on the location of settlements and receptors in the predominant wind directions prevailing within the study area during the monitoring period. Apart from that, logistical factors such as consent of villagers, mainly the house owners, power connection, approachability, security, etc. were also considered in finalising the monitoring stations. To assess the present air quality of the area, four (4) Ambient Air Quality Monitoring (AQ) Stations were setup. The locations of the monitoring stations for air quality study were selected based on meteorological data, topography, sensitive locations, easy approach and security etc. The details of the location of air quality monitoring are presented in ***Table 4.13*** and ***Figure 4.33.***

Table 4.13. Ambient Air Quality Sampling Locations

Sl.	Sampling Station	Station Code	Geographic Location	Location Setting	Distance from Project Boundary, km	Rational* for the site location selection
1.	Bhuiya House, Dudhghata, Sonargaon	AQ1[15]	23°37'05.8" N, 90°35'28.6" E	North side of the project boundary	0.75	Downwind and Nearest to the project site, located beside Purbapara Jame Masjid and other sensitive receptors like school & mosques;
2.	Molla House, Pirojpur, Boronagar, Sonargaon	AQ2	23°37'49.2" N, 90°35'53.2" E	North east side of the project boundary	1.48	Upwind during 1st season, Crosswind during second season, located in populated area beside Battala-Mangna Road (near the road joining with Dhaka-Chittagong Highway
3.	Sultannagar Moor, Kala Dorga, Sonargaon	AQ3	23°38'32.10" N, 90°34'35.55" E	NNW side of the project boundary	3.06	Downwind, located beside village road in densely populated area, also has schools & Masjids within 150-200 m.
4.	Kalabagh Jame Mosque, Shabdi, Bandor	AQ4	23°36'32.06" N, 90°32'47.28" E	West side of the project boundary	4.46	Crosswind located at the periphery of the project site in immediate vicinity of Sabdi Kolgachia Road. This location is nearest to Narayanganj Industrial area located within 5 km from AQ4 site.

**The selection of the Ambient Air quality monitoring stations has been done based on the predominant wind direction, location of sensitive receptor, understanding of sources of pollution in the study area from reconnaissance survey & secondary sources and availability of infrastructure for setting up of station.*

[15] *The plant components shall be designed corresponding to the air quality measured at AQ1*

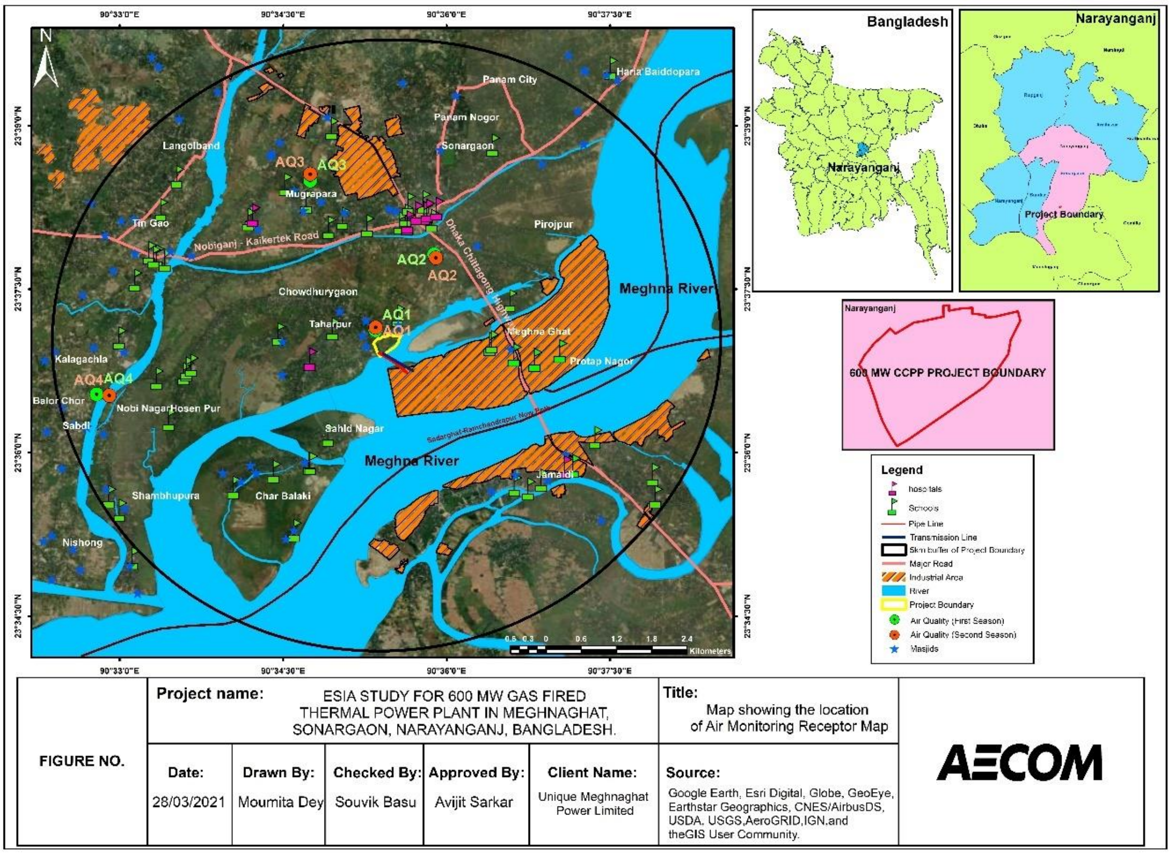


Figure 4.33: Air, Noise and Traffic Quality Sampling Location

Monitoring Method

Sampling and analysis of ambient air quality were conducted by referring to the recommendation of the United States Environmental Protection Agency (USEPA). The Haz-Scanner Environmental Perimeter Air Station (EPAS) was used to collect ambient air monitoring data. Sampling rate or air quality data were measured automatically everyone minute and directly read and recorded onsite for measured parameters (SO_2, NO_X, CO, O_3, SPM, PM_{10}, $PM_{2.5}$) as shown in ***Table 4.14.*** Sampling pump was operated at 2 L/min. Different analysis methods are integrated in the instrument, such as Particulates 90° Infrared Light Scattering for particulate matter (SPM, PM_{10}, $PM_{2.5}$) and electrochemical sensors for toxic gases (CO, NOx, SO_2 and O_3). Air quality monitoring has been conducted at four different locations on 24-Hourly Basis and twice a week for the two seasons.

Table 4.14: Sampling and Analysis Method for Air Quality

No.	Parameter	Analysis Method
1.	Sulphur dioxide (SO_2)	On Site Reading by electrochemical sensors
2.	Oxide of Nitrogen (NOx)	On Site Reading by electrochemical sensors
3.	Carbon monoxide (CO)	On Site Reading by electrochemical sensors
4.	Ozone (O_3)	On Site Reading by electrochemical sensors
5.	Suspended Particulate Matter (SPM)	On Site Reading by Infrared Light Scattering
6.	Particulate Matter 10 (PM_{10})	On Site Reading by Infrared Light Scattering
7.	Particulate Matter 2.5 ($PM_{2.5}$)	On Site Reading by Infrared Light Scattering

Source: Field Survey, October-November 2019

Monitoring Result

The photographs of monitoring are presented in ***Figure 4.34***

AQ1: Bhuiya House, Dudhghata, Sonargaon

AQ2: Molla House, Pirojpur, Boronagar, Sonargaon

AQ3: Sultannagar Moor, Kala Dorga, Sonargaon

AQ4: Kalabagh Jame Mosque, Shabdi, Bandor

Figure 4.34: Ambient air monitoring pictures

4.5.11.2 Ambient Air Quality monitoring result

The air quality survey results have been analysed from the data sampled twice a week for 24-hours at each monitoring site during the two seasons (October 2019-November 2019 and June 2020) were combined to make daily average values (24 hours) for further evaluation and comparison with corresponding National Ambient Air Quality Standards (NAAQS). The monitored ambient air quality is summarized in ***Table 4.15.***

Table 4.15: Ambient Air Quality in the Study Area

Location	Observed	Concentration in (µg/m^3)						
		SPM*	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO*	O_3*
AQ1	Maximum	134.8-146.5	73.3-96.9	32.7-40.20	8.6-9.5	26.6-36.2	180-860	21.7-26.2
	Minimum	68.8-92.5	35.8-56.5	16.6-17.5	5.3-6.6	13.3-18.2	115-340	9.6-21.5
	Average	96.6-121.7	52.6-79.5	25.3-28.4	7.0-7.4	18.3-26.2	148-530	15.7-23.0
AQ2	Maximum	105.5-165.3	68.3-98.2	35.1-38.5	8.3-15.3	30.5-35.2	310-850	21.3-23.3
	Minimum	61.2-136.9	32.7-81.5	19.2-20.2	6.8-7.5	13.6-16.8	170-230	11.7-22.5
	Average	86.9-158.1	46.11-90.0	25.1-27.2	7.9-10.3	22.4-23.3	221-440	15.5-22.9
AQ3	Maximum	162.5-182.6	78.6-115.2	36.5-42.2	8.5-10.5	28.4-34.5	350-960	13.3-26.4
	Minimum	54.5-119.5	25.5-69.8	13.3-19.9	5.8-6.6	11.7-13.2	150-240	7.9-25.5
	Average	81.1-140.8	40.2-86.4	22.5-25.0	7.5-7.7	16.4 -20.5	218-480	10.2-25.9
AQ4	Maximum	147.5-244.2	86.4-149.4	28.4-40.3	6.4-7.6	19.6-23.3	160-540	17.6-28.5
	Minimum	46.6-94.6	27.5-55.2	15.4-16.4	3.3-6.3	9.8-12.5	80-220	7.4-22.2
	Average	90.5-126.5	51.7-73.3	21.1-27.0	4.8-6.9	14.5-16.5	124-350	13.5-24.7
Standards								
Bangladesh**	8 hourly	200	-	-	-	-	10000	157

Location	Observed	Concentration in (μg/m^3)						
		SPM*	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO*	O_3*
	24 hourly	-	150	65	365	-	-	
	Annual	-	50	15	80	100	-	
WHO* **	8 hourly	-	-	-	-	-	-	100
	24 hourly	-	50	25	20	-	10000	
	Annual	-	20	10	-	NO_2- 40	-	

** SPM and CO concentrations and standards are 8-hourly only.*
*** The Bangladesh National Ambient Air Quality Standards have been taken from the Environmental Conservation Rules, 1997 which was amended on 19th July 2005 vide S.R.O. No. 220-Law/2005.*

**** WHO Ambient Air Quality Guideline Values (2005 and 2000), which are also being referred in the World Bank and IFC's General EHS Guidelines (2007)*

The 24-hourly average SPM concentrations in the monitoring locations varied between 81.1-182.6 μg/m^3. The monitored values of SPM are found to be within Bangladesh NAAQS except at AQ4 where it exceeds Bangladesh NAAQS. The higher concentration at AQ4 may be attributed to the ongoing construction activities adjacent to AQ4 site during the second season of monitoring and also due to its proximity to Narayanganj Industrial area (towards its west).

The 24-hourly average PM_{10} concentrations in the monitoring locations varied between 40.2-90.0 μg/m^3. All the monitoring value are within the NAAQS (150 μg/m^3-24 hourly average) at all monitoring locations, however it is above WHO, 2005 (50 μg/m^3-24 hourly average) standard.

The 24-hourly average $PM_{2.5}$ concentrations in the monitoring locations varied between 21.1 to 28.44 μg/m^3. The monitoring values are within the NAAQS (65 μg/m^3-24 hourly average) at all the monitoring stations, however some of these exceed WHO, 2005 (25 μg/m^3-24 hourly average) standard at some of the locations during certain times.

It may be seen that for both the seasons, the average concentration of particulate matter is well within Bangladesh NAAQS; however, the values of PM_{10} exceed the WHO guidelines values. This is attributed to the presence of operating industries in the upwind direction (South and South-east) of the site. The Meghnaghat Industrial Area commences within approximately 300 m along the southern eastern part of the site. The Jamaldi Industrial Area is located along the South and Southeast at approximately 3.5 km from the site. During the monitoring period i.e. June and October, the plant site and the monitoring locations were downwind to these Industrial areas. The recorded Particulate concentration includes the prevalent emissions from these industries, which has resulted in high baseline ambient air quality values. Moreover, apart from Dhaka-Chittagong Highway and Kaikertek Sonargaon Road, which are the two major roads passing through the study area, there are other roads like Battala-Mangna Road, Hosenpur Road and other village roads which are not black-topped. Fugitive emission from transportation seem to contribute largely to the high level of particulates in the ambient air.

Based on the existing AAQ status and information derived from secondary sources, it may be concluded that the concentration of particulate matter is high in the airshed. However, the concentration of particulates is well within the Bangladesh NAAQS.

The 24-hourly average SO_2 concentrations in the monitoring locations ranged between 4.8 to 10.3 μg/m^3. The monitoring values are within the NAAQS (365 μg/m^3-24 hourly average) in all the monitoring however it is above WHO, 2005 (20 μg/m^3-24 hourly average) standard.

The average NOx concentrations in the monitoring locations varied between 14.5 to 26.2 μg/m^3 which are well within the Bangladesh and WHO standards /guideline values. The average CO concentrations in the monitoring locations ranged between 124 to 530 μg/m^3. The average concentration of CO was within the NAAQS (10,000 μg/m^3-8 hourly average) in all the monitoring locations. The average O_3 concentrations in the monitoring locations varied between 10.2-25.9 μg/m^3. The average concentration of O_3 for both seasons was within the NAAQS (157 μg/m^3-8 hourly average) and WHO, 2005 (100 μg/m^3-8 hourly average) at all the monitoring locations.

4.5.12 Ambient Noise Quality

Noise levels were recorded at eight (8) locations in the study area during the monitoring period of October 2019 and June 2020. Noise levels were recorded in the form of sound pressure levels using Center 322-data logger sound level meter. The details of noise monitoring locations are given in Table 4.16 and depicted in Figure 4.35.

The purpose of ambient noise level measurement was to determine sound intensity in the AoI as these locations were chosen in such a way to present representative data all over the AoI.

The sound level is recorded in form of A-weighted equivalent continuous sound pressure level (Leq) values with the use of A-weighting filters in the noise-measuring instrument.

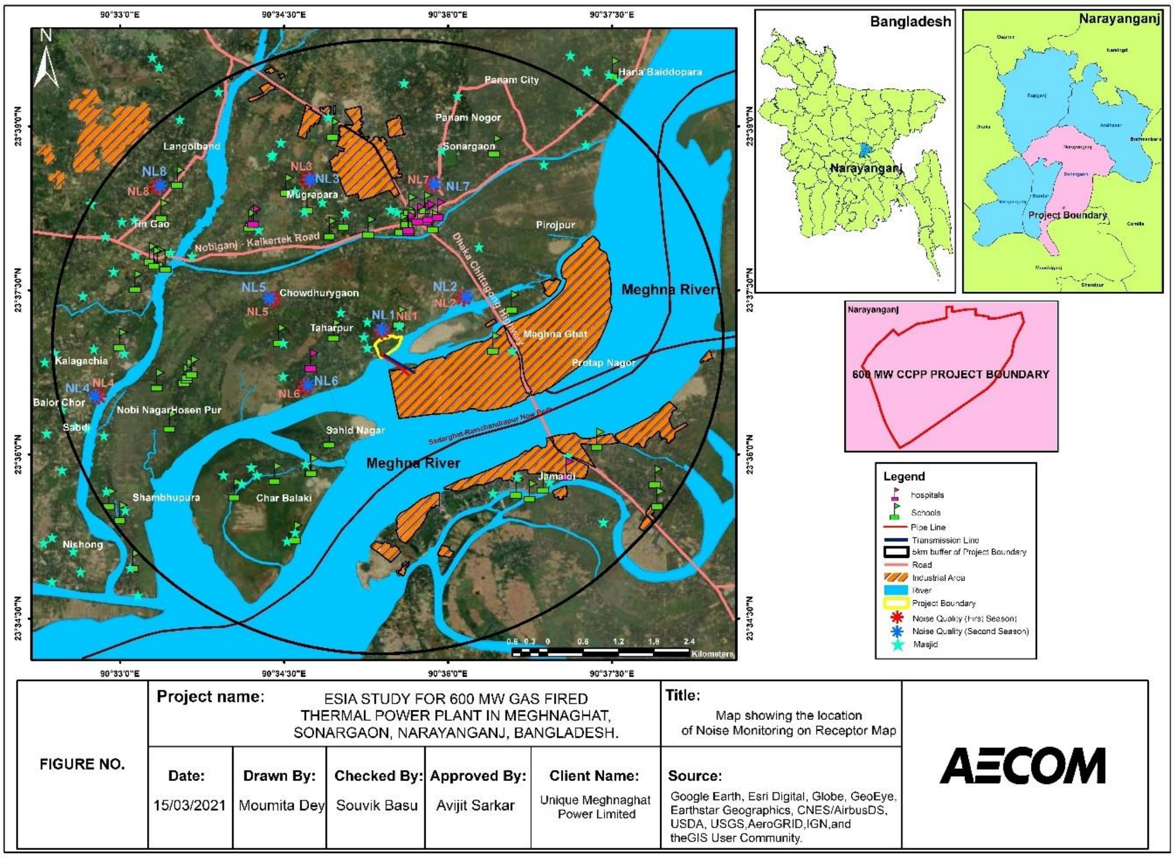


Figure 4.35: Noise monitoring locations in the two seasons

Table 4.16: Details of Ambient Noise Monitoring Locations

Code	Location	Geographic location	Distance and Direction from Project Boundary	Location setting	Basis of selection
NL1	Bhuiya House, Dudhghata, Sonargaon	23°37'05.71" N 90°35'28.45" E	0.17 km, N	Residential	Monitoring done in the immediate vicinity of the project site and near to three sensitive receptors namely Purbapara Jame Masjid, Madhyapara Jame Masjid and Dudhghata Govt. Primary School
NL 2	Molla House, Noyagaon, Sonargaon	23°37'26.67" N 90°36'11.75" E	1.5 km, ENE	Residential	Monitoring done in residential area, beside Battala -Mangna Road to understand present noise level due to transportation & other anthropogenic activities
NL 3	Sultannagar Moor, Kala Dorga, Sonargaon	23°38'30.71" N 90°34'36.66" E	3.1 km, NNW	Silent[16]	This area is considered as Silent area as it is located within 100m of schools & masjids. This is a representative location to understand the present noise level in silent zone.
NL 4	Near Balur Chor Bridge,	23°36'31.94" N 90°32'47.17" E	4.4 km, SW	Residential	Monitoring conducted beside sensitive receptor (Kolabag Jama Masjid) near the periphery of the study area, to understand the baseline noise level

[16] *Area up to a radius of 100 meters around hospitals or educational institutions or special institutions/ establishments identified/to be identified by the Government is designated as Silent Zones where use of horns of vehicles or other audio signals, and loudspeakers are prohibited.*

Code	Location	Geographic location	Distance and Direction from Project Boundary	Location setting	Basis of selection
	Kolagachia, Bandar				
NL 5	Choudhurygaon, Bandor	23°37'25.23" N 90°34'23.84" E	1.8 km, WNW	Mixed	Monitoring conducted beside sensitive receptor (Chodigao Mosque) and village road, to understand the baseline noise level of mixed location type
NL 6	Pachani Bazar, Sonargaon	23°36'39.57" N 90°34'41.73" E	1.1 km, SW	Mixed	Monitoring conducted near sensitive receptor (Konapara Mosque) and village road in vicinity of the project site, to understand the baseline noise level and assessment of augmented noise level due to the project (through simulation)
NL 7	Mograpara, Sonargaon	23°38'14.08" N 90°35'51.99" E	2.36 km, NE	Mixed	Monitoring done in densely habituated area, beside Sonargaon road and near to intersection of Sonargaon Road with Dhaka-Chittagong Highway
NL8	Barpara, Bandor	23°38'25.86" N 90°33'22.98" E	4.3 km, NW	Residential	Monitoring conducted in medium densely populated residential area

Noise level monitoring was carried out for 24 hours during monitoring period with 1-min equivalent sound pressure levels. The equivalent noise levels have been converted to hourly equivalent noise levels. Finally, the measurements were carried out by dividing the 24 hours into two parts, i.e., daytime, which is considered from 0600 to 2100 hours and night from 2100 to 0600 hours. At each location, daytime Leq has been computed from the hourly sound pressure level values measured between 0600 to 2100 hours and night-time Leq has been computed from the hourly sound pressure level values measured between 2100 to 0600 hours.

NL1: Bhuiya House, Dudhghata, Sonargaon

NL2: Molla House, Noyagaon, Sonargaon

NL3: Sultannagar Moor, Kala Dorga, Sonargaon

NL4: Kolagachia, Bandor

NL5: Choudhurygaon, Bandor

NL6: Pachani Bazar, Sonargaon

NL7: Mograpara, Sonargaon

NL8: Barpara, Bandor

Figure 4.36. Noise monitoring Pictures

The noise levels at the monitoring locations during October 2019 and June 2020 is presented in the following table:

Table 4.17: Nose quality result for both season Location Code

Location Code	Average Noise level (dB(A))		Location Setting	Applicable Bangladesh Standard* (dB(A))		World Bank Standard** (dB(A))	
	Leq Day	Leq Night		Day	Night	Day	Night
NL1	49.5-71.1	43.0-60.5	Residential	55	45	55	45
NL2	51.9-54.9	42.7-49.3	Residential	55	45	55	45
NL3	47.8- 52.5	38.0-38.6	Silent	50	40		
NL4	50.2-55.5	40.5-50.7	Residential	55	45	55	45
NL5	49.8-57.3	45.0-49.6	Mixed	60	50	-	-
NL6	53.0-57.0	44.1-47.73	Mixed	60	50	-	-
NL7	54.8-60.8	48.4-51.10	Mixed	60	50	-	-
NL8	50.6-55.2	42.8-48.6	Residential	55	45	55	45

It can be seen there monitoring data during June 2020 indicates higher noise levels in NL1 located adjacent to the project site, where the higher level of ambient noise is presumably generated due to construction activities including vehicular noises. Noise levels are slightly higher in NL3, NL4, NL7 and NL8. It was also observed that during the second season monitoring that the sound caused by shower on the roofs of the houses (asbestos, GI sheets or similar materials) contributed fairly remarkably to the ambient levels. In addition, noise level was recorded in the camp site for 24-hours. The Leq day and Leq Night was found to be 53.08 dB(A) 43.89 dB(A) respectively.

4.5.13 Traffic and Transportation

4.5.13.1 Road Traffic

Traffic surveys were conducted within the study period in the study area, to analyse the traffic and transport network characteristics. The survey was conducted in two different seasons to analyse the seasonal variation in the traffic volume. Photographs showing the traffic survey is presented below. The main objective of classified traffic volume count is to assess the traffic characteristics in terms of average daily traffic, hourly traffic variation, peak hour traffic and traffic composition. The traffic surveys were conducted continuously for 24 hours, manually on a normal working day and weekend. The traffic survey was conducted for both way movement of vehicles and categorization as Heavy vehicle (Truck/Trailer/Lorry/Cover Van), Medium vehicle (Private Car/Microbus, vans Pickup, power tiller), Light vehicle (CNG, Easy bike, motorcycle) and non-motorized vehicle (rickshaw, bicycle etc.). In order to express the intensity of traffic, it would be convenient to express mixed traffic comprising of different vehicle types in terms of passenger car unit (PCU). For this purpose, the PCU factors have been adopted as stated in ***Table 4.18.***

Table 4.18 : Adopted passenger car units

Mode	PCU factor
Truck	3.0
Bus	3.0
Minibus	3.0
Utility	1.0
Car	1.0
Baby Taxi	0.75
Motorcycle	0.75
Bicycle	0.5
Cycle Rickshaw	2.0
Bullock Cart	4.0

Source: Geometric Design Standards for Roads & Highways Department, Government of the People's Republic of Bangladesh Ministry of Communications Roads and Railways Division, October 2000

http://www.rhd.gov.bd/Documents/ConvDocs/Road%20Geometric%20Design%20Manual.pdf

The first season traffic survey was conducted in October 2019 and the summary for the same is provided in *Table 4.20.* The location details of the traffic survey is tabulated in *Table 4.19* and presented in ***Table 4.19***.

Table 4.19: Traffic Survey Location

Location Code	Geographic Coordinate	Location	Basis of Selection
T1	23°39'36.22" N, 90°34'0.87" E	Langalband Bus Stand, Sonargaon	Traffic survey conducted on Dhaka-Chittagong Highway, at the entry-exit point of traffic from Dhaka to the study area
T2	23°37'28.44" N, 90°36'17.22" E	Noyagaon Bus Stand, Sonargaon	Traffic survey conducted at the intersection of Dhaka-Chittagong Highway with Battala-Mangana, the main road for approach to the site
T3	23°37'56.32" N, 90°32'59.06" E	Minarbari Moor, Bandor	Traffic survey done at the intersection of Nobiganj Kaikertek Road with Madanganj Lagalbandh Road carrying traffic in & out of Study area from Narayanganj & Sonargaon

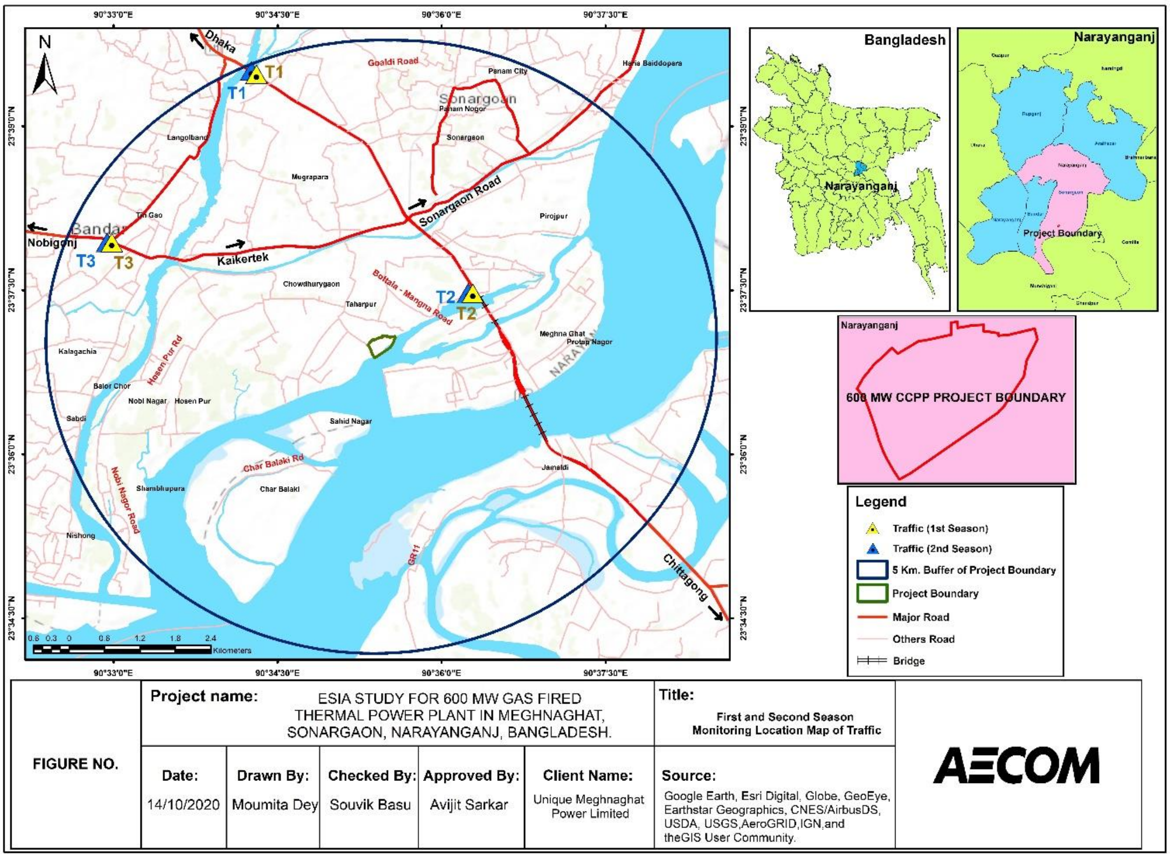


Figure 4.37. Traffic survey location for both the season of monitoring

Table 4.20: Status of Road Traffic Survey conducted for First Season Monitoring

Description	T1		T2		T3	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Heavy vehicle (Truck/Trailer/Lorry/Cover Van)	220	228	13	26	496	404
Medium vehicle (Private Car/Microbus, vans Pickup, power tiller)	540	366	62	89	1207	1339
Light vehicle (CNG, Easy bike, motorcycle)	2520	2462	154	171	2923	4527
Non-motorized vehicle (rickshaw, bicycle etc.)	2300	2175	108	149	1023	1677
Total traffic volume (Nos) in 24 hrs	5580	5231	337	435	5649	7947
Average traffic volume/hr	233	218	14	18	235	331

Description	T1		T2		T3	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Total PCU (Nos.) in 24 Hours (To & From)	7,690	7,247	433	593	6,933	9,300
Average PCU Flow/Hr	320	302	18	25	289	388
Max Traffic volume in PCU (Nos)/hr	675	629	46	58	580	723
Min traffic volume in PCU (Nos)/hr	15	74	1	0	19	38
Minimum traffic flow (in PCU) hours	04.00 Hrs to 05.00 Hrs	03.00 Hrs to 04.00 Hrs	03.00 Hrs to 05.00 Hrs	03.00 Hrs to 04.00 Hrs	03.00 Hrs to 04.00 Hrs	04.00 Hrs to 05.00 Hrs
Maximum traffic flow (in PCU) hours	11.00 Hrs to 12.00 Hrs	10.00 Hrs to 11.00 Hrs	14.00 Hrs to 15.00 Hrs	16.00 Hrs to 17.00 Hrs & 18.00 Hrs to 19.00 Hrs	15.00 Hrs to 16.00 Hrs	12.00 Hrs to 13.00 Hrs

Source: Primary Survey, October 2019

Among the three traffic survey locations, the traffic was observed to be the highest at T1 Survey Point. It has been observed that traffic volume is higher on weekdays at all the locations when compared to weekends. As per observations made for traffic density, the maximum average PCU recorded per hour for weekday and weekend was found at T1 and T3 with average PCU value of 320 and 388 respectively. The major contributor of the vehicular traffic was light vehicles followed by non-motorized and medium vehicle.

The second season traffic survey was conducted in June 2020 and the summary for the same is provided in ***Table 4.21***

Table 4.21: Status of Road Traffic Survey conducted for Second Season Monitoring

Description	T1		T2		T3	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Heavy vehicle (Truck, Bus, Dumper, Tanker, Trailer)	12545	6870	13	11	365	245
Medium vehicle (Car, Jeep, Van, Metador, Tractor, Tempo, Minibus)	14926	6570	120	64	995	405
Light vehicle (Scooter, Motorcycle, Auto, Moped)	1529	577	366	194	6997	5170
Non-motorized vehicle (Bicycle, Tricycle)	68	42	35	24	42	28
Total traffic volume (Nos) in 24 hrs	29068	14059	534	293	8399	5848
Average traffic volume/hr	1211	586	22	12	350	244
Total PCU (Nos.) in 24 Hours (To & From)	53844	27697	504	291	7422	5074
Average PCU Flow/Hr	2243	1154	21	12	309	211
Max Traffic volume in PCU (Nos)/hr	3222	1620	58	40	506	406
Min traffic volume in PCU (Nos)/hr	1466	599	0	0	5	5
Minimum traffic flow (in PCU) hours	08.00 Hrs to 09.00 Hrs	03.00 Hrs to 04.00 Hrs	01.00 Hrs to 05.00 Hrs	00.00 Hrs to 05.00 Hrs	04.00 Hrs to 05.00 Hrs	03.00 Hrs to 04.00 Hrs.
Maximum traffic flow (in PCU) hours	17.00 Hrs to 18.00 Hrs	11.00 Hrs to 12.00 Hrs	08.00 Hrs to 09.00 Hrs	07.00 Hrs to 08.00 Hrs	09.00 Hrs to 10.00 Hrs	08.00 Hrs to 09.00 Hrs

Source: Primary Survey, June 2020

Among the three traffic survey locations, the traffic was observed to be the highest at T1 Survey Point. It has been observed that traffic volume showed a declining trend on weekends when compared to weekdays. As per observations made for traffic density, the maximum average PCU recorded per hour for weekday and weekend was found at T1 with average PCU value of 2243 and 1154 respectively. The comparison of the PCU for weekend and weekdays showed, a decline in total PCU on holidays. The major contributor of the vehicular traffic was medium vehicle at T1 and light vehicles at T2 and T3.

Traffic survey at T1

Traffic survey at T2 (UP)

Traffic survey at T2 (DOWN)

Traffic survey at T3 (UP)

Traffic survey at T3 (DOWN)

Figure 4.38: Traffic survey photographs

Seasonal Variation

The 24-hourly traffic survey was conducted for two different seasons to observe the seasonal variation in traffic data and is summarised in ***Table 4.22*** below.

Table 4.22 : Seasonal Variation of Traffic

Intersection	T1				T2				T3			
	First Season Monitoring		Second Season Monitoring		First Season Monitoring		Second Season Monitoring		First Season Monitoring		Second Season Monitoring	
	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends	Weekdays	Weekends
Heavy vehicle (Truck, Bus, Dumper, Tanker, Trailer) Heavy vehicle (Truck, Bus, Dumper, Tanker, Trailer)	220	228	12545	6870	13	26	13	11	13	26	365	245
Medium vehicle (Car, Jeep, Van, Metador, Tractor, Tempo, Minibus)	540	366	14926	6570	62	89	120	64	62	89	995	405
Light vehicle (Scooter, Motorcycle, Auto, Moped)	2520	2462	1529	577	154	171	366	194	154	171	6997	5170
Non-motorized vehicle (Bicycle, Tricycle)	2300	2175	68	42	108	149	35	24	108	149	42	28
Total traffic volume (Nos) in 24 hrs	5580	5231	29068	14059	337	435	534	293	337	435	8399	5848
Average traffic volume/hr	233	218	1211	586	14	18	22	12	14	18	350	244
Total PCU (Nos.) in 24 Hours (To & From)	7,690	7,247	53844	27697	433	593	504	291	433	593	7422	5074
Average PCU Flow/Hr	320	302	2243	1154	18	25	21	12	18	25	309	211
Max Traffic volume in PCU (Nos)/hr	675	629	3222	1620	46	58	58	40	46	58	506	406
Min traffic volume in PCU (Nos)/hr	15	74	1466	599	1	0	0	0	1	0	5	5

The comparison of data obtained from the traffic survey conducted, shows a higher average PCU per hour during the second season monitoring than during the first season monitoring for both weekdays and weekends for TS1 and TS3. The average PCU per hour shows a slight decline during the second season monitoring.

The maximum traffic volume in terms of PCU is found to be highest at TS1 and the peak hour corresponding to the maximum traffic volume is tabulated below in ***Table 4.23.*** The trend in the variation of heavy, medium, light and non-motorised vehicles along with the average traffic volume per hour is presented in ***Figure 4.39 .***

Table 4.23: Peak hours at the Surveyed Intersection

SL No	Intersection	First Season Monitoring		Second Season Monitoring	
		Weekdays	Weekends	Weekdays	Weekends
1	Langalband Bus Stand, Sonargaon	11.00 Hrs to 12.00 Hrs	10.00 Hrs to 11.00 Hrs	17.00 Hrs to 18.00 Hrs	11.00 Hrs to 12.00 Hrs
2	Noyagaon Bus Stand, Sonargaon	14.00 Hrs to 15.00 Hrs	16.00 Hrs to 17.00 Hrs & 18.00 Hrs to 19.00 Hrs	08.00 Hrs to 09.00 Hrs	07.00 Hrs to 08.00 Hrs
3	Minarbari Moor, Bandor	15.00 Hrs to 16.00 Hrs	12.00 Hrs to 13.00 Hrs	09.00 Hrs to 10.00 Hrs	08.00 Hrs to 09.00 Hrs

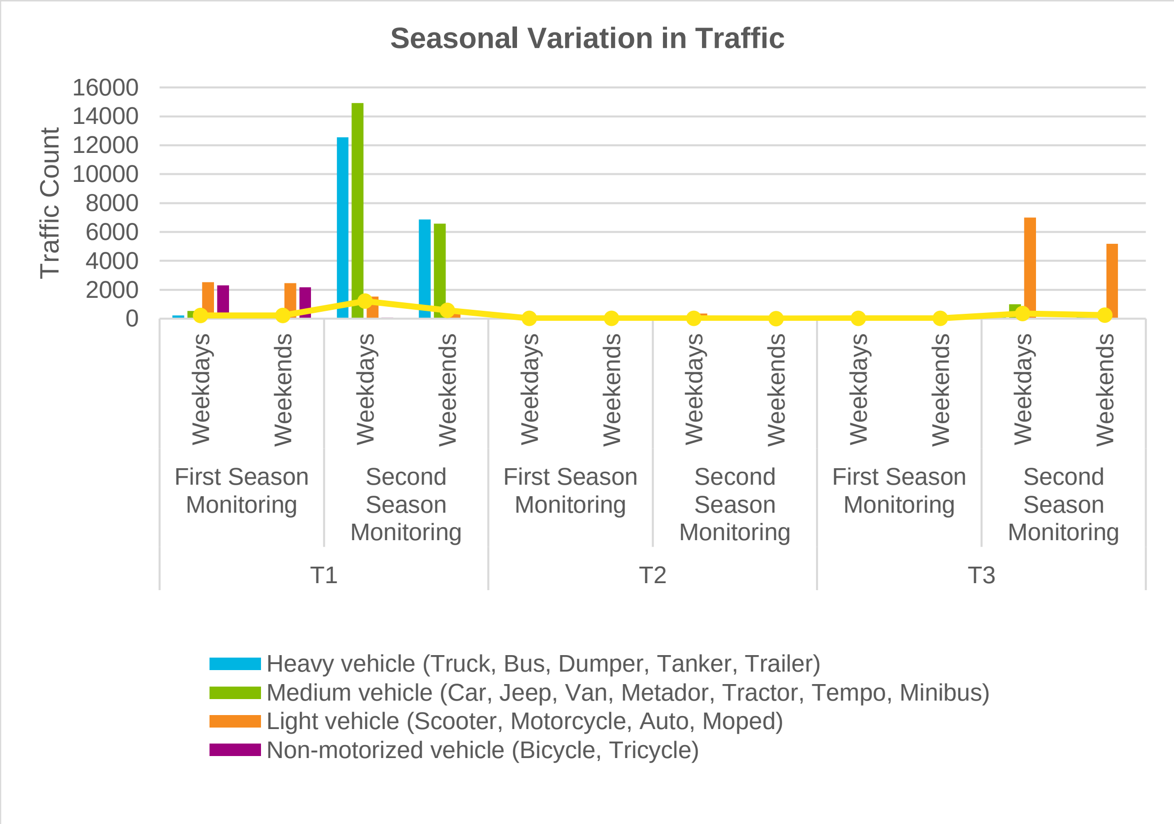


Figure 4.39: Seasonal Variation in Traffic Volume

TS1: Langalband Bus Stand, Sonargaon

TS2: Noyagaon Bus Stand, Sonargaon

TS3: Minarbari Moor, Bandor

Figure 4.40: Traffic survey pictures

4.5.13.2 River Traffic

Meghna rivers are important waterways in Bangladesh. It is reported that a large number of commercial vessels and passenger ferries are operating on these waterways. Most of the river traffic is utilising mechanical vessels operated on fuel oils. The spillage and leakage from vessels possibly add to the pollution level in the rivers. Bilge and ballast water discharges from commercial vessels are also expected to add to the pollution levels in the river. In order to assess the existing total daily traffic, peak hour traffic and traffic composition traffic volume survey was conducted in Meghna river at four different locations in weekdays and weekend and the traffic volume counts was recorded continuously for 24 hours for one time.

Figure 4.41: River traffic survey photographs

Table 4.24. Status of Water Traffic

River Traffic Count Survey for Unique Meghna Ghat Power Plant Limited

Location Name: Unique Meghnaghat Power Plant Power (Project Site).
GPS Code: 23'36'45"N, 90'36'23"E
Name of the River: Meghna River

Date: 10-08-2020 to 11-08-2020. (Weekdays)

Sr. No.	Hours	Upstream to Down Stream (From Munshiganj Side to Narayanganj Side)						Downstream to upstream (From Narayanganj Side to Munshiganj Side)						Total
		Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	
1	10:00-11:00	2	5	4	3	0	0	1	4	3	2	0	0	24
2	11:00-12:00	1	6	5	3	0	0	1	5	4	2	0	0	27
3	12:00-13:00	1	4	4	2	0	0	2	3	1	1	0	0	18
4	13:00-14:00	2	3	3	1	0	0	0	2	3	2	0	0	16
5	14:00-15:00	1	4	3	2	0	0	1	4	3	1	0	0	19
6	15:00-16:00	0	3	2	2	0	0	0	2	3	0	0	0	12
7	16:00-17:00	2	2	3	1	0	0	2	2	2	2	0	0	16
8	17:00-18:00	1	3	1	2	0	0	1	1	1	3	0	0	13
9	18:00-19:00	0	2	2	1	0	0	1	3	2	2	0	0	13
10	19:00-20:00	1	3	2	2	0	0	1	2	3	1	0	0	15
11	20:00-21:00	1	0	1	1	0	0	0	3	1	1	0	0	8
12	21:00-22:00	0	2	2	2	0	0	1	0	1	2	0	0	10
13	22:00-23:00	0	1	0	1	0	0	0	2	1	1	0	0	6
14	23:00-00:00	0	2	1	0	0	0	0	0	1	2	0	0	6
15	00:00-01:00	0	0	1	1	0	0	1	1	2	0	0	0	6

River Traffic Count Survey for Unique Meghna Ghat Power Plant Limited

Location Name: Unique Meghnaghat Power Plant Power (Project Site).
GPS Code: 23'36'45"N, 90'36'23"E
Name of the River: Meghna River

Date: 10-08-2020 to 11-08-2020. (Weekdays)

Sr. No.	Hours	Upstream to Down Stream (From Munshiganj Side to Narayanganj Side)						Downstream to upstream (From Narayanganj Side to Munshiganj Side)						Total
		Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	
16	01:00-02:00	1	1	2	0	0	0	0	2	1	1	0	0	8
17	02:00-03:00	0	1	0	1	0	0	1	2	1	1	0	0	7
18	03:00-04:00	1	2	2	1	0	0	0	3	1	2	0	0	12
19	04:00-05:00	0	2	2	2	0	0	0	2	2	2	0	0	12
20	05:00-06:00	1	3	1	1	0	0	1	3	2	3	0	0	15
21	06:00-07:00	1	4	2	2	0	0	0	2	3	2	0	0	16
22	07:00-08:00	2	5	3	2	0	0	2	3	2	2	0	0	21
23	08:00-09:00	1	4	2	3	0	0	2	4	1	2	0	0	19
24	09:00-10:00	1	6	3	2	0	0	1	3	2	3	0	0	21
Total		**20**	**68**	**51**	**38**	**0**	**0**	**19**	**58**	**46**	**40**	**0**	**0**	**340**

River Traffic Count Survey for Unique Meghna Ghat Power Plant Limited

Location Name: Unique Meghnaghat Power Plant Power (Project Site).
GPS Code: 23'36'45"N,90'36'23"E
Name of the River: Meghna River

Date: 14-08-2020 to 15-08-2020 (Weekend)

Sr. No.	Hours	Upstream to Down Stream (From Munshiganj Side to Narayanganj Side)						Downstream to upstream (From Narayanganj Side to Munshiganj Side)						Total
		Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	
1	10:00-11:00	2	5	3	1	0	0	0	5	4	2	0	0	22
2	11:00-12:00	1	6	4	2	0	0	2	4	2	2	0	0	23
3	12:00-13:00	1	5	2	2	0	0	1	3	3	1	0	0	18
4	13:00-14:00	0	3	1	1	0	0	0	2	2	2	0	0	11
5	14:00-15:00	2	4	0	2	0	0	2	4	3	2	0	0	19
6	15:00-16:00	1	3	3	0	0	0	1	2	2	2	0	0	14
7	16:00-17:00	2	3	1	2	0	0	1	3	0	1	0	0	13
8	17:00-18:00	1	5	2	3	0	0	2	4	2	3	0	0	22
9	18:00-19:00	0	3	3	2	0	0	1	2	3	2	0	0	16
10	19:00-20:00	2	2	2	2	0	0	0	3	1	1	0	0	13
11	20:00-21:00	1	3	5	2	0	0	2	4	1	3	0	0	21
12	21:00-22:00	0	2	3	3	0	0	1	2	2	2	0	0	15
13	22:00-23:00	0	1	1	2	0	0	0	3	3	0	0	0	10

River Traffic Count Survey for Unique Meghna Ghat Power Plant Limited

Location Name: Unique Meghnaghat Power Plant Power (Project Site).
GPS Code: 23'36'45"N,90'36'23"E
Name of the River: Meghna River

Date: 14-08-2020 to 15-08-2020 (Weekend)

Sr. No.	Hours	Upstream to Down Stream (From Munshiganj Side to Narayanganj Side)						Downstream to upstream (From Narayanganj Side to Munshiganj Side)						Total
		Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	
14	23:00-00:00	1	3	3	2	0	0	0	2	2	2	0	0	15
15	00:00-01:00	0	1	1	3	0	0	0	0	1	1	0	0	7
16	01:00-02:00	0	0	0	2	0	0	1	0	0	0	0	0	3
17	02:00-03:00	1	0	0	0	0	0	0	3	0	0	0	0	4
18	03:00-04:00	0	2	2	0	0	0	0	2	3	2	0	0	11
19	04:00-05:00	0	2	3	2	0	0	0	3	2	3	0	0	15
20	05:00-06:00	2	3	1	2	0	0	2	0	2	2	0	0	14
21	06:00-07:00	2	4	5	3	0	0	2	4	4	3	0	0	27
22	07:00-08:00	1	4	6	1	0	0	1	3	2	2	0	0	20
23	08:00-09:00	1	5	2	1	0	0	0	3	3	1	0	0	16
24	09:00-10:00	1	3	3	2	0	0	1	4	2	3	0	0	19
	Total	22	72	56	42	0	0	20	65	49	42	0	0	368

River Traffic Count Survey for Unique Meghna Ghat Power Plant Limited

Location Name: Unique Meghnaghat Power Plant Power (Meghna Bridge). GPS Code: 23'36'12"N,90'49.44"E Name of the River: Meghna River

Date: 14-08-2020 to 15-08-2020 (Weekend)

Sr. No.	Hours	Upstream to Down Stream (From Munshiganj Side to Narayanganj Side)						Downstream to upstream (From Narayanganj Side to Munshiganj Side)						Total
		Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	
1	10:00-11:00	4	8	14	5	4	0	3	8	16	3	3	1	69
2	11:00-12:00	3	9	15	4	3	1	4	7	13	2	2	0	63
3	12:00-13:00	2	6	16	6	5	0	3	6	20	4	5	0	73
4	13:00-14:00	4	5	14	5	2	1	4	7	17	3	4	0	66
5	14:00-15:00	4	7	15	4	4	0	2	5	13	4	2	1	61
6	15:00-16:00	5	8	12	6	3	1	3	7	11	5	1	0	62
7	16:00-17:00	2	7	9	5	0	0	2	5	15	5	3	0	53
8	17:00-18:00	2	6	14	4	4	0	3	8	10	6	2	0	59
9	18:00-19:00	3	8	10	4	5	1	4	6	10	4	0	0	55
10	19:00-20:00	2	4	12	5	3	0	2	5	10	3	5	1	52
11	20:00-21:00	4	5	11	4	2	0	1	4	8	5	4	0	48
12	21:00-22:00	2	6	8	0	3	0	0	5	10	2	3	0	39
13	22:00-23:00	1	2	9	3	2	0	0	4	9	1	0	0	31
14	23:00-00:00	0	0	7	0	3	0	1	2	8	0	2	0	23
15	00:00-01:00	0	3	4	3	2	0	0	0	9	1	1	0	23

River Traffic Count Survey for Unique Meghna Ghat Power Plant Limited

Location Name: Unique Meghnaghat Power Plant Power (Meghna Bridge). GPS Code: 23'36'12"N,90'49.44"E Name of the River: Meghna River

Date: 14-08-2020 to 15-08-2020 (Weekend)

Sr. No.	Hours	Upstream to Down Stream (From Munshiganj Side to Narayanganj Side)						Downstream to upstream (From Narayanganj Side to Munshiganj Side)						Total
		Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	
16	**01:00-02:00**	1	0	6	2	0	0	0	3	5	1	3	0	21
17	**02:00-03:00**	0	4	0	0	2	0	1	0	0	0	2	0	9
18	**03:00-04:00**	0	0	2	4	3	0	1	0	3	0	1	0	14
19	**04:00-05:00**	2	5	3	5	0	0	1	6	0	5	0	0	27
20	**05:00-06:00**	2	7	6	6	3	0	2	5	5	4	2	0	42
21	**06:00-07:00**	2	8	10	7	4	0	3	7	9	7	3	0	60
22	**07:00-08:00**	3	6	12	3	3	1	3	4	16	4	2	1	58
23	**08:00-09:00**	3	3	16	4	5	0	4	5	14	6	4	0	64
24	**09:00-10:00**	4	9	20	4	3		4	6	11	5	3	0	69
	Total	55	126	245	93	68	5	51	115	242	80	57	4	1141

River Traffic Count Survey for Unique Meghna Ghat Power Plant Limited

Location Name: Unique Meghnaghat Power Plant Power (Meghna Bridge).
GPS Code: 23'36'12"N,90'49.44"E
Name of the River: Meghna River

Date:10-08-2020 to 11-08-2020 (Weekdays)

Sr. No.	Hours	Upstream to Down Stream (From Munshiganj Side to Narayanganj Side)						Downstream to upstream (From Narayanganj Side to Munshiganj Side)						Total
		Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	Manual Passeng er Boat	Fishing Boat	Country Cargo Boat	Trawle r	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	
1	10:00-11:00	3	8	11	3	4	1	4	6	9	3	2	0	54
2	11:00-12:00	2	6	10	5	3	0	3	7	6	5	1	0	48
3	12:00-13:00	4	9	11	7	5	0	4	6	8	4	4	1	63
4	13:00-14:00	4	10	10	8	6	0	2	7	10	5	5	0	67
5	14:00-15:00	3	8	13	6	4	1	3	8	12	6	3	0	67
6	15:00-16:00	3	11	14	3	3	0	2	7	13	4	6	0	66
7	16:00-17:00	4	6	11	6	2	0	4	4	9	6	4	0	56
8	17:00-18:00	4	8	13	8	0	0	3	7	14	3	5	1	66
9	18:00-19:00	3	6	11	2	3	0	4	9	12	5	2	0	57
10	19:00-20:00	2	2	10	3	2	0	4	2	13	3	3	0	44
11	20:00-21:00	2	3	14	2	0	1	2	4	14	2	1	0	45
12	21:00-22:00	1	1	12	0	1	0	1	2	10	0	0	0	28
13	22:00-23:00	2	0	8	1	2	0	0	2	9	0	2	0	26
14	23:00-00:00	1	0	9	2	3	0	0	2	7	1	0	0	25
15	00:00-01:00	1	1	6	0	0	0	1	0	6	0	2	0	17

River Traffic Count Survey for Unique Meghna Ghat Power Plant Limited

Location Name: Unique Meghnaghat Power Plant Power (Meghna Bridge).
GPS Code: 23'36'12"N,90'49.44"E
Name of the River: Meghna River

Date:10-08-2020 to 11-08-2020 (Weekdays)

Sr. No.	Hours	Upstream to Down Stream (From Munshiganj Side to Narayanganj Side)						Downstream to upstream (From Narayanganj Side to Munshiganj Side)						Total
		Manual Passenger Boat	Fishing Boat	Country Cargo Boat	Trawler	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	Manual Passeng er Boat	Fishing Boat	Country Cargo Boat	Trawle r	Large and Medium Container/ Cargo Vessel/ Ship	Passenger Launch	
16	**01:00-02:00**	0	0	9	1	2	0	0	0	8	2	1	0	23
17	**02:00-03:00**	0	0	7	1	1	0	1	0	11	0	1	0	22
18	**03:00-04:00**	0	2	9	3	1	0	0	1	14	3	0	0	33
19	**04:00-05:00**	0	8	10	4	3	0	1	0	10	4	0	0	40
20	**05:00-06:00**	2	7	9	7	4	0	3	8	9	3	2	0	54
21	**06:00-07:00**	3	8	8	2	5	0	4	9	10	4	4	0	57
22	**07:00-08:00**	5	9	12	3	4	0	3	10	9	4	5	1	65
23	**08:00-09:00**	5	7	10	8	3	1	2	11	8	5	3	0	63
24	**09:00-10:00**	4	10	11	5	4	0	4	12	12	4	4	0	70
Total		**58**	**130**	**248**	**90**	**65**	**4**	**55**	**124**	**243**	**76**	**60**	**3**	**1156**

4.6 Ecological Environment

4.6.1 Introduction

An Ecology and Biodiversity study of the project area was conducted for assessing the biological diversity of the area with the objective of identifying species and habitats likely to be impacted by the proposed project infrastructure and activities. The study area contains both terrestrial and aquatic ecosystems, of which, the aquatic component predominantly consists of riverine ecosystems. Hence, the ecological assessment comprises of two separate studies, a terrestrial study and an aquatic study. The fieldwork was carried out in the month of October to November 2019.

This section describes the significant ecological features of the study area, presents the primary and secondary data collected to create an ecology and biodiversity baseline, and identifies species and habitats of conservation concern with respect to the proposed project infrastructure and activities. The study objectives were divided into following two parts;

Floral Assessment

- Assessment of the status of floral components like Trees, shrubs, herbs, and climbers within the Project Site and its surrounding buffer areas of 5 km radius from the Project Site centre;
- Collection and compilation of secondary information on the status of floral components of different vegetation types in the AoI;
- Identification, listing and quantification of floral species of conservation significance in accordance with Global IUCN Red List, 2015.

Faunal Assessment

- Assessment of the status of major faunal groups (Fishes, Amphibians, Reptiles, Terrestrial and Aquatic birds and Mammals) within the AoI;
- Collection and compilation of secondary information on the status of faunal components located in the AoI; and
- Identification, listing and quantification of faunal species of conservation significance (Rare, Endangered and Threatened (RET) species) in accordance with Global IUCN Red List 2015. within the AoI.

4.6.2 Delineation of Area of Influence (AoI)

The AoI was delineated into two zones: 1. Project area (Core Zone): It includes the area of the project site, which is about 21.07 acres, which was already filled with sand and 2. Project Site Surrounding area (Buffer Zone): The buffer zone includes area within 5 km radius from the project site. The buffer area includes various habitats such as Meghna River and its channels, settlement area and homestead plantations, water bodies such as village ponds and marshy land, agricultural land etc. Following methodology was adopted to enumerate the floral and faunal species in AoI.

4.6.3 Approach and Methodology

The ecological study within the Area of Influence (AoI) has been undertaken by adopting a combination of primary and secondary data collection. The primary data collection was undertaken in the post-monsoon season in the month of October to November 2019 in order to establish an ecological baseline. A primary survey of core zone and its buffer zone was undertaken to record the existing floral and faunal compositions and to identify different habitats within proposed project site and its buffer area. Secondary study has also been carried out through extensive desktop study, reference to peer reviewed scientific journals and reports, study of forest types maps of Bangladesh, official reports of forest department and wildlife department, scientific reports of eminent institutions and review of available floral and faunal census data pertaining to identified AoI.

Terrestrial Ecology

For survey of floral and faunal species, line transect method was applied to record the floral and faunal species by travelling a known distance (1 ± 0.05km). Primary data was collected during most of the diurnal period from early morning till late evening. Assessment of faunal species was also done using indirect method, wherein searching for evidences such as scats, pug marks, prey kills, calls, nests, feathers, skin molts, road-kills etc was done. Data were noted from consultations with local people. Field identification was based on professional experience and in accordance with standard field guides and identification keys. Fauna was also checked with Global IUCN Red list status, 2020-2 within the AoI.

Aquatic Ecology

For phytoplankton analysis, one litre of water sample was collected from each selected collecting point. All collections were done before 10 am. Sampling bottles were kept for about 6hrs, following which 10-mL precipitation was collected from the bottle. The precipitated sample was analysed, and the remaining sample was preserved using 5% formalin solution for the future reference. The identification and quantitative analysis of phytoplankton samples was done by using Leica microscope.

For qualitative and quantitative analysis of zooplankton, the samples were collected in 100 ml bottles by filtering 50 litre of water using No. 25 bolting silk cloth plankton-net (with 64μm aperture size and allowing nearly 33% open area) from each site. Sample volumes of 100 ml was maintained for all sample bottles. Zooplankton was estimated by Lackey – Drop Method (1938). From decanted samples, subsamples of 0.2 ml each was taken in a microscopic grooved slide and covered with square cover glass. Ten such counts were averaged and represented as number of organisms present in one litre of water.

Benthos samples were collected from three sites by using a grab sampler (Ekman's dredge). The mud content was removed, and benthos samples were preserved in a 250 ml plastic container with 10% neutralized formalin. Collected samples were transferred to an empty tray, classified by groups and counted.

The second season sampling of aquatic ecological parameters was planned in March-April 2020. However, pandemic situation due to outbreak of COVID-19 severely hindered the planned aquatic ecological sampling activity. The COVID-19 outbreak followed by nationwide lockdown in both India & Bangladesh during March to June 2020 followed by restrictions on international travel in the entire 2020 prevented AECOM from carrying out second season survey.

4.6.4 Terrestrial Ecology

There are twenty-five (25) recorded bio-ecological zones in Bangladesh (source: Bio-ecological Zones of Bangladesh, IUCN Publication, 2002). The AoI fall under Bio-ecological Zone 11: Major Rivers, as classified by IUCN in the context of physiographic and biological diversity. Details on this bio-ecological zone is given below and it is also presented in ***Figure 4.42 .***

Bio-ecological Zone 11: Major Rivers

Location: 22°55'-26°15' N and 88°10'-90°37' E

Relevant Admin HQ: Rajshahi, Kushtia, Faridpur, Shariatpur, Chandpur, Narayanganj, Manikganj, Tangail, Sirajganj, Kurigram, Rangpur

Physiography: Young Brahmaputra floodplain; Ganga River floodplain

Soil: Calcareous alluvium (non-saline); Calcareous alluvium

Rainfall: 1270-2290 mm

Temperature: Maximum 37° C, Minimum 9° C

Flooding depth: Medium Highland

Land use: Rabi-Aus-T. Aman (2a); Rabi-Mixed-B. Aus & Aman (7a); Rabi-B. Aus-Fallow (1e)

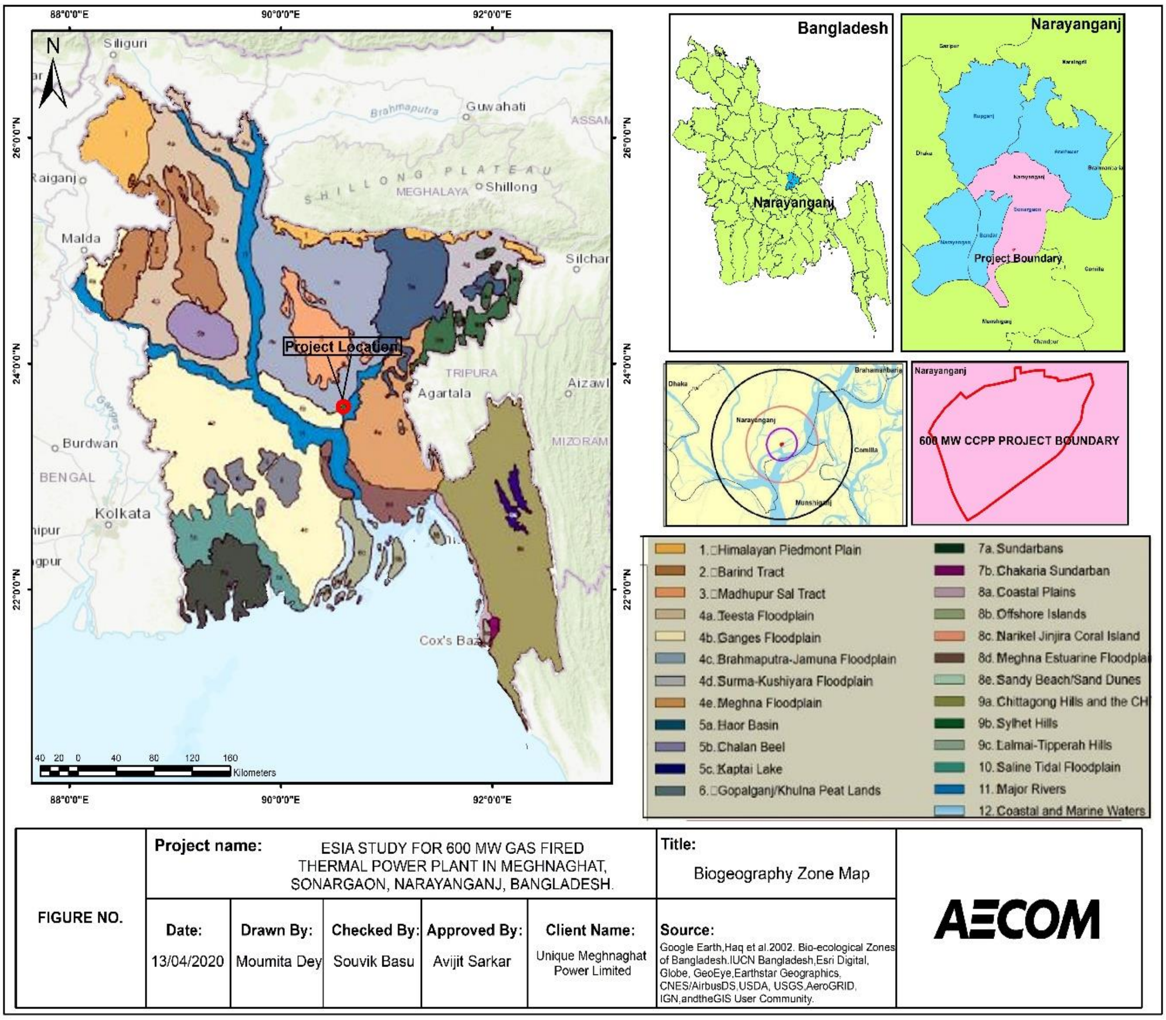


Figure 4.42: Bio-ecological Zones of Bangladesh

Primary data was collected at eight sampling sites selected by applying the stratified systematic sampling method. ***Table 4.25*** and ***Figure 4.43*** present details of the sampling sites of terrestrial ecology.

Table 4.25: Study Sites for Terrestrial Ecology Study

Sl. No.	Sites Name	Coordinate	Direction and aerial distance from project site	Habitat Type
1.	TE1	23°37'14.69"N, 90°35'15.54"E to 23°36'53.83"N, 90°35'22.60"E	Project site and its surrounding	Homestead plantation
2.	TE2	23°37'10.42"N, 90°35'16.33"E to 23°36'49.38"N, 90°34'58.26"E	West, nearest point 230m	Home side plantation, Settlement Area, Agricultural Land
3.	TE3	23°37'35.86"N, 90°36'11.54"E to 23°37'15.35"N, 90°35'53.75"E	North-East, nearest point 630m	Natural vegetation, Settlement Area, Homestead plantation
4.	TE4	23°37'5.02"N, 23°36'44.25"N to 23°36'44.25"N, 90°34'25.25"E	South-West, nearest point 1.54km	Agricultural land, Settlement Area
5.	TE5	23°35'27.62"N, 90°33'14.57"E to 23°36'5.06"N, 90°33'17.68"E	South-West, nearest point 3.86km	Natural vegetation, Agriculture Land
6.	TE6	23°35'7.61"N, 90°35'19.26"E to 23°34'53.19"N, 90°35'32.44"E	South, nearest point 3.31km	Natural vegetation, Barren Land
7.	TE7	23°39'20.87"N, 90°36'6.61"E to 23°39'9.70"N, 90°36'31.24"E	North, nearest point 3.29km	Homestead plantation, Settlement, Some natural vegetation
8.	TE8	23°38'26.09"N, 90°35'31.76"E to 23°38'15.30"N, 90°35'1.44"E	North East, nearest point 4.34km	Settlement, Roadside plantation, Agricultural land, Some Natural Vegetation

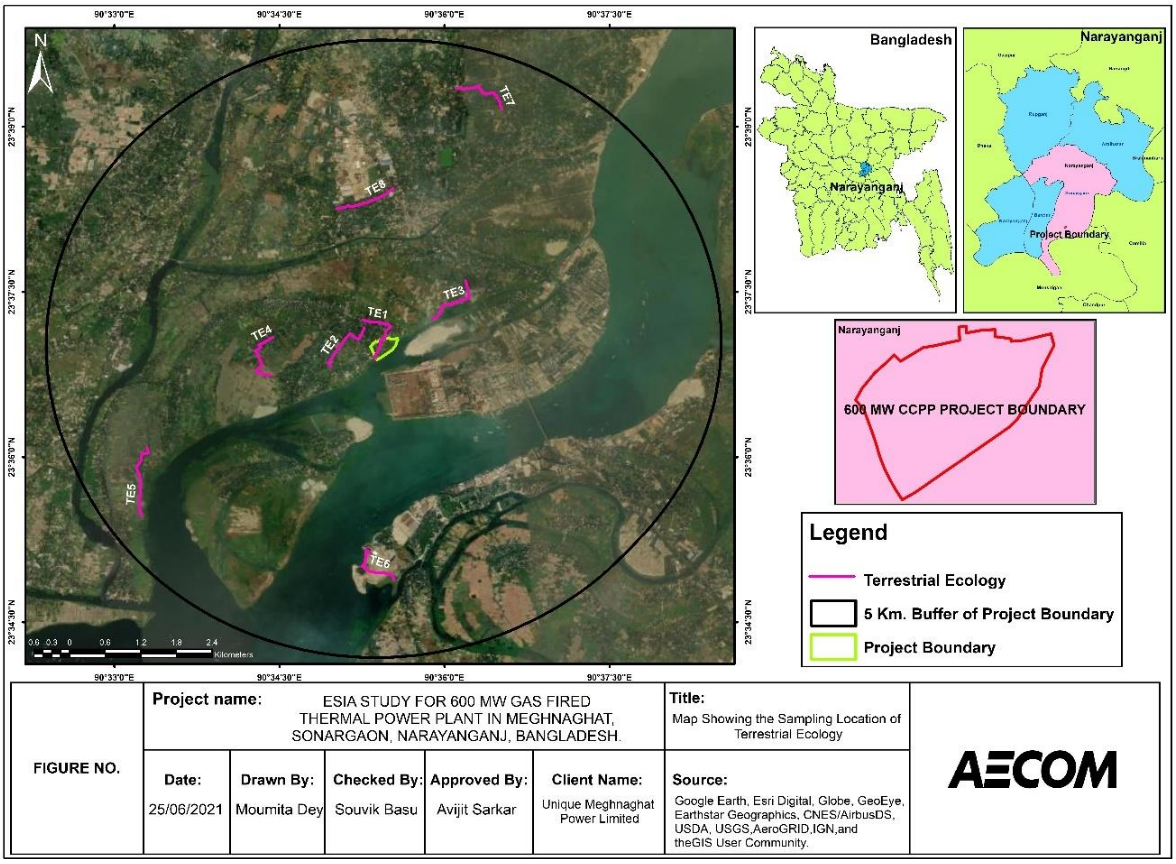


Figure 4.43: Terrestrial Ecology Study Sites Location Map

4.6.4.1 Floral Diversity

At the time of primary survey, the total project area was filled with sand. Thus, no vegetation was found in the project area. However, within 5 km around the project area, a variety of indigenous and exotic species were present. No designated parks and gardens are located nearby the project site. Out of 100 floral species, 38 species belonging to tree, 17 species shrub, 29 species herb and 15 species climbers were recorded. 38 of the above floral species were recorded from homestead plantation. Villagers surrounding the project area planted different kinds of trees around their houses for food, fodder and fuel wood. Commonly planted tree species recorded were Aam (*Mangifera indica*), Arjun (*Terminalia arjuna*), Supari (*Areca catechu*), Narikel (*Cocos nucifera*) and Bans (*Bambusa* sp.). Commonly planted shrubs were Lebu (*Citrus aurantifolia*), Pepe (*Carica papaya*), Togor (*Tabernaemontana divaricata*) and herbs were Kalomegh (*Andrographis paniculate*), Notesak (*Amaranthus viridis*).

In case of roadside plantation, only tree species were planted; and the commonly planted trees were Akashmoni (*Acacia moniliformis*), Neem (*Azadirachta indica*), Sissu (*Dalbergia sissoo*), Krishnachura (*Delonix regia*) and Debdaru (*Polyalthia penduriformis*).

Total 52 plants were recorded in agricultural land. Paddy (*Oryza sativa*) being the main agricultural crop in the AoI predominates with some seasonal vegetables like Lau (*Lagenaria siceraria*), Tomato (*Solanum lycopersicum*), Begun (*Solanum melongena*), Sim (*Lablab purpureus*), Jingha (*Luffa cylindrica*), Corola (*Momordica charantia*) etc. Common naturally growing plants in and around the agricultural land were Dumur (*Ficus hispida*), Khejur (*Phoenix sylvestris*), Boutasak (*Chenopodium album*) and Sarnalata (*Cuscuta reflexa*) . The details of the flora in the study area are provided in ***Table 4.26.***

Table 4.26: List of Plants recorded in the Study Area

Sr. No.	Scientific Name	Common Name	Family	Types	Habitat	Uses	IUCN Status
1	*Acacia moniliformis*	Akash moni	Mimosaceae	Tree	Roadside plantation	Fuel Wood	NE
2	*Acalypha hispida*	Bara hatisur	Euphorbiaceae	Shrub	Agricultural land	-Medicine	NE
3	*Adhatoda zeylanica*	Basak	Acanthaceae	Shrub	Homestead plantation	Medicine	NE
4	*Aegle marmelos*	Bel	Rutaceae	Tree	Homestead plantation	Food	NE
5	*Alocasia esculenta*	Mankachu	Araceae	Herb	Agricultural land	Vegetable	NE

Sr. No.	Scientific Name	Common Name	Family	Types	Habitat	Uses	IUCN Status
6	*Aloe vera.*	Alovera	Aloaceae	Herb	Homestead plantation	Medicine	NE
7	*Alstonia scholaris*	Chatim	Apocynaceae	Tree	Roadside plantation	Fuel Wood	NE
8	*Amaranthus viridis*	Noteshak	Amaranthaceae	Herb	Homestead plantation	Vegetable	NE
9	*Andrographis paniculata*	Kalomegh	Acanthaceae	Herb	Homestead plantation	Medicine	NE
10	*Artocarpus heterophyllus*	Kanthal	Moraceae	Tree	Homestead plantation	Food	NE
11	*Asparagus racemosus*	Satamuli	Liliaceae	Climber	Agricultural land	Medicine	NE
12	*Averrhoa carambola*	kamranga	Averrhoaceae	Tree	Agricultural land	Food	NE
13	*Azadirachta indica*	Neem	Meliaceae	Tree	Roadside plantation	Food	LC
14	*Bougainvillea glabra*	Bagan bilas	Nyctaginaceae	Climber	Agricultural land	Ornamental	NE
15	*Bryophyllum pinnatum*	Patharkuchi	Crassulaceae	Herb	Agricultural land	Medicine	NE
16	*Calotropis gigantean*	Akanda	Asclepiadaceae	Shrub	Agricultural land	Medicine	NE
17	*Carica papaya*	Pepe	Caricaceae	Shrub	Homestead plantation	Food	NE
18	*Centella asiatica*	Thankuni	Apiaceae	Herb	Agricultural land	Medicine	NE
19	*Chrysanthemum morifolium*	Chandramollica	Asteraceae	Herb	Homestead plantation	Ornamental	NE
20	*Citrus aurantifolia*	Lebu	Rutaceae	Shrub	Homestead plantation	Food	NE
21	*Citrus maxima*	Batabi	Rutaceae	Tree	Homestead plantation	Food	NE
22	*Cocos nucifera*	Narikel	Arecaceae	Shrub	Homestead plantation	Fruit & Fodder	NE
23	*Codiaeum variegatum*	Patabahar	Euphorbiaceae	Shrub	Homestead plantation	Ornamental	NE
24	*Cynodon dactylon*	Durba	Poaceae	Herb	Agricultural land	Medicine	NE
25	*Dalbergia sissoo*	Sissu	Fabaceae	Tree	Roadside plantation	Timber	NE
26	*Datura metel*	Dutra	Solanaceae	Shrub	Agricultural land	Medicine	NE
27	*Delonix regia*	Krishna chura	Fabaceae	Tree	Roadside plantation	Medicine	NE
28	*Ficus hispida*	Dumur	Moraceae	Tree	Agricultural land	Vegetable	NE
29	*Hibiscus rosa-sinensis*	Jaba	Malvaceae	Shrub	Homestead plantation	Ornamental	NE
30	*Impatiens balsamina*	Doparti	Balsamiaceae	Herb	Homestead plantation	Ornamental	NE
31	*Ixora chinensis*	Rangon	Rubiaceae	Shrub	Homestead plantation	Ornamental	NE
32	*Jasminum auriculatum*	Jui	Oleaceae	Climber	Homestead plantation	Ornamental	NE
33	*Jasminum gradiflorum*	Chameli	Oleaceae	Climber	Homestead plantation	Ornamental	NE
34	*Jasminum sambac*	Beli	Oleaceae	Climber	Homestead plantation	Ornamental	NE
35	*Lagerstroemia speciosa*	Jarul	Lythraceae	Tree	Agricultural land	Fuel Wood	NE
36	*Mangifera indica*	Aam	Anacardiaceae	Tree	Homestead plantation	Food	NE
37	*Mimusops elengi*	Bakul	Sapindaceae	Tree	Agricultural land	Medicine	NE
38	*Phoenix sylvestris*	Khejur	Arecaceae	Shrub	Agricultural land	Fruit	NE
39	*Polyalthia penduriformis*	Debdaru	Annonaceae	Tree	Roadside plantation	Fuel wood	NE
40	*Psidium guajava*	Peara	Myrtaceae	Tree	Homestead plantation	Fruit	NE
41	*Punica granatum*	Dalim	Punicaceae	Shrub	Homestead plantation	Fruit	NE
42	*Rosa chinensis*	Kantagolap	Rosaceae	Shrub	Homestead plantation	Ornamental	NE
43	*Rosa damascenes*	Golap	Rosaceae	Shrub	Homestead plantation	Ornamental	NE
44	*Tabernaemontana divaricata*	Tagor	Apocynaceae	Shrub	Homestead plantation	Ornamental	NE
45	*Tagetes patula*	Gada	Asteraceae	Herb	Homestead plantation	Ornamental	NE
46	*Tamarindus indica*	Tetul	Caesalpiniaceae	Tree	Homestead plantation	Fruit	NE
47	*Tectona grandis*	Segun	Verbenaceae	Tree	Roadside plantation	Timber	NE
48	*Terminalia arjuna*	Arjun	Combretaceae	Tree	Roadside plantation	Timber & Medicine	NE
49	*Ageratum conyzoides*	Phulkuri	Asteraceae	Herb	Agricultural land	Medicine	NE
50	*Albizia chinensis*	Kkoroi	Mimosaceae	Tree	Agricultural land	Fuel Wood	NE
51	*Amaranthus tricolor*	Lalshak	Amaranthaceae	Herb	Agricultural land	Vegetable	NE
52	*Ammannia baccifera*	Acidpata	Lythraceae	Herb	Agricultural land	Medicine	NE

Sr. No.	Scientific Name	Common Name	Family	Types	Habitat	Uses	IUCN Status
53	*Anisomeles indica*	Bontulshi	Lamiaceae	Herb	Agricultural land	Medicine	NE
54	*Annona reticulate*	Ata	Annonaceae	Tree	Homestead plantation	Fruit	NE
55	*Atylosia scarabaeoides*	Kukshim	Fabaceae	Climber	Agricultural land	Manure	NE
56	*Axonopus compressus*	Chapraghas	Poaceae	Herb	Agricultural land	Grazing	NE
57	*Brassica nigra*	Shorisha	Brassicaceae	Herb	Agricultural land	Oil	NE
58	*Chenopodium album*	Botua shak	Chenopodiaceae	Herb	Agricultural land	Vegetable	NE
59	*Chloris barbata*	Ghash	Poaceae	Herb	Agricultural land	Grazing	NE
60	*Cleome rutidosperma*	Hurhurey	Capparaceae	Herb	Agricultural land	Medicine	NE
61	*Coccinia cordifolia*	Telakucha	Cucurbitaceae	Herb	Agricultural land	Medicine	NE
62	*Cucurbita maxima*	Mistikumra	Cucurbitaceae	Climber	Agricultural land	Vegetable	NE
63	*Dillenia indica*	Chalta	Dilleniaceae	Tree	Agricultural land	Fruit	NE
64	*Heliotropium indicum*	Hatisur	Asteraceae	Herb	Agricultural land	Medicine	NE
65	*Melia azedarach*	Gora Neem	Meliaceae	Tree	Roadside plantation	Fuel Wood	NE
66	*Moringa oleifera*	Shojna	Moringaceae	Tree	Homestead plantation	Vegetable	NE
67	*Ricinus communis*	Rerhi/Vrenda	Euphorbiaceae	Shrub	Agricultural land	Medicine	NE
68	*Saccharum spontaneum*	Kash	Poaceae	Herb	Agricultural land	Ornamentation and medicine	NE
69	*Senna occidentalis*	Kolkashunda	Caesalpiniaceae	Shrub	Agricultural land	Medicine	NE
70	*Solanum lycopersicum*	Tomato	Solanaceae	Herb	Agricultural land	Vegetable	NE
71	*Solanum melongena*	Begun	Solanaceae	Herb	Agricultural land	Vegetable	NE
72	*Swietenia mahagoni*	Mehagoni	Meliaceae	Tree	Roadside plantation	Timber	NE
73	*Spondias pinnata*	Amra	Anacardiaceae	Tree	Agricultural land	Fruit	NE
74	*Syzygium cumini*	Jam	Myrtaceae	Tree	Agricultural land	Fruit	NE
75	*Thevetia peruviana*	Holud korobi	Apocynaceae	Tree	Agricultural land	Ornamental	NE
76	*Tinospora cordifolia*	Gulancha	Menispermacea e	Climber	Agricultural land	Ornamental	NE
77	*Ziziphus mauritiana*	Kul	Rhamnaceae	Tree	Homestead plantation	Fruit	NE
78	*Cuscuta reflexa*	Sharnalata	Cuscutaceae	Climber	Agricultural land	Medicine	NE
79	*Lagenaria siceraria*	Lau	Cucrbitaceae	Climber	Agricultural land	Vegetable	NE
80	*Citrus grandis*	Jambura	Rutaceae	Tree	Agricultural land	Medicine	NE
81	*Trewia nudiflora*	Pitali/Latim	Euphorbiaceae	Tree	Homestead plantation	Fuel Wood	NE
82	*Bambusa sp.*	Bans	Gramineae	Tree	Homestead Plantation	Thatching	NE
83	*Albizia lebbeck*	Sirish	Leguminosae	Tree	Homestead Plantation	Timber and fuelwood	NE
84	*Albizia richrdiana*	Gogon Sirish	Leguminosae	Tree	Homestead Plantation	Timber	NE
85	*Tamarindus indica*	Tetul	Leguminosae	Tree	Homestead Plantation	Fruit	NE
86	*Cassia siamea*	Minjuri	Leguminosae	Tree	Homestead Plantation	Fuel Wood	NE
87	*Rorippa indica*	Ban sarisha	Cruciferae	Herb	Agricultural land	Vegetable	NE
88	*Diospyros discolor*	Bilatigab	Ebanaceae	Tree	Homestead plantation	Fruit	NE
89	*Diospyros perigrina*	Gab	Ebanaceae	Tree	Homestead plantation	Fruit & Timber	NE
90	*Ficus benghalensis*	Bot	Moraceae	Tree	Homestead plantation	Fuel Wood	NE
91	*Chenopodium album*	Botua shak	Chenopodiaceae	Herb	Agricultural land	Vegetable	NE
92	*Lablab purpureus*	Shim	Fabaceae	Climber	Agricultural land	Vegetable	NE
93	*Luffa cylindrica*	Jhinga	Cucurbitaceae	Climber	Agricultural land	Vegetable	NE
94	*Momordica charantia*	Korolla	Cucurbitaceae	Climber	Agricultural land	Vegetable	NE
95	*Passiflora foetida*	Jhumkalata	Passifloraceae	Climber	Agricultural land	Medicine	NE
96	*Areca catechu*	Supari	Arecaceae	Tree	Homestead plantation	Fruit & fodder	NE
97	*Phyllanthus niruri*	Bhuiamla	Euphorbiaceae	Herb	Agricultural land	Medicine	NE
98	*Oryza Sativa*	Dhan (Amon)	Poeaceae	Herb	Agricultural land	Food & Fodder	NE
99	*Vetiveria zizaniodes*	Binna Ghash	Poeaceae	Herb	Agricultural land	Grazing and Medicine	NE
100	*Rumex maritimus*	Datipalong	Polygonaceae	Herb	Agricultural land	Medicine	NE

IUCN Status code: CR-Critically Endangered, EN-Endangered, VU-Vulnerable, NT-Near Threatened, LC-Least Concern, DD-Data Deficient, NE-Not Evaluated

Figure 4.44: Different vegetation in the study area

4.6.4.2 Amphibians and Reptiles

From consultations with local people and observations during the field study, eleven amphibian species and twenty reptiles were listed. The common amphibians reported in the nearby villages within 5km buffer of the project area were Asian common toad (*Duttaphrynus melanostictus*), Bangladeshi Cricket Frog (*Fejervarya pierrei)*, Asian bullfrog (*Hoplobatrachus tigerinus*), Spotted tree frog (*Polypedates maculatus*) and Common tree frog (*Polypedates leucomystax*). All the amphibian species found in the study area is listed in ***Table 4.27.*** According to the IUCN red list global status 2020-2, the species listed in the table below are of least concern. However, as per IUCN Bangladesh status 2015, Yellow-striped frog and Balloon frog found in the study area are vulnerable. Out of twenty reptiles listed in the project area, Common Skink (*Eutropis carinata*), Common house gecko (*Hemidactylus frenatus*), House Lizard (*Hemidactylus flaviviridis*), Oriental garden lizard (*Calotes versicolor*), Spectacled cobra (*Naja naja*), Checkered keelback (*Xenochrophis piscator),* Monocled Cobra (*Naja kaouthia*), Indian rat snake (*Ptyas mucosa*), Vine Snake (*Ahaetulla nasuta*) are found around the nearby villages within 5km buffer of the project area. All the reptile species found in the study area is listed in ***Table 4.28***. According to the IUCN global red list status 2020-2 and IUCN Bangladesh status 2015, out of twenty species reported in the study area, one species (Indian Rock Python) is vulnerable. Additionally, two species (Bengal Monitor Lizard and Pond Tortoise) are classified as Near Threatened as per IUCN global red list status 2020-2, while rest are Least Concern and Not Evaluated. However, as per IUCN Bangladesh status, along with Pond Tortoise, Spectacled cobra and Monocled Cobra are Near threatened species. During primary survey, the entire project area was filled with sand. Thus, no amphibian and reptile species were found in the project area.

Table 4.27: List of Amphibia in the Study Area

Sr. No.	Common Name	Scientific Name	IUCN Status (Global)	IUCN Status Bangladesh
1	Asian common toad	*Duttaphrynus melanostictus*	LC	LC
2	Yellow-striped Frog	*Hylarana tytleri*	LC	VU
3	Skittering frog	*Euphlyctis cyanophlyctis*	LC	LC
4	Asian bullfrog	*Hoplobatrachus tigerinus*	LC	LC
5	Large pygmy frog	*Microhyla berdmorei*	LC	LC
6	Balloon frog	*Uperodon globulosus*	LC	VU
7	Common tree frog	*Polypedates leucomystax*	LC	LC
8	Ornate Microhylid Frog	*Microhyla ornata*	LC	LC

Sr. No.	Common Name	Scientific Name	IUCN Status (Global)	IUCN Status Bangladesh
9	Green Pond Frog	*Euphlyctis hexadactylus*	LC	LC
10	Spotted Tree Frog	*Polypedates maculatus*	LC	LC
11	Pierre's Cricket Frog	*Fejervarya pierrei*	LC	LC

IUCN Status code: CR-Critically Endangered, EN-Endangered, VU-Vulnerable, NT-Near Threatened, LC-Least Concern, DD-Data Deficient, NE-Not Evaluated

Table 4.28: List of Reptiles in the Study Area

Sr. No.	Common Name	Scientific Name	IUCN Status	IUCN Status Bangladesh
1	Common Skink	*Eutropis carinata*	LC	LC
2	Common house gecko	*Hemidactylus frenatus*	LC	LC
3	House Lizard	*Hemidactylus flaviviridis*	NE	LC
4	Tokay Gecko	*Gekko gecko*	LC	LC
5	Oriental garden lizard	*Calotes versicolor*	LC	LC
6	Checkered keelback	*Xenochrophis piscator*	LC	NE
7	Banded krait	*Bungarus fasciatus*	LC	LC
8	Spectacled cobra	*Naja naja*	NE	NT
9	Monocled Cobra	*Naja kaouthia*	LC	NT
10	Brahminy blind snake	*Indotyphlops braminus*	NE	LC
11	Indian rat snake	*Ptyas mucosa*	NE	LC
12	Vine Snake	*Ahaetulla nasuta*	NE	LC
13	Common Krait	*Bungarus caeruleus*	NE	LC
14	Banded Krait	*Bungarus fasciatus*	LC	LC
15	Green Pit Viper	*Trimeresurus albolabris*	LC	LC
16	Indian Rock Python	*Python bivittatus*	VU	VU
17	Common Wolf Snake	*Lycodon aulicus*	NE	LC
18	Bengal Monitor Lizard	*Varanus bengalensis*	NT	LC
19	Pond Tortoise	*Melanochelys trijuga*	NT	NT
20	Roofed Turtle	*Pangshura tecta*	LC	LC

IUCN Status code: CR-Critically Endangered, EN-Endangered, VU-Vulnerable, NT-Near Threatened, LC-Least Concern, DD-Data Deficient, NE-Not Evaluated

4.6.4.3 Birds (Avifauna)

During the survey tenure, a total of 83 species were observed/ recorded after consultation with local people of nearby villages within 5km buffer of the project area. Due to sand filling and lack of vegetation in project area, only Black crow (*Corvus capensis*) was noticed on the transmission line tower at the project site. Bangladesh falls under East Asian–Australasian Migratory Flyway and the transmission line is present in East-West direction. Significant number of birds' flight diverters (Hanging colour ball) are present in the transmission line to divert the birds. During the study period, no migratory birds were observed; and after consultations with local people also could not the presence of migratory birds in the study area. Moreover, no research papers, articles and publications of Bangladesh have mentioned about any sighting or habitat of migratory birds within 10km of the project area. Out of 83 avian species, two species such as Red-breasted Parakeet (*Psittacula eupatria*) and Alexandrine Parakeet (*Psittacula alexandri*) belong to Near Threatened according to IUCN Global Red List 2020-2. However, they are Least Concern as per IUCN Bangladesh status 2015. Thus, as per IUCN Global Red List, 81 avian species are under Least Concern (LC) and as per IUCN Bangladesh Status all 83 avian species are Least Concern. Rose-ringed Parakeet (*Psittacula krameri*) and Bank Myna (*Acridotheres ginginianus*) are introduced species in Dhaka, Bangladesh. In the surrounding village area of project site birds like Indian Cormorant, Purple Swamphen, Pond Heron, Egrets, House Sparrow, Common Myna were very common. The details of the avifauna in the study area are provided in ***Table 4.29.***

Table 4.29: List of birds (Avifauna) in the Study Area

Sr. No.	Common Name	Scientific Name	IUCN Status Global	IUCN Status Bangladesh
1	Baya Weaver	*Streptopelia orientalis*	LC	LC

Sr. No.	Common Name	Scientific Name	IUCN Status Global	IUCN Status Bangladesh
2	Ashy Woodswallow	*Streptopelia decaocto*	LC	LC
3	Ashy Drongo	*Cypsiurus balasiensis*	LC	LC
4	Black Drongo	*Dicrurus macrocercus*	LC	LC
5	Rock Pigeon	*Centropus bengalensis*	LC	LC
6	Spotted Dove	*Spilopelia chinensis*	LC	LC
7	Eurasian Collared Dove	*Spilopelia chinensis*	LC	LC
8	Asian Palm Swift	*Cacomantis passerinus*	LC	LC
9	House Swift	*Streptopelia orientalis*	LC	LC
10	Lesser Coucal	*Streptopelia decaocto*	LC	LC
11	Jacobin Cuckoo	*Cypsiurus balasiensis*	LC	LC
12	Common Koel	*Apus nipalensis*	LC	LC
13	Grey-bellied Cuckoo	*Centropus bengalensis*	LC	LC
14	Drongo Cuckoo	*Clamator jacobinus*	LC	LC
15	White-breasted Waterhen	*Amaurornis phoenicurus*	LC	LC
16	Watercock	*Gallicrex cinerea*	LC	LC
17	Common Moorhen	*Gallinula chloropus*	LC	LC
18	Asian Openbill	*Anastomus oscitans*	LC	LC
19	Indian Pond Heron	*Ardeola grayii*	LC	LC
20	Cattle Egret	*Bubulcus ibis*	LC	LC
21	Grey Heron	*Ardea cinerea*	LC	LC
22	Great Egret	*Ardea alba*	LC	LC
23	Intermediate Egret	*Ardea intermedia*	LC	LC
24	Little Egret	*Egretta garzetta*	LC	LC
25	Little Cormorant	*Microcarbo niger*	LC	LC
26	Indian Cormorant	*Phalacrocorax fuscicollis*	LC	LC
27	Red-wattled Lapwing	*Vanellus indicus*	LC	LC
28	Bronze-winged Jacana	*Metopidius indicus*	LC	LC
29	Black-winged Kite	*Elanus caeruleus*	LC	LC
30	Crested Serpent Eagle	*Spilornis cheela*	LC	LC
31	White-tailed Sea Eagle	*Haliaeetus albicilla*	LC	LC
32	Brahminy Kite	*Haliastur indus*	LC	LC
33	Black Kite	*Milvus migrans*	LC	LC
34	Spotted Owlet	*Athene brama*	LC	LC
35	Common Hoopoe	*Upupa epops*	LC	LC
36	Common Flame-backed Woodpecker	*Dinopium javanense*	LC	LC
37	Streak-throated Woodpecker	*Picus xanthopygaeus*	LC	LC
38	Grey-capped Pygmy Woodpecker	*Dendrocopos canicapillus*	LC	LC
39	Fulvous-breasted Woodpecker	*Dendrocopos macei*	LC	LC
40	Lineated Barbet	*Psilopogon lineatus*	LC	LC
41	Blue-throated Barbet	*Psilopogon asiaticus*	LC	LC
42	Coppersmith Barbet	*Psilopogon haemacephalus*	LC	LC
43	Green Bee-eater	*Merops orientalis*	LC	LC
44	Chestnut-headed Bee-eater	*Merops leschenaulti*	LC	LC
45	Indian Roller	*Coracias benghalensis*	LC	LC
46	Common Kingfisher	*Alcedo atthis*	LC	LC
47	Pied Kingfisher	*Ceryle rudis*	LC	LC
48	Stork-billed Kingfisher	*Pelargopsis capensis*	LC	LC
49	White-throated Kingfisher	*Halcyon smyrnensis*	LC	LC
50	Indian Nightjar	*Caprimulgus asiaticus*	LC	LC
51	Red-breasted Parakeet	*Psittacula alexandri*	NT	LC
52	Alexandrine Parakeet	*Psittacula eupatria*	NT	LC
53	Rose-ringed Parakeet	*Psittacula krameri*	LC	LC

Sr. No.	Common Name	Scientific Name	IUCN Status Global	IUCN Status Bangladesh
54	Indian Golden Oriole	*Oriolus kundoo*	LC	LC
55	Black-naped Oriole	*Oriolus chinensis*	LC	LC
56	Chestnut-tailed starling	*Sturnia malabarica*	LC	LC
57	Long-tailed Shrike	*Lanius schach*	LC	LC
58	Rufous Treepie	*Dendrocitta vagabunda*	LC	LC
59	House Crow	*Corvus splendens*	LC	LC
60	Purple Sunbird	*Cinnyris asiaticus*	LC	LC
61	Red Avadavat	*Amandava*	LC	LC
62	Scaly-breasted Munia	*Lonchura punctulata*	LC	LC
63	Black-headed Munia	*Lonchura malacca*	LC	LC
64	House Sparrow	*Passer domesticus*	LC	LC
65	Citrine Wagtail	*Motacilla citreola*	LC	LC
66	White Wagtail	*Motacilla alba*	LC	LC
67	Plain Prinia	*Prinia inornata*	LC	LC
68	Common Tailorbird	*Orthotomus sutorius*	LC	LC
69	Red-whiskered Bulbul	*Pycnonotus jocosus*	LC	LC
70	Red-vented Bulbul	*Pycnonotus cafer*	LC	LC
71	Jungle Babbler	*Turdoides striata*	LC	LC
72	Asian Pied Starling	*Gracupica contra*	LC	LC
73	Common Myna	*Acridotheres tristis*	LC	LC
74	Bank Myna	*Acridotheres ginginianus*	LC	LC
75	Oriental Magpie Robin	*Copsychus saularis*	LC	LC
76	White-rumped Shama	*Kittacincla malabarica*	LC	LC
77	Barn Swallow	*Hirundo rustica*	LC	LC
78	Lesser Whistling-Duck	*Dendrocygna javanica*	LC	LC
79	Common Sandpiper	*Actitis hypoleucos*	LC	LC
80	Green Sandpiper	*Tringa ochropus*	LC	LC
81	Paddyfield Pipit	*Anthus rufulus*	LC	LC
82	Purple Swamphen	*Porphyrio*	LC	LC
83	Jungle Crow	*Corvus levaillantii*	LC	LC

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Indian Pond Heron (*Ardeola grayii*)

Black Drongo (*Dicrurus macrocercus*)

Common Myna (*Acridotheres tristis*)

Green Bee-eater (*Merops orientalis)*

Chestnut-tailed starling (*Sturnia malabarica*)

House Sparrow (*Passer domesticus*)

Purple Swamphen (*Porphyrio porphyrio*)

Indian Cormorant (*Phalacrocorax fuscicollis*)

Asian Openbill (*Anastomus oscitans*)

Cattle Egret (*Bubulcus ibis)*

Bronze-winged Jacana (*Metopidius indicus*)

Red-wattled lapwing (*Vanellus indicus*)

Jumgle Babbler (*Turdoides striata*)

White-throated Kingfisher (*Halcyon smyrnensis*)

Oriental Magpie Robin (*Copsychus saularis)*

White Wagtail (*Motacilla alba*)

Red Vented Bulbul (*Pycnonotus cafer*)

White-breasted waterhen (*Amaurornis phoenicurus*)

Figure 4.45: Birds observed in the study area

4.6.4.4 Mammals

Nineteen mammal species were listed in the study area in consultation with local people and available secondary information. Little Indian field mouse (*Mus booduga*), House mouse (*Mus musculus*), Asian House Shrew (*Suncus murinus*), Small Asian Mongoose (*Herpestes auropunctatus*), Lesser bandicoot rat (*Bandicota bengalensis*), Common House Rat (*Rattus rattus*), Small Indian Mongoose (*Herpestes auropunctatus*) and Indian palm squirrel (*Funambulus palmarum*) were identified & listed within the study area. List of Mammals recorded in the Study Area is provided in ***Table 4.30.***

According to the IUCN red list global status 2020-2, all the listed species are Least Concern. However as per IUCN Bangladesh status 2015, only one species (Rhesus Macaque) is Vulnerable and three species (Jungle Cat, Large Indian Civet, Small Indian Civet) are Near threatened; rest are Least Concern species.

During the primary survey, the entire project area was filled with sand and was devoid of any vegetation. No mammalian species were found in the project area.

Table 4.30: List of Mammals in the Study Area

Sr. No.	Common Name	Scientific Name	IUCN Status Global	IUCN Status Bangladesh
1	Little Indian field mouse	*Mus booduga*	LC	LC
2	House mouse	*Mus musculus*	LC	LC
3	Asian House Shrew	*Suncus murinus*	LC	LC
4	Small Indian Mongoose	*Herpestes auropunctatus*	LC	LC
5	Lesser bandicoot rat	*Bandicota bengalensis*	LC	LC
6	Large Bandicoot Rat	*Bandicota indica*	LC	LC
7	Brown Rat	*Rattus norvegicus*	LC	LC
8	Common House Rat	*Rattus rattus*	LC	LC
9	Lesser Asiatic Yellow Bat	*Scotophilus kuhlii*	LC	LC
10	Rhesus Macaque	*Macaca mulatta*	LC	VU
11	Jungle Cat	*Felis chaus*	LC	NT
12	Large Indian Civet	*Viverra zibetha*	LC	NT
13	Small Indian Civet	*Viverricula indica*	LC	NT
14	Greater False Vampire	*Megaderma lyra*	LC	LC
15	Indian Flying Fox	*Pteropus giganteus*	LC	LC
16	Little Indian Bat	*Pipistrellus coromandra*	LC	LC
17	Least Pipistrelle	*Pipistrellus tenuis*	LC	LC
18	Small Indian Mongoose	*Herpestes auropunctatus*	LC	LC
19	Common Palm Civet	*Paradoxurus hermaphroditus*	LC	LC

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4.6.5 Aquatic Ecology

Aquatic Vegetation

The project site is located on the bank of Meghna river. Different aquatic and semi aquatic vegetation were found at the time of plankton sampling in Meghna River. Various aquatic plants were also noticed at village ponds, marshy area & agricultural area. A total of 34 species were enlisted from riverine habitat, village ponds, marshy area and agricultural field. The riverine vegetation is predominantly represented by *Eichhornia crassipes, Salvina cucullate, Colocasia esculenta, Mersilea quadrifoliate*, and *Phragmites karka*. Also, huge number of floating water hyacinth (*Eichhornia crassipes*) was trapped by the local people in Meghna river. They use bamboo poles for trapping. They use this place to attract different kinds of fishes as shelter place. The dominant aquatic and semi aquatic plants observed in & around pond and marshy land were *Nymphoides indicum, Alternanthera sessiles, Alternanthera philoxiroides, Azolla pinnata, Colocasia esculenta, Glinus oppositifolius, Wolffia microscopica, Ipomoea aquatic, Lemna perpusilla,* and *Commelina benghalensis.*The list of aquatic vegetation recorded in the study area is provided in **Table 4.31.**

Table 4.31. List of Aquatic Vegetation

Sr. No.	Scientific Name	Common Name	Family	Types
1	*Eclipta alba*	Kalokeshi	Asteraceae	Shrub
2	*Glinus oppositifolius*	Gimashak	Molluginaceae	Herb
3	*Commelina benghalensis*	Kanchira	Commelinaceae	Herb
4	*Corchorus olitorius*	Bonpat/Titpat	Tiliaceae	Herb
5	*Croton bonplandianus*	Banmarich	Euphorbiaceae	Herb
6	*Alternanthera sessilis*	Chhoto chanchi	Amaranthaceae	Shrub
7	*Amaranthus gangeticus*	Notey shak	Amaranthaceae	Herb
8	*Amaranthus spinosus*	Katanotey	Amarantaceae	Tree
9	*Colocasia esculenta*	Kachu	Araceae	Herb
10	*Nymphaea nouchali*	Shapla	Nymphaeaceae	Herb
11	*Polygonum barbatum*	Bishkatali	Polygonaceae	Herb
12	*Eichhornia crassipes*	Kochuripana	Pontaderiaceae	Herb
13	*Azolla pinnata*	Kutipana	Salviniaceae	Herb
14	*Salvina cucullata*	Kuripana	Salviniaceae	Herb
15	*Trapa natans*	Singra	Trapaceae	Herb
16	*Mersilea quadrifoliata*	Susnisak	Mersileaceae	Herb
17	*Nymphoides indicum*	Panchuli	Menyanthaceae	Herb
18	*Lemna perpusilla*	Khudipana	Lemnaceae	Herb
19	*Wolffia microscopica*	Guripana	Lemnaceae	Herb
20	*Spirodela polyrhiza*	Khudipana	Lemnaceae	Herb
21	*Utricualria exoleata*	Chotojhanjhi	Lentibulariaceae	Herb
22	*Vallisnaria spiralis*	Biha	Hydrocharitaceae	Herb
23	*Phragmites karka*	Nol	Gramineae	Herb
24	*Hygroryza aristata*	Putki	Gramineae	Herb
25	*Sagittaria sagittifolia*	hotokul	Alismataceae	Herb
26	*Alternanthera philoxiroides*	Helencha	Amaranthaceae	Herb
27	*Aponogeton natans*	Ghentu	Aponogetonaceae	Herb
28	*Pistia stratiotes*	Topapana	Araceae	Herb
29	*Ceratophyllum desmersum*	Jhangi	Cearatophyllaceae	Herb
30	*Ipomoea aquatica*	Kalmi sak	Convolvulaceae	Herb
31	*Scirpus juncoides*	hisra	Cyperaceae	Herb
32	*Enhydra fluctuans*	Helencha	Cyperaceae	Herb
33	*Cyperus sp.*	Mutha	Cyperaceae	Herb
34	*Bacopa monnieri*	Bramhi	Scrophulariaceae	Herb

Figure 4.46: Different types of aquatic vegetation in the study area

Aquatic Planktons and Benthos

Three plankton sampling points were selected for the primary survey. The sampling locations are presented in Table 4.32 and Figure 4.47. For phytoplankton analysis, one litre of water sample was collected from each sampling point using Luggol’s Iodine preservative. From the precipitated samples, all workout has been done and 5% formalin solution used to preserve it for the future reference. The identification and quantitative analysis of phytoplankton samples have been done by using Leica microscope. For qualitative and quantitative analysis of zooplankton, the samples have been collected by filtering 50L of water using No. 25 bolting silk cloth plankton-net (with 64µm aperture size and allowing nearly 33% open area). The concentrated sample thus collected was fixed using adequate preservatives carried to laboratory for analysis. Benthos samples have been collected from three sites by using a grab sampler (Ekman’s dredge). The mud content has been removed and benthos samples preserved in a 250 ml plastic container with 10% neutralized formalin and habitat water solution further laboratory study.

Also, various diversity indices were calculated for phytoplankton, zooplankton and benthos for each site. Species diversity is the best measure of community structure and is sensitive to various environmental stresses. General diversity of an area was calculated using the Shannon–Wiener diversity index. Besides diversity indices like Simpson's dominance index, Pielou's evenness index, and Margalef's richness index were also calculated. Shannon–Wiener diversity index and Simpson's dominance index both were based on the proportional species abundance in the studied area. However, Shannon–Wiener diversity index is more sensitive to rare species, whereas Simpson's dominance index gives more importance to common species. Pielou's evenness index reflects homogeneity among the species. Margalef's richness index was considered for both abundance and species richness.

Table 4.32: Study Sites for Aquatic Ecology Study

Sl. No.	Sites Name	Coordinate	Description	Observation
1.	Site 1	23°36'54.18"N, 90°35'29.23"E	Sample was collected from branch channel of Meghna river. It is located 50 meters away from the bank of proposed project site.	At the time of aquatic sampling, site 1 was located in proximity to the water intake point at the Meghna River. However, as per final layout of Site plan the Site 1 is located between water intake point and water discharge point. Hot water discharge from an operational power plant and pulp and paper industry was observed within 500 meters radius of the sampling location
2.	Site 2	23°35'49.33"N, 90°35'11.71"E	Sample was collected at 2.1 km downstream of the proposed project site on Meghna River. It is 1.15km away from the hot water discharge location of an operational power plant.	-
3.	Site 3	23°38'2.52"N, 90°37'37.05"E	Sample was collected at 4.8km upstream of the proposed project site on Meghna River.	-

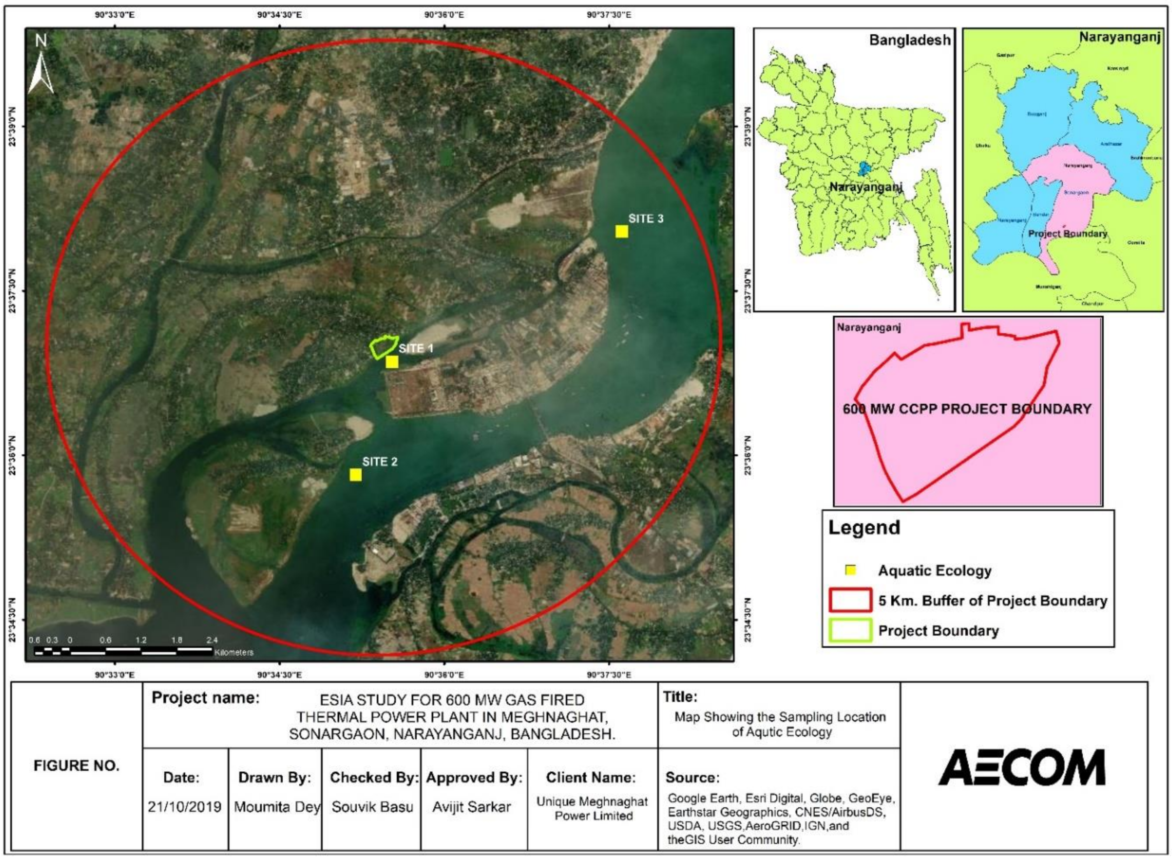


Figure 4.47: Aquatic Ecology Study Sites Location Map

Figure 4.48: Sampling site for aquatic ecology

4.6.5.1 Phytoplankton

The species distribution of phytoplankton was calculated after sampling at three sites and is summarized in Table 4.33 and Figure 4.49. Cholorophyceae is the dominated phytoplankton class followed by Cyanophyceae, Bacillariophyceae and Myxophyceae. Out of 24 species of phytoplankton, *Spirulina* sp., *Chlamydomonas* sp., *Microspora* sp. *Ulothrix* sp. and *Anabaena* sp. were the most common species observed. Site wise phytoplankton counts and different diversity indices are furnished in ***Table 4.33*** and ***Table 4.34.*** Higher phytoplankton counts were recorded in Site 3 as compared to other two sites. The low phytoplankton count and lesser diversity observed at Site 1 may be attributed to thermal discharge from the nearby thermal plant. Site wise variations of number of individuals, number of species of phytoplankton with the changes of diversity indices are presented in Figure 4.49. The phytoplankton diversity and dominance were highest in Site 3 followed by Site 2, however phytoplankton richness in Site 2 was higher than Site 3. The phytoplankton distribution in Site 1 was found to be more even than Site 2, despite Site 2 having more species, diversity & richness.

Table 4.33: Species Wise Distribution of Phytoplankton (individual/L)

Sl No	Class	Species	Site 1	Site 2	Site 3
1.	Cyanophyceae	*Spirulina* sp.	9	12	17
		Scenedesmus sp.	0	2	7
		Ankistrodesmu sp.	4	1	5
2.	Cholorophyceae	*Ceratium* sp.	0	0	2
		Chlamydomonas sp.	11	8	12
		Closterium sp.	0	6	6
		Gonatogygon sp.	0	0	4
		Microspora sp.	8	16	12
		Spirogyra sp.	0	0	2
		Schroederia sp.	6	0	5
		Pediastrum sp.	0	1	2
		Zygnema sp.	5	4	7
		Mougeotia sp.	2	0	2
3.	Dinophyceae	*Ulothrix* sp.	6	6	15
4.	Myxophyceae	*Coelosphaerium* sp.	1	1	0
		Anabaena sp.	7	4	6
		Merismopedia sp.	0	3	0
		Oscillatoria sp.	1	3	3
5.	Bacillariophyceae	*Melosira* sp.	0	2	0
		Diatoma sp.	2	2	8
		Synedra sp.	1	1	2
		Navicula sp.	2	1	4
6.	Euglenophyceae	*Phacus* sp.	0	2	1
		Euglena sp.	0	2	6
		Sum	65	77	128

Table 4.34: Site Wise Number of Phytoplankton and Different Diversity Indices

	Site 1	Site 2	Site 3
No. of Species	14	19	21
No. of Individuals	65	77	128
Simpson's Dominance Index	0.8951	0.8969	0.9277
Shannon's Diversity Index	2.395	2.565	2.805
Pielou's Evenness Index	0.7834	0.6846	0.7873
Margalef's Richness Index	3.114	4.144	4.122

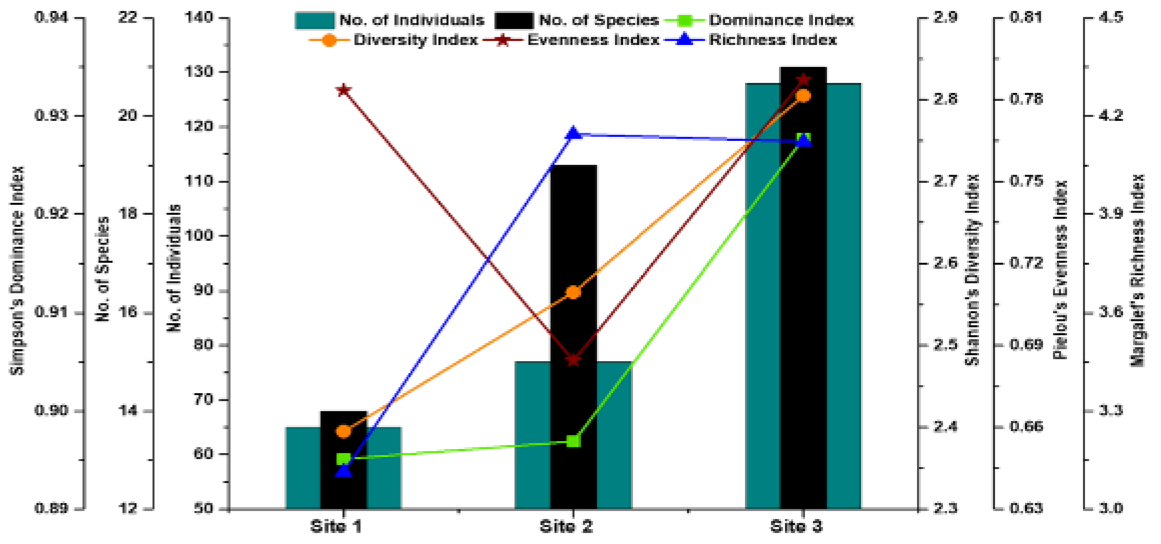


Figure 4.49: Site Wise Variations of number of individual, number of species of Phytoplankton with the changes of Diversity Indices

4.6.5.2 Zooplankton

The species distribution of the zooplankton calculated after sampling at three sites are summarized in ***Table 4.35.*** Similar to phytoplankton distribution pattern, zooplanktons were found to be most abundant in Site 3 while Site 1 had the lowest zooplankton count. *Cyclops* sp., *Nauplius* sp. were found to be predominant among Copepoda Class, while *Daphnia* sp. *was predominant* among Cladocera Class. Similarly, *Brachionus* sp. was predominant among the rotifers, while only *Cypris* sp. was recorded among Ostracod class in Site 2 and Site 3. Site wise zooplankton count and different diversity indices are given in ***Table 4.36.*** Site wise variations of number of individuals, number of species of zooplankton with the changes of diversity indices is given in ***Figure 4.50.*** The zooplankton diversity, dominance and richness were found to be highest in Site 3 followed by Site 2. Evenness index was calculated to be highest in Site 1, which indicates more even distribution of zooplankton in Site 1 than the other two sites despite lower abundance, diversity and richness of zooplankton species in Site 1.

Table 4.35: Species Wise Distribution of Zooplankton (Individual/L)

Sl No.	Class	Species	Site 1	Site 2	Site 3
1.	Copepoda	*Cyclops* sp.	8	12	21
		Nauplius sp.	14	7	15
		Diaptomus sp.	0	0	4
2.	Cladocera	*Daphnia* sp.	8	14	18
		Bosmina sp.	0	2	0
		Closterium sp.	3	6	0
		Gonatogygon sp.	0	0	4
3.	Rotifers	*Brachionus* sp.	16	24	31
		Keratella sp.	0	2	6
		Polyarthra sp.	2	0	6
		Trichocerca sp.	0	0	2
4.	Ostracoda	*Cypris* sp.	0	11	16
		Sum	51	75	119

Table 4.36: Site Wise Number of Zooplankton and Different Diversity Indices

	Site 1	Site 2	Site 3
No. of Species	6	8	10
No. of Individuals	51	75	119
Simpson's Dominance Index	0.772	0.8092	0.8434
Shannon's Diversity Index	1.593	1.827	2.026
Pielou's Evenness Index	0.82	0.7766	0.7582
Margalef's Richness Index	1.272	1.621	1.883

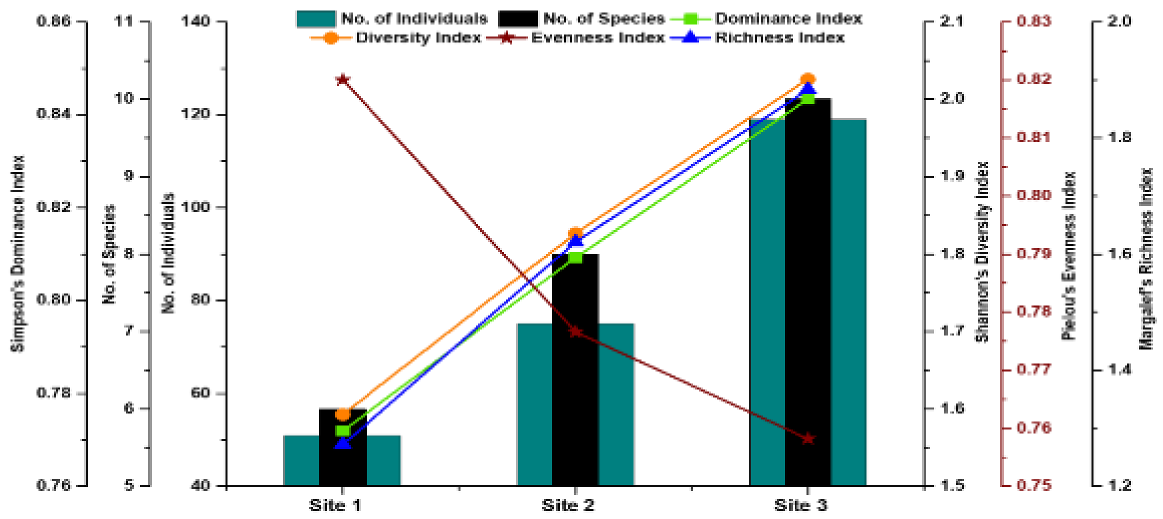


Figure 4.50: Site Wise Variations of Number of Individual, Number of Species of Zooplankton with the Changes of Diversity Indices

4.6.5.3 Benthos

Six (6) benthic gastropods and bivalve were identified in the samples collected during the survey. The species distribution of the Benthos at three sites as observed after analysis are summarized in ***Table 4.37***. More benthic samples were collected in Site 3 as compared to Site 1 & Site 2. *Bellamya* sp. and *Lamellidens jenkinsianus* were common in all three sites with *Bellamya* sp. predominating the benthic fauna. Site wise number of benthos and different diversity indices are given in Table 4.38. Site wise variations in number of individuals, number of species of benthos with the changes of diversity indices is given in ***Table 4.38***. The diversity and richness of benthic fauna were calculated to be highest in Site 3, whereas species dominance and evenness were higher in Site 1 than Site2 & Site 3.

Table 4.37: Species Wise Distribution of Benthos Organism (Individual/m^2)

	Class	Family	Species	Site 1	Site 2	Site 3
1.	Gastropoda	Planorbidae	*Indoplanorbis exustus*	15.5	0	0
2.		Viviparidae	*Bellamya* sp.	31	170.5	325.5
3.		Thiaridae	*Thiara* sp.	0	0	31
4.	Bivalvea	Solecurtidae	*Novaculina gangetica*	0	46.5	31
5.		Unionidae	*Lamellidens jenkinsianus*	31	62	46.5
6.		Unionidae	*Lamellidens marginalis*	0	31	62

Table 4.38. Site wise number of benthos and different diversity indices

	Site 1	Site 2	Site 3
No. of Species	3	4	5
No. of Individuals	77	309	495
Simpson's Dominance Index	0.64	0.625	0.5371
Shannon's Diversity Index	1.055	1.166	1.105
Pielou's Evenness Index	0.9572	0.8019	0.6038
Margalef's Richness Index	0.4604	0.5233	0.6447

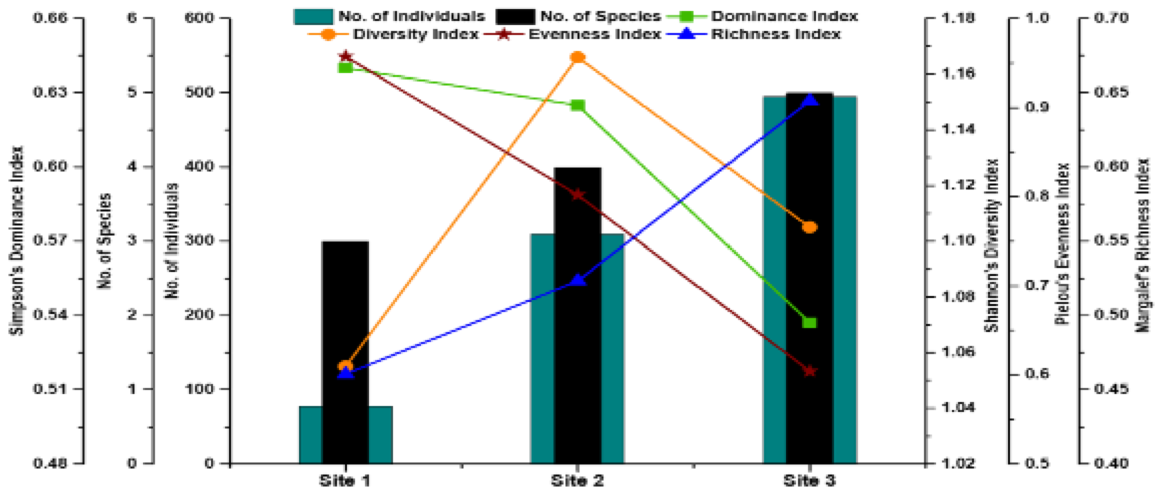


Figure 4.51: Site Wise Variations of Number of Individual, Number of Species of Benthic Fauna with The Changes of Diversity Indices

The results show low abundance of phytoplankton, zooplankton and benthos in the Meghna river which may be attributed to hot water discharge from nearby thermal power Plants, high water traffic and low nutrient content. The low abundance indicates that in this part of Meghna river the food required for good fish yield is low and this result corroborates with the present fish yield of this river within the study area.

4.6.5.4 Fish and Fisheries

Fishing time and duration and productivity

The diversity of fishes in Meghna river in Bangladesh has been recorded in different scientific studies. It was reported by local fishing community that they engage in fish catching from 5-8 km downstream of project area at Meghna river throughout the year. However, no fishing activity was observed in front of project site area at Meghna River Channel area. The list of different fishes which were reported from the Meghna river is given in Table 4.39. Fishing activity, at present, has not been reported within the project AOI in the Meghna river channel. Moreover, during consultation with fish merchant in local fish market, it was found that due to discharge of different types of industrial wastewater and hot water within the Meghna River in the area, the fishing activity has been shifted 5-8km downstream of project area in Meghna river. It is reported, the local fishermen used to catch about 1.2 – 2.4 kg fish per day per person earlier from Meghna River, but at recent times it has decreased: due to low fish yield in this area. However, during the peak period (June-August), about 2.0-4.0 kg fish per day per person could be caught at 5-8km downstream of Meghna river.

Table 4.39: Checklist of Fish found in Meghna River at Meghna Ghat area of Bangladesh (BDs).

Sl. No.	Local Name	Group Name	Order	Family	Scientific Name	IUCN Status Global	IUCN Status Bangladesh
1	Kuchia	Eels	Synbranchiformes	Synbranchidae	Monopterus cuchia	LC	VU
2	Baim	Eels		Mastacembelidae	Mastacembalus armatus	LC	EN
3	Baan	Eels	Anguilliformes	Anguillidae	Anguilla bengalensis	NT	NT
4	Pankal	Eels	Synbranchiformes	Synbranchidae	Ophisternon bengalense	LC	LC
5	Kakila	Gars	Beloniformes	Belonidae	Xenentodon cancila	LC	LC
6	Taki	Snakeheads	Channiformes	Channidae	Channa punctatus	NE	LC
7	Chela	Barbs & Minnows	Cypriniformes	Cyprinidae	Salmostoma acinaces	LC	LC
8	Darkina	Barbs & Minnows			Esomus danricus	LC	LC
9	Along	Barbs & Minnows			Megarasbora elanga	LC	EN
10	Mola	Barbs & Minnows			Amblypharyngodon mola	LC	LC
11	Sarpunti	Barbs & Minnows			Puntius sarana	LC	NT
12	Tit punti	Barbs & Minnows			Puntius ticto	LC	VU
13	Phutani punti	Barbs & Minnows			Puntius phutunio	LC	LC
14	Kalibaus	Carps			Labeo calbasu	LC	LC
15	Rui	Carps			Labeo rohita	LC	LC
16	Bata	Carps			Labeo bata	LC	LC
17	Catla	Carps			Gibelion catla	LC	LC
18	Mrigal	Carps			Cirrhinus mrigala	LC	NT
19	Boal	Catfishes	Siluriformes	Siluridae	Wallago attu	NT	VU
20	Pabda	Catfishes			Ompok bimaculatus	NT	EN
21	Shilong	Catfishes		Schilbeidae	Silonia silondia	LC	LC
22	Kajuli	Catfishes			Ailia coila	NT	LC
23	Bacha	Catfishes			Eutropiichthys vacha	LC	LC
24	Ghaura	Catfishes			Clupisoma garua	LC	EN
25	Pangas	Catfishes		Pangasidae	Pangasius pangasius	LC	EN
26	Rita	Catfishes		Bagridae	Rita rita	LC	EN
27	Air	Catfishes			Sperata aor	LC	VU

Sl. No.	Local Name	Group Name	Order	Family	Scientific Name	IUCN Status Global	IUCN Status Bangladesh
28	Tengra	Catfishes			Mystus vittatus	LC	LC
29	Gang tengra	Catfishes		Sisoridae	Nangra nangra	LC	LC
30	Gang tengra	Catfishes			Gagata youssoufi	NE	NT
31	Gang tengra	Catfishes			Gogangra laevis	DD	DD
32	Baghair	Catfishes			Bagarius Bagarius	NT	CR
33	Ilish	Clupeids	Clupeiformes	Clupeidae	Tenualosa ilisha	LC	LC
34	Chapila	Clupeids			Gudusia chapra	LC	VU
35	Kachki	Clupeids			Corica soborna	LC	LC
36	Chaukka	Clupeids		Pristigasteridae	Ilisha megaloptera	NE	LC
37	Olua	Anchovies		Engraulidae	Coilia dussumieri	NE	LC
38	Phasa	Anchovies			Setipinna phasa	LC	LC
39	Foli	Feather backs	Osteoglossiformes	Notopteridae	Notopterus notopterus	LC	VU
40	Chitol	Feather backs			Chitala chitala	NT	EN
41	Tailla	Threadfins	Perciformes	Polynemidae	Eleutheronema tetradactylum	NE	NE
42	Koi	Perches		Anabantidae	Anabas testudineus	DD	LC
43	Chanda	Perches		Ambassidae	Pseudambassis baculis	LC	NT
44	Chewa	Mudskippers		Gobiidae	Pseudapocryptes elongatus	LC	LC
45	Baila	Mudskippers			Awaous guamensis	LC	LC
46	Bele	Mudskippers			Awaous grammepomus	LC	VU
47	Bele	Mudskippers			Glossogobius giuris	LC	LC
48	Chewa	Mudskippers			Taenioides cirratus	DD	LC
49	Poa	Croakers		Sciaenidae	Otolithoides pama	NE	LC

IUCN Status code: CR-Critically Endangered, EN-Endangered, VU-Vulnerable, NT-Near Threatened, LC-Least Concern, DD-Data Deficient, NE-Not Evaluate

Fish and fisheries items of inland water in Bangladesh, still are caught by using traditional crafts and gear. Depending on types of water body, depth of water and availability of target species to the caught, the fishermen selected their fishing gears. The main categories of traditionally used fishing gears of fishermen community of Meghnaghat area as the following: fishing nets, fishing traps and wounding gears. To make these fishing gears several types of materials like steel wire ropes, twine, plastic structural and fasteners, clips and swivels, purse rings, polyester, polyethylene, nylon, cotton, polypropylene, mixed fibres, floats and sinkers, bamboo, wood are used. The types and description of different types of fishing gears are described below:

Table 4.40: Types of fishing gear used in the Meghna River

Types	Name of gears	Description
Fishing Nets	Moi jal	Mesh size 2-5cm having a length of 2 to 3m. By using boat and a long thread this type pf net is operated in the bottom of the river. The net is mainly used to catch prawn.
	Khara jal	Mesh size is 0.5-2 cm, 5 to 7m long and front side 2.5-3.5m wide. It is a triangular shape net with two bamboos attachment at an angle of 35º. Small size fish like Pangus, Poa, Tengra, Bele, Shoal, Punti, Koi, and Prawn are caught by the net.
	Thela jal	Mesh size 0.2-1cm, triangular shaped with an extended handle of two bamboo poles, fixed at an angle of 30º. By using boat and a long thread this type pf net is operated in the bottom of the river. The net is mainly used small size fish like Koi, Chewa and Prawn
	Ber jal	Mesh size 0.5-2.3cm, 50 to 200 m long and 5 to 6m wide. This net mainly used to catch almost all types of fishes.
	Dharma jal	The mesh size of the net is 0.5 to 2 cm. The shape of net is square, fitted with two bamboo strips in cross-bars and with four corners of the net it is connected. The main species caught by the net are Bele, Shoal, Punti, Koi, Baim etc.
	Khapla jal	The mesh size of the net is 0.625 to 1.25 cm, 3 to 6m long, to 12m in diameter, conical shaped net. The main species caught by the net are Bata, Chela, Baim, Koi etc.
	Behundi jal	The mesh size at the mouth is 5-6.25cm and at the end pouch is 0.5-1.25 cm, length is 12-15m and width is 11-12m. Bata, Kuchia, Koi, Chewa, Poa etc. are mainly caught by this net.
	Gosi jal	Mesh size 0.2-1cm, usually 0.5-1.0 km long and 1-2m wide. Bamboo poles are staked in the river bed soil and the net is placed at the bottom of the pole to catch small fish and Hilsha.
	Jagat ber jal	Mesh size ranges between 0.5-2.3 cm, 50-200m long and 5-6m wide. The ground rope is hauled up from the centre and two ends of the net are drawn together to catch fish like pangash, poa, hilsha.
	Bata jal	Mesh size differs from 2.5-5cm, length 6.5-33m and width 1.25-2m, rectangular shaped. Main species trapped in the net are Bata, Chewa and Poa.
	Fash jal	Rectangular shaped with mesh size 4.5-15.0cm, length 20-200m and width is 1m. The net is fixed in the water with two bamboo poles for catch fish like Pangas, Poa, Hilsa, Bata, Air.
	Poa jal	The mesh size is 3.5cm, length 60-70m, width 3.6-4.5m. The net is rectangular in shape. Hilsa, Poa and Bata are the main species caught by net.
Fishing Traps	Vair	The height varies from 1-1.2m with a length of 0.5-1m and width 0.5-0.85m. It is a long box like trap with a door extending from its base, made of by bamboo sticks and the gap between two bamboo sticks is 1-4cm. Rui, Catla, Carpio, Boal, Shoal, Baim etc.
	Kholsum	It is a rectangular box shaped fish trap. This trap is made of by split bamboo. Height of the trap is 0.75-1m, length 1-1.25m and width 0.3 to 0.5m and the gap between two bamboo sticks is 0.5-1cm. In this trap small fish like Punti, Tengra, Baim, Koi, Katchki, Mola, and small prawn are trapped
	Bitte	Bitte is a basket shaped fishing trap, made of split bamboo. with two or three entrances and an opening on the trap for collecting fish. Height of the trap is 0.25-0.5m, length 0.25-1 m and width 0.1-0.5m and the gap between two bamboo sticks is 0.5-1cm. Baim, Koi, Punti, Tengra, small prawn etc. are caught by this trap.
Wounding gear	Borshi	It is a very simple barbed hook tied with one end of a line and the other end with a bamboo stick. Kalibaus, Koi, Shingi, Punti, Rita, Tengra are caught by this Borshi. Apsrt from that tana borshi, zomka borshi are also used.
	Konch	More than 10 pieces of bamboo splits with pointed ends are firmly fixed in a bunch. Fish caught by this gear are Rui, Catla, Shoal, chana etc.
	Borsha	Made up of narrow small portion of dried bamboo It is used to catch Koi, Punti, Tengra and some other small fish.

Hilsha spawning ground, nursery ground and Impacts on fish breeding habitats

From the economic point of view, the main migratory fish of Bangladesh is Hilsha (*Tenualosa ilisha*). The major spawning season of Hilsha is September-October and a minor spawning season is February-March. According to Halder and Islam (2008), four main spawning ground of adult brood Hilsa is located in Bangladesh[17]. These are Dhalerchar of Charfashion in Bhola (about 125 sq. km area); Moulavichar of Hatia in Noakhali (about 120 sq. km

[17] Halder, G. C. and Islam, M. R. 2008. Ilish Mach Sangrakhan abang Unnoun Babashthapona koushal (In Bengali) (Hilsa Fisheries Conservation, Development and Management Technique), Department of Fisheries (DoF), Dhaka, Bangladesh. pp. 1-40.

area); Kalirchar of Sandwip (about 194 sq. km area); Monpura in Bhola (about 80 sq. km area) and all are in coastal and estuary areas of Bangladesh.

- The proposed project sites do not fall under the above-mentioned spawning grounds of Hilsha.

Nursery grounds: After hatching, the “Jatka” (fish sized less than 25 cm) grows for 6-10 weeks before going back to the sea. Five nursery grounds have been identified in Bangladesh[18] and they are – i) Shatnol of Chandpur to Char Alexander of Laxmipur, ii) Bheduria of Bhola to char Rustom of Patuakhali, iii) Madanpur / char Ilisha to char Pial of Bhola district, iv) Narhira to Bhedarganj of Shariatpur district and v) Andharmanik River route at Kalapara upazilla of Patuakhali district. For conservation of Jatka, all these nursery grounds have been declared as sanctuary.

- The proposed project site does not fall under the above-mentioned nursery grounds of Hilsha. The nearby nursery ground is Shatnol of Chandpur, which is 17km downstream of Meghna River from the proposed project site.

A checklist of the Fishes found in Meghna River at Meghna Ghat area of Bangladesh (BD) is given in Table 4.39. Though As per IUCN Bangladesh status 2015 one Critically Endangered, seven Endangered and seven Vulnerable species have reported range, however, considering global status of IUCN 2020-2, only six fish species belong to Near Threatened and no Critically Endangered, Endangered and Vulnerable species were recorded from the study sites. Different carps (Kalibaus, Rui, Bata, Catla, Mrigal), Hilsha (Ilish), cat fishes (Air, Tangra, Bagahir, Bacha, Kajuli, Boal), mudskippers (Baila, Bele), parch (Koi), Barbs & Minnows (Sarputi, Mola) are found to be very common in Meghna Ghat area.

[18] *DoF. 2013. Jatka Conservation Week, Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh*

Figure 4.52. Pictures of aquatic ecology survey

Figure 4.53. Pictures of fishes found in Meghna river

**These pictures have taken from Meghnaghat Bazar. After consulting with fisherman, it has been confirmed that all the fishes were captured in 5-8km downstream of the Meghna River from the project site.*

4.6.6 Protected Areas

The AoI does not site any protected areas as per Bangladesh regulations and international conventions. The project site and AoI does not site any areas identified as Critical habitats, including those areas either legally protected or officially proposed for protection, such as areas that meet the criteria of the World Conservation Union classification, the Ramsar List of Wetlands of International Importance, and the United Nations Educational, Scientific, and Cultural Organization's world natural heritage sites, Alliance for Zero Extinction (AZE) sites.

Nearest protected area is Bhawal National Park located at the North-Western side of the project area at 53.5 km aerial distance from the project site. The protected areas of Bangladesh are shown in ***Figure 4.54.*** The nearby nursery ground is in Shatnol of Chandpur, which is 17 km downstream of the proposed project site.

Nearest Important Bird Area (IBA) Rema-Kalenga Wildlife Sanctuary and Jamuna Brahmaputra River area are located at aerial distances of 122 km and 136 km respectively from the project area. The IBA's of Bangladesh is presented in Figure 4.55. Bangladesh falls under East Asian–Australasian Migratory Flyway. However, no migratory birds were observed during the primary survey. This was further corroborated from information available from consultations with local people and review of secondary reports, articles on the presence of migratory birds in around the project area. Apart from that, no Gharial, Dolphin and Otter habitats are located in and around 25km radius of the Project Area. It may be noted that during primary survey, no Gharials, Dolphins and Otter were spotted and the same was also confirmed at the time of consultations with local people. The Gharial, Dolphin and Otter habitat map is presented in ***Figure 4.54.***

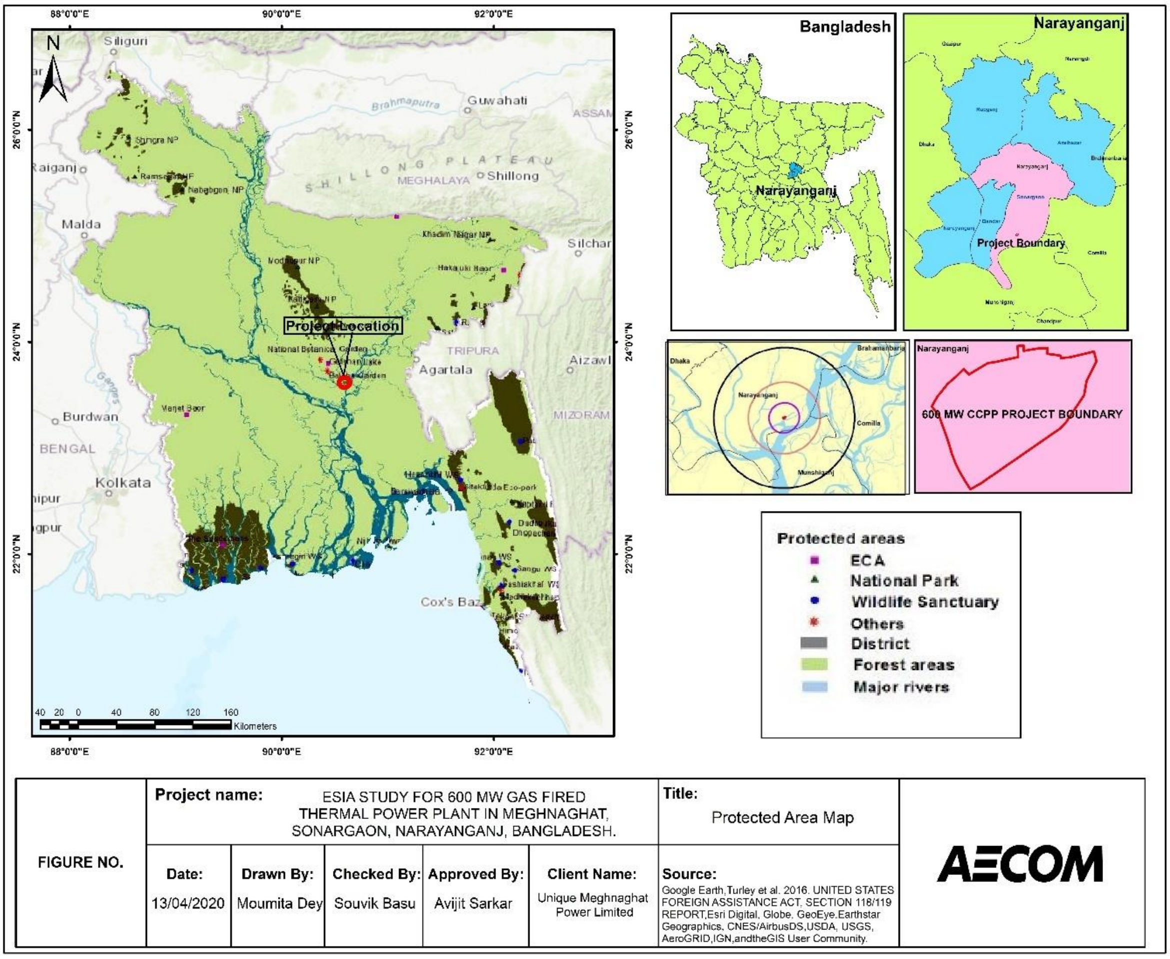


Figure 4.54. Protected area Map of Bangladesh

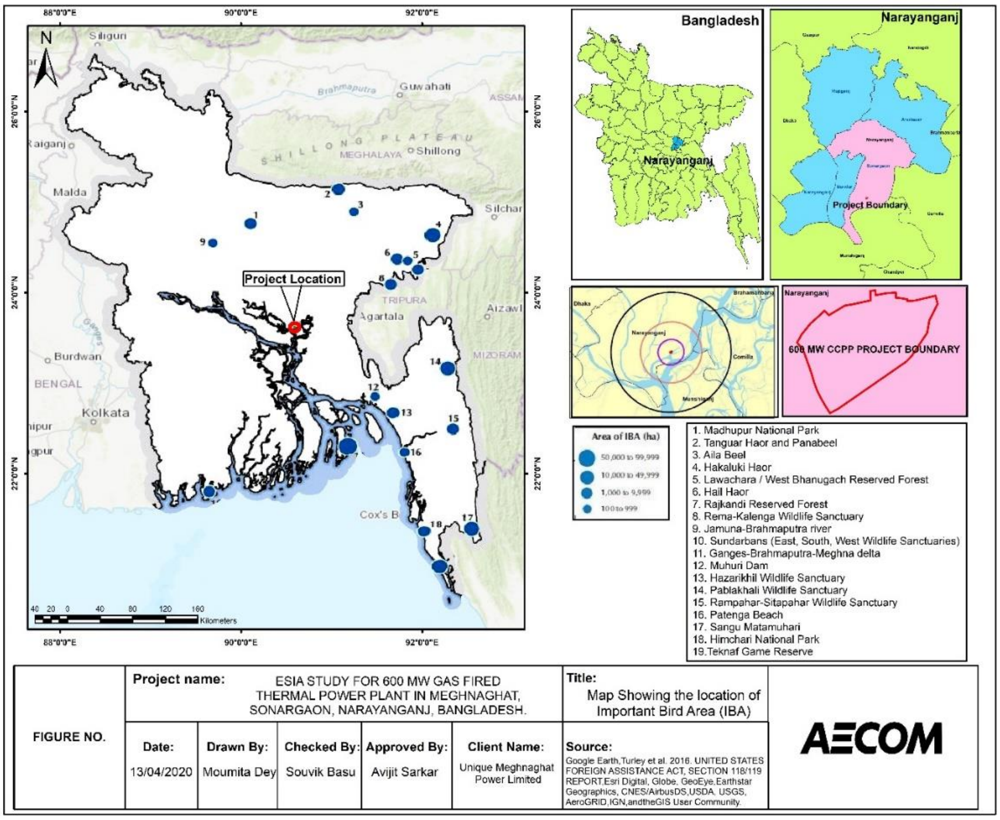


Figure 4.55: The Important Bird Areas (IBA's) of Bangladesh

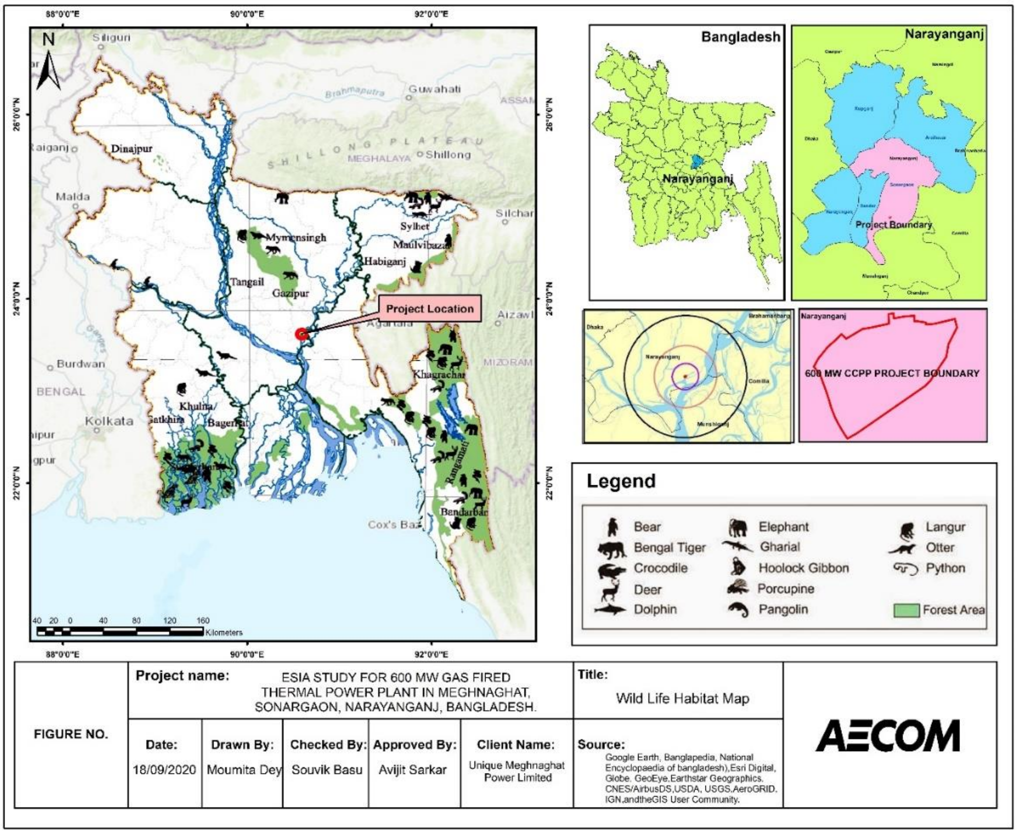


Figure 4.56. The Gharial, Dolphin and Otter habitat map of Bangladesh

4.6.7 Habitat Profile of the Study Area and Screening of Critical Habitat Assessment

Habitats are classifiable into natural habitat, modified habitat and critical habitat. Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified the area's primary ecological functions and species composition.

Modified habitats are areas that contain a considerably large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified the area's primary ecological functions and species composition. Modified habitats may include areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands. Definition of the modified habitat also includes significant biodiversity value, as determined by the risks and impacts identification process required in Performance Standard 1. UMPL would minimize impacts on such biodiversity and implement mitigation measures as appropriate.

Critical habitat (as per IFC PS 6, 2012) are the areas with high biodiversity value, including (i.) habitat of significant importance to Critically Endangered and/or Endangered species; (ii.) habitat of significant importance to endemic and/or restricted-range species; (iii.) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv.) highly threatened and/or unique ecosystems; and/or (v.) areas associated with key evolutionary processes.

To assess critical habitat criteria, as defined in IFC's Performance Standard (PS) 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources (IFC, 2012a) and the associated guidance note (IFC, 2012b), habitat identification and the screening of Critical habitats has been carried out in the following **Table 4.41** and **Table 4.42** respectively.

Table 4.41. Habitat Identification as per IFC 2012 PS 6

Land Use Class.	Characteristics	Habitat Type	Justification
Homestead Plantation	Out of 100 terrestrial floral species 38 species were recorded from homestead plantation. Villagers of surrounding the project area planted different kind of tree around their house for food, fodder and fuel wood. Common planted tree species were Aam (*Mangifera indica*), Arjun (*Terminalia arjuna*), Supari (*Areca catechu*), Narikel (*Cocos nucifera*) and Bans (*Bambusa* sp.) and common planted shrubs were Lebu (*Citrus aurantifolia*), Pepe (*Carica papaya*), Togor (*Tabernaemontana divaricata*) and herbs were Kalomegh (*Andrographis paniculate*), Notesak (*Amaranthus viridis*).	Modified	All trees/ shrubs / herbs planted are for domestic use purpose like fuel wood, timer, fodder, food and no succession have been observed and human planted habitat cannot be considered as a Natural Habitat
Roadside Plantation	10 planted species were observed as roadside plantation. In case of roadside plantation only tree species were planted, and the commonly planted trees were Akashmoni (*Acacia moniliformis*), Neem (*Azadirachta indica*), Sissu (*Dalbergia sissoo*), Krishnachura (*Delonix regia*) and Debdaru (*Polyalthia penduriformis*).	Modified	All trees are mainly used for roadside shed tree and timber. The habitat planted by human cannot be considered as a Natural Habitat
Agricultural Land	Total 52 plants were recorded from agricultural land. Paddy (*Oryza sativa*) being the main agricultural crop in the AoI is the largest habitat available along with some seasonal vegetables like Lau (*Lagenaria siceraria*), Tomato (*Solanum lycopersicum*), Begun (*Solanum melongena*), Sim (*Lablab purpureus*), Jingha (*Luffa cylindrica*), Corola (*Momordica charantia*) etc. Common planted plants in and around the agricultural land were Dumur (*Ficus hispida*), Khejur (*Phoenix sylvestris*), Boutasak (*Chenopodium album*), Sarnalata (*Cuscuta reflexa*) are very common. The common weed occurring in the agricultural lands are *Cynodon dactylon*, *Chloris barbata*, *Rumex dentate*, *Axonopus compressus*, *Saccharum spontaneum* etc.	Modified	Due to relatively minimal succession in agricultural land, components of agricultural lands cannot be considered Natural Habitat.
Riverine Habitat	Meghna River and its Channel area is the riverine habitat in the study area. Different aquatic and semi aquatic vegetation were found in the Meghna River and bank of the river. The naturally growing riverine vegetation is predominantly with *Eichhornia crassipes*, *Salvina cucullate*, *Colocasia esculenta*, *Mersilea quadrifoliate*, and *Phragmites karka*.	Natural	The Meghna river and its channel is confined mostly within natural banks and minimum alteration has been done. Also, aquatic vegetation and aquatic faunal components are naturally growing without any human intervention.

Table 4.42. Screening of Critical Habitat as per IFC PS6 (2012) and PS6 Guidance Note (2019)

Sr No.	Criterion	Observations
1	Critically endangered (CR)and/or Endangered (EN) species	No Critically Endangered and/or Endangered* species were recorded as per IUCN Red List global status. As per IUCN Bangladesh status, one fish species Baghair (*Bagarius Bagarius*) is Critically Endangered, but as per IUCN global status it is Near Threatened. Based on community consultations, the species were listed, and no secondary reports is available regarding the presence of this fish species in AoI of the project area. Also, no direct records of this fish were observed during primary survey. Also, as per IUCN Bangladesh status, seven fish species are Endangered, but among them Pabda (*Ompok bimaculatus*) and Chitol (*Chitala chitala*) are Near Threatened as per IUCN Global status. Based on community consultations, the species were listed, and no direct records of these fishes were available during primary survey in the AoI and nearby Meghnaghat Fish Market. Rest five endangered fish species i.e. Baim (*Mastacembalus armatus*), Along (*Megarasbora elanga*), Ghaura (*Clupisoma garua*), Pangas (*Pangasius pangasius*) and Rita (*Rita rita*) are Least Concern as per IUCN global status. As per the IUCN distribution map, all the seven fishes have wide distribution across Bangladesh[11].Moreover, as per IUCN Bangladesh status seven fish species are Vulnerable, but as per Global Status one is NT and six are LC. Therefore, the fishes could be potential triggers for the Meghna River Channel part of the Project Site to qualify as a Critical Habitat. However, owing to a significant lack of data on these fish populations specific to the Study Area, a dedicated assessment is recommended to ascertain the CH status.
2	Criterion 2: Habitat of significant importance to endemic and/or restricted-range species	No endemic and/or restricted-range species recorded
3	Criterion 3: Habitat supporting globally significant concentrations of migratory species and/or congregatory species	Bangladesh falls under Central Asian Fly way and East Asian–Australasian Migratory Flyway. However, during the site survey and from other secondary information sources no migratory species or congregatory species were found.
4	Criterion 4: Highly threatened and/or unique ecosystems	No threatened, Biome restricted, rare species observed in this area. Also, due to project activity no highly potential significant risk is envisaged for which the quality of area would decrease.
5	Criterion 5: Areas associated with key evolutionary processes	1. No isolated areas were observed with populations that are phylogenetically distinct. 2. High endemism of floral and faunal species were not observed, 3. No such landscapes was found which have high spatial heterogeneity, 4. Specific juxtapositions of soil types were not found, 5.No such biological corridors which ensure species migration and gene flow and help in conservation of metapopulation were observed.

IUCN Status code: CR-Critically Endangered, EN-Endangered, VU-Vulnerable, NT-Near Threatened, LC-Least Concern, DD-Data Deficient, NE-Not Evaluated

** As listed on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. The determination of critical habitat based on other listings is as follows: (i) If the species is listed nationally / regionally as critically endangered or endangered, in countries that have adhered to IUCN guidance, the critical habitat determination would be made on a project by project basis in consultation with competent professionals; and (ii) in instances where nationally or regionally listed species' categorizations do not correspond well to those of the IUCN (e.g., some countries more generally list species as "protected" or "restricted"), an assessment would be conducted to determine the rationale and purpose of the listing. In this case, the critical habitat determination would be based on such an assessment.*

Therefore, no designated protected area, Ramsar Wetlands, Important Birds Area are present within the 10km of the project area. The project site does not fall under any spawning grounds and nursery grounds of Hilsha. As per criteria for critical habitats defined in IFC PS6 (2012) and Guidance Notes (GN6) (IFC, 2019), and based on the screening of the critical habitat assessment, critical habitat assessment has been carried out for the project area as reported ranges of Critically endangered (CR), Endangered (EN) and Vulnerable spices has been found within the AoI and presented in **Appendix V.**

A critical habitat assessment has been carried out for the project. As per the assessment, a total of eighteen (18) species were assessed under Criterion 1. The study area and the distributed species within the study area do not qualify as a CH Criterion 2 to 5. Also, no part of the project area falls under any IUCN categorized Ia, Ib and II protected area, nationally/internationally recognized Key Biodiversity areas and Ecologically Sensitive Zone.

The eighteen (18) species were reported from the study area as potential CH trigger species comprising one (01) CR, seven (07) EN and ten (10) VU species as per IUCN Bangladesh status, however, as per IUCN global status only two (02) vulnerable species (Python bivittatus, Wallago attu) trigger CH and rest sixteen (16) species do not trigger CH criterion as their global IUCN status is Near Threatened and Least Concern.

Based on the assessment as per IFC (PS6) and its Guidance Note (2019), none of the species hold the threshold limit of Criterion 1 in the study area. The study area also does not qualify as a CH Criterion 2 to 5 and does not fully or partially overlap with any internationally and/or nationally designated area.

Thus, it has been concluded that the proposed 600 MW RLNG based Combined Cycle Power Plant (CCPP) Project area and the study area, is not a Critical Habitat for any of the identified species, because the study area does not meet any of the IFC(PS6), 2012 and its Guidance Note (2019) criteria during the critical habitat assessment study. Hence, the Project area does not qualify for critical habitat areas and doesn't need to institute a Biodiversity Action Plan

4.7 Socio-economic Profile

This section provides an understanding of the administrative set up of the district, the demographic profile of the villages in the project area, the social groups present, the vulnerable groups identified, the livelihood profile of the community, the land use patterns in the area, the social and physical infrastructure available in terms of the education and health infrastructure, sanitation facilities and connectivity. It is based on the secondary information available on the state, district and block level as well as the primary consultations undertaken in the study area by AECOM during the site visit. Due to the nature of the study area, the following discussion would be concentrated on the study area with comparisons being drawn to the block and district where appropriate.

4.7.1 Methodology

The socio-economic baseline has been developed on the basis of integrating existing quantitative data with some additional qualitative assessments that were undertaken through primary data collection. In particular, the key components of the methodology included:

Survey of Landowner: Socio Economic survey was carried out among 333 landowners (approximately 97%) out of 343 landowners, including 7 residential structure owner whose land/residential structure had been purchased. Rest of the 10 landowners were not found in the site during survey. The survey was carried out to understand socio economic condition of the landowners, land purchase process, any agitation during land purchase and disbursement of land price. Socio Economic Survey was conducted in July 2020 by the social expert of EQMS (local partner). AECOM social expert has virtually supervised the entire survey. AECOM social expert was unable to be present at the site due to restrictions imposed on international travel for COVID-19 pandemic. Photographs taken during the socio-economic survey is presented below.

Figure 4.57: Survey of landowner

Survey of Land Dependent: Two types of land dependency identified during the assessment are dependency on land taken on lease at the project site for agriculture and dependency on land used for approaching the river front for fishing and anchoring their fishing boat. Apart from that, there were people practising agriculture on the land which were taken by UMPL on lease from Hamdard Laboratory and were filled up by sand. Total 18 land dependents and 60 fishermen have been identified during survey with the help of UMPL, local community and landowners. Socio economic survey was also carried out among these 78 Project Affected People (PAP) to understand their dependency on the land and impact on their livelihood.

Key Informant Interview: Meetings with key informants like Union Chairman, land aggregator, Sub Register Sonargaon Upazila, Deed writer Union of Sub Register Office of Badiyer Bazar were undertaken to assess the actual land price, land price negotiation process, land registration process, any agitation at community level during the land purchase.

Meeting with Land Aggregator and Member of Pirojpur Union Parisad

Meeting with Land Deed Writer Union of Sub registry office Badiyer Bazar

Meeting with Pirojpur Union Chairman

Figure 4.58: Key informant interview

Focus Group Discussion and Community Consultation: Focus group discussion was also carried out with landowners, Purbapara Jame Masjid Committee, Madhya Para Jame Masjid Committee, Dudhghata Primary School, land dependents, farmer groups, river water users, woman groups, fishermen group and youth groups to understand the socio- economic condition of the study area. Photographs of FGD and Community Consultation is presented below. Transcript and attendance sheet of the FGD is attached in the **Appendix M.**

FGD With Fisherman Group

FGD with Land Dependent and Farmers

FGD with Landowner and Masjid Committee

FGD with Women Folks and River Water User


FGD with Youth Group

Meeting with Dudhghata School Teacher

Meeting with Purbapara Jame Masjid Committee

Meeting with Madhyapara Jame Masjid Committee and Landowners

Figure 4.59. Photographs of social survey

4.7.2 Area of Influence

The proposed Project site is located in Dudhgahta Mouza of Pirojpur Union of Sonargaon Upazila, Narayanganj District. The social baseline has been assessed covering a distance of up to 5 km from project boundary designated as the Area of Influence. This entire area of influence is subdivided into core area and buffer area. The social baseline has been assessed covering Dudhghata Mouza designated as the core area and remaining part of the AOI outside the core area as the buffer area.

The core area is defined as the area in which the proposed power plant would be constructed and this has been considered as core area based on the understanding that magnitude of impact in this Influence area is likely to be more visible than the remaining portion of study area, particularly in terms of likely impact caused by land procurement process, impact on livelihood, environmental impact like noise generation, air emission. The study area includes total 12 unions in two districts (Narayanganj district and Munshiganj districts of Bangladesh). List of unions is presented in in the ***Table 4.43***.

Table 4.43: Upazilas & Unions within the Study Area

District	Upazila	Mouza/Union
Core Area		
Narayanganj	Sonargaon	Dudhghata Mouza
Buffer Area		
Narayanganj	Bandar	Bandar
		Kalagachhia Union
		Musapur
	Sonargaon	Baidyer Bazar
		Mugra Para
		Pirojpur
		Sanmandi
		Shambhupura
		Sonargaon Paurashava
Munshiganj	Gazaria	Baluakandi
		Hossaindi
		Tenger Char

4.7.3 Administrative Structure

Narayanganj District

The total area of the district is 684.37 sq. km. (264.23 sq. miles). It lies between 23°33' and 23°57' north latitudes and between 90°26' and 90°45'east longitudes. Narayanganj district is bounded on the north by Gazipur district and Narsingdi district, east by the river Meghna, Brahmanbaria district and Comilla district, south by the river

Dhaleshwari, Munshiganj district and west by Dhaka District. District consists of 5 upazilas, 41 unions, 680 populated mauzas, 1204 villages, 6 paurashavas, 54 wards and 282 mahallas. The name of the upazilas are Araihazar, Bandar, Narayanganj Sadar, Rupganj and Sonargaon.

Sonargaon Upazila

The upazila occupies an area of 171.67 sq. km. It is located between 23°32' and 23°46' north latitudes and between 90°31' and 90°41' east longitudes. This upazila is bounded on the north by Rupganj Upazila and Araihazar Upazila, east by the river Meghna, Homna Upazila of Comilla district and Araihazar Upazila, south by Munshiganj Sadar Upazila and Gazaria Upazila of Munshiganj district and west by Bandar Upazila, Narayanganj Sadar Upazila and Rupganj Upazila.

Munshiganj District

The total area of Munshiganj district is 1004.29 sq.km. (387.75 Sq. Miles). This district lies between 23°23' and 23°38' north latitude and between 90°10' and 90°43' east longitudes. The district is bounded on the north by Dhaka district and Narayanganj district, east by Comilla district and Chandpur district, south by Sharipur district and Madaripur district and west by Dhaka district and Faridpur district. District consists of 6 upazilas 67 unions 615 populated mouzas, 919 villages, 2 paurashavas, 18 wards and 73 mahallas. the name of the upazilas are Gazaria, Lohajanj, Mounshiganj Sadar, Tongibari, Serajdikhan and Sreenagar.

Gazaria Upazila

The Upazilas occupies an area 131.00 sq. km. It is located between 23°29' and 23°37' north latitude and between 90°34' and 90°43' east longitudes. This upazila is bounded on the north by river Meghna, Badar Upazilas of Narayanganj district and Meghna Upazilas of Comilla district, east by Meghna Upazila and daudkandi Upazila of Comilla district, south by river Meghna and Matlab Uttar Upazila of Chandpur district and west by the river Meghna and Munishiganj Sadar Upazila.

4.7.4 Demography of the Project area

As per the Census of Bangladesh (2011), the total population of Narayanganj and Munshiganj district is estimated at 2948217 comprising 675652 households and 1445660 comprising of 313258 household respectively. The average annual increase in population in Narayanganj and Munshiganj since 2001 has been estimated at 3.05%and 1.10% respectively. The following ***Table* 4.44** provides an overview on the population trends of Narayanganj and Munshiganj district over a period of 10 years from 2001 to 2011.

Table 4.44. Population trends of Districts

Index	Population Details of Narayanganj District		Population Details of Munishiganj District	
	2011	**2001**	**2011**	**2001**
Total Households	675652	453627	313258	250850
Total Population	2948217	2173948	1445660	1293972
Annual rate of Growth over period of 10 years (%)	3.05	2.16	1.10	0.85
Average Household (HH) size	4.34/	4.76	4.55	5.13

Source: *Population and Housing Census 2011, Bangladesh Bureau of Statistics (BBS), 2011*

Project site is located in Sonargaon upazila. The population of Sonargaon upazila is estimated at 400358 as per the 2011 census and constitutes approximately 13.57% of the total population of Narayanganj District. Total Population of the Gazaria upazila which is also located in the area of influence is 34994. The population density of Sonargaon and Gazaria Upazila is 2332 persons and 1206 per square kilometre respectively. The following ***Table 4.45*** accounts for the key demographic indicators of Sonargaon upazila.

Table 4.45. Population trends of Sonargaon Upazila

Upazila	Index	2011	2001
Sonargaon	Total Households	89565	60805
	Total Population	400358	305562

Upazila	Index	2011	2001
	Population Density	2332	1780
	Sex Ratio[19]	104	109
	Annual rate of Growth over period of 10 years (%)	2.70	1.55
	Average Household Size	4.43	4.98
Gazaria	Total Households	34994	26651
	Total Population	157988	138108
	Population Density	1206	1055
	Sex Ratio[20]	99	102
	Annual rate of Growth over period of 10 years (%)	1.33	0.73
	Average Household Size	4.50	5.16

Source: Population and Housing Census 2011, Bangladesh Bureau of Statistics (BBS), 2011

Demography of the Core Area

Dudhghata Mouza consists of three villages e.g. Dudhghata, Chanderchak and Korbanpur. Total population of Dudhghata Mouza is 4009, residing in 887 household as per Census 2011. Total male female population is 2095 and 1914 respectively. Sex ratio of the Dudhgahta Mouza is 91 per 100 male population which is lower than sex ratio of Pirojpur union. Population details of the Dudhghata Mouza is presented in ***Table 4.46.***

Table 4.46. Demographic Profile of the Dudhghata Mouza

Index	Dudhghata Village	Kurbanpur Village	Chanderchak Village	Dudhgahta Mouja Total
Population	2642	1088	279	4009
Household	597	232	58	887
Household Size	4.7	4.4	4.8	4.5
Male Population	1396	549	160	2095
Female Population	1246	539	119	1914
Sex Ratio	89	98	74	91

Source: Population and Housing Census 2011, Bangladesh Bureau of Statistics (BBS), 2011

Demography of the Landowner

Out of total 343 landowners and 7 residential structure owners, total 333 households (252 households from Dudhghata, 67 households from Kurbanpur and 14 households from Chanderchak) were surveyed. Rest of landowners were not found during the survey. Total population of the surveyed household is 1357. Average household size is 4.58 which is less than the Dudhghata Mouza. Out of 1357, male population is 733 which is 54.01% of total population and female population is 624 which is 45.98% of total population. Sex ratio 85, which is less than the sex ratio of Dudhgahta Mouza.

Demography of the Land Dependent and Fisherman

Total 78 including 60 fishermen from Dudhghata and 18 land dependent household from Dudhghata village were surveyed. Total population of the surveyed household is 331.Average household size is 4.24 which is less than the Dudhghata Mouza. Out of 331, male population is 182 which is 54.98% of total population and female population is 149 which is 45.01% of total population. Sex ratio 82 which is less than the sex ratio of Dudhghata Mouza.

Demography of the Buffer Area

According to the Population and Housing Census (2011), about 79,950 households (HHs) with a total population of 3,55,694 are the receptors of the proposed project within the buffer area. The average sex ratio is 104 against the national figure of 100. Moreover, average household size (4.4) of the study area is equal to national figure. Table 4.47 shows the demography profile of Study area.

[19] *Sex ratio per hundred male/female*
[20] *Sex ratio per hundred male/female*

Table 4.47. Demographic Profile of the Buffer Area

Upazila	Union	Total HHs	Total Pop	Avg. HH size	Sex Ratio
Bandar	Bandar	7326	29578	4	102
	Kalagachhia Union	9877	43556	4.4	98
	Musapur	5918	25933	4.4	103
Sonargaon	Baidyer Bazar	4802	23035	4.8	102
	Mugra Para	7736	33506	4.3	107
	Pirojpur	9917	45440	4.5	119
	Sanmandi	8403	38029	4.5	99
	Shambhupura	5967	26646	4.5	96
	Sonargaon Paurashava	7289	32796	4.4	105
Gazaria	Baluakandi	3855	17440	4.5	98
	Hossaindi	5246	24680	4.7	113
	Tenger Char	3614	15055	4.2	104
	Total	**79950**	**355694**		

Source: Population and Housing Census 2011, Bangladesh Bureau of Statistics (BBS), 2011

4.7.5 Age Wise Distribution of Area of Influence

The census of Bangladesh divides the population age groups into ten (10) categories which constitutes of those below the age of 4, between 5 and 9, 10 to 14, 15 to 19, 20 to 24, 25 to 29, 30 to 49, 50 to 59, 60 to 64 and those above the age of 64 respectively. The following figure highlights the comparative trend in the age-wise population distribution between buffer area, core area and surveyed population.

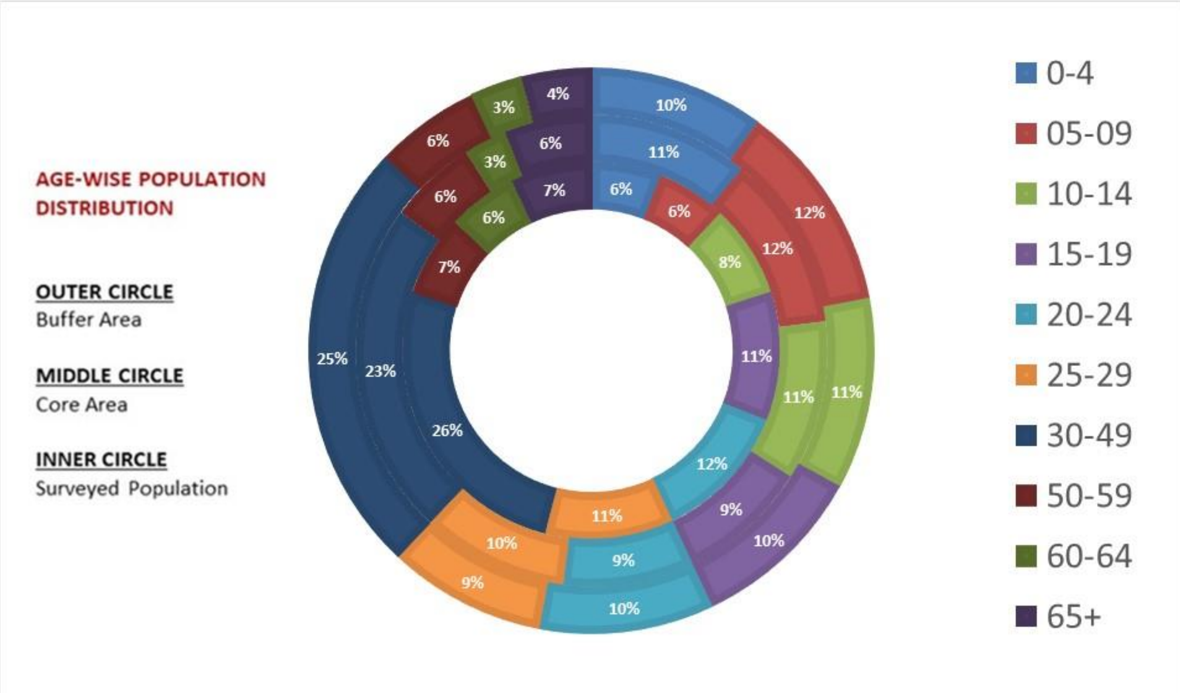


Figure 4.60. Comparison of age-wise population distribution within Core area, Buffer Area and Surveyed Population

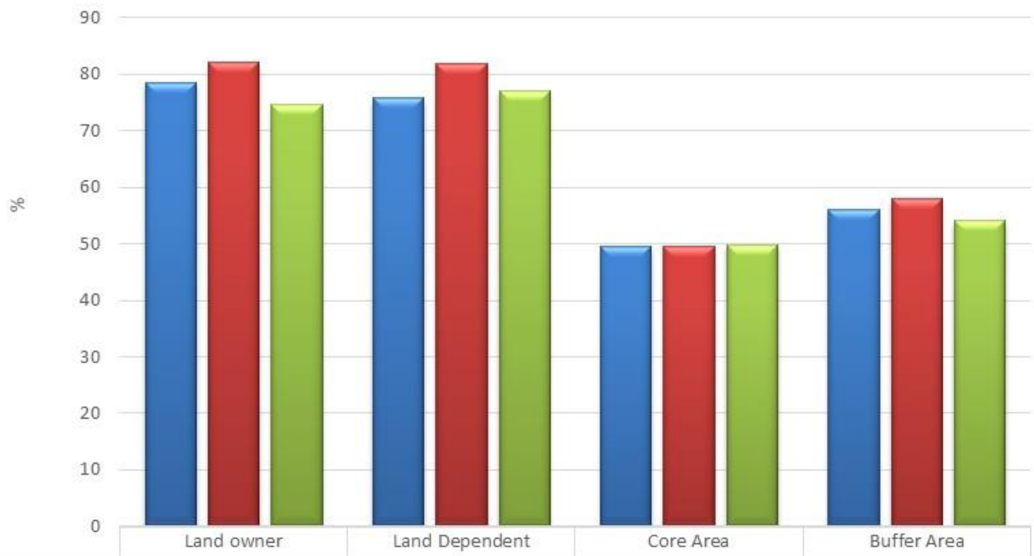
It can be observed from the above figure that the larger proportion of the population (26%) in surveyed population data falls within the age group of 30 to 49 years followed by population within the age group of 25-29. The trend is similar in the larger prospective of the area where the larger percentage of population in within core area and buffer area falls within the age group of 30 to 49 years.

Thus 69% of the population among the surveyed population is in the economically active age group (15-59 years), while rest 31% of the population is understood to be dependent. Similar trend can be observed in the Core area and buffer area where more than 50% population are in economically active age group. There are 25-30% of the population which falls in the age bracket of 15 to 30 Years, considered as the potential population which looks for livelihood diversification. It is also important to note that around 20% of the total population constitute infants and elderly population, whose sensitivity to health needs to be considered during impact assessment study.

4.7.6 Literacy Profile

Literacy Profile of Core Area

The literacy rate in Dudhghata Mouza is estimated at 49.5%, which is lower than the national literacy rate of 51.8%. The graphical representation of literacy indicators is shown in ***Figure 4.61.***



	Land owner	Land Dependent	Core Area	Buffer Area
Over all Literacy Rate	78.61	75.75	49.5	56.08
Male Literacy Rate	82.14	81.86	49.5	57.94
Female Literacy Rate	74.55	77.18	49.8	54.13

Figure 4.61. Literacy Profile within AOI

Literacy Profile of Landowner and Land Dependent

Literacy rate among the landowner household is 77.23% which is higher than the national literacy rate (61.5%) as per population and housing census 2011. Male literacy rate is 81.24% and female literacy rate is 75.26%. Among them quite a good number of people (53%) are educated till upper primary or higher.

It can be observed from the graph above that literacy profile among the landowner (78.61%) and land dependent (75.75%) is higher than the national average and core and buffer area average. Among the landowners, about 53% are educated till upper primary or higher and similar trend can be observed in case of land dependents. Based on the literacy profile among the Project Affected People, there is a possibility of employing these people in unskilled/semi-skilled services during the construction and operation phases of the project. Specific skill set assessment is presented under Training Need Assessment.

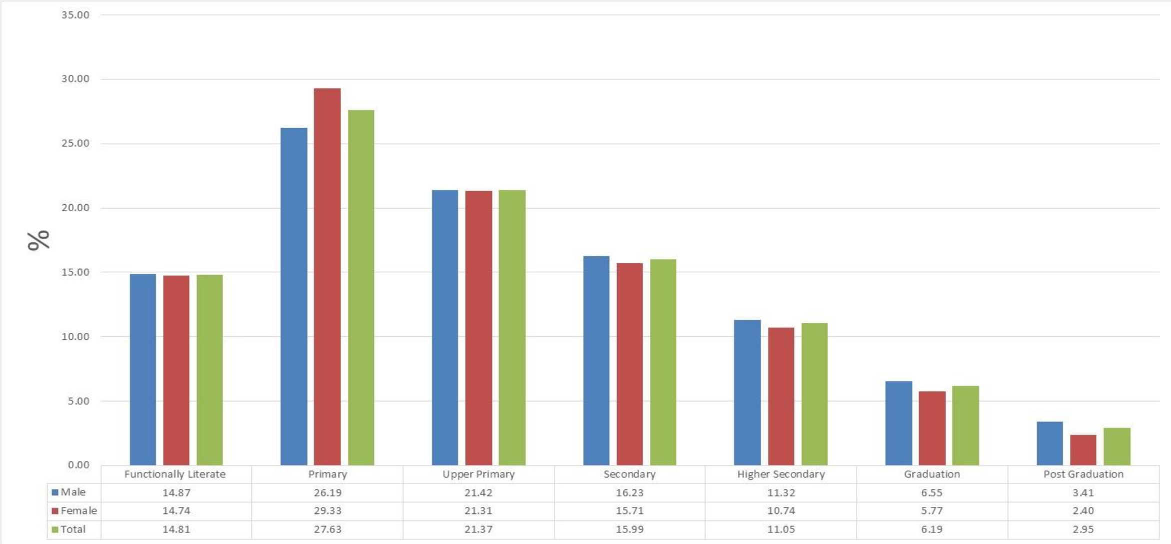


Figure 4.62. Literacy Level among Landowner

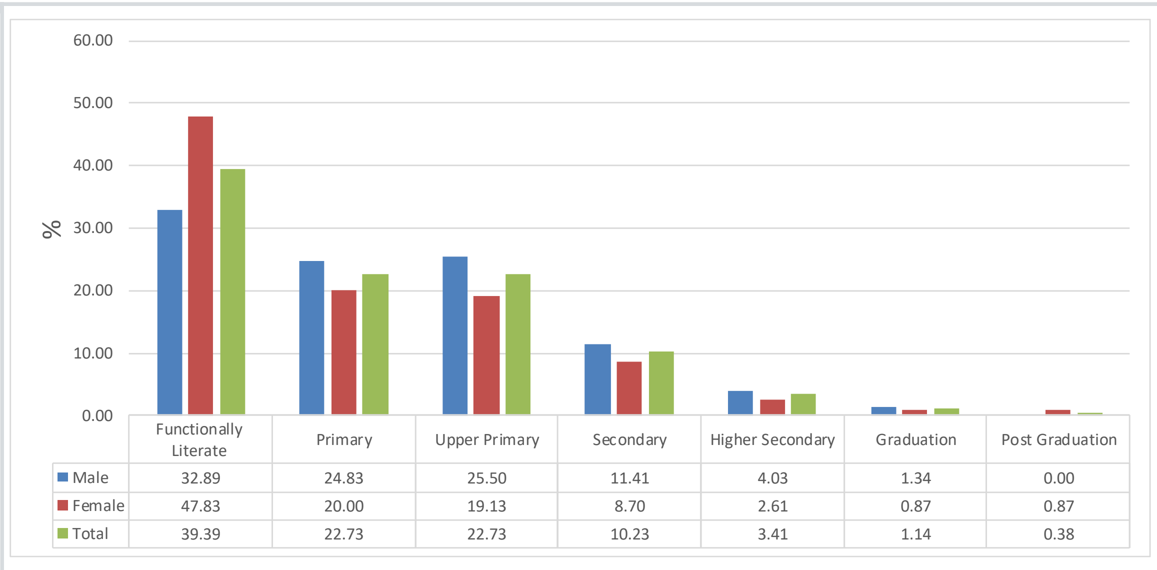


Figure 4.63: Literacy Level Among the Lan Dependent

Literacy Profile of Buffer Area

The literacy profile of buffer area within 5 km area is presented in ***Table 4.48***. It shows that the literacy rate (56.14%) of these influenced unions is higher than the national average of 51.8%. With respect to individual literacy trends amongst males and females, it can be observed that literacy amongst women is lower than their male counterparts.

Table 4.48. Literacy Profile of the Buffer Area

Union/Paurashava	Literacy		
	Total	Male	Female
Bandar	55.4	55.9	54.9
Kalagachhia Union	60.5	62.3	58.7
Musapur	47.6	48.9	46.4
Baidyer Bazar	42.1	42.4	41.8
Mugra Para	62.7	64.7	60.5
Pirojpur	59.8	63.8	55
Sanmandi	51.8	53.2	50.4

Union/Paurashava	Literacy		
	Total	Male	Female
Shambhupura	55.3	57.3	53.5
Sonargaon Paurashava	63.39	64.94	61.72
Baluakandi	57.7	61.8	53.6
Hossaindi	53.6	55.2	51.9
Tenger Char	63.8	65.6	61.9

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

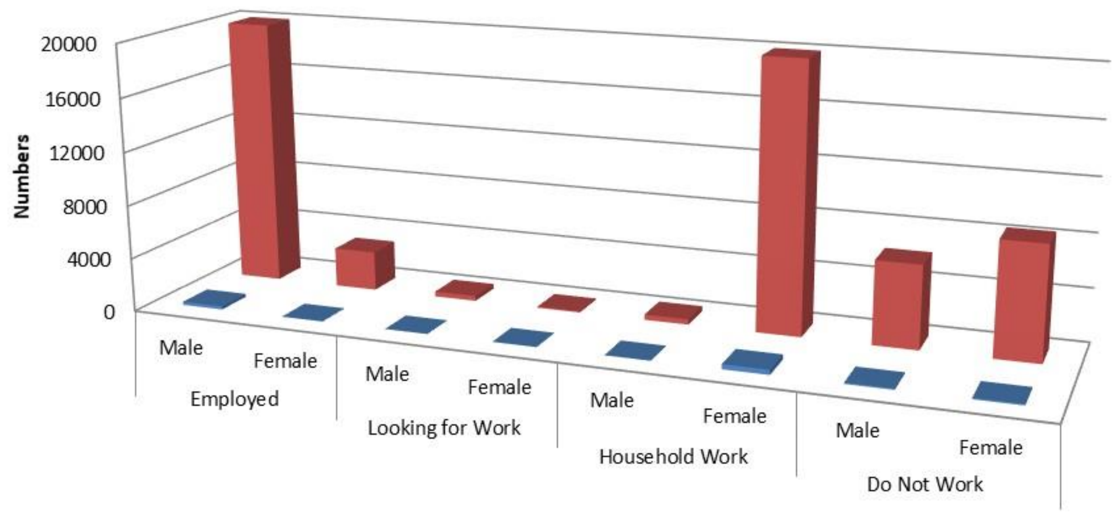
4.7.7 Religion and Ethnic Composition

All the surveyed population and population residing in Dudhghata Mouza are Muslim. According to the Population and Housing Census (2011), Bangladesh Bureau of Statistics (BBS), no other ethnic community is identified to be residing within the study area.

4.7.8 Local Economy and Employment

Employment Scenario within AOI

The employed population in core and buffer area is only 70% of the working age population (15-65 Yrs.), however female working population is quite low (only 0.72% in core area and 3.58% in buffer area). Female population is mainly engaged in household work. Hence, the employment situation of female population looks quite grim in project area.



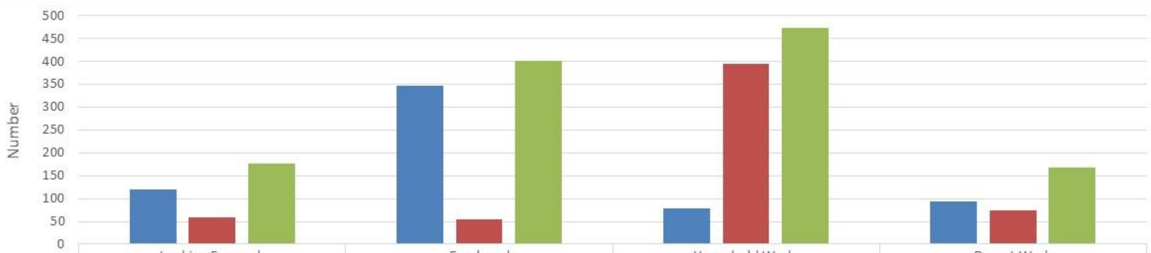
	Employed		Looking for Work		Household Work		Do Not Work	
	Male	Female	Male	Female	Male	Female	Male	Female
Core Area	240	6	2	0	9	366	99	104
Buffer Are	31140	2963	371	100	400	32939	6194	8490

Figure 4.64. Employment Scenario of the AOI

Employment Scenario among Landowner Household

In case of employment scenario among the landowners, same situation of AOI prevails among the landowners. In case of employment scenario among the landowners, only 32.86% landowner are employed, amongst which 67.23% are male population and only 32.77% are female. Female population is mainly involved in household work

(83.5%). 14.54% population among the landowner households are looking for work[21]. Project can employ them or create some livelihood opportunity by providing training and economic support.

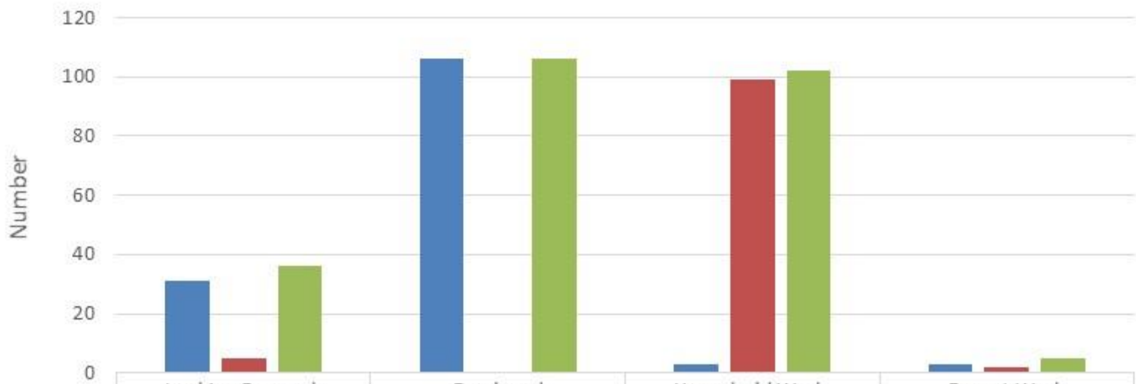


	Looking For work	Employed	Household Work	Do not Work
Male	119	346	78	94
Female	58	54	395	73
Total	177	400	473	167

Figure 4.65. Employment Scenario Among Landowner Household

Employment Scenario among Land Dependent and Fisher Man Household

Among the land dependent households, 42.57% employed are all male whereas 40.96% population is involved in household work, 97.05% of which are female. About 14.45% population is looking for jobs, 86.11% of which are male population who has the potential to work in the project or involved in other livelihood options through proper training. Business, working outside the country, industrial work etc. for man and household work for female are main nonfarm livelihood.



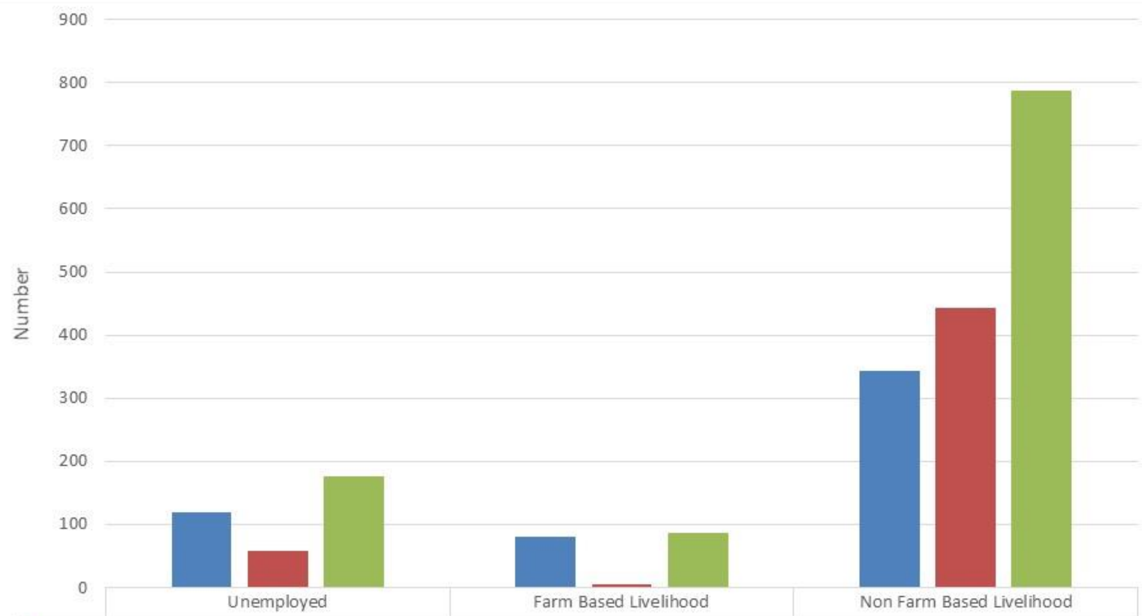
	Looking For work	Employed	Household Work	Do not Work
Male	31	106	3	3
Female	5	0	99	2
Total	36	106	102	5

Figure 4.66. Employment Scenario Among Land Dependent Household

Economic Activity of Landowner Household

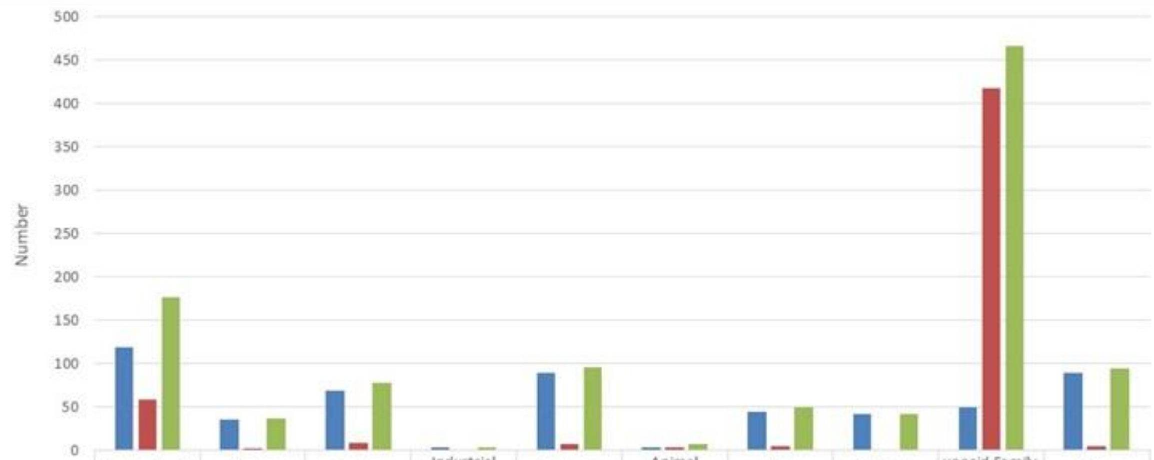
Majority of surveyed population are engaged in non-farm based economic activity like own business (9.14%) followed by service (7.43%). Apart from that few people are also involved in fishing, Animal Husbandry, labour in agriculture, industry etc. Few people have also migrated to other countries for job purpose. Number of people who are solely dependent on agriculture are very less. Percentage of unemployed population is quite high (16.86%). UMPL may employ them in the project based on their qualification and credential or provide them some training for engaging in alternate livelihood opportunities.

[21] *Looking for work- Person who are actively looking for job.*
Do not work-Persons who are engaged in education as student.
This is classification considered by Population and Housing census of Bangladesh.



	Unemployed	Farm Based Livelihood	Non Farm Based Livelihood
Male	119	80	344
Female	58	6	443
Total	177	86	787

Figure 4.67. Economic Activity of Landowner Household



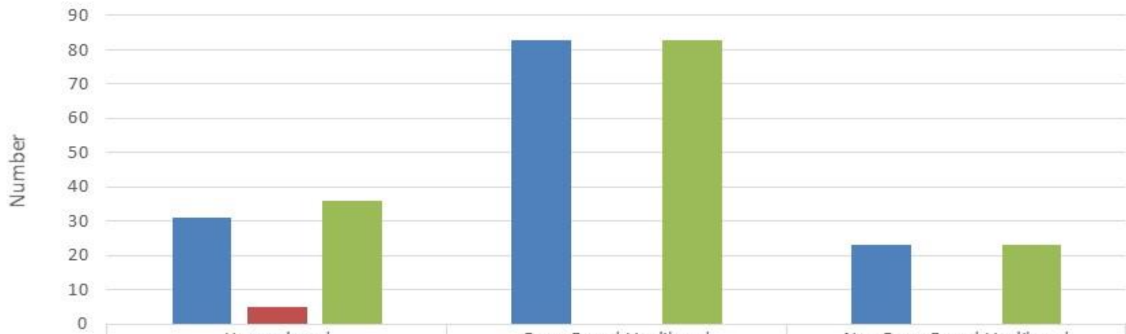
	Unemployed	Farmer	Service	Industrial Worker	Business	Animal Husbendary	Labour	Fishing	unpaid Family Work	Other
Male	119	35	69	3	89	3	45	42	49	89
Female	58	2	9	0	7	4	5	0	417	5
Total	177	37	78	3	96	7	50	42	466	94

Figure 4.68. Different Economic Activity of Landowner Household

Economic Activity of Land Dependent Household and Fisherman

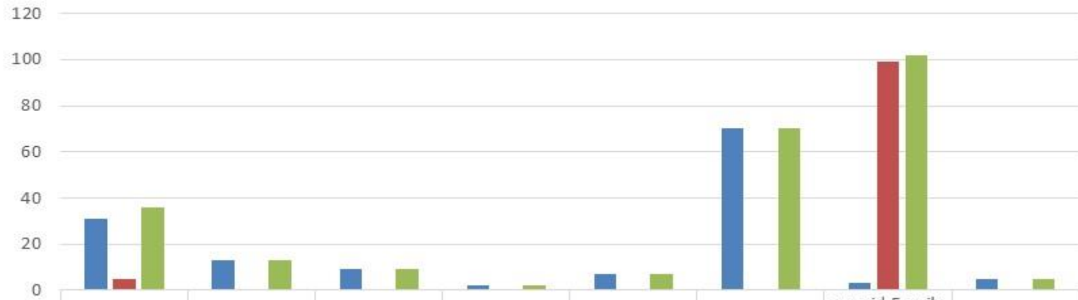
It can be observed form graph below that majority (58.45%) of the land dependent household is involved in farm-based livelihood, 84.33% of which is fishing, and rest of the population is involved as farmer. 14.75% are unemployed and seeking livelihood opportunity.

During consultation with fisherman community, it is revealed that they catch fish in 5-8 km downstream of the project site in Meghna river. Approximately 2000 BDT per month is the earning of each fisherman during fishing season. During off season, the fishermen are involved in other activity like agriculture, wage labour etc.



	Unemployed	Farm Based Livelihood	Non Farm Based Livelihood
Male	31	83	23
Female	5	0	0
Total	36	83	23

Figure 4.69. Economic Activity of Land Dependent Household

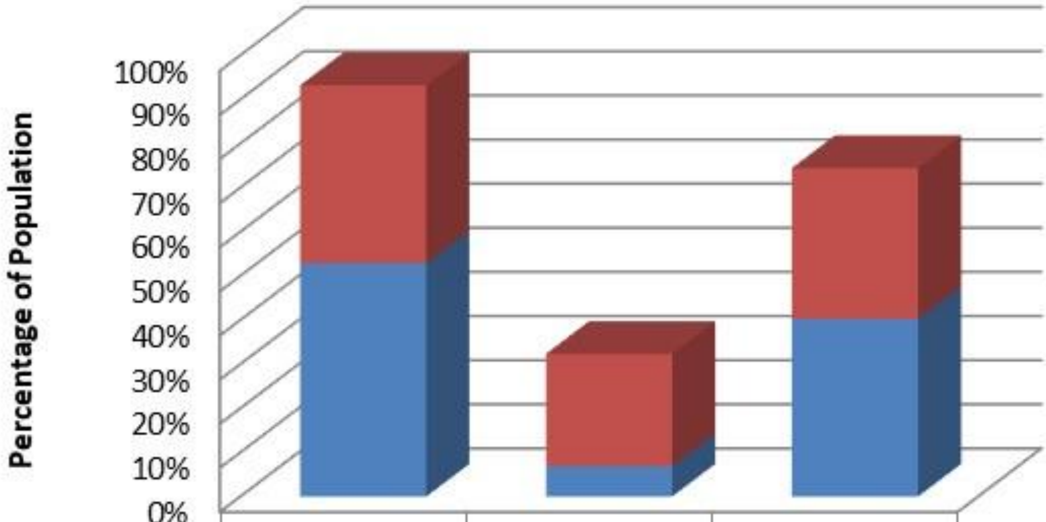


	Unemployed	Farmer	Service	Business	Labour	Fishing	unpaid Family Work	Other
Male	31	13	9	2	7	70	3	5
Female	5	0	0	0	0	0	99	0
Total	36	13	9	2	7	70	102	5

Figure 4.70. Different Economic Activity of Land Dependent Household

Economic Activity in Core Area

Agriculture is the prime economic activity in Dudhghata mouza and 52.85% population is involved in agriculture activity; while 40.24% population is involved in other activities like own business, job in private and govt sectors, wage labour in industry or other sectors. Graphical presentation below shows the economic activity scenario of core and buffer area.



	Agriculture	Industry	Service
Buffer Area	40.37	25.44	34.19
Core Area	52.85	6.91	40.24

Figure 4.71. Economic Activity in Core and Buffer Area

Economic Activity in Buffer Area

According to the Population Census of Bangladesh (2011), Service is the major source of employment in the study area. Approximately, 39.21% (34.48% male and 43.94% female) of the total employed population is engaged in agricultural sector. Moreover, 32.64% of total employed population (23.73% male and 41.55% female) are involved in Industry sector while 28.15% employed population (41.80% male and 14.51% female) are working in Agriculture sector. ***Table 4.49.*** shows the economy and employment of the project study area.

Table 4.49. Economy and Employment of the Study Area

Union	Field of Activity					
	Agriculture		Industry		Service	
	Male	Female	Male	Female	Male	Female
Bandar	21.30	12.96	36.76	54.65	41.94	32.39
Kalagachhia Union	31.92	26.39	16.91	20.83	51.16	52.78
Musapur	39.04	15.16	32.68	53.43	28.28	31.41
Baidyer Bazar	44.70	23.08	7.64	12.59	47.66	64.34
Mugra Para	27.41	20.75	24.17	26.10	48.42	53.14
Pirojpur	29.15	6.70	37.43	56.70	33.41	36.60
Sanmandi	52.44	15.26	12.67	30.92	34.89	53.82
Shambhupura	75.79	30.23	8.79	34.88	15.42	34.88
Sonargaon Paurashava	61.18	20.51	16.71	33.33	22.12	46.15
Baluakandi	63.79	4.84	22.27	34.68	13.94	60.48
Hossaindi	56.55	11.23	40.94	57.26	2.51	31.51
Tenger Char	71.85	21.36	19.58	52.43	8.57	26.21

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)s

4.7.9 Income Generation

Income generation of Landowner Households

Socio economic survey reveals that average annual income of the landowner households is 275615 BDT and average annual income generated from procured land was 26810 BDT which is approximately 10% of annual income of the landowner households. However, focus group discussion reveals that most of the landowners agreed that UMPL has provided good price for their land and they can buy better quality of land with the land compensation provided by UMPL.

Income generation of Land Dependent Households and Fishermen

Majority of the land dependent household had taken this procured land on lease. During the survey, it was found that of Eighteen (18) land dependent household, fourteen (14) land dependent household would become landless after land procurement by UMPL for the proposed site and land lease taken by UMPL for laydown area. There are many fishermen communities present in Dudhghata. Discussion with fisherman community reveals that, they have two major concerns- firstly project land was used by them for approaching the river front; now they have to take longer route to approach the river front. Secondly, the project would prevent their earlier practice of drying their fishing net in the project land.

Agriculture Landlessness[22]

Among the 333 surveyed landowners, 90 landowners[23] became Agricultural landless who were mostly dependent on farm-based activity or household work. As per discussion and survey data, their livelihood is mostly impacted, and they would need further support. Among 18 land dependent households, 14 households have become agricultural land less after procurement and they did not get any compensation for land as they do not have any legal rights on the procured land. Detail list of agriculturally land less households is presented in Livelihood restoration plan.

Household Level Income

Landowner Household

As per socio economic data, among 90 agricultural landless households' maximum number households (24) monthly income is below 15000 BDT per month followed by 20 household below 20000 BDT per month. There are 22 households whose financial condition are quite poor and earns below 10000 BDT per month. Only 7 households where family member are working outside the country earns a good amount of money per month. As per survey, majority of landowner earns 1000 to 1200 BDT per decimal in paddy cultivation during summer months and earns 800 to 1000 BDT per decimal in vegetable and pulse cultivation in winter months. Cultivation was not possible in procured land due to water logging.

Table 4.50. Household category based on Monthly Income.

Category of Monthly Earing	Number of Household
Below 10000 BDT per month	22
Below 15000 BDT per month	24
Below 20000 BDT per month	20
Below 25000 BDT per month	11
Below 30000 BDT per month	6
More than 30000 BDT per month	7

As per the socio-economic survey of landowner shows that 85% household lost less than 10% of their annual income and 15% household lost less than 20% of their annual income.

Land Dependent Household

Among land dependents, maximum number (20) of households belongs to 15000 BDT per month earing category. After that same number of household (16) belongs to below 20000 BDT and above 30000 BDT per month category respectively.

Table 4.51. Household category based on Monthly Income.

Category of Monthly Earing	Number of Households
Below 10000 BDT per month	10

[22] *Agriculture Land less means they sold out their entire agricultural land to UMPL. However, they have their residential land. As per socio economic survey carried out by AECOM, total 90 landowner households sold out their entire agricultural land to UMPL.*
[23] *During survey these landowners inform to AECOM survey team that they do not have any other agricultural land for cultivation. So, they have been considered as land less. AECOM could not validate land information shared by landowners.*

Category of Monthly Earing	Number of Households
Below 15000 BDT per month	20
Below 20000 BDT per month	16
Below 25000 BDT per month	10
Below 30000 BDT per month	6
More than 30000 BDT per month	16

Vulnerable Household

During Socio Economic survey total 29 vulnerable household was identified based on different vulnerability criteria. List of vulnerable households and the reason of vulnerability is presented in Livelihood restoration plan.

Fisherman Community

During the socio-economic survey by UMPL social team, total sixty (60) fishermen families were identified through local community, member of Pirojpur union from Dudhghata village. These 60 households previously used the land parcels on which project is proposed, for the approaching river front, drying of fish net, and anchoring of boat. Due to procurement of the Land for the project and subsequent land filling, access to these land parcels has been restricted and they would now have to access the river front from the near-by Purbapara ghat located adjacent to the project boundary in the northeastern side. It has been understood from the discussion with fisherman community that as UMPL is not restricting access to the bank of the Meghna Branch Channel, fishermen would have sufficient space for boat docking and net drying. FGD with the fishermen also revealed that the ghat is not in good shape and remains inapproachable during rainy reason. List of the fisherman is presented in Livelihood Restoration Plan.

Gender Based Economic Activity and Land Ownership Pattern

As per the social structure of rural Bangladesh society, male members of the family are mainly responsible for earning livelihood of the family and women members of family are responsible for household work. Land and assets are mainly owned by male member of the family. However, some time daughters get land from their parents during or after marriage and this land belongs to the woman member of the family. In this project 125 women are listed as landowners along with other family members like brother or father. Along with other family members, women members of the family have also got the share of land price during land procurement.

In case of economic activity of woman headed household, majority (12 household among 17 household) of the head of household are unemployed and involved in household work and others are involved in animal husbandry and daily labour. Average monthly income of the woman headed households are less (below 10000 BDT). Average land holding size of the woman headed household is 15 acres.

Training Need Assessment

During socio-economic survey, AECOM survey team also collected information related to skill-oriented trainings which the surveyed population wished to undergo in order to enhance their vocational skill and improve their livelihood opportunity.

Data shows that majority of the surveyed landowner households (214) expressed their interest to obtain training related to computer-based skill development (90), cattle rearing or poultry farming (95) and sewing (47) which would help them in earning their livelihood. Apart from that, there were seventy-seven (77) households who were not interested to undertake any training. Other trainings selected by surveyed household comprises of fish framing, driving, electronics repairing, plumbing etc. Women are interested to participate in sewing training and are also keen to take training to support male counterpart in livelihood earning.

Majority of land dependent households out of total eighteen (18) numbers selected cattle rearing/ poultry farming (8) followed by Sewing Training (5), computer training (3) and agriculture training (2).

Among sixty (60) fisherman households, majority of the households (20) expressed their interest to undertake training on fish farming followed by cattle rearing or poultry farming (11) and sewing training (12) and computer training (10).

4.7.10 Housing

Housing Structure among the surveyed Population

Majority (74%) of the housing structure among the surveyed population are semi-pucca type; while 15% are pucca house and 11% are kutcha house.

Housing Structure within Core Area

Kutcha type of house are major (72%) housing structure in Dudhghata mouza followed by semi-pucca house (19%). Only few (8%) house are pucca in Dudhghata mouza. Graphical analysis of the housing structure in core and buffer area is presented in figure below.

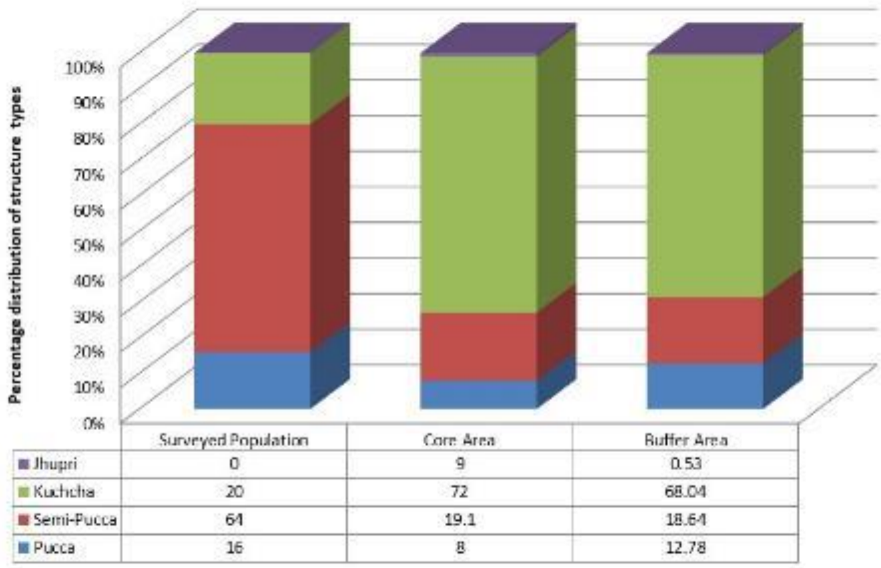


Figure 4.72. Type of Housing Structure

Housing Structure within Buffer Area

According to population and housing census (2011), predominant structure of these study area is Kutcha [24] (68.04%) followed by Semi-Pucca[25] (18.64%), Pucca[26] (12.78%) and Jhupri[12] (0.53%). Table 4.52 shows the settlement and housing patterns within the study area.

Table 4.52. Settlement & Housing Patterns within the Study Area

Union	Type of Structures (%)			
	Pucca	Semi-pucca	Kutcha	Jhupri
Bandar	12.8	22.7	64.2	0.2
Musapur	8.9	16.3	73.7	1
Baidyer Bazar	6.1	7.1	86.5	0.2
Mugra Para	28.2	22.7	48.8	0.2
Pirojpur	21.5	31.5	46.8	0.2
Sanmandi	5.2	9.4	85.2	0.2
Shambhupura	9.4	21.9	67.8	0.9
Sonargaon Paurashava	18.08	20.47	61.14	0.52
Baluakandi	13.4	17.1	69.2	0.3
Hossaindi	5.5	12.6	81.6	0.3
Tenger Char	13.1	19.7	65.8	1.4

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

[24] "Kutcha is defined by the structures whose walls are made of clay, wood, bamboo, straw or raw bricks and roofs are made of tin, bamboo and straw", BBS (2015)
[25] "Pucca is structures whose floor, wall and roof are made of cement, brick and stones", BBS (2015)
[26] "Semi-pucca is defined by the structures whose walls are made of cement and bricks and roof is made of tin, asbestos, wood or bamboo", BBS (2015)

4.7.11 Sanitation

Among the surveyed population, 93% people have approach to sanitary latrine. Among them 76% are water sealed sanitary latrine and 16% are non-water sealed sanitary latrine. Only 7% has non sanitary facility.

In the study area, about 79% households use sanitary latrine including 22.53% water sealed and 60.13% non-water-sealed facility. Moreover, 15.47% households use non-sanitary facilities. On contrary, 1.57% households have no approach to latrine facility and defecate in open places. The sanitary approach is shown in ***Table 4.53.***

Table 4.53. Sanitary Approach within the Study Area

Union	Sanitary		Non-sanitary	None
	Sanitary (Water sealed)	Sanitary (Non-water sealed)		
Bandar	32.1	51.4	15.8	0.6
Kalagachhia Union	23.5	52.5	20.8	3.1
Musapur	25	58.1	16.1	0.8
Baidyer Bazar	15.6	71.8	10.9	1.6
Mugra Para	29.4	56.1	13.8	0.7
Pirojpur	21.6	69	8.7	0.6
Sanmandi	0.6	67	30.4	2
Shambhupura	2.6	94	2.9	0.5
Sonargaon Paurashava	21.31	54.54	19.7	1.12
Baluakandi	40.1	48.1	9.8	2
Hossaindi	14.2	54.5	26.2	5.2
Tenger Char	44.3	44.5	10.5	0.6

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

4.7.12 Education Facility

Two schools, one Primary School (Dudhghata Govt. Primary School) one high school (Korbanpur Govt high school) are present within the Dudhghata Mouza.

As per district statistics, 2011, there are 32 government primary school, 24 registered primary school, 1 Government secondary school, 8 non- government secondary school, 1 non-government collage present in Kutubdiha Upazila. There are also 7 madrasah, 4 kawmi madrasah and 14 ebtedayee madrasah present in this Upazila.

4.7.13 Health Facility

Only one community clinic is present in Korbanpur village of Dudhghata Mouza.

Every Union under the study area has local general health service centre that provides only outpatient services. Besides this, there are Upazila & District level health service centres/hospitals (providing emergency health services). The nearest upazila health complex for emergency health services is Sonargaon Upazila Health Complex under Narayanganj District situated around 8.3 km away from the project site. Moreover, the nearest District hospital from the project site is the 300-bed hospital in Narayanganj with approximate 30 km distance from the project site. **Table 4.54** shows the distance of health facilities from the project site.

Table 4.54. Approach to Health Facilities within the Study Area

Health Facilities	Distance from the project site (km)
District Hospitals	
300 bed hospital (Narayanganj)	30
100 bed General Victoria Hospital (Narayanganj)	30.9
250 bed hospital (Narayanganj)	40.6
General Hospital (Munshiganj)	55.9
Upazila Health Complexes	
Sonargaon Upazila Health Complex	8.3
Bandar Upazila Health Complex	13.2

Health Facilities	Distance from the project site (km)
Gazaria Upazila Health Complex	16.3

4.7.14 Water Supply

Entire surveyed population use tube well water for drinking purpose and other domestic purpose. Among them 86% has their own tube well whereas 14% use shared tube well facility.

Major source of drinking water source in Dudhghata Mouja is tube-well for 99.6% population. On the other hand, only 0.3% people have approach to tap water. Other 0.1% people have approach to neither tube-well nor tap water and consequently rely on nearest surface water sources i.e. river, pond or canal. ***Table 4.55*** below shows the approach to water within the study area.

Table 4.55. Water Approach within the Study Area

Union	Source of Drinking Water		
	Tap (%)	Tube-well (%)	Other (%)
Bandar	0.3	99.6	0.1
Kalagachhia Union	1	95.9	3.1
Musapur	0.8	97.3	1.9
Baidyer Bazar	0.7	95.8	3.6
Mugra Para	16.5	81.8	1.7
Pirojpur	8.7	90.1	1.2
Sanmandi	1.6	96.5	1.9
Shambhupura	0.2	99.5	0.3
Sonargaon Paurashava	4.09	94.61	1.27
Baluakandi	2.6	85.6	11.8
Hossaindi	5.4	92.5	2.1
Tenger Char	3.81	93.56	2.63

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

4.7.15 Electricity

Electricity is an important indicator for measuring the quality of life. ***Table 4.56*** shows the percentage of electricity connection of the study area. In these study areas, only 94.08% of the households have electricity connections

Table 4.56. Electricity Approach within the Study Area

Union	Electricity connection, %
Bandar	97.5
Kalagachhia Union	96.1
Musapur	97.3
Baidyer Bazar	97.7
Mugra Para	97
Pirojpur	98
Sanmandi	98.2
Shambhupura	97.4
Sonargaon Paurashava	97.64
Baluakandi	59.9
Hossaindi	83.4
Tenger Char	92.74

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

5 Impact Assessment and Mitigation Measures

5.1 Introduction

This section identifies, predicts, evaluates and provides mitigation measures for the probable impacts on different environmental parameters due to construction and operation of the proposed 600MW CCPP in Meghnaghat, Bangladesh. Monitoring and assessment of the existing baseline environmental and socio-economic scenario has been done through primary & secondary data collection, reviewing the process and as per the statutory requirements. The environmental impacts that the proposed project is likely to usher during construction and operation phases are identified and assessed in this section along with recommended mitigation measures. Superimposing impacts on the existing baseline scenario would enable formulation of a suitable and site-specific Environmental Managemental Plan in the subsequent section of the report.

Identification of anticipated significant environmental impacts due to the activities during the pre-construction, construction and post-construction as well as operation stages of the proposed power plant project was carried out using the checklist method during the course of IEE exercise and later during EIA study. Such anticipated impacts without any mitigation measure had been characterized as being of varied intensities – minor, medium and major and were mostly of adverse nature. Beneficial impacts, although few, were characterized as significant. Based on the checklist of the IEE process, further modified during EIA study, identification of significant environmental impacts due to the activities during various stages of the proposed power plant project and proposing corresponding mitigation measures have been done through a detailed matrix developed in this section for purpose of ESIA.

Identification of anticipated significant environmental impacts of the proposed project has been followed by formulation of measures toward mitigating them. Enhancement measures for beneficial impacts and compensation to project affected persons have also been proposed. The mitigation measures, in addition to the EIA regulatory requirements have also taken into consideration the compliance requirements of environmental and social risk management standards/guidelines of Institutional Funding Agencies like IFC E&S Performance Standards and EHS Guidelines, AIIB E&S Standards, EP 4 guidelines etc.

5.2 Assessment methodology

Impact identification and assessment begins with scoping and continues through the remainder of the process.

- **Impact prediction:** determination of what could potentially happen to resources/receptors as a consequence of the Project and its associated activities.
- **Impact evaluation:** Evaluation of the significance of the predicted impacts by considering their magnitude and likelihood of occurrence, and the sensitivity, value and/or importance of the affected resource/receptor.
- **Mitigation and enhancement:** Identification of appropriate and justified measures to mitigate negative impacts and enhance positive impacts.
- **Residual impact evaluation:** Evaluation of the significance and scale of the environmental impacts predicted to remain after the application of mitigation measures outlined in this EIA study

5.2.1 Impact Criteria and Ranking

Once all project environmental aspects were comprehensively identified for the different activities of the project, the level of impact that may result from each of the activity-component interactions has been assessed based on subjective criteria.

For this, three key elements have been taken into consideration based on standard environmental assessment methodologies:

- **Severity of Impact:** Degree of damage that may be caused to the environmental components concerned;
- **Extent of Impact:** Geographical spread of impact around project location and corridors of activities; and

- **Duration of Impact:** Time for which impact lasts taking project life-cycle into account.

These elements have been ranked in three levels viz. 1 (low), 2 (moderate) and 3 (high) based on the following criteria provided in ***Table 5.1.***

Table 5.1: Impact Prediction Criteria

Impact Elements	Criteria	Ranking
Intensity	• Impact resulting in long term and/ or medium damage to the natural environment. • Major impact on community and occupational health (e.g. serious injury, loss of life) on account of accidental events and related operational activities.	3
	• Impact resulting in short term change and / or damage to the natural environment. • Temporary loss of land, source of livelihood for affected communities • Impact on terrestrial habitat, endangered species, drainage pattern and community resources. • Moderate impact on occupation and community health & wellbeing (e.g. noise, light, odour, dust, injuries to individuals)	2
	• Impact causing temporary change in air shed, surface water quality, loss of some species etc. • Limited impact on human health and well-being (e.g. occasional dust, odour, light, and traffic noise).	1
Extent	• Where the extent of impact is beyond the AoI to cover impacts that affect nationally important environmental resources or affect an area that is nationally important/protected or have macro-economic consequences	3
	• Impacts extend beyond the area of influence to affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries.	2
	• when impact due to the proposed Project related activities is restricted within Area of Influence which has been determined as 5 km.	1
Duration	• when impacts would occur during the development of the Project and cause a long-term change in the affected receptor or resource that endures substantially beyond the Project lifetime	3
	• when impacts would continue for an extended period of time; this is based on the understanding that there would be recovery of the effected environmental component to its best achievable pre-project state within 1 to 5 years	2
	• when impact is likely to be restricted for a duration of less than 6 months; This is based on the understanding that there would be recovery of the effected environmental component to its best achievable pre-project state within 1 year;	1

A positive or beneficial impact that may result from this project has not been ranked and has been depicted in the form of ++.

5.2.2 Impact Significance

The significance of impact has been determined based on a multiplicative factor of three element rankings. ***Table 5.2*** depicts impact significance in a scale of LOW-MEDIUM-HIGH and would be used for delineation of preventive actions, if any, and management plans for mitigation of impacts.

Impact significance has been determined considering measures which have been factored in the design and planning phase of the project. Legal issues have been taken into account, wherever appropriate in the criterion sets, to aid in UMPL effort to comply with all relevant legislation and project HSE requirements. Additionally, the results of quantitative impact prediction exercise, wherever undertaken, have also been fed into the process.

Table 5.2: Criteria Based Significance of Impacts

Severity of Impact (A)	Extent of Impact (B)	Duration of Impact (C)	Impact Significance (A X B X C)	
1	1	1	1	Negligible
1	1	2	2	Low
1	2	1	2	
2	1	1	2	
1	1	3	3	

Severity of Impact (A)	Extent of Impact (B)	Duration of Impact (C)	Impact Significance (A X B X C)	
1	3	1	3	
3	1	1	3	
1	2	2	4	
2	1	2	4	
2	2	1	4	
1	2	3	6	Medium
1	3	2	6	
2	3	1	6	
3	1	2	6	
3	2	1	6	
2	1	3	6	
2	2	2	8	
3	1	3	9	
3	3	1	9	
1	3	3	9	
2	2	3	12	High
2	3	2	12	
3	2	2	12	
2	3	3	18	
3	2	3	18	
3	3	2	18	
3	3	3	27	
Beneficial Impact -			++	Positive

The impacts on each of the environmental components and its significance during the different stages of the project is presented in ***Table 5.3*** and discussed in detail in the following section. This is followed by a point wise outline of mitigation measures recommended.

5.2.3 Residual Impacts

Residual impacts refer to those environmental and social impacts predicted to remain after the application of mitigation measures outlined in the ESIA. The predicted residual effects are considered for each Project phase (Construction, Operation, Decommissioning/post-decommissioning, and Unplanned Events).

Table 5.3: Anticipated Impact of Important Environmental Components – Natural and Socio-economic Environment

Environmental Aspect / Activity	Physical Environment		Physico-Chemical Environment							Ecological Environment		Human Environment								
	Land Use	Topography & Drainage	Soil/ Sediment Quality	Air Quality	Noise & Vibration	Surface water resource	Surface water quality	Ground water resource	Ground water quality	Terrestrial Flora & Fauna	Aquatic Flora & Fauna	Aesthetic & Visual Impact	Job & economic opportunity	Social & Cultural Structures	Economy & Livelihoods	Infrastructure & Services	Resettlement	Cultural Resources	Community Health & Safety	Occupational health & safety
Pre- Construction Phase																				
Procurement of Land by Company	■														■		■			
Removal of Trees										■		■			■					
Procurement of Sand for Filling											■									
Pumping of Sand Slurry on to the Land		■	■	■	■					■			■		■				■	
Discharge of Return Water from Slurry							■				■									
Levelling and Compaction of the Sand				■	■														■	■
Storage and Handling of Fuels (Unplanned Release)			■				■		■											■
Construction Phase																				
Building of Construction camp and facilities	■	■	■	■	■	■	■			■	■	■	■		■				■	
Laying of Treated Sewage Pipeline	■		■												■					
Transport of Raw Material, Manpower				■	■		■												■	
Development of Foundation for Power Plant	■			■	■		■	■	■		■		■						■	■
Erection of Structure for Power Plant	■			■	■		■	■			■	■	■							■
Transport of Equipment							■				■								■	■
Construction of Water Intake and Jetty	■		■				■				■				■					■

Environmental Aspect / Activity	Physical Environment		Physico-Chemical Environment							Ecological Environment		Human Environment								
	Land Use	Topography & Drainage	Soil/ Sediment Quality	Air Quality	Noise & Vibration	Surface water resource	Surface water quality	Ground water resource	Ground water quality	Terrestrial Flora & Fauna	Aquatic Flora & Fauna	Aesthetic & Visual Impact	Job & economic opportunity	Social & Cultural Structures	Economy & Livelihoods	Infrastructure & Services	Resettlement	Cultural Resources	Community Health & Safety	Occupational health & safety
Generation of Sewage and Discharge																				
Storage and Handling of Chemicals/Fuels (unplanned release)																				
Laying of Gas Pipeline																				
Construction of Transmission Line																				
Waste Handling and Storage																				
Testing and Commissioning																				
Decommissioning of Temporary structures used during construction																				
Demolition of Jetties (2 Nos.)																				
Demolition of construction camp																				
Reinstatement of jetty areas																				
Reinstatement of construction camp site																				
Operation Phase																				
Operation of Main Plant																				
Operation of Utilities (Water Intake, Water Treatment, ETP, DM Plant, Compressor)																				
Maintenance of Main Plant																				
Maintenance of Utilities																				
Management of Non-Hazardous Waste (O&M)																				
Management of Hazardous Waste (O&M)																				

Environmental Aspect / Activity	Physical Environment		Physico-Chemical Environment							Ecological Environment		Human Environment								
	Land Use	Topography & Drainage	Soil/ Sediment Quality	Air Quality	Noise & Vibration	Surface water resource	Surface water quality	Ground water resource	Ground water quality	Terrestrial Flora & Fauna	Aquatic Flora & Fauna	Aesthetic & Visual Impact	Job & economic opportunity	Social & Cultural Structures	Economy & Livelihoods	Infrastructure & Services	Resettlement	Cultural Resources	Community Health & Safety	Occupational health & safety
Operation of transmission line,																				
Decommissioning Phase (End of Project life cycle)																				
Dismantling of plant & equipment, demolition of buildings,																				
Removal of hard standings and restoration of soil																				

5.3 Assessment of Environmental Impact- Pre-Construction and Construction Phase

5.3.1 Impact on Land Use

Impact on land use during preconstruction and construction phase may arise due to below mentioned activity

Preconstruction Phase

- Procurement of land for power plant construction
- Approach restriction

Construction Phase

- Land lease for setting up construction camp
- Laying of treated sewage pipeline

Impact Due to Procurement of Land

Total land requirement of the project is 21.07 acres. As per the land records, majority of the land parcels are single crop agricultural land and few land parcels are waste land.

The establishment of the project would result in Long-term change in land use of the proposed project site from agricultural to industrial.

This land is also used by local community for approaching the river front for fishing, bathing and collecting water. However, there is already an existing approach road to the river front hence impact significance is negligible.

The direct resultant impact (adverse) of land use change in the project area is the reduction in land area available for agriculture and resultant livelihood impacts on landowners, lease holder; however, the magnitude of impact in terms of change in land use would be low (~0.65%) in comparison to the total arable land available in Dudhghata Mouja and Pirojpur Unions. Industrialisation in the region would also have a positive impact in terms of increase in employment and allied opportunities, better infrastructure and amenities, etc. whose benefits are not only restricted at the local site level but also at the Union level. Thus, impact on land use due to procurement of land for construction of power plant would be low.

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 4 i.e. Low					

Mitigation Measures

The following measures would be implemented to mitigate Impact on land use.

- Minimum amount of land required for construction of power plant would be procured
- Payment of compensation prior to taking possession of land.
- Additional compensation for Vulnerable Household[27] if any
- Enhancement of sustainable livelihood of the affected wage labour, sharecropper and lessee farmers through skill development for alternate employment.
- Improvement of existing river ghat.
- Unskilled labour during the project construction phase would be sourced from the local community; and
- Training would be provided to the local people for their skill enhancement.

[27] *Vulnerable households/DPs may include (i) households that are headed by women with dependents, (ii) household heads with disabilities, (iii) households falling under the generally accepted indicator for poverty, (iv) elderly households who are*

Residual impact

With implementation of the precautionary and the mitigation measures mentioned for the land use, impacts on land use would be negligible. However, the proposed project would initiate a long-term drive towards development of additional industrial units in the vicinity of the proposed project site thus resulting in further change in present agricultural land use.

Impact Due to Land Lease for Setting Up of Construction Camp

Land would be required for setting up construction camp and lay down area during construction period. UMPL has taken total 1200 (12 acres) decimal land in Dudhghata Mouza from Hamdard Laboratories on lease for three years. This land parcel has been procured by Hamdard Laboratories long back for setting up their facility, but has remained unused for a substantial period of time. UMPL has also procured on short-term lease about 1.49 acres of land adjacent to the project site for storage of material and equipment for laying of gas pipeline. This land would be raised to the same level as the plant. As per the condition of the lease, UMPL would return the land to its original owners. Since the land is not having any use as such, there would not be significant impact due to land lease.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	2
Impact Significance = 4 i.e. Low					

Impact Due to laying of Treated Sewage Pipeline

The construction camp located Dudhghata mouza would also be used as residential facility of EPC contractor and UMPL officials. Discussion with UMPL revealed that they are planning to lay a treated sewage pipeline from construction camp to public sewage channel to discharge the treated wastewater from STP located in construction camp. Approximate length of the pipeline would be appropriately 105 meters and it would be laid along ROW of the Union Parishad Road. As the pipeline is temporary and would be laid along the ROW of the road, impact due to this activity is assessed to be negligible.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	1
Impact Significance = 1 i.e. Negligible					

Impact Due to Transmission Line

The transmission line is not envisaged to cause any impact on land use as the route of the transmission line is across the Meghna Channel and parallel to one other existing transmission line. The TL consists of two tower footings on the two sides of Meghna Branch Channel, one tower located within the site. The other tower footing is located on BIWTA land. UMPL has obtained necessary permit/license (Memo No. 18.11.67580.067.03.540.19 (Unique Meghnaghat Power)/225 dated 04/01/2021) from BIWTA for RoW of the Tower footings and the transmission line. The route of the transmission line neither cause hindrance to or obstruction/stoppage of any activity, removal of trees nor pass through any ecologically protected area which could lead to change in land use or disturbance in the existing land use pattern along the route of the transmission line.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	1
Impact Significance = 1 i.e. Negligible					

Residual impact

There will be no residual impact, as such.

5.3.2 Impact on Topography and Drainage

Impact on land topography and drainage pattern is envisaged due to filling of land for construction of proposed power plant and the laydown area.

Land for proposed power plant is a low-lying land and is located on the bank of branch channel of Meghna river. Thus, land filling is required before commencement of construction activity. Before sand filling, land elevation varied between 5.0 m & 8.0 m. The land has been elevated uniformly up to 7.76 m meters in line with present road level located at the north side of the project boundary to avoid flood. Approximately, 566337 cum of sand have been required for elevating and developing the proposed project site up to the safer level.

However, there is a possibility of the impoundment of rainwater within the Dudhghata Purbapara village due to change in topography of project site located in between river and the village and blocking of micro drainage channel due to land filling. Total length of the proposed site is approximately 500 meters and there are other low-lying areas outside the project boundary having slope towards the river. Rainwater which accumulates within the village boundary may be channelized towards the river through this area. Thus, chance of impoundment of rainwater within village boundary would be limited and impact is assessed to be low.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	3
Impact Significance = 3 i.e. Low					

Mitigation Measures

The following measures would be implemented to mitigate Impact on topography and drainage.

- It is recommended to channelize the incoming rainwater water flow from the outer catchment area towards the river to restrict impoundment and flooding within the village land during the construction period. The stormwater drain would be aligned in a manner to ensure stormwater flow by gradient from the villages into the river through stormwater drain constructed around the Proposed Plant at its outer periphery.
- Regular cleaning of internal drains would be done to restrict the blockage in the drain, ensuring free flow of water.

Residual impact

With implementation of the precautionary and the mitigation measures mentioned for the land filling and to avoid or minimise impacts of land filling would be negligible.

As per Lender's requirement, AECOM has carried out the Environment & Social audit for the pre-construction phase as presented in Appendix H.

Impact Due to Filling of Land for Setting of Construction Camp

1200 decimal land which is taken on lease from Hamdard Laboratory is primarily an agriculture land and is low lying. This area has natural slope from south-east to north-west, thus land filling of the proposed land may create water logging impact on the surrounding agricultural land which are located south-east of the land proposed for construction camp; hence water logging would be limited to low-lying areas adjoining the proposed camp site land. However, construction camp would be temporary in nature and will be dismantled & restored post construction phase. Apart from that, this land has been taken on lease for only three years and land would be given back to Hamdard Laboratory after three years. Hence the Impact due to land filling activity for setting up of construction camp is temporary & low.

The additional land procured on lease adjacent to the plant has also been proposed to be raised to the plant's level. This may lead to impoundment of rainwater in the surrounding area blocking of micro drainage channel. Rainwater which accumulates within the village boundary would be channelized towards the river. Thus, impact due to land filling is assessed to be low.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	1
Impact Significance = 2 i.e. Low					

Mitigation Measures

The following measures would be implemented to mitigate Impact of topography and drainage.

- It is recommended to construct peripheral drains around the proposed Labour camp to channelize the rainwater from the site to existing natural drainage system to restrict impoundment
- Regular cleaning of drains to be done to restrict the blockage in the drain, ensuring free flow of water.

Residual impact

With implementation of the precautionary and the mitigation measures, the residual impact is likely to be negligible.

5.3.3 Impact on Soil and Sediment Quality

The potential sources of impacts to soil and sediment quality due to the preconstruction and construction phase activities include:

Preconstruction Phase

- Land filling activity in proposed power plant area using sand slurry
- Discharge of return water from sand slurry
- Storage and handling of fuel

Construction Phase

- Land filling activity for setting up construction camp
- Laying of treated Sewage Pipeline
- Construction of water Intake pipeline and Jetty
- Storage and handling of Fuel and Chemical,
- Spills and leaks of oil and hazardous chemical
- Laying of Gas Pipeline
- Waste handling and Storage

Impact Due to Land Filling in Proposed Power Plant Area and Construction Camp Area Using Sand Slurry

Proposed power plant area has been filled with sand before construction as this land is very low lying. River sand have been procured from authorised Contractors and used for land filling by pumping to the site in slurry form using river water. During filling, it is highly probable that surrounding fertile agricultural land may be impacted by reduction in fertility, due to sand deposition from overflow of the sand slurry from the site. The soil & groundwater may get impacted due to presence of contaminants in the fill material. However, analysis of fill material for presence of potential contaminants may not be possible due to non-availability of competent laboratory in Bangladesh to undertake contamination analysis. Also, during the dry season the sand would get be wind-borne and carried over, affecting the nearby households.

However, UMPL has adopted measures like bunding or constructing an embankment surrounding the land to be elevated using bamboo stick, plastic sheet and dry sand before filling to restrict transfer of sand out of the land filling site. Considering the above, the impact due to land filling of the site & construction camp is envisaged to be high

Intensity of Impact	**3**	**Extent of Impact**	**3**	**Duration of Impact**	**2**
Impact Significance = 18 i.e. High					

Impact Due to Return Water from Sand Slurry

As the sand is pumped from the carrying boat in slurry form using river water, after settlement of compacted sand in the proposed site, water would return back to the river though the lowest gradient of the proposed land. Thus, some amount of sand would be mixed with water and flow into the river, causing impacts like increased turbidity in the river water and potential change in sediment quality. However, return water would be channelized through a designated pondage for settling of the sand particles and channel the clarified water through laid down pipes into the river. Apart from that, as it is a temporary activity and fill material is river sand dredged from river, change in sediment quality is not envisaged to be significant. However, analysis of filling material for presence of potential contaminants may not be possible due to non-availability of competent laboratory in Bangladesh to undertake contamination analysis. Hence, the impact on sediment related to return of water from the sand slurry is assessed to be high.

Intensity of Impact	3	Extent of Impact	3	Duration of Impact	2
Impact Significance = 18 i.e. High					

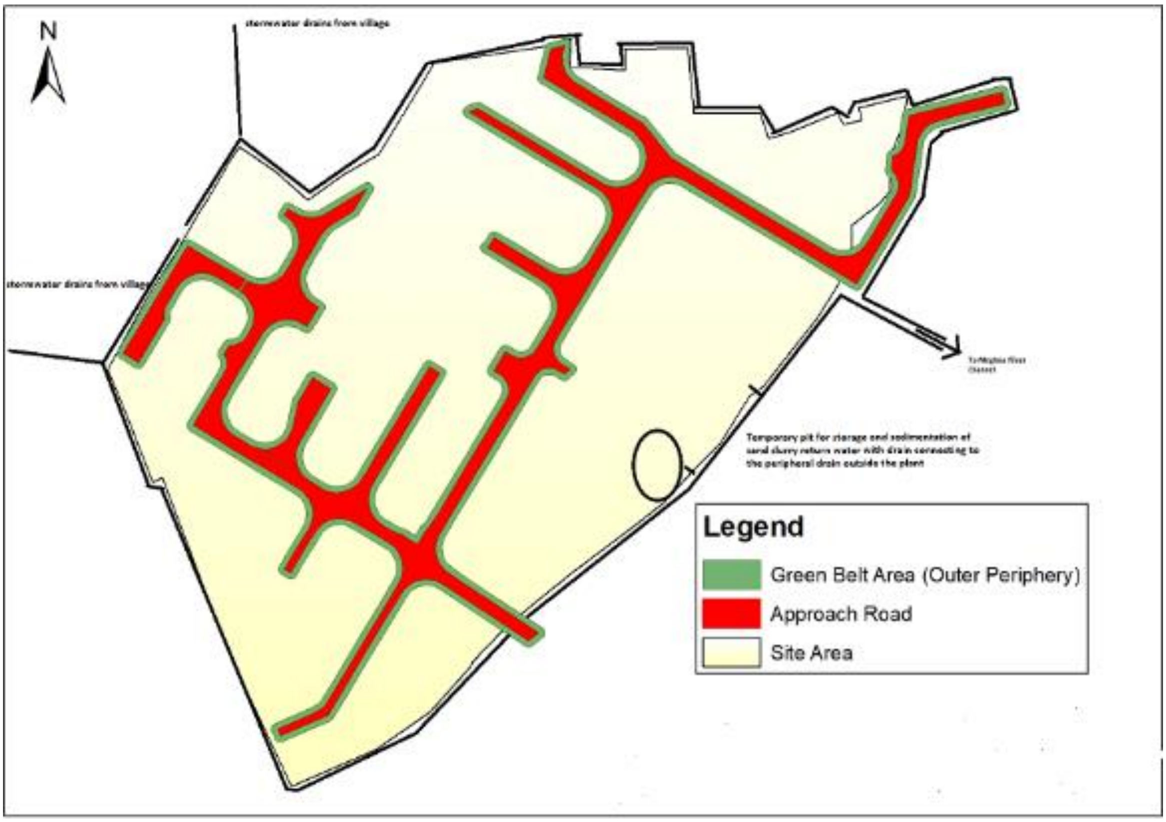


Figure 5.1: Temporary Pit for storage and sedimentation of slurry return water.

Mitigation Measures

The following measures would be implemented to mitigate Impact due to sand filling:

- Regular surveillance of the condition of the embankment by UMPL personnel during the entire period of sand filling.
- Periodic Water sprinkling at site during the dry seasons to contain fugitive dust emission.
- Immediate scraping done in case any sand or slurry deposited accidentally in the surrounding land
- Return water discharged in the river through designated channels.
- Silt trap in the designated channel installed before commencement of sand filling.
- UMPL is recommended to undertake testing of the filling sand to determine the concentration of heavy metals, BTEX and PAHs.

Residual impact

With implementation of the precautionary and the mitigation measures, the residual impact is likely to be moderate. If the analysis does not indicate presence of contaminants, the residual impact is likely to be low.

Impact Due to Storage and Handling of Fuel & Chemicals

Fuel (oil) would be stored within the site during preconstruction period to refuel the earth moving vehicle. Accidental release of fuel oil can contaminate the soil of that area and also can contaminate the river water and sediment by flowing to river though rainwater. However, preconstruction activity would be for limited period and small amount of fuel would be stored. Soil contamination during the construction phase may result from leakage and spillage of oil, lubricants, fuel from heavy equipment or leakage from chemical/fuel storage. Sediment contamination may take place during the construction of temporary jetty, land development, and unloading of heavy equipment. Fuel, chemical or any other hazardous materials would be stored in a designated covered place with concrete floor & secondary containment and refuelling of the earth moving vehicle and handling of chemical would be carried out by trained staff within a designated place. UMPL has a hazardous material management plan in place to manage handling, storage and disposal of hazardous materials. UMPL also has a spill management procedure in place to handle the incidents of spill, A site-specific Emergency Response Plan has been prepared for soil clean-up and decontamination. Following these measures would reduce the chances of accidental spillage of oil into open area (soil) and associated impact is low.

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 4 i.e., Low					

Mitigation Measures

The following measures would be implemented to further mitigate Impact due to accidental spillage of fuel

- Drip tray would be used during refuelling apart from their provisions at chemical storage area and diesel generators.
- Maintenance of earth moving vehicle would be carried out in designated place with concrete floor and bund.
- Hazardous materials would be stored at a minimum 50-100 m distance away from the waterbodies.
- The construction contractor would implement a training program to familiarise staff with emergency procedures and practices related to contamination events. The construction contractor would implement a training program to familiarise staff with emergency procedures and practices related to contamination events. It should be ensured that the records of the training programs held are verified and documented.

Residual impact

With implementation of the precautionary and the mitigation measures, the residual impact is likely to be negligible.

Impact Due to Spills & Leakages of Hazardous Materials, Fuels, Oil & Lubricants

Contamination of soil may result from leaks and spills of fuel, oil, lubricants, from heavy equipment or leakage from chemical/fuel storage. Sediment contamination may take place during the construction of the temporary jetties and unloading of heavy equipment. Such incidents of spills can have long-term impact on soil and sediment quality which is, however, expected be localised in nature. A spill response plan is in place for the construction phase that delineates the key measures for preventing spill including appropriate designs in relation to appropriate containment systems around storage tanks (e.g. fuels, oils etc.), leak detection facilities, fire prevention measures, and appropriate storm water management systems. There are two chemical spill kits available within the plant for use during any spillage, by trained personnel. The incidents of spill have been categorised into three tiers; Tier I(Tiny): Less than 2 Liters, Tier II(Small): More than 2 Litres, less than 10 Litres and Tier III(Large): More than 10 Liters and actions following each tier of spill have been delineated. A site-specific Emergency Response Plan has been prepared for soil clean-up and decontamination. Following these measures would reduce the chances of accidental spillage of oil into open area (soil) and associated impact is low.

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 4 i.e. Low					

Mitigation Measures

The following measures would be implemented to further mitigate Impact due to accidental spillage of fuel

- Drip tray would be used during refuelling.
- Maintenance of earth moving vehicle would be carried out in designated place with concrete floor and bund.

Residual impact

With implementation of the precautionary and the mitigation measures, the residual impact is likely to be negligible.

Impact Due to Laying Treated Sewage Pipeline

Laying of treated sewage pipeline (Ø300) made of unplasticized polyvinyl chloride (UPVC) of length 105 m has the potential to cause adverse impact on soil along the alignment through compaction, spillage of oil from earth moving vehicle and chemical used in pipeline laying. However, right of use of the pipeline would be very limited, period of this activity would be limited to very short period and restricted along the alignment. The pipeline carrying the treated sewage will be discharged nearby local nala 105 m away from the laydown area. Hence impact associated with this activity is considered to be negligible.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	1
Impact Significance = 1 i.e., Negligible					

Mitigation Measures

The following measures would be implemented to mitigate Impact due to laying of treated Sewage pipeline

- All measures would be adopted to recycle the treated sewage through a necessary holding pit for miscellaneous use including dust sprinkling; only the surplus treated sewage would be discharged
- Pipeline laying activity would be limited along alignment.
- Construction area of the pipeline laying would be restored up to the previous condition Right of Use (ROU) of the of the pipeline would be restored up to the previous condition after end of lease period and decommissioning of lay down area.

Residual impact

There will be no residual impact as such.

5.3.4 Impact Due to Water Intake Station and Unloading Jetty

UMPL would construct an water intake station and two unloading jetties on Meghna Branch Channel.

Two temporary jetties would be used to transport construction material and heavy equipment during the construction phase and would be demolished at the end of the construction phase. The major activities like driving of sheet piles, excavation and dewatering on landward side, loading & unloading of excavated & raw materials, storage of material & its transportation, etc. would have impact on the water quality of Meghna river and aquatic flora and fauna.

Impact due to dredging in Meghna Branch Channel for construction of intake water channel: As per the preliminary design, the maximum depth required for the water channel is (-)5.5 m below msl. The present depth of Meghna River channel where the construction of proposed water intake channel would be constructed varies from (-)0.3m to (-)4.0 m below msl. During the construction of the river water intake channel, dredging would be required to a depth upto 1.5 m to 5.2 m in the water channel. Steel sheet pile would be used to enclose the open water intake channel due to the deep excavation during the construction period. The outer side of the cofferdam would be sealed with plastic cloth to stop leakage. Schematic diagram of cofferdam is as follows:

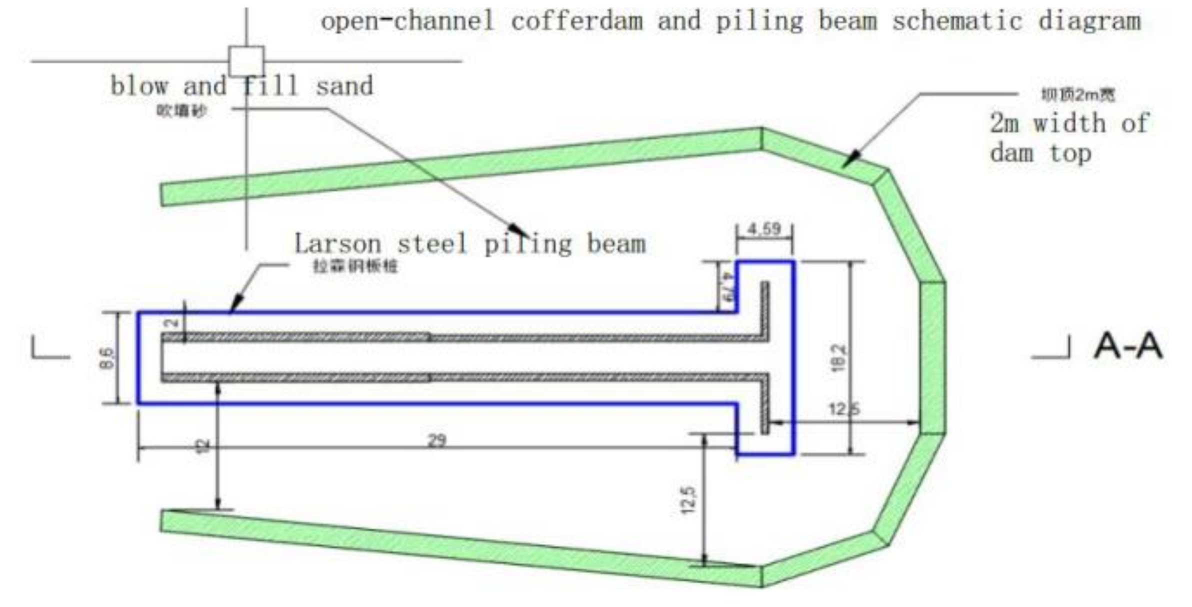


Figure 5.2: Schematic diagram of Cofferdam for construction of Water intake channel

The estimated quantity of dredging required for constructing the water intake channel would be determined during detailed Engineering phase. UMPL has already obtained permission from BIWTA (presented in Appendix S) to carry out dredging in Meghna River Channel for maintaining navigability of the channel for intake of water. Dredging may lead to increase in turbidity of the water in Meghna Branch Channel if proper mitigation measures are not adopted. Increased turbidity has the potential to reduce dissolved oxygen (DO) in and around the dredged area thereby impacting the aquatic life in that zone of the water body. Dredging may also result in alterations in the pattern of flow and sedimentation in Meghna River Channel.

Impacts can be further specifically addressed when the detailed dredging plan comprising dredging quantity, specific areas of dredging, dredging schedule is available. However, construction of this water intake channel would require about 3-4 months and would be undertaken during the driest period of the year (December – March). Moreover, construction of the water intake channel would be undertaken using sheet pile and coffer dam, which would restrict any untoward pollution of the riverine water beyond the zone of construction. The dredged material is proposed to be handed over to M/s Meghna Enterprise for handling and appropriate disposal in line with applicable regulations. M/s Meghna Enterprise is a BIDA approved vendor who has been entrusted for solid waste collection, processing or disposal for the project. Hence, the overall impact due to dredging along the water intake channel is envisaged to be low.

Intensity of Impact	**2**	**Extent of Impact**	**2**	**Duration of Impact**	**1**
Impact Significance = 4 i.e. Low					

Impact due to construction of water intake station on surface water quality: Since the pilling work during construction of the jetties & water intake station would generate fine sediments and result in resuspension of sediments in water, leading to increase in turbidity of river water. Increase in turbidity has adverse impact on aquatic ecology as it affects the primary productivity. However, the construction activities of the jetties and the water intake structure is a short-term activity and would take place for a short span during the construction phase of the project.

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 2 i.e. Low					

Impact on noise quality due to sheet piling: Sheet piling activities generates noise level in range of 65 - 70 dB(A) at about 150 m from the source. Higher noise level of the piling activity would marginally increase the ambient noise level when the activity is carried out, which is likely to add to the construction noise. Hence the impact due to noise generated during sheet piling activities is envisaged to be low as the duration of the activity is short termed.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	1
Impact Significance = 2 i.e. Low					

Impact on Ambient noise quality during use of the Jetty: The movement of vessels, estimated at about 2 fleets a day during peak construction period would slightly increase the ambient noise level for an intermittent period, however the duration and intensity of such increment is not likely to pose adverse impact on the wellbeing of working personnel & disturbance in general environmental settings of the area.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	1
Impact Significance = 1 i.e. Negligible					

Impact on Air Quality during use of the Jetty: There would be emission of pollutants like SO_2 & CO from combustion of HSD in the engines of the vessel fleets. However, this is an intermittent activity and temporary concern for the proposed project.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	1
Impact Significance = 2 i.e., Low					

Impact due to generation of hazardous waste during use of the Jetty: There would be no major maintenance activities or overhauling in the jetty other than minor and emergency repairing of vessels. The likelihood of hazardous waste generation is low, and any hazardous waste generated during emergency repair would be handled and disposed as per prevalent regulations through authorized vendors. Hence the impact significance is assessed to be low.

Intensity of Impact	2		1	Duration of Impact	2
Impact Significance = 4 i.e. Low					

Impact due to spillage and leakage of HSD/lubricants: Accidental spillage & leakage of HSD/lubricants from vessels may potentially impact the water quality and the aquatic organisms; however; considering the construction activity is temporary with only 2 vessels moving per day; and with necessary spill prevention and control measures of UMPL in place, the impact can be reduced to a considerable extent.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	2
Impact Significance = 4 i.e. Low					

Impact on movement of boats & trawlers: The Meghna Channel where water pump house and the Jetty would be constructed is not a shipping route of large vessels. Shipping takes place in the main Meghna River. However, fishing boats and vessels use this channel. It is envisaged that due to the construction activities, there may be temporary suspension in boating in that route. Once the short-term construction activity is completed, it would be required to avoid the water channel area while using the channel in the future.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	3
Impact Significance = 6 i.e. Medium					

Impact in form of Riverbank erosion: The riverbank will be raised along with the using filled material. To prevent erosion of the riverbank, stone pitching is considered as a part of design consideration. Hence the impact is envisaged to be low. Construction of jetties and water station may cause erosion of riverbank due to weakening of soil from the construction activities. However, considering the construction phase being a short-term temporary activity and with necessary soil strengthening work included in the design of piling work, the impact is assessed to be low.

- Both the Jetties would be operational during the construction phase only and would be decommissioned once the construction is completed.

The design has taken into consideration enhancement of embankment through site elevation above the maximum flood level and adopt flood protection/erosion protection measures during both construction phase (which is a short-term temporary activities) and operation phase. Moreover, the entire river bank along the site extending over a length of approximately 600 m in total (slope 1:2), *shall* be compacted to construct a proper embankment and its slopes lined with protective covering including stone pitching to prevent any bank erosion in the long-term. Considering all the factors, the impact significance on the riverbank erosion due to the construction of Jetties and water intake structure is considered to be low.

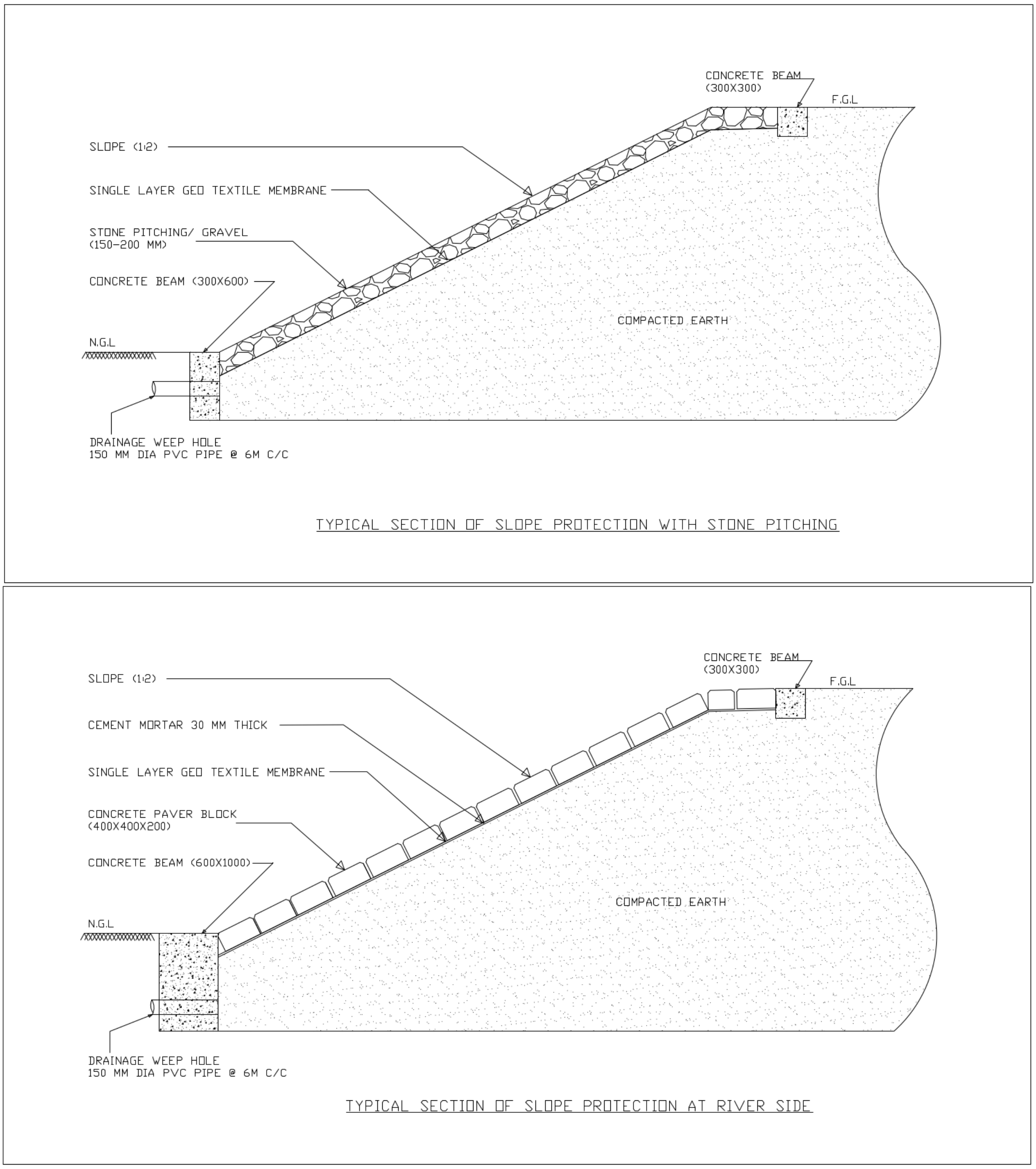


Figure 5.3: Typical Section of Slope Protection Measures

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 3 i.e. Low					

Mitigation Measures

The following measures would be implemented to mitigate Impact due to construction of water intake station and unloading jetty.

- In order to specifically assess the impact of construction of water intake channel into the Meghna Branch channel, it is recommended to carry out Hydrodynamic modelling of the branch channel to understand the flow regime in the channel due to this construction activity.
- In order to manage the impacts due to dredging, UMPL is recommended to prepare a specific Dredged management plan which comprise of quantity of dredged material, dredging location, dredging schedule and chain of activities following capital dredging operation during the construction activities. Dredging would be carried out and dredged material managed as per the Dredged Material Management Plan. Indiscriminate dumping of dredged material would be strictly prohibited.
- It would be ensured that the dredged material undergo waste characterisation before disposal.
- The turbid water would be routed to a sedimentation pit for settling of the suspended particulates, the clarified water would be taken to Clarified water pit and would be reused for construction activities.
- Isolation of construction zone including the intake channel area at the River Channel side using sheet piles
- Proper storage of excavated materials in a designated area with toe drains for arresting any particulate/sediment overflow.
- Sheet piling activity to be restricted during day time only.
- Vessel/Trawler speed would be controlled to minimize aquatic fauna kill and the design of vessel and acoustic treatment would be done for vessel to minimize the sound exposure of aquatic fauna Vessel/Trawler speed would be controlled to minimize aquatic fauna kill and the design of vessel and acoustic treatment would be done for vessel to minimize the sound exposure of aquatic fauna
- Cutting and filling at the riverbank would be avoided to the extent possible during construction of jetties and water intake structure to avoid the river erosion.
- Spill Management Plan would be in place for prevention and quick clean up, in case spill of oil & lubricants happens from the vessels and the construction equipment.
- Installing markers in the wet well area to warn the boats & vessels about the presence of the well.
- Adequate dismantling plan to be prepared to prevent subsidence of soil.

Residual impact

With implementation of the precautionary and the mitigation measures mentioned for the construction of jetty and water intake station impacts of land filling would be low.

5.3.5 Impact Due to Laying of Gas Pipeline

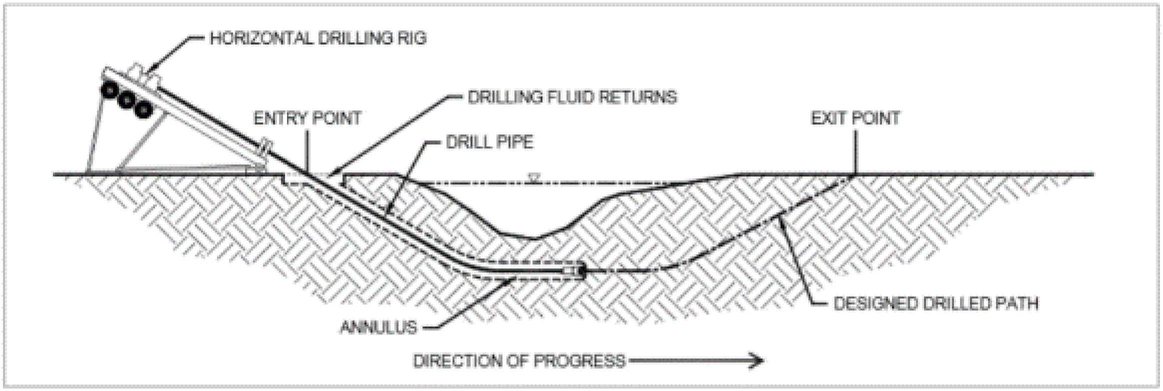
Underground gas pipeline would be laid from Titas gas valve station to power plant. This pipeline would be laid underneath the riverbed using HDD (Horizontal Directional Drilling). Water soluble bentonite mud is proposed to be used in drilling.

HDD is a fairly simple process consisting of three major phases.

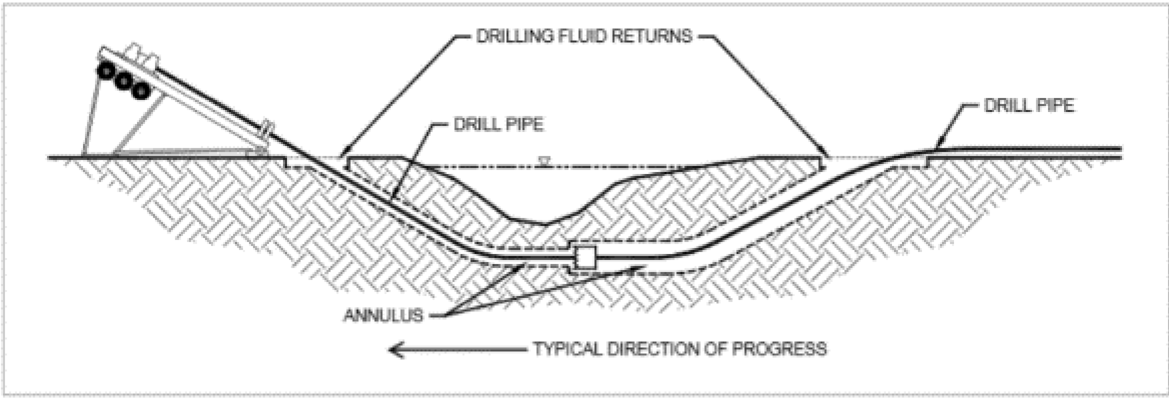
- Pilot Bore phase in which a drilling equipment, called drill rig, is used to drill through the ground and create a small diameter borehole which would be enlarged using a larger diameter reamer and into which a product pipe would be pulled in before final connections are made. The drill string is pushed into the ground using the drill rig and a drill head is attached to the beginning of the drill string to penetrate through the ground by cutting the soil and displacing it. The drill head makes a slightly larger hole than the drill string to create annular space for the movement of soil cuttings back to the ground with the help of a pressurized drilling fluid. The “pilot boring” phase ends when the drill string reaches the exit pit which is the other end of the desired pipeline installation.
- In Reaming phase, a reamer is attached to the drill string at the exit point and the drill string is pulled back into the bore hole in order to enlarge it for the product pipe to fit through. Pressurized drilling fluid is continuously pumped to push the soil cuttings out of the borehole.

- In Pull back phase of HDD construction, the product pipe is pulled through the enlarged bore hole. In order to minimize the torsion on the product pipe, a swivel is used to connect the pull section to the leading reaming assembly. The swivel prevents the product pipe from rotating even when the drill string is rotated. The pipeline installation is completed when the product pipe is successfully pulled back to the entry point.
  - The illustration of HDD Operation is presented in the ***Figure 5.4.***

Pilot Bore Phase



Reaming Phase



Pull Back Phase

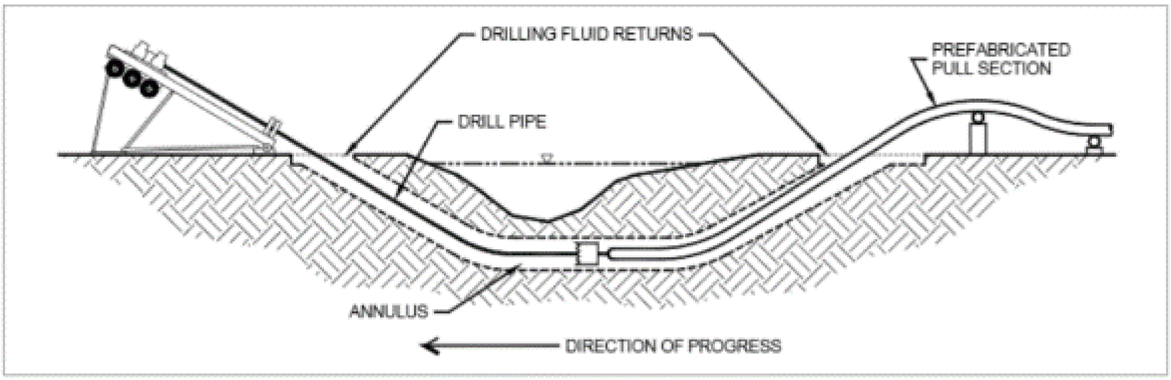


Figure 5.4: Phases of HDD operation

HDD has certain advantages over conventional drilling in terms of construction, operation and from environmental point of view:

- No additional issues arising from closed streets, irrigation canals or railways
- Minimal reclamation requirements to the obstacle crossed since surface disruption along the alignment drilled is minimized
- The need for removal, restoration, monitoring, maintenance associated with trench settlement is eliminated/minimized to a large extent through the use of HDD crossings
- HDD construction time is much lesser than conventional crossing methods

- Generation of Less noise and dust, lesser construction waste

HDD method comes with some sustainable construction criteria like lesser construction waste including provision of using safe material like bentonite, less noise, lesser impact to the environment. However, it is imperative to dispose the drilling mud & drill cuttings in an environment friendly manner as per the prevalent regulations, to avoid issues like contamination to soil & water resource, etc.

- Impact on Ambient Air Quality: There would be adverse impact on the ambient air quality by fugitive dust emission due to activities like clearing and earthworks, including trenching, levelling during construction & vehicular movement and emission of pollutants namely SO_2 & CO from the combustion of fossil fuels (mainly HSD) used for construction equipment and DG sets. However, impact due to generation of dust & pollutants would be localised and temporary, causing adverse impact on the ambient air quality only during the construction period. Emission of greenhouse gases due to construction of pipeline below the river would also be insignificant.
- Generation of fugitive dust has adverse impact on ability of nearby vegetation to survive and maintain effective evapotranspiration. However, the project area was found not to have any vegetation during site survey and was filled with sand. No parks and gardens have been located nearby the project site. Hence there would be low impact on vegetation due to the construction of pipeline.

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 2 i.e. Low					

- Impact on Ambient Noise Quality: The construction activities would cause noise generation by equipment associated with the construction activities including clearing, ditch digging, drilling, blasting, pipe handling, vehicle movements, etc, leading to rise in ambient noise level. The noise generated during construction phase including horizontal drilling for pipeline layout is likely to generate high noise only during day time and would be temporary in nature.

Intensity of Impact	**2**	**Extent of Impact**	**2**	**Duration of Impact**	**1**
Impact Significance = 4 i.e., Low					

- Impact on Surface water quality: There would be insignificant impact on surface water quality due to laying of pipeline on riverbed as horizontal Directional Drilling (HDD) method would be adopted, which causes very little disturbance to surface activities, requires less working space and requires lesser time than traditional open-cut method. Impact on surface water quality like increase in turbidity of water due to increased sedimentation, removal of vegetation, disturbance to aquatic fauna are not envisaged due to HDD method of pipeline construction. Hence, the impact on surface water is considered to be insignificant.

Intensity of Impact	**1**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 1 i.e., Negligible					

- Impact on Soil: The HDD is likely to impact soil quality along the alignment due to spillage of oil from earth moving vehicle and chemical used in pipeline laying. However, period of this activity would be very short period and restricted along the alignment. Hence impact associated with this activity is envisaged to be negligible. Impact on Soil: The HDD is likely to impact soil quality along the alignment due to spillage of oil from earth moving vehicle and chemical used in pipeline laying. However, period of this activity would be very short period and restricted along the alignment. Hence impact associated with this activity is envisaged to be negligible.

Intensity of Impact	**1**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 1 i.e., Negligible					

- HDD drilling activity is estimated to generate about 260 m^3 of drill cuttings & drilling mud. Generation of drilling mud (bentonite) with drill cuttings is anticipated to pose risk to the health and safety of human being and animals, pose threat to the ecology and may impact the water & soil quality if not stored properly and disposed in an environmentally sound manner as per the prevalent regulations. The drilling mud also acts as quicksand and pose potential risks to the safety of human being and animals if disposed indiscriminately. The drill cuttings and drilling mud would be disposed though authorised third-party agency. Drilling being onetime activity, generation and use of safe materials like water soluble bentonite would render the impact to be of moderate to low significance.

Intensity of Impact	3	Extent of Impact	2	Duration of Impact	1
Impact Significance = 6 i.e. Medium					

- Impacts resulting from storage and disposal of pipeline hydrotest water: Hydrostatic (Hydro) Testing of the gas pipeline would be done assessment of strength and leaks. It is proposed that for each test the pipeline would be filled with water and as per feasibility, the hydrotest water would be temporarily stored in a sump and reused. Hydrotest water is contaminated with materials used during pipe manufacture and also particulates from construction. Chemicals like oxygen scavengers and biocides may be added to hydrotest water to prevent corrosion damage and build-up of micro-organism in the pipeline. Disposal of this water to unpaved land or river would have potential to contaminate soil, ground and surface water. However, considering that this is a short-term activity and large amount of water is not expected to be discharged, the impact is considered to be of medium significance.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	2
Impact Significance = 6 i.e. Medium					

Mitigation Measures

The following measures would be implemented to mitigate Impact due to laying of gas pipeline

- Working area of HDD on both sides of the river would be restricted in minimum space required
- Working area would be restored up to previous condition after the end of pipeline laying activity.
- Adequate management of drilling mud (e.g. bentonite and drill cuttings) including testing for its hazardous characteristics; safe storage and disposal. The drilling mud & drill cuttings would be stored in a designated area with paving and secondary containment like dyke to obliterate chances of soil, surface & groundwater contamination due to seepage & surface run-off.
- In order to alert the working personnel and community from the quicksand properties of bentonite, the storage area of drilling mud & drill cuttings would have proper signages and boundary. Entrance to the drilling mud storage area would be strictly restricted except those deputed to work in the area and adequately barricaded under proper security monitor.

The following measures are proposed to mitigate the impacts from improper storage and disposal of hydrotesting water.

- Monitoring of the hydrotesting water and ensuring compliance to Standard for disposal to Inland Surface Water as per ECR 1997 or IFC's guidelines on effluent discharge, whichever is stringent, before discharge to the surface water
- Exploring possibility to reuse the water for multiple tests, as per requirement
- Exploring possibilities of reducing chemical additives and judicious selection of additives in terms of dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential
- Preparation of hydrotest water disposal plan considering monitoring aspects, safe disposal, chemical use and environmental risk associated with the disposal

Residual impact

With implementation of the precautionary and the mitigation measures, the residual impact is likely to be low.

5.3.6 Impact Due to Waste Handling and Storage

Construction and operation of the project would lead to generation of solid wastes constituting of hazardous and non-hazardous solid waste. During the construction phase, there would be generation of non-hazardous solid wastes like wooden palette, scrap metal, plastic packaging, rubber wastes, cardboards, Bottles of water, cans, plastic bags, food packaging, Domestic Wastes like food waste, etc. and hazardous wastes like Paint cans and used brushes, hazardous chemical waste, used oils and grease from machinery and equipment, used or spent lead-acid batteries, contaminated spill, bio-medical wastes, empty toners/ink cartridge, etc. Improper handling and storage of wastes may cause contamination of soil and groundwater. Run-off from hazardous waste storage area may lead to contamination of surface water body and sediment. Improper storage and littering of wastes may also cause adverse impact on health of the working personnel. However, majority of wastes would be non-hazardous in nature and stored in designated place. Hazardous waste would be stored in designated place having paving, cover and secondary containment. EPC contractor has formulated Waste Management Plan for managing the solid wastes. Training would be imparted to the labourers for waste segregation and disposal in designated areas and use of sanitation facilities. M/S Meghna Enterprise have been entrusted for collection and disposal of the wastes from the Plant and construction camp. Considering the above, the impact due to waste storage and handling is envisaged to be low.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 3 i.e. Low					

Mitigation Measures:

The measures in place to properly manage waste and thereby minimize any impacts to soil and sediment quality are:

- The waste storage area would be minimum 50-100 m away from Meghna River / any other surface stream
- Batteries containing liquid would be kept on impervious surfaces.
- Implementation of construction materials inventory management system to minimise over-supply of the construction materials, which may lead to disposal of the surplus materials at the end of the construction period.
- Ensure storage of wastes in closed containers away from direct sunlight, wind and rain.
- Provision of regular inspection of wastes to monitor leaks or spills.

Residual impact

With implementation of the precautionary and the mitigation measures mentioned for the storage and handling of chemicals and to avoid /minimise impacts to soil/sediment the residual impact would be negligible.

5.3.7 Impact on Air Quality

Impact on air quality may arise due to below mention activity

Preconstruction Phase

- Operation of diesel driven pump during pumping of sand slurry during land filling activity in proposed site
- Air borne dry sand during levelling and compaction activity of the proposed power plant site

Construction Phase

- Operation of diesel driven pump of sand slurry during land filling activity in construction camp site
- Air borne dry sand during levelling and compaction activity of the proposed construction camp site
- Dust and emission generated during laying of treated sewage pipeline.
- Fugitive dust from operation of concrete batching plant of capacity 90 cum/hr
- Dust and emission generated during transport of raw material and manpower
- Dust and emission generated during development of foundation for power plant

- Dust and emission generated during erection of structure for power plant
- Pre-fabrication and fabrication work including shot/sand blasting onsite.
- Emission generated due to operation of diesel driven drilling machine during laying of 960m length pipeline for transportation of natural gas from Titas substation to the site

Dust generated from many of these activities would increase the particulate matter levels in ambient air causing adverse impact due to increase in exposure to dust and annoyance due to dust soiling. Vehicles and equipment exhaust emissions can lead to increases in levels of nitrogen oxides (NOx), sulphur dioxide (SO_2), particulate matter (PM_{10} and $PM_{2.5}$), volatile petroleum hydrocarbon constituents and carbon monoxide (CO), which are key pollutants of concern with respect to human health.

Dust Generation

Most of the construction activities mentioned above have the potential to generate dust. Dust generated would consist of SPM, PM_{10} and $PM_{2.5}$. The extent of impacts from dust would depend on the exact location of these activities and on the weather conditions; stronger winds and dry conditions would enhance the transfer of dust, while damp or wet conditions would reduce this impact. Impacts from dust is also related to proximity of the receptors and the magnitude of the activities causing dust emission. Construction dust dispersion is expected to be localised due to the relatively high mass of the dust particles which would tend to confine the most significant dust impacts to the area within 100 m of the source of generation. However, due to presence of sensitive receptors like Mosques and human habitation within 100 m, it is imperative to adopt and implement dust suppression techniques to further reduce dust propagation to these receptors. The onsite workers would be also vulnerable to the fugitive dust generated during the pre-construction & construction phase of the project. During the dry season, dust suppression techniques like periodic water sprinkling would be adopted, and stockpile would be covered to minimise fugitive dust emissions. Use of wind barrier to restrict dust propagation, particularly to the sensitive receptors may also be considered. The potential for dust emissions during the wet season would be lower, due to the moistening of dust particles. Based on "Guidance on the assessment of dust from demolition and construction (Version 1.1) by Institute of Air Quality Management", considering the area of the site, the quantity of sand filling required, the magnitude or extent of dust emission is envisaged to be large for earthwork, medium for construction activities [28]. Dust emission due to vehicular emission depends on factors like vehicle size, vehicle speed, vehicle numbers, geology and duration. As per "Guidance on the assessment of dust from demolition and construction (Version 1.1) by Institute of Air Quality Management", the dust emission magnitude from trackout is considered to be medium.

Exhaust Emissions

Heavy equipment such as DG sets excavators, cranes, and compactors would be used on-site. Emissions of SO_2, NO_x, CO and VOCs from these equipment and diesel generator sets would cause impacts to ambient air quality. Transportation of construction material by vessels/barges and other transport vehicles along the approach road during the daytime would also contribute to exhaust emissions. Exhaust emission could adversely impact human health

However, considering the construction period to be short term and the emission from the above sources to be localised, the impact is envisaged to be of medium significance. The implementation of the good site practices, such as the regular maintenance of vehicles and equipment, using cleaner fuels and switching off vehicles when not in use would reduce exhaust emissions from the operation of the diesel-powered construction equipment and therefore minimise adverse air quality impacts.

Intensity of Impact	3	Extent of Impact	2	Duration of Impact	1
Impact Significance = 6 i.e. Medium					

Mitigation Measures:

To reduce dust impacts, the following measures would be put in place:

[28] Earthwork -Large when Total site area >10,000 m2 , potentially dusty soil type,
Construction - Medium: Total building volume 25,000 m3 – 100,000 m3 , potentially dusty construction material (e.g. concrete), on site concrete batching;
Trackout - Medium: 10-50 HDV (>3.5t) outward movements in any one day, moderately dusty surface material (e.g. high clay content), unpaved road length 50 m – 100 m

- Periodic water-spraying/sprinkling and sweeping of unpaved and paved roads to minimise dust and remove mud and debris. Sprinkling of water in dust prone activities like transportation on unmetalled road, digging works, material handling etc would be taken up.
- Covered transportation of dusty materials to prevent materials being blown from the vehicles while travelling.
- Locating the concrete batching plant away from sensitive receptors and additional net fencing/ solid barrier on section of boundary wall facing the sensitive receptors to minimise transport of the dust
- Ensuring any temporary site roads are no wider than necessary to minimise their surface area and thus the fugitive emission.
- Storing dusty materials away from site boundaries and in appropriate containment (e.g., sheeting, sacks, barrels etc.).
- If the residents and pedestrians complain about the dust and gas, the consultant of the supervision and contractors would reconsider the construction technique.
- Burning of wastes generated at the construction sites, work camps and any other project activity related site would be strictly prohibited.
- All stockpile materials which are likely to generate airborne fugitive dust would be covered with canvas or plastic sheets during windy season.
- Storage of excavated materials in dumping/disposal areas designated for this purpose.
- Installing wind barriers, particularly across locations of sensitive receptors to prevent dust propagation.
- Considering unloading of materials and other activities to be sited away from the location of sensitive receptors in the surroundings.
- In case of dry spillages, equipment must be readily available on site to clean up as soon as reasonably practicable using wet cleaning methods.

Exhaust emissions would be minimized as follows:

- Enforcing speed limits for vehicles to 20 km/hr on unmade surfaces to minimise dust entrainment and dispersion.
- Vehicles and machineries would be regularly maintained to conform to the emission standards stipulated under Environment Conservation Rules, 1997
- Monitoring would be conducted for air quality parameters and in case the parameters are on borderline or exceeds the environmental standards, stricter control measures would be adopted.
- Consideration would be made on using prefabricated materials where possible so that localised air pollution is minimised.
- Vehicles and equipment would be switched off when not in use.
- Avoiding fabrication work and shot/sand blasting work onsite.
- Adopting sustainable and non-polluting travel plans for workers like cycling, car-pooling etc to reduce additional emissions.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned for prevention/reduction of dust generation and exhaust emission the residual impacts would be low.

5.3.8 Impact Due to Generation of Noise and Vibration

This section identifies and evaluates the Impacts of the project activities due to noise generation during preconstruction and construction phases; and formulates the measures to mitigate and manage the identified impact.

The main sources of noise at preconstruction and construction sites are as follows:

Preconstruction Phase

- Noise Generated during operation of Diesel driven pump during pumping of sand slurry in proposed power plant site would cause temporary disturbance due to noise and vibration.
- Movement of heavy earth moving vehicle during levelling and compaction of sand proposed power plant site would cause temporary noise and vibration pollution.

Construction Phase

- Heavy machineries and transportation of equipment. Materials handling equipment, stationary equipment and other types of equipment etc. would be the major sources of temporary noise during construction and construction activities.
- Horizontal Directional Drilling (HDD), cutting of pipe and laying of pipeline for transportation of natural gas from Titas to the site would generate significant and temporary noise and vibration.
- Traffic congestion and vehicular movements in the Approach road used by construction workers to commute to and from the site, would generate temporary noise and vibration .
- Pre-fabrication and fabrication work including shot/sand blasting onsite.

Noise prediction modelling has been carried out using SoundPLAN 8.2 to predict noise levels that would result from the construction equipment during construction phase of 600 MW Gas Fired Thermal Power Plant in Meghnaghat, Sonargaon, Narayanganj, Bangladesh. This assessment is attentive on evaluating the noise contributions from the construction phase of the plant to the sensitive receptors in adjoining area.

Basis of Sound PLAN Modelling Software

SoundPLAN is a modelling and presentation tool that helps optimizing the noise control measures and visualizing the effects of noise propagation throughout complex systems. This model is very useful to calculate sound pressure levels and generate noise maps. The output of this software is a graphical representation of the calculated sound pressure levels, considering reflections and diffractions of sound, and considering the geometry of buildings at the site and topography. The pressure level calculated or interpolated for each point within the modelling domain are shown as a grid of sound pressure, from which a contour map is generated showing isophones (lines of equal sound pressure).

Accumulated levels of sound pressure can be calculated combining the sound contribution generated during the operation phase considering the conditions of existing background noise. The elevation of the study area obtained and calculated from Google Map or OSM, which most closely approximates the actual topography. For the proposed project, the elevation of the site is considered to be about 7.76 m above msl while the adjoining areas are taken to be of 4.8 m high. This software generates and manages all geometrical data and accepts ASCII, DXF and ESRI Shapefile formats, amongst other Data is easily manipulated using the transformation and coordinate operation features. Objects are easily digitised within the Geo-database and are arranged in a hierarchical order. Obstacles to noise propagation, e.g., vegetation cover, infrastructure, located near the site also considered. The ground absorption factor (G) is determined by the software automatically for evaluating ground effects on sound propagation.

The Industrial Noise Propagation module of SoundPLAN 8.2 consists of two main components, the emission calculation and the propagation calculation. The emission calculation is performed internally within the noise source database, where operation equipment's sound power (SP)/ pressure (SPL) level, sound generation height, their positions are defined. The propagation calculation is performed inside the calculation core of SoundPLAN. The performance of this module is further enhanced when used in conjunction with Wall Design to design and optimise the location and extent of noise barriers. Implemented calculation standards include BS5228-1:2009, CoRTN, CoRTN Lden, NORD 2000 and RLS-90, amongst many others. It is assumed that there would be provision of a 2-m high boundary wall made of NPW sheet metal around the site which is considered for the modelling study.

The main noise sources of the construction site of the plant are presented in below ***Table 5.4:***

Table 5.4: Noise Level of Construction Equipment in Project Construction site:

No.	Noise Generating Equipment & Noise Sources	No of equipment in operation	Noise Level dB(A)	Comments
1.	Diesel Generator 550kw	3	101	1m Away
2.	Diesel Generator 500kw	2	84	1m Away
3.	Excavator	1	105	1m Away

No.	Noise Generating Equipment & Noise Sources	No of equipment in operation	Noise Level dB(A)	Comments
4.	Borehole Drilling Rig	2	108	1m Away
5.	Hydraulic Pile Driver	2	136	1m Away
6.	RMC TRUCK	2	79.1	1m Away
7.	Transit Mixer	1	79.1	1m Away
8.	Dump truck	2	86	1m Away
9.	Crawler Crane	2	69.8	1m Away
10.	Mobile Crane	2	81.5	1m Away
11.	Crane	1	85.7	1m Away

(Source: UMPL)

The following assumptions were made during preparation of:

- The main emission sources were assumed to be point sources based on their nature. Sound waves from point sources travel in all directions (spherical propagation).
- Small elements, such as structures, pipes and racks may be used during construction, were not included as noise sources or sound barriers. Although a construction barrier of 2m height considered.
- All noise sources were assumed to be operating continuously throughout day night (24h), including discontinuous noise sources, which corresponds to a conservative approach (higher acoustic impact). Stand-by units were not considered in the model as noise sources.

Model Results and Discussion

The results of the model as noise contour are presented ***Figure 5.5.*** below, that were generated from a colour-coded noise level distribution grid. The colour scale was chosen so that cool colours (green) represent low values of sound pressure and warm colours (deep blue) represent elevated values of sound pressure. Contour lines (isophones) are representative of noise pressure intervals of 5 dB(A).

For the noise prediction in operation phase, construction activity for 100% for 24 h Time Histogram considered to calculate the cumulative noise levels.

Predicted noise in construction period is in higher side. This predicted noise is in worst case scenario, i.e. all the construction equipment operated all together at any single instance. The construction activities at the construction site would be changing constantly as the construction progresses and it is for a limited period. After the construction period over, in operation phase the noise would be definitely in lower side in the adjoining area. The noise simulation studies indicate that the boundary wall and homestead vegetation in the adjoining scattered village area around the plant site acts as a noise protection barrier. The noise levels at the nearest sensitive Receptors have been assessed, considering all the construction equipment are running at any single instance i.e. in worst case scenario. Also, we run this model with two-layer 6 m high boundary wall (3 m gap in between) made of NPW sheet metal and presented in below table. The actual monitored results (monitored & shared by UMPL) shows lower noise levels compared to assessed values. The estimated noise level at the surrounding nearby sensitive receptors in the vicinity of the plant is shown in ***Table 5.5:*** It may be observed from Table 5.5 that the predicted noise level exceeds national as well as IFC/WHO noise standards.

Table 5.5: Sensitive receptors in the vicinity of the plant

Sensitive Receptor Name	Direction	Distance from Boundary	Construction Phase Estimated noise level*, dB (A) with 2 m high boundary wall made of NPW sheet metal	Construction Phase Estimated noise level*, dB (A) with 6 m high double layered boundary wall made of NPW sheet metal	Monitored Noise level, db(A)**
Korbunpur Jamia mosque	West	67 metre.	80.52	70.19	-
Sardarbari Mosque	North-West	112 metre.	74.70	69.55	58.4
Purbapara Jame Masjid	North-East	26 metre.	75.77	67.76	64.2

Sensitive Receptor Name	Direction	Distance from Boundary	Construction Phase Estimated noise level*, dB (A) with 2 m high boundary wall made of NPW sheet metal	Construction Phase Estimated noise level*, dB (A) with 6 m high double layered boundary wall made of NPW sheet metal	Monitored Noise level, db(A)**
Madhya Para Jame Masjid	North-East	135 metre.	76.78	56.82	-
Dudhghata Govt Primary School	North-East	142 metre.	72.82	72.22	57.9

**Worst case scenario considering all the construction equipment are running at any single instance*

***Data shared by UMPL*

Note: Considering residential area, the Noise level as per ECR 1997 are 55 dB (A) during day -time (6 am – 10 pm) and 45 dB (A) during night time (10 pm – 6 am)

The Details of noise modelling is provided in **Appendix I.**

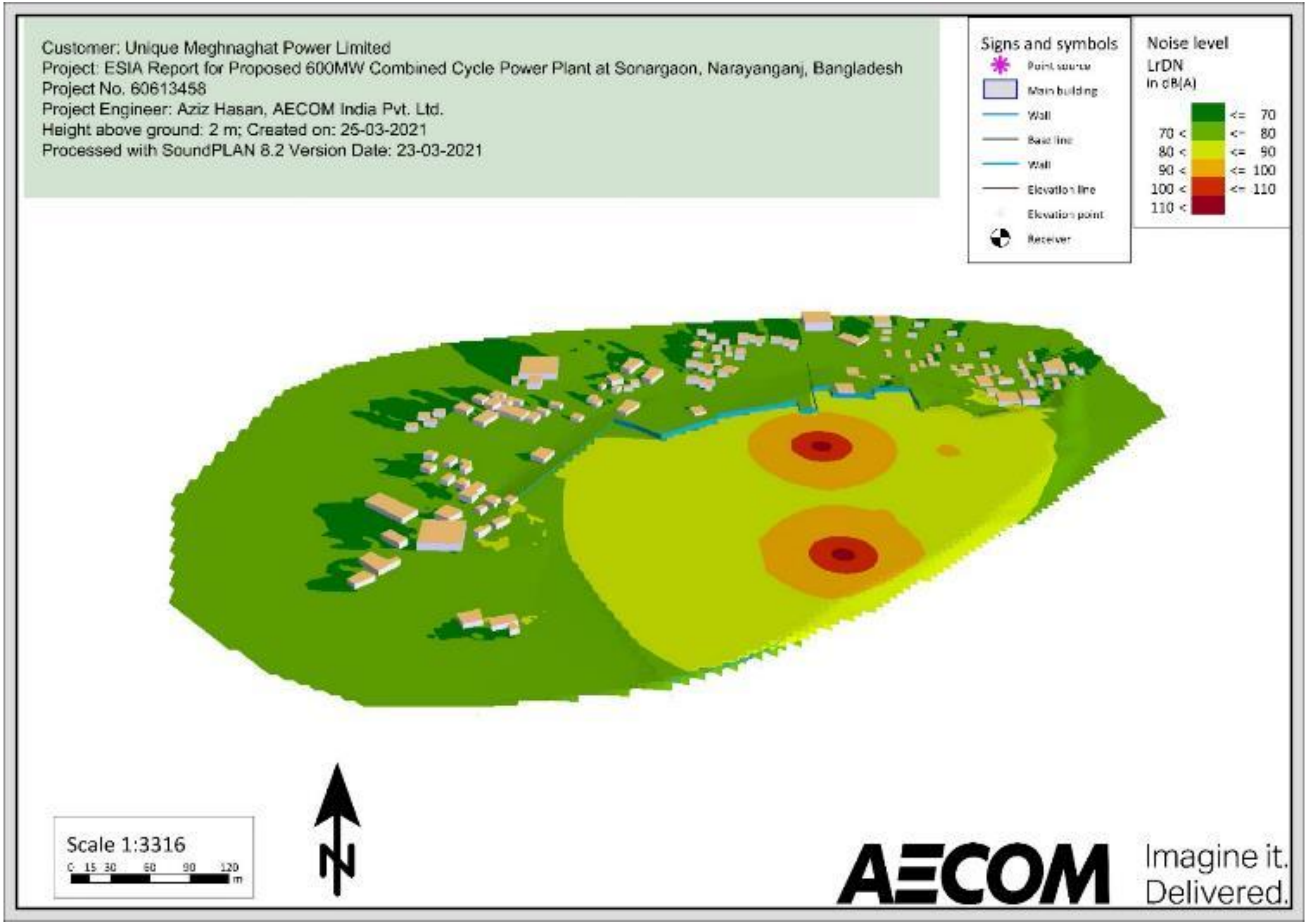


Figure 5.5. Noise level contours during construction phase (without mitigation measures, Boundary wall– 2m high)

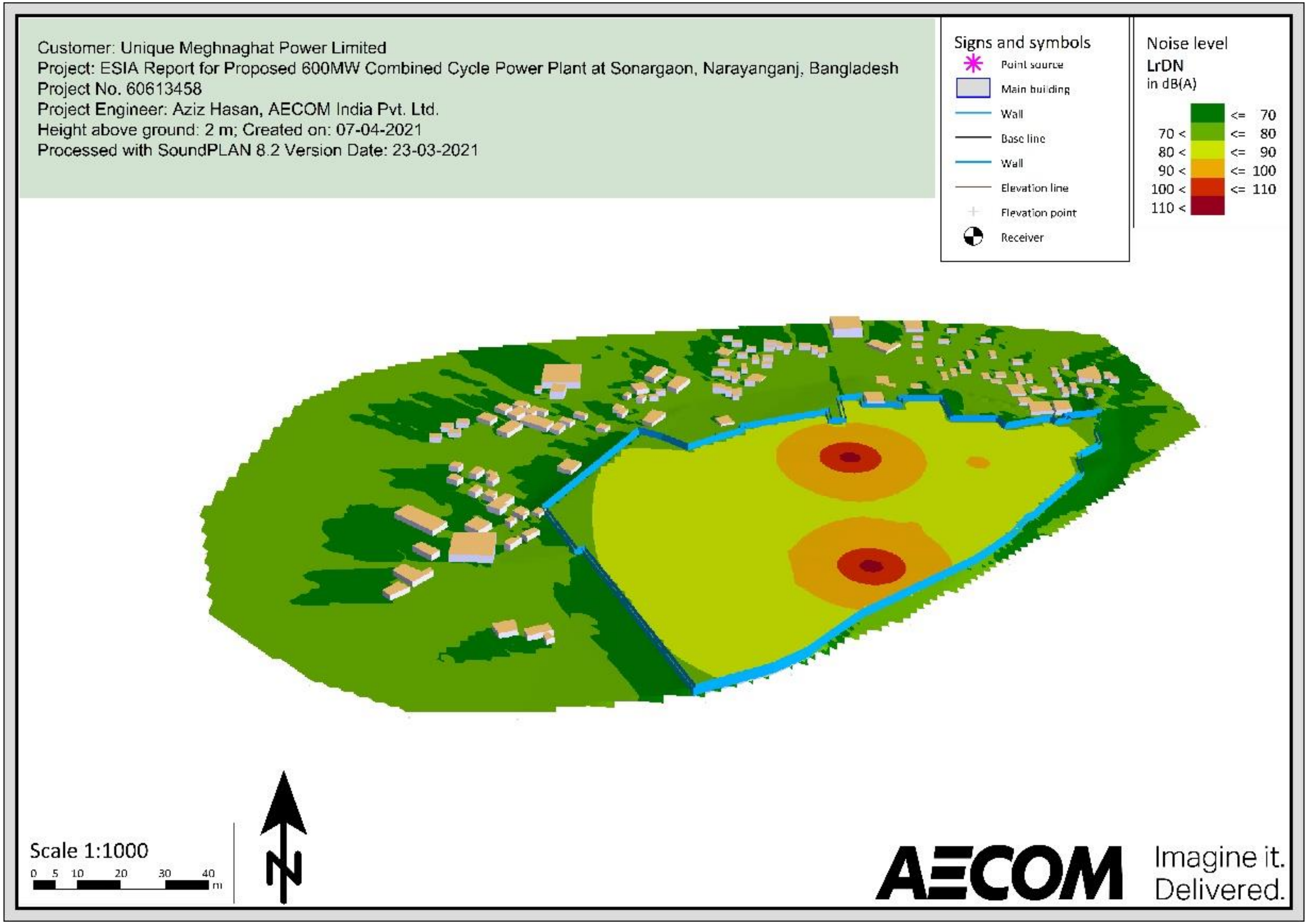


Figure 5.6. Noise level contours during construction phase (Boundary wall – 6 m high)

Considering that the construction phase is temporary and of short duration, the noise impact is anticipated to be medium.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 6 i.e. Medium					

Mitigation Measures:

During construction work, the management measures would include in the first place, use of state-of-the-art low-noise equipment wherever feasible. Material and equipment transportation vehicles would ensure adoption of techniques for reducing noise generation including engineering control mechanism such as installation of mufflers and speed reduction in the residential area, therefore the vehicle noise impact would be minimized. Other measures include:

- Use of acoustic enclosures for DG sets during construction phase.
- Normal working hours of the contractor would be between 06:00 and 21:00 hours from Saturday to Thursday. If work needs to be undertaken outside these hours, it would be limited to activities that do not exceed the noise criteria at nearby noise sensitive receptors; Strict adherence to OSHA standards for noise exposure to be ensured
- Conducting noise monitoring at receptors as per the proposed monitoring schedule and in case exceedance happens, temporary sound barriers would be used at the working equipment with high sound power level.
- Regular maintenance of equipment and machinery used for construction.
- It is recommended to use Low noise generating equipment as far as practicable.
- Equipment known to emit noise strongly in one direction would be orientated so that the noise is directed away from nearby residential areas and sensitive receptors.
- Restriction on night-time vehicle movement through the approach road and restriction on honking.
- Mandatory use of ear plug, ear mufflers by construction workers working in high noise areas.
- Distribution of free ear plug to villagers of adjoining areas.
- Rotation of workers schedule to prevent worker’s prolonged exposure to noise

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned for prevention/reduction in noise generation at source impacts would be Low.

5.3.9 Impact on Surface Water Quality

Impact on surface water quality may arise due to below mention activity

Preconstruction Phase

- Discharge of return water from sand slurry in the river
- Storage and handling of fuel

Construction Phase

- Discharge of return water from sand slurry in the river
- Construction of Water Intake Station and jetty
- Sewage Discharge
- Storage and handling of fuel
- Excavation and construction activity of the power

Impact Due to Discharge of return water from sand slurry in the river during sand filling

As the sand is pumped from the carrying boat in slurry form using river water, after deposition of sand in the proposed site, water would return back to the river though the lowest gradient of the proposed land. Thus, some amount of sand can be mixed with water and flow into the river, causing impacts like increased turbidity in the river water and change in sediment quality (discussed earlier). However, return water would be channelized thorough a designated channel where slit trap would be installed to trap the sand at the proposed site. The project site would be having silt collection device, turf, flushing pool, drainage outlet and surrounding dock, or other silt control measures to prevent silt, debris, mud from entering drains or other adjacent place as required by applicable regulatory requirements. This, along with the fact that it is temporary activity, the impact on water quality like increased turbidity would not be significant.

Intensity of Impact	**1**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 1 i.e. Negligible					

Mitigation Measures

The following measures would be implemented to mitigate Impact due to sand filling.

- Return water would be discharged in the river thorough designated channel.
- Silt trap would be installed before commencement of sand filling.
- Proper working of the silt trap and other silt control measures through regular inspections and in case of any blockages, immediate measures are to be implied.

Residual Impact

There will be no residual impact as such.

Impact due to Accidental Leakage and Spillage of Fuel and Chemical During Preconstruction and Construction Activity

Accidental release of fuel oil & chemical stored and used at site can contaminate the river water by flowing to river with surface run-off. Fuel, chemical or any other hazardous materials would be stored in a designated covered place and refuelling of the earth moving vehicle and handling of chemical would be carried out by trained staff within a designated place. In order to prevent impingement of leakage and spillage, differentiated peripheral drainage, rainwater drainage and process dredging would be provided. The sewerage system of adequate capacity designed to contain the overflowing of construction waste and chemicals. Hence chances of accidental spillage of oil would be very limited and chance of contamination of river water due to mixing of surface run-off would be low considering the embedded prevention measures.

Intensity of Impact	**1**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 2 i.e. Low					

Mitigation Measures

The following measures would be implemented to mitigate Impact due to accidental spillage of fuel

- Drip tray would be used during refuelling
- Maintenance area and the washing bays of earth moving vehicle or other equipment, would be carried out in designated place with concrete floor and bund.
- Oil and Chemical Storage area would be covered and concrete floor and bund.
- Use of spill control kits to contain and clean small spills and leaks
- The Contractor would prepare guidelines and procedures for immediate clean-up actions following any spillages of oils, fuels or chemicals.

- A site-specific Emergency Response Plan would be prepared by the Contractor for soil clean-up and decontamination; and
- The construction contractor would implement a training program to familiarise staff with emergency procedures and practices related to contamination events.
- Impact due to construction of water of water intake station & unloading jetty have been delineated in preceding section.
- Dredged material would be stocked in a designated place with bunds.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned, the residual impact is assessed to be Low.

Impact Due to Discharge of Sewage

Sewage would be generated from the proposed power plant site and construction camp. However, the EPC contractor has installed septic tank at plant site and construction camp site and treated sewage is disposed through tankers by authorised vendors. Though septic tank is presently in operation in the construction camp during the initial days of construction phase, installation of STP is in the advanced stages and STP would be commissioned to treat sewage in the construction camp/ laydown area to meet the standards specified in Schedules 9 and 10 of the ECR, 1997 respectively and IFC EHS Guidelines prior to discharge to land/inland waters. Hence the impact significant is assessed to low.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	1
Impact Significance = 3 i.e. low					

Impact due to Discharge of Wastewater from Construction Activity

Wastewater from the construction activities is likely to pose significant impact on the surface water quality if discharged without adequate treatment and mitigation measures. The surplus wastewater (if any) from the concrete batching would be treated to comply with discharge standards before it is discharged. There would be adequate sanitary facilities, i.e., modular toilets and showers for the construction workforce. Portable toilets would be provided in case permanent toilets are absent. Considering the short duration of the construction activities and implementation of the measures specified by the Environmental Monitoring & Management Plan prepared by the project proponent and treatment of wastewater to be done before, the impact is assessed to be low and can be mitigated with following mitigation measures.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	1
Impact Significance = 3 i.e., Low					

Mitigation Measures:

- Restricting the earth work activities during monsoon season; installation of fence against earth and sand deposition around the excavation area to prevent flow of earth and sand into the surface water.
- The effluent generated from washing of equipment/miller wash would be stored and treated in a sedimentation tank, to be installed on a temporary basis, because chemicals may be used at the time of washing the equipment. The effluent would be discharged following coagulation/flocculation and removal of supernatant (and their discharge in an environmental sound manner) from the sedimentation tank.
- Channelize all surface runoff from the construction site through storm water drainage system and provide adequate size double chambered sedimentation tank.

Residual impact Residual impact

With implementation of the precautionary and the mitigation measures mentioned for prevention of surface water contamination the residual impacts would be negligible.

5.3.10 Impact on Ground Water resource and Quality

Ground water would be used for construction activities & drinking purposes during the construction phase. There are presently two (2) borewells for which UMPL has approval/license from the concerned local authority, i.e. Upazila Parishad. UMPL has been recording the ground water abstraction and testing the ground water quality at periodic intervals. Considering the ground water abstraction to be temporary and with all licenses in Place, no impact due to ground water abstraction is envisaged. Periodic testing of abstracted ground water quality also ensures adherence to local & international water quality standards (e.g., WHO standard).

There is no impact anticipated on ground water quality during preconstruction phase. Impact on ground water quality may arise due to below mention construction activity.

- Development of foundation of the power plant
- Discharge of Sewage on the ground
- Storage and hand handling of chemical and fuels
- Waste handling and storage

Development of Foundation of the Power Plant

Development of foundation of the proposed power plant would be carried out using pile driver which would use drilling mud. The drilling mud, based on its composition, mud could be a potential contaminating of the ground water. However, water soluble bentonite would be used as mud hence chance of ground water contamination would be remote.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	1
Impact Significance = 1 i.e. Negligible					

Storage and handling of Chemical and Fuels and Waste

The proposed construction activities may contaminate the groundwater through spillage of hazardous chemicals/hazardous wastes into the open ground, and seepage of contaminated rainwater from site. If there is occurrence of contamination of groundwater, it may have high impact on local community who use ground water for drinking purpose, and the duration of impact would be for long-term in nature. However, all hazardous chemical, fuel and waste would be stored in covered area with concrete/paved flooring and bund and handled by trained staff. Immediate containment and clean-up of oil leakage or spillage would be carried out. Waste oil would be collected and stored for recycling or disposal. The site will have adequate sanitary facilities, i.e., modular toilets and showers for the construction workforce. Portable toilets would be provided in case permanent toilets are absent. Hence chance of contamination would be low.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	1
Impact Significance = 3 i.e. Low					

Mitigation Measures:

- Storage of hazardous chemicals and wastes on paved surface with temporary bund wall and shed along with safe handling and disposal.
- Preparation and Implementation of procedures to formulate preventive and corrective actions against any potential spillage of harmful materials.
- Provision of appropriate spill kit.
- Periodic monitoring of groundwater quality.
- Scraping off contaminated soil immediately after spillage for safe disposal to prevent transport of contaminants into the groundwater aquifer.
- Channelize all surface runoff from the construction site through storm water drainage system and provide adequate size double chambered sedimentation tank.

Residual impact

With implementation of the precautionary and the mitigation measures mentioned for prevention of groundwater contamination the residual impacts would be negligible.

5.3.11 Impact due to Associated facility

The widening and strengthening of the existing village road between Battala Bazar and the Plant Gate is considered an Associated Facility (AF) as the village road will also be used as access road for the proposed project. The widening of the existing village road is being conducted by the Local Government Engineering Department (LGED) under the Rural and Culvert Maintenance Program. Thus, UMPL has no control over the AF and no influence on the construction management of the road widening.

The adverse environmental impacts of AF are mostly construction related as follows:

- Generation of fugitive dust & noise
- Discharge of wastewater from construction site
- Generation & disposal of solid waste including debris
- Blockage of access and congestion of traffic
- Hindrance to micro-drainage
- Occupational health & safety issues of workers

Good practice measures would be adopted including construction of drains to channelize stormwater to nearest public drain, storing of construction & municipal wastes in designated area, water sprinkling during dry period, restriction on use of high noise generating equipment near sensitive receptor during night-time and during period of congregation for prayer. These impacts are considered insignificant if managed well. Considering that it is a populated area, land clearance would be kept minimum to the extent practicable for construction of the approach road so that any alteration of the natural topography or landscape is largely avoided.

Intensity of Impact	**1**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 1 i.e., Negligible					

5.3.12 Impact on Terrestrial Flora and Faua

Impact on terrestrial flora and fauna may arise due to below-mentioned preconstruction and construction activity.

Preconstruction Phase

- Removal of vegetation in proposed project area, construction camp site and deposition of sand slurry

Construction Phase

- Erection of Transmission Towers
- Movement of vehicles, machinery and people

Pre- construction

Impact due to removal of vegetation in Proposed project Area, construction camp site and deposition of sand slurry

During the primary baseline data collection for ecological study, the representative of UMPL reported that 11 big trees under homestead plantation, which was located in the project area, were cut down and compensation has been given to the respective owners. There are no big trees located in the camp site area.

Filling of sand will lead to loss of agricultural land and its associated vegetation (small shrubs and herbs) loss and affect the species within the proposed project site and indirectly to those faunal species who use this land as a residence and corridor for movement.

Moreover, IUCN Global status designated Critically Endangered (CR) / Endangered (EN) species, Migratory species, Congregatory species or Endemic/ Restricted Range species have not been recorded during study period from direct observations and consultation with local peoples. Among reptiles, Indian Rock Python is categorised as Vulnerable (VU), Bengal Monitor Lizard and Pond Tortoise are categorised as Near Threatened (NT). All these above-mentioned species were listed based on community consultations; no direct sighting was made during ecological baseline survey. Correspondingly, no designated protected area, Ramsar Wetlands, Important Birds Area are present within the 5 km of the project area.

However, impact on terrestrial ecology would be short term as the activities would be limited for the development and construction period and the extent would be local. The resource sensitivity is Low for habitat due to absence of any protected areas. Hence the overall impact is negligible.

Intensity of Impact	**1**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 1 i.e. Negligible					

Impacts due to erection of Transmission Tower

During the construction activities soil excavation will be done for the erection of foundation. As a practice the excavate soil is stored around the excavation as a sort of bund. There are chances that domesticated livestock can fall into these excavations and get hurt. Since these excavations would be for a short period of time, the duration is low, and extent is local, the overall impact is negligible.

Intensity of Impact	**1**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 1 i.e. Negligible					

Movement of vehicles, machinery and people

During the construction phase regular movement of vehicles, machinery and people will be there. Movement of vehicles and machinery over the land surface not only exposes the natural environment to vehicular emissions and unnatural levels of noise, light and vibrations, but also dislodges fine soil particles creating dust. Presence of vehicles, machinery and construction workers cause visual and auditory disturbance to the fauna in the area.

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 4 i.e. Low					

Mitigation Measures

- Land clearing would be kept minimum to the extent practicable for the approach road and damage to the natural topography and landscape would be minimized. Provision of landscaped areas, where possible, around and within the Project Site would be done using indigenous species to supply habitat for terrestrial and riparian species and improve aesthetics.
- The noise generating activities would be schedule during daytime only to avoid disturbance of local fauna in the night-time.
- Strict prohibition would be implemented on trapping / catching of fishes by the subcontractors and would bring a penalty clause under contractual agreements.
- Green belt development would be initiated with plantation of local species for stabilization of the filled in material and engage with local forest department and Upazila administration for plantation activities outside the project area.
- Adequate bird's flight diverters (Hanging colour ball), wishbone-type equipment's and insulators would be present in the transmission line to increase the visibility of transmission line for the birds.
- Fencing around the site to prevent entry of any domesticated animals on site.
- Preference to the local workers would be given in construction activities to avoid any pressure on the natural resources.

- To reduce the impacts of soil compaction and rutting of soil the movement of vehicles should be strictly restricted to pre-designated routes.
- To control the impacts of increased emission, vehicle emissions should be checked and maintained within prescribed standards. For heavy machinery, there would be strict adherence to all standard dust, noise and vibration mitigation measures.
- Project personnel need to be educated for not spreading any plant seeds intentionally.

Residual impact

With implementation of the precautionary and the mitigation measures mentioned for conservation of terrestrial flora fauna the residual impacts would be negligible.

5.3.13 Impact on Aquatic Flora and Fauna

Preconstruction Phase

- Dredging of river sand for filling

Construction Phase

- Return Water of sand slurry in proposed power plant area and proposed construction camp area
- Accidental spillage and leakage of different construction activities and river transportation
- Discharge of sewage into the river water
- Construction of water intake station, jetty and Gas pipeline

Pre- construction

Impact Due to Dredging of River Sand for Filling

Approximately 465,000 cum of sand was procured by UMPL for filling of proposed power plant site. Apart from that, approximately, 101337 cum of sand was also procured for filling of construction camp site of 1200 decimal of land area. Sand has been procured from approved vendor M/s Meghna Enterprise under contract agreement Work Order- SFL/OPS/2019/0036 Date- 27/10/2019 and Work Order- SFL/OPS/2020/0057 Date- 01/09/2020 and from designated dredging location. The sand is procured from Dakkhin Nayanpur (23°32'21.01"N 90°34'20.84"E) in Bangladesh. Contractor can dredge the river sand for the district authority designated place under same law after getting permission. As all the required permissions for sand sourcing from government authorised designated sources are available, hence impact related to sand procurement would be negligible.

Construction Phase

Impact due to Return water of sand slurry to proposed power plant area and proposed construction camp area.

Return water from sand slurry used for landfilling may lead to increase in turbidity of river water, change in sediment quality and cause associated impact on aquatic flora & fauna. However, return water would be channelized through a designated channel installed with silt trap to prevent mixing of sand with return water. Considering this and that the activity is of short duration, the impact on aquatic flora & fauna would be low.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	2
Impact Significance = 2 i.e. low					

Impact due to accidental spillage and leakage of different construction activities and river transportation

Surface runoff from construction site, discharge of hydro-testing water, spillage & leakage of oil and lubricate, from construction site could cause surface water pollution, affecting the aquatic ecosystem. Moreover, transportation of machinery and construction material to the project site would be transported through Meghna river. A floating Jetty would be used for offloading the material at the Project site. There is a likelihood of accidental spillage of oil and other chemicals during unloading activities and from the storage during construction phase. This may reach the Meghna directly or by runoff and impact the aquatic flora and fauna.

The predicted impact on aquatic ecosystem envisaged due to barge/vessel movement directly and indirectly due to contamination from any accidental spillage. Impact would be short term as it would be limited to construction period only. The impact magnitude would be low considering the embedded prevention measures.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	2
Impact Significance = 4 i.e. low					

Impact Due to Discharge of Sewage

Sewage would be generated from the proposed power plant site and construction camp. However, that sewage would be treated in STP installed in plant site and construction camp site. There would be efforts to recycle the treated sewage and surplus treated sewage would be discharged in the river. Also, the treated water would be discharged as per Schedule 10 (Standards for Waste from Industrial Units or Projects Waste) of the Environmental Conservation Rules, 1997, Bangladesh) and Effluent Guidelines, IFC EHS Guidelines for Thermal Power Plants, 2008. Hence the impact significant is assessed to be low.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	2
Impact Significance = 2 i.e. low					

Construction of water intake station, jetty and gas pipeline

Impact on aquatic ecology: The construction of water intake channel & outfall inside the Meghna River Channel may cause disturbance in the riverine environment which would affect the movement of aquatic faunal species. Also, intake of water during testing of equipment would lead to localised vortex formation at the intake point which is going to be affected the existing aquatic floral and faunal composition.

Construction of temporary jetty has been envisaged in the project design. This activity would affect the aquatic fauna in the Meghna river channel by creating physical hinderance during their movement. The piling activity during the construction of jetty would primarily increase the turbidity of the water which also going to affect the aquatic environment.

For gas supply to the plant, it has been proposed that 20-inch (508 mm) diameter subsurface pipeline will be laid by using Horizontal Directional Drilling at a depth of 15.79 m, across the river from nearby valve station located on the other side of the Meghna branch channel. It has been anticipated that the river ecology in the Meghnaghat Channel area will not be affected by this type of drilling activity.

Considering the duration of impact is only restricted to the construction activity period and the extent of impacts is confined to a limited area, the overall impact on aquatic ecology due to water intake, Jetty and gas pipeline formation is low.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	2
Impact Significance = 2 i.e. Low					

Mitigation Measures for Aquatic Ecology

- It is to be ensured that silt trap is installed in the return water channel, through which the return water is discharged to the river.
- The movement of large barges and vessels would create swells and may erode the banks, so compaction and stabilization of banks must be done to ensure that no bank soil is washed away.
- The faunal activity reduces in mid-afternoon so, the ideal time to enter the Khal by vessels would be preferably mid-afternoon.
- Presence of adequate spill kits at site must be ensured to handle accidental oil spillage. Also, special attention and care must be taken at the time of transportation and material exports through jetty to prevent any accident which may impact the aquatic environment.

- Project proponent would promote local fish breeding in consultation with Fishery Department with involvement of fishermen present in the study area to conserve the fish resources in the Meghna River. This would support the local fishermen by fish spawning and introduction of pollutant resistant fish species in the nearby fishing zone.
- Avoidance of river water pollution resulting from discharge of wastewater during the construction work and installation of equipment which is already described in water pollution section of the report.
- Avoidance of any leakage of fuels and other contaminants from barges/trawlers to Meghna River.
- Trawlers/barges with valid requisite licenses and emergency handling capacity or tie-ups would only be engaged

Residual impact

With implementation of the precautionary and the mitigation measures mentioned for conservation of aquatic flora fauna the residual impacts would be negligible.

5.3.14 Aesthetic and Visual Impact

Potential Aesthetic and visual impact may arise due below mention activity

Preconstruction Phase

- Removal of Trees and Crops in proposed power plant site
- Levelling and compaction of Sand in proposed power plant site

Construction Phase

- Removal of Trees and Crops in construction Camp Site
- Levelling and compaction of Sand in construction Camp Site
- Erection of Structure for Power Plant
- construction of Transmission Line

Impact Due to Removal of Trees and Crops in Proposed Power Plant Site and construction Camp Site

It has been discussed earlier that there are no big trees present within the proposed power plant site and construction Camp Site. Hence it is anticipated that there would be no impact on aesthetics due to removal of trees.

Impact Due to Levelling and Compaction of Sand in Proposed Power Plant Site and construction Camp Site

After sand filling, the site would remain vacant for drying and natural compaction of sand. After that levelling and mechanical compaction activity would start on dry sand. This activity would generate fugitive emissions of small sand particle which create a significant aesthetics and visual impact of fence line community. However, it is a temporary activity which would be carried out for only few months and limited to immediate site surroundings only. Hence the impact would be low.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	1
Impact Significance = 2 i.e. Low					

Mitigation Measures

- Boundary wall would be constructed before commencement of levelling and compaction work
- Water sprinkling would be carried out in the working zone before commencement of each day's levelling work.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned, the residual impact is assessed to be negligible.

Impact Due to Erection of Power Plant Structure, Transmission Tower and Transmission Line

UMPL project site is located in village settings of Dudhghata mouza where the residing community adjoining the proposed project can see the river front from their respective houses. However, due to construction of power plant block their view of the river front and the branch channel of river meeting the main channel would get obstructed, which may create aesthetics and visual impact on the local population. Transmission towers and line for evaluation of power generated in UMPL plant would be erected within the plant boundary. Apart from that PGCD 400 KV transmission line and tower is already present in this area since a long time. Dudhghata mouza is located in the boundary of Meghnaghat Industrial area, and it is presumed that the local people are already adapted to the visual façade of industrial set up. Hence impact significance of aesthetic and visual impact would be negligible.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	1
Impact Significance = 1 i.e. Negligible					

5.3.15 Impact on Traffic and Transportation during Preconstruction and construction Phase

The project site is located in the area adjoining Meghna river, thus the bulk of the heavy machinery and equipment, construction material which would be required for the development of the proposed project is/ would be transported via the waterways. Two Jetties having area of 735 sq. m and 810 sq. m would be used to receive construction material as well as heavy equipment & machinery.

However, the road traffic movements in the Project Area are likely to increase during the construction phase of the proposed project. The approach road to the site was an unpaved village road having a width of about 15 ft. It passes through Dudhghata village with houses on both sides. LGED has undertaken developmental activities on the approach road, whereby it has been widened to approximately 20 ft and paved. As it is stated, road transportation will be availed for personnel commuting to and from work along with river traffic, there would be additional on the existing traffic due to plying of pick-up vans and sedans of UMPL.

The inflow of construction vehicles carrying workers during construction is likely to generate noise and dust emissions during the daytime and in the evening as well. Key environmental impacts during construction phase are likely to be:

- Community disturbance and potential safety hazards, with pedestrians and cyclists using local roads would have to exercise more care with increase of vehicular traffic on the said roads; Exhaust emission from vehicles, likely to cause rise in air pollutants. Exhaust emission from vehicles, likely to cause rise in air pollutants.
- Increase of fugitive dust due to traffic movement.
- Increase in probability of accidents involving human as well as domestic animals.
- Increase of community disturbance due to the increase of traffic related noise and vibration.

River Traffic:

- Accidental contamination from oil spill/construction materials from ship/motorboat that would carry the machinery and construction materials for the proposed project.
- Accidental introduction of invasive alien species during import of machinery/equipment through cargo
- Increase of exhaust emission from motorboat/ship, which would pollute local atmospheric air.
- Increase of river traffic movement may hamper the local fisherman on their fishing activity.

There is Traffic management plan in place which also includes River Traffic Management Plan. The major aspects covered in Traffic Management Plan are as follows:

- All vehicle would undergo routine repair and maintenance to keep the vehicle in good operating condition
- Drivers and operators would be checked for fitness and any driver/operator impaired due to any reason, including but not confined to: the influence of drugs and / or alcohol would not be allowed to drive.

- Defensive driving techniques would be adopted to ensure driving well within the safe limits of the vehicle and equipment operating limits and leaving enough time and room to react in the event of an unexpected condition or movement of another person, vehicle or equipment to avoid a collision or out of control situation.
- Speed limit of 20 km/hr within the site would be followed and use of mobile phone while driving would be prohibited
- Implementation of a safety program (signage, speed restrictions, lights on trucks, truck load restrictions etc.) within the construction area.
- To ensure safety of villages along the Approach Road, all drivers would be adequately trained to understand the road condition during the site EHS Induction, be sensitive and cautious when driving through the villages to avoid any conflict with local villagers. There would be a driver behavioural guide in place.
- All drivers would follow the speed limit, direction of signalman, particular humps or bridges, sensitive locations, horn usage restriction, high beam lights, etc.
- As a part of River traffic management, it would be ensured that there are proper Safety warning signage for river jetty area, prevent Spills or discharges of oil, chemicals, cargo, sewage, grey water and ballast water, All boat/ship/Barge slow down to speed of 8 knots around the jetty area) to turn around, maintain safe distance from others Boats (Local Boat) around jetty area and ensure all the required safety equipment on vessel.

For the proposed project, machinery and equipment would be imported during the construction period through cargo. However, the ships would deliver the cargo in Chittagong Port, from where the cargo would be loaded to barges and transferred to UMPL site. The vessels or ship carrying the cargo from abroad would be inspected as per National regulations and international framework of International Maritime Organisation (IMO). Therefore, the chances to spread of IAS, if any, in UMPL site will be remote and the subsequent impact is envisaged to be low.

With the traffic management plan in place and its implementation and inspection by the site management team (with support of site EHS team), the impact significance on traffic is considered to be low.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**1**	
Impact Significance = 3 i.e. Low						

Mitigation Measures

- The following measures are suggested in addition to the existing Traffic management plan:
- Collaboration will be undertaken with local communities and responsible authorities to improve signage (e.g. pedestrian crossings, speed limits etc.), visibility and awareness for pedestrian safety;
- The transportation of raw materials would be carried out in covered condition (sheeting). Restrict night-time movement of vehicles carrying raw materials, fuel, chemical and transporting workers. Ensure quick deployment of spill response procedure to allow quick response to clean up any offsite spills of oil/lubricants from the ships or machinery. Ensure quick deployment of spill response procedure to allow quick response to clean up any offsite spills of oil/lubricants from the ships or machinery.
- Depending upon the tidal activity the movement of boat & barges associated with proposed project related transportation, would be operated.
- It is recommended that the movement of vessels carrying construction material and equipment to the site would be restricted between 10 pm to 4 am, without affecting other users significantly, especially the local fishermen.
- Install traffic signals with vehicle stop mark lines at intersection points and designated crossovers (zebra crossing)
- Adoption of Stakeholder measures for avoidance of traffic incidents like display of educational materials and signboards to ensure elderly and children are aware of the increased traffic risk and safety measures
- UMPL is recommended to formulate and implement site-specific Invasive Alien Species Management Plan. An Invasive Alien Species Management Plan is drafted and presented in **Appendix T.**

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on traffic movement would be negligible.

5.3.16 Impact Due to Land Procurement During Preconstruction and Construction Phase

Impacts associated with land procurement prior for the project is described below.

- Loss of Land
- Loss of Household
- Economy and Livelihood of the local community

Loss of Land

According to UMPL, a total of 21.07 acres land has been required for the proposed power plant which has already been purchased from 343 landowners based on negotiation through willing buyer and willing seller process. Land price has been negotiated based on replacement cost (Market value of the land with transaction cost). Out 343 landowners, 6.79-acre land has been procured from owner of Probida company.

As per the discussions with landowner and local community, land procured for power plant was used as agriculture land before procurement. However, there were no standing crop and trees present during procurement and this land tract is free from any encroacher or squatter. Sufficient time was allowed to the landowners/lessee farmers to harvest their crops before commencement of pre-construction activities

Socio-economic survey of landowner conducted by AECOM team also reveals that negotiated price of the land has already been paid to the respective landowners in Cash. However, there are 26 vulnerable household presents among the landowners. Hence the impact significance would be medium.

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**3**
Impact Significance = 6 i.e. Medium					

Loss of Residential Structure

Consultation with local community, landowner and land procurement team of UMPL revealed that seven (7) residential structures were present within the project site during procurement. However, UMPL land procurement team has negotiated with them on land price along with compensation for the assets. Based on the negotiated price, UMPL has procured their land & assets present on the land. All the moveable assets have been removed by the landowner. Hence the impact due to resettlement is assessed to low.

Intensity of Impact	**1**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 2 i.e. Low					

Impact on Economy and Livelihood of the Local Community

Landowners

Loss of income or livelihood were expected to be significant as the 90 landowners (26%) would be rendered agriculturally landless due to selling of these land parcels; considering they do not have additional land for cultivation, while 25 landowner households are evaluated as vulnerable household. However, the landowners have income from other livelihoods like small business and services. Hence the impact significance is assessed to be medium.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 6 i.e. Medium					

Lessee Farmer and Land User

Lessee Farmers dependent on the land area procured for the power plant and land users of the land for Construction camp procured from Hamdard would not be able to continue with the agriculture practice after land procurement. Restriction on use of land in project area will lead to a short-term impact on their livelihood and income e.g. loss of income during the transition phase and could be mitigated once the they find a new site to earn their livelihood. . Hence impact significance is medium.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 6 i.e. Medium					

Mitigation Measure:

- Payment of compensation prior to taking possession of land.
- Dissemination of information about the procurement and compensation calculation process.
- Preparation of livelihood restoration plan and eligibility for livelihood restoration measures.
- Additional compensation for Vulnerable Household[29] if any
- Enhancement of sustainable livelihood of the affected lessee farmers through skill development for alternate employment.
- Unskilled labour during the project construction phase would be sourced from the local community.
- Training would be provided to the local people for their skill enhancement.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts due to land procurement would be low.

5.3.17 Impact Due to Access Restriction

Proposed project site is located between the branch channel of Meghna river and Madhya para hamlet of Dudhghata Mouza. Consultations with local community of Madhya para reveal that they use the proposed power plant land to access the branch channel for daily household activity e.g. bathing, washing etc. and fishing activity in main Meghna river. After construction of the proposed plant, this access route of the local community would be blocked and impede the routine activities of the community. Community consultations also reveal that apart from this access route through the proposed power plant area, two other walking routes are also present (through Dakshin Para Hamlet located at the west side of the power plant and through existing river ghat of Purba Para Hamlet located outside the east boundary of the power plant area). However, condition of Purba para ghat is not good. These two routes are also used by the local community for accessing the branch channel. The existing access roads to the riverfront is shown in ***Figure 5.7.***

[29] Vulnerable households/DPs may include (i) households that are headed by women with dependents, (ii) household heads with disabilities, (iii) households falling under the generally accepted indicator for poverty, (iv) elderly households who are landless and with no other means of support, indigenous peoples or ethnic minority households and (v) agriculture landless households or severely affected households

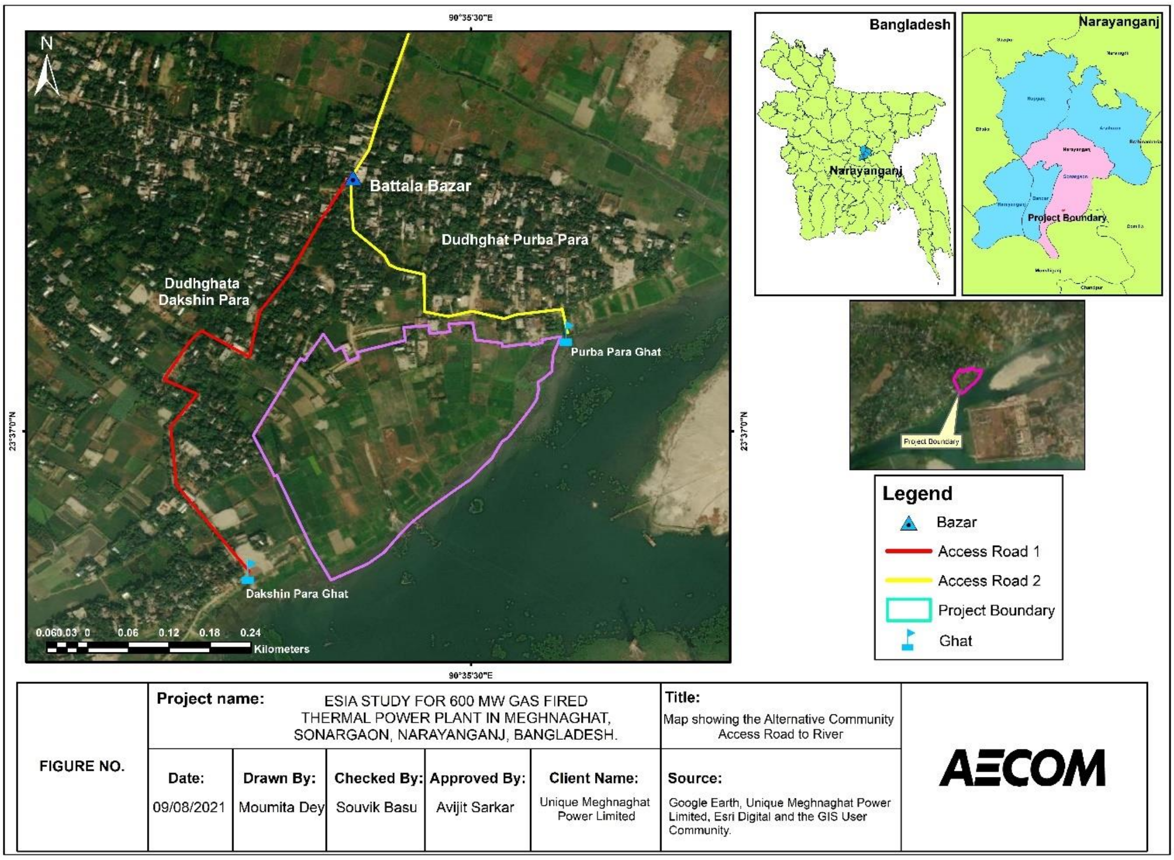


Figure 5.7: Alternate community access to the river

Based on the above, ssignificance of impact is considered low as two other alternate routes are also available in vicinity.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	2
Impact Significance = 2 i.e. Low					

Mitigation Measure:

UMPL would undertake a focus group discussion with the local community of the Madhya para hamlet before implementation of the below-mentioned mitigation measures.

- Development of existing ghat and adjoining road of Purba Para for easy access of local people

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts due to access restriction would be negligible.

5.3.18 Impact on Fishing Livelihoods

Like other parts of Bangladesh, fishing is also a major occupation in Dudhghata village, especially practiced by those who live in close proximity to the river. The proposed project site is located on the banks of the Meghna Branch channel. This channel is used by the villagers located adjacent to it for navigation, watering the agricultural fields and fishing. However major fishing is done at Meghna River in the south of proposed plant area which is about 5 km aerial distance from site.

Dudhghata Mouza has a small population of fishing community, 60 household of fishermen of the fishing community who use Purbapara ghat for fishing, anchoring their boat and drying their fishing net. The fishermen go for fishing twice a day during the high tides. Small fishes and shrimps are the usual catch from the Meghna river that are sold by the fishermen at local markets. However due to land procurement, they have been facing problems related to accessing river front and drying fishing net. However, discussions with fishermen reveal that they have other access route to access the river front and place for drying their fish net is also available. Hence impact significance is low.

During site visit, it was observed that around fifty (50) fishermen boats were docked adjacent to the area where the water intake channel is proposed to be constructed. It is envisaged that during the construction of water intake channel, fishermen may not be able to dock their boats in that area and need to find out alternative place for docking their boats. This may have an adverse impact on their livelihood during the construction period of the water intake channel, however, considering the construction period is 3-4 months only, the impact is considered to be low.

Intensity of Impact	2	Extent of Impact	2	Duration of Impact	1
Impact Significance = 4 i.e. Low					

Mitigation Measures

UMPL would put in place the following mitigation measures:

- Livelihood restoration plan would be prepared for the impacted fisherman
- Renovation of Purbapara Ghat would be undertaken by UMPL to assist the fisherman to access the river front, docking their boat and fish net drying.
- Existing dilapidated ghat would be renovated for easy access of the fisherman top river front.
- During the construction and operations phase, adequate stakeholder engagement measures will be put in place to ensure that the community's access to branch channel and Meghna river is not interrupted due to the movement of barges carrying construction material.
- UMPL would help the fishermen to identify alternative location nearby for docking their boats.
- UMPL would undertake consultation with the affected fishermen to ensure that their livelihood is not adversely impacted during the construction of water intake channel.

Residual Impact

With implementation of the mitigation measures mentioned above, impacts on fishermen community would be negligible.

5.3.19 Impact due to conflict with local people

Consultations in the neighbouring village indicate that the people in the area look forward to new employment to be generated by the project. Even though UMPL & the contractors would endeavour to provide maximum employment to the local people, there would be constraints due to the lack of required technical skills and expertise in the local population. So, certain percentage of semi-skilled and highly skilled migrant labourers would be used by contractors for manning these activities. It is anticipated that occasional conflicts would arise with the local community over the recruitment of migrant workers. Conflicts with the local population are also likely due to the cultural difference between migrant workers and nuisance caused by workers due to improper sanitation facilities etc. However, these may be managed with good labour practices. Since the conflicts can cause temporary disruption in work, the impact is considered to be of medium significance.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	1
Impact Significance = 2 i.e. Low					

Mitigation Measures

- All the workers would sign and follow the Code of Conduct.
- Communication in the affected villages during the construction phase and the installation of an effective grievance redressal mechanism.
- Training on the Code of Conduct and local culture, norms, tradition and value system would be imparted to the workers

- Labour camp would be provided with all amenities like drinking water, sanitation Facility, cooking facility
- Labourers would not enter the nearby villages without prior information
- Access of the local community in labour camp should be restricted
- Labour should not share any village resource
- Periodic health check-up of labourers would be carried out
- Labour Management Plan and Labour Accommodation Plan has been prepared and given in Appendix N and O respectively.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on due community conflict would be negligible.

5.3.20 Impact Due to Increment in Cost of Living

The economic growth and the overall development of the region would also have some drawbacks especially on the quality of life. The employment generation would result in increase in expendable income in the areas. The resultant increased cash flow in the area would increase the cost of living in the area which would have negative impacts on the population. However, the economic development in the area would also increase the purchasing power of the people in the area; hence the negative impacts of increment in cost of living would be of lower significance.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	2
Impact Significance = 2 i.e. Low					

5.3.21 Impact on Community Health and Safety

Impacts on community health and safety may arise due changes in environmental quality, influx of non-resident workers to the area and additional river traffic and road traffic movement in approach road.

Dust and Noise Discomfort

Proposed project site and approach road is surrounded by several rural settlements. Inhabitants residing close to site and approach roads would get affected due to noise and dust generated from vehicular movements, site preparation operation of machineries, construction activities. Water sprinkling on the approach roads and at the construction sites would reduce dust emissions considerably. To reduce noise related impacts, project vehicles would not blow horns near settlements and the night-time, movement of vehicles and construction activities would also be restricted.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	1
Impact Significance = 2 i.e. Low					

Transmission of Infectious Diseases

It is anticipated that about 25% of the total workers would be non-locals. The influx of workers to the community may cause impacts to public health, especially an increase in prevalence of diseases. Influx of migrant labours during construction can cause mixing of the migrant workforce with the local people. This mixing of the groups may cause some adverse impacts to public health in the neighbouring villages with the potential for spread of infectious diseases like AIDS and COVID-19. Improper sanitation facilities and disposal of municipal solid waste in the construction labour camps can also trigger vector borne diseases. Measures such as proper collection, storage and disposal of wastes, construction of septic tanks to prevent contamination of water resources from sanitary effluents generated from labour camps would be implemented. However, considering COVID-19 is extremely contagious that has resulted in pandemic, the impact due to transmission of diseases is evaluated to be of medium significance.

Intensity of Impact	3	Extent of Impact	2	Duration of Impact	1
Impact Significance = 6 i.e. Medium					

Traffic Movement in Approach Road

An increase in traffic during the peak construction activities and may create public safety issues for local residents, especially along the site approach road. Impacts may include blocking approach, congestion and traffic accidents along the approach road. With mitigation measures as speed control in place the impact to communities from heavy vehicular movement is assessed to be of **moderate** significance during the construction phase.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	2
Impact Significance = 6 i.e. Medium					

Mitigation Measures

The following mitigation measures would be put in place to reduce impacts on community to as low as reasonably practicable:

- Sprinkling of water in dust prone activities like transportation on unmetalled road, digging works, material handling etc would be taken up.
- Locating the concrete batching plant away from sensitive receptors and additional net fencing/ solid barrier on section of boundary wall facing the sensitive receptors to minimise transport of the dust
- Ensuring any temporary site roads are no wider than necessary to minimise their surface area and thus the fugitive emission;
- Storing dusty materials away from site boundaries and in appropriate containment (e.g. sheeting, sacks, barrels etc.).
- If the residents and pedestrians complain about the dust and gas, the consultant of the supervision and contractors would reconsider the construction technique.
- Burning of wastes generated at the construction sites, work camps and any other project activity related site would be strictly prohibited.
- All stockpile materials which are likely to generate airborne fugitive dust would be covered with canvas or plastic sheets during windy season.
- Installing wind barriers, particularly across locations of sensitive receptors to prevent dust propagation.
- In case of dry spillages, equipment must be readily available on site to clean up as soon as reasonably practicable using wet cleaning methods.
- Equipment known to emit noise strongly in one direction would be orientated so that the noise is directed away from nearby residential areas and sensitive receptors.
- Restriction on night-time vehicle movement through the approach road and restriction on honking.
- Restriction in honking in the approach road
- Distribution of free ear plug to villagers of adjoining areas.
- Emphasizing safety aspects among drivers, particularly with regards to safe driving speeds.
- Ensuring that only licensed drivers are employed by the Project.
- Regular maintenance of vehicles and use of manufacturer approved parts to minimize potentially serious accidents caused by equipment malfunction or failure; Regular maintenance of vehicles and use of manufacturer approved parts to minimize potentially serious accidents caused by equipment malfunction or failure;
- Collaboration with local communities and responsible authorities to install traffic signals with vehicle stop mark lines at intersection points and designated crossovers (zebra crossing), improve signage, visibility and awareness of traffic and pedestrian safety.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts would be low to negligible.

5.3.22 Impact Related to Gender Based Violence (GBV)/ Sexual Exploitation, Abuse and Harassment (SEAH) during Construction Phase

GBV and SEAH based issues may be raised during construction phase of the project where women worker would work along with male worker. These issues may also arise between women member of local community and migrant workers who would be working during construction phase. Hence significant of the impact may be medium.

Intensity of Impact	**3**	**Extent of Impact**	**2**	**Duration of Impact**	**1**
Impact Significance = 6 i.e. Medium					

Mitigation Measures

- UMPL is recommended to formulate and implement specific Gender Action Plan in the workplace for all the workers working directly under UMPL or their sub-contractor. A Gender Action Plan is given in Appendix L.
- UMPL is also recommended to formulate a sexual harassment committee headed by woman member of UMPL management and formulate SOP for daily working procedure of the committee and formulate and implement code of conduct related to GBV and SEAH for every employee and worker.
- Regular training programme should be carried out during induction of new worker and employee and yearly for the worker and employee working in power plant.
- Complaint Box should be installed in various place of the power plant and worker accommodation

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above, impacts on community health and safety would be low.

5.3.23 Impact on Cultural Resource

There are four (4) mosques located in and around the plant boundary, Korbunpur Jamia mosque located west of the plant (67 m), Sardarbari Mosque located north-west of the plant (112 m), Purbapara Jame Masjid and Madhya Para Jame Masjid located north-east of the plant (26 m and 135 m). Due to their location in close vicinity of the plant, these mosques would be impacted from dust and noise generated during the construction period. There may be disturbance during the prayer time due to the higher noise level, during the construction period. The impact extent is local and the duration is temporary as it would be limited during pre-construction and initial period of construction stage. However, considering that the receptor sensitivities are high, the impact on cultural heritage site is assessed as medium.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**2**
Impact Significance = 6 i.e. Medium					

Mitigation Measures

- Approach of the community people to the mosque would not be restricted due to construction activity. It would be ensured that during the construction phase no spill-over takes place to any of these mosques due to staging of construction materials.
- Construction activity from high noise generating equipment would be controlled during the prayer time.
- Concrete batching plant to be placed away from sensitive receptors and additional net fencing/ solid barrier on section of boundary wall facing the sensitive receptors to minimise transport of the dust Storing dusty

materials away from site boundaries, especially away from these Mosques, and in appropriate containment (e.g., sheeting, sacks, barrels etc.).

- Installing wind barriers, particularly across locations of sensitive receptors to prevent dust propagation.
- Equipment known to emit noise strongly in one direction would be orientated so that the noise is directed away from these sensitive receptors.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts would be low.

Positive Impact ++

5.3.24 Impact on Occupational Health and Safety

Source of Impact: The sources of impact to the health and safety of the Project's construction workforce are listed below.

- Accidents and injuries associated with the operation of heavy machinery and other preconstruction and construction activities; and
- Health impacts associated with environmental conditions and changes in environmental quality, arising from emissions to air, water, land and noise emissions from construction activities as well as from storage and handling of waste, particularly hazardous waste.
- The construction workforce comprising of managerial, skilled and unskilled workers would be exposed to occupational health and safety impacts arising from construction activities. Impact on health & safety of workers are also envisaged from working at heights during the erection of transmission tower and stringing of the conductor, etc and Electrocution during testing and commissioning.

Embedded Control: The project embedded control measures are as follows:

- The EPC Contractor has prepared and implemented an Occupational Health and Safety Plan in line with OHSAS 18001: 2007 Health and safety management system, OSHA CFR 1926 as construction regulations etc., ISO14001:2015 Environmental Management System and National standards, that includes method statements for working methods, plant utilisation, construction sequence safety arrangements and inspections.
- A Permit to Enter system has been established to ensure that only authorised persons gain entry to the site.
- Weekly inspections would be conducted to check occupational safety and health arrangements including Scaffolding, Excavations, Mobile and Lifting Equipment, Confined Spaces, hazardous conditions, LOTO implementation and Corrective actions would be proposed requiring prompt correction.
- Use of Personal Protective Equipment (PPE) is mandatory onsite. This includes appropriate safety shoes, safety eyewear, and hard hats. Non-slip or studded boots would be worn to minimize the risk of slippage and injury.
- Hazard analysis and Risk Assessment, Accident Reporting, Investigation and Recordkeeping would be an inherent part of the OHS management plan
- Fire-fighting equipment (fire truck, hose, nozzles, fire buckets, and fire extinguishers) have been provided.
- Documentation of training, audits and inspections with corrective actions and occupational safety and health monitoring activities would be maintained
- Accidents and Injuries from General Construction Activities, Over-exertion, ergonomic injuries and illnesses, such as repetitive motion, over-exertion, and manual handling, are among the most common causes of injuries on construction sites. Loose construction materials, liquid spills, and uncontrolled use of electrical cords and ropes on the ground, are also among the most frequent causes of lost time accidents at construction sites. Falls from elevation associated with working with ladders, scaffolding, and partially built structures are also among the most common causes of fatal or long-term disabling injury at construction sites.

Construction activities may pose significant hazards related to the potential for dropping materials or tools, as well as ejection of solid particles from abrasive or other types of power tools which can result in injury to the head, eyes, and extremities.

Vehicle traffic, use of lifting equipment and the movement of machinery and materials on a construction site may pose temporary hazards, such as physical contact, spills, dust, emissions, and noise. Heavy equipment operators have limited fields of view close to their equipment and may not see pedestrians close to the vehicle. Center-articulated vehicles create a significant impact or crush hazard zone on the outboard side of a turn while moving.

Construction sites may pose a risk of exposure to dust, chemicals, hazardous or flammable materials, and wastes in a combination of liquid, solid, or gaseous forms. Approach to construction areas, including the pipeline corridor and the approach road, would be restricted to reduce risks to public health and safety. These risks could create long-term impacts to the health and safety of the construction workforce and therefore the impact severity is assessed to be medium. Measures would be implemented to ensure that these risks are considered prior to the commencement of construction, and that all risks are communicated to the workforce. Appropriate PPE would be provided, and equipment maintained and inspected regularly. Subcontractor has also been included under the purview of the site's OHS management plan and they would be required to implement the requirements of this OHS Plan as per the applicability. All Subcontractors would be solely responsible for carrying out all activities in their scope while complying with the requirements of this plan, training of subcontractors' workers, maintaining safe and healthy work conditions, and preventing environmental impacts. and preventing environmental impacts.

Taking this into account, the impact to the health and safety of workers is assessed to be low.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 3 i.e. Low					

Health Impact associated with Environmental Conditions

Changes in the environmental quality of air, surface water, groundwater and soil quality may occur as a result of construction activities. There would be generation of fugitive dusts in the work zone during the construction work. High noise levels are also expected from the operation of heavy machinery.

An increase in dust and noise during the construction period has the potential to lead to health impacts associated with respiratory issues, eye irritation and general disturbance to daily activities. Waste would be generated during the construction including excavated material, construction waste, hazardous waste, sewage sludge and general refuse. The discharge of domestic waste effluent from construction workers' camp may have the potential to cause contamination of surface water and groundwater in this area.

There is a potential for long term impact on workers' health from changes in environmental quality, as workers would be exposed to higher levels of emissions than off-site receptors.

The OHS plan for the construction phase also takes into account the health hazards associated with various activities, use of hazardous materials & chemicals. Health hazards would include physical hazards, psychological & ergonomic stressors. Health-check would be carried out prior employment and at periodic intervals. The EPC contractor and the subcontractor would comply with industrial hygiene standards and national environmental laws for managing health and hygiene conditions during the construction phase. Heath safety measures include enforcement of strict hygiene maintenance, use of appropriate techniques to minimize heat stress like adequate ventilation, sun shields, rest breaks, etc, use of anti-vibration tools, anti-vibration gloves, and proper work practices, as appropriate, bio-medical waste management, implementing hearing protection program for workers if exposed to noise above applicable threshold values, communication program and training for all personnel on site at the site EHS orientation, used of appropriate PPEs, and Administrative controls including job rotation to minimize exposure to high noise. Daily Toolbox talks would be arranged.

The health and safety impact associated with changes in environmental conditions is considered to have low significance considering implementation of all embedded control measures.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 3 i.e. Low					

Mitigation Measures

- It is recommended to ensure that Measures would be implemented to reduce the likelihood and consequence of the following hazards:
  - falling from height.

  - falling into water.
  - entanglement with machinery.
  - tripping over long-term obstacles or short-term obstructions.
  - slipping on greasy walkways.
  - falling objects.
  - asphyxiation.
  - explosion.
  - contact with dangerous substances.
  - electric shock.
  - mistakes in operation.
  - variable weather conditions.
  - lifting excessive weights; and
  - traffic operations.
- Competent and adequately resourced sub-contractors would be used where construction activities are to be sub-contracted.
- All workers would be properly informed, consulted and trained on health and safety issues; All workers would be properly informed, consulted and trained on health and safety issues.
- Before starting work all the appropriate safety equipment and the first-aid kit would be assembled and checked as being in working order. Breathing apparatus would be tested at regular intervals in the manner specified by the makers.
- All lifting equipment and cranes would be tested and inspected regularly. All hoist ways would be guarded.
- All scaffolds would be erected and inspected, and the appropriate records maintained by the Contractor.
- Safety hoops or cages would be provided for ladders with a height in excess of two metres.
- When there is a risk of drowning, lifebelts would be provided and it would be ensured that personnel wear adequate buoyancy equipment or harness and safety lines, and that rescue personnel are present when work is proceeding.
- All breathing apparatus, safety harnesses, lifelines, reviving apparatus and any other equipment provided for use in, or in connection with, entry into Confined Spaces, and for use in emergencies, would be properly maintained and thoroughly examined at least once a month, and after every occasion on which it has been used.
- Where sound levels cannot be reduced at the source, suitable hearing protection would be provided when noise levels indicate a Leq of more than 90 dB(A). When hearing protection is used, arrangements would be made to ensure the wearers can be warned of other hazards.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts would be negligible.

5.3.25 Impact on Climate Change

Greenhouse gases produced from natural as well as anthropogenic activities absorb and radiate infrared radiation emitted by Earth, and reradiate in all directions, some to space and some back toward the surface, where it further warms the surface and the lower atmosphere eventually contributing to global warming and finally climate change. In order, the most abundant greenhouse gases in Earth's atmosphere are Water vapor, Carbon dioxide, Methane, Nitrous oxide, Ozone, Chlorofluorocarbons.

For the construction phase of the proposed 600 MW CCPP project of UMPL, some specific potential GHGs emissions sources based on planned construction activities identified are as follows:

- Emissions from DG sets.

- Vehicular emission in the project boundary.
- Air conditioner in Porta cabins.
- Construction equipment and machinery operations.
- Transportation of labour and raw material to the site.

The total green-house gas emission from various emission sources, during the construction phase is estimated to be about 2896 tonnes of $CO_{2\ eq}$. Detailed GHG estimation is presented in Section 6.2 of this report. However, considering the construction activities to be temporary and of short duration, the impact is not assessed to be significant.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	1
Impact Significance = 2 i.e. Low					

Mitigation Measures

- Use of construction equipment and vehicles only with appropriate pollution fitness certificates.
- Estimate, maintain and publish carbon footprint (month wise) during construction activities and reduce vehicular movement where possible.
- Avoid use of Ozone Depleting Substances during construction phase.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts would be negligible.

5.4 Impact due to decommissioning of temporary facilities

5.4.1 Impact due to decommissioning of Construction camp and treated sewage discharge pipeline

The labour camps constructed temporarily on the land parcels of Hamdard, and the treated sewage pipeline from temporary construction labour camp would be dismantled upon completion of construction activities. UMPL will develop a robust site restoration plan to decommission all the temporary structures as mentioned above in an environmentally sound manner, and restore the site by removing all the concretes, metals, pipelines and other construction and demolition wastes and either reusing the C&D wastes in other sterile zones onsite for back-filling or disposing the same in an environmentally sound manner to authorized waste disposal facility. During the dismantling of all temporary facilities which would be used for construction all care would be taken so as to not pollute any surface or ground water, ambient air quality in the vicinity and ensuring minimum disturbance with respect to the ambient noise levels, movement of vehicles in the adjoining village roads leading the state highway.

Once the dismantling of structures and disposal of C&D waste is complete, the original site condition will be restored by laying the topsoil in the area (which was earlier removed from the area during site preparation during construction phase and restored properly) and proper landscaping and plantation would be undertaken to restore the site conditions at least near to the original conditions if not to a better condition to suit the requirements of the landowners and overall desire of the nearby settlements. A certificate of acceptance from the land owner will be obtained upon hand-over and completion of necessary inspections by land-owners thereby ensuring conditions specified in the land lease agreement are fully adhered by UMPL and their EPC contractor. Hence the impacts arising from decommissioning of the aforesaid structures is not envisaged to be significant and the restoration plan duly considers mitigation measures of the minor impacts if any. Considering the above measures to be adopted during the decommissioning of temporary labour camp and considering the impacts arising from dismantling activity to be short-term and temporary in nature, the overall impact is assessed to be low.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	1
Impact Significance = 2 i.e., Low					

Mitigation Measures

In addition to be above environmental good practices to be adopted by UMPL and their contractor(s) during decommissioning of labour camp and site restoration, the following mitigation measures will further alleviate the impacts of decommissioning activities.

- The demolition wastes would be recycled where feasible. The mixed wastes and rubbles, metallic wastes would be disposed to authorized waste disposal facility.
- All the equipment and machineries used in dismantling should have adequate engineering control mechanisms to prevent abnormal emissions to air and generation of noise.
- DG sets operating at site should be adequate stack height, acoustic enclosures and would be kept on paved and bunded areas within the site with adequate spill prevention measures in place for the day-tanks.
- The dismantling activities would be avoided at nigh time to reduce impact of noise on the community.
- Periodic sprinkling of water on deposited rubbles and spoils would reduce the fugitive dust emissions. Movement of vehicles removing dismantled materials from the site would be restricted with a speed limit of 20km/hr when passing through the village roads, the materials would be carried with tarpaulin covers, and vehicles would have valid emission compliance certificate to ensure vehicular emissions are within the prescribed norms.
- Any sludge and sewage recovered/pumped out during the dismantling of sewage pipeline would be sent into the operating STP in the UMPL Plant site. The soil sample from the decommissioned site (both camp site and sewage pipeline area) would be collected and tested for potential contaminants and compared with the baseline soil quality of the area to determine the completeness of restoration work, before handing over to Hamdard.

The dismantling activities will involve engagement of local semi-skilled and unskilled labours; hence this phase is likely to generate sustainable income generation among the local population.

Residual Impact

The residual impact post implementation of the above mitigation measures and environmental best practice is assessed to be negligible.

5.4.2 Impact of Demolition of Jetties and Reinstatement of Jetty Area (2 Nos.)

UMPL will construct two river jetties for transferring construction material like sand, cement, aggregates through a jetty of dimension 810 sq., m and heavy equipment and machinery through another Jetty. As most of the heavy equipment is expected to be unloaded at Chittagong Port, the river network is the best feasible option to ferry heavy equipment. The use of the jetties will be limited to construction period. Once construction of the power plant is completed, the jetties will be dismantled. A letter vide reference letter *UMPL 777-BITWA-L-0220 dated 10th January 2021* was sent to BIWTA intimating about removal of the temporary Jetty (810 sq. m) from the Meghna Riverbank post completion of construction activities.

The process of demolition of Jetties is presented below:

- Removal of steel sheet piles – The sheet piles would be removed using the cutting process to cut the steel piles and steel bars that were connected. While removing the steel sheet pile, the verticality of the steel sheet pile should be strictly controlled.
- Excavation of sand inside the jetty - After the steel sheet pile removal is completed, the inner side of the jetty would be excavated with excavators with a bucket. During the excavation process, a drainage ditch would be formed along the bottom of the steel sheet pile.
- Dredging in the Jetty area- The jetty would be dredged to restore the navigable conditions of the river after the jetty is dismantled. Site cleaning would be carried out by excavators.
- River dredging - Dredging the river channel would be carried out using a suction boat and suction dredger. The pipeline of the suction dredger would be arranged in smooth line with anchor, with no dead ends. The silt would be discharged into the cofferdam of the sludge yard, and slope protection measures at the junction of the discharge port and the cofferdam would prevent water erosion. The sludge would be transported to the designated location. Instrumental control would assist in detecting changes of instrument parameters to

prevent pipe blockage and pipe bursting, and accurately and timely judge underwater debris. The sludge discharge pipe joints would be tightly tightened, and the entire pipeline and joints would not leak mud or water. If any leak is found, it would be repaired immediately.

- Monitoring would assist in observation and measurement of changes in elevation and plane position, water seepage, local deformation of components, and changes in the groundwater level of each component during the entire process of demolition of steel sheet piles in the jetty.
- Along with demolition of the jetties dredging would be carried out to meet the navigable condition of the water ways, dredging would be required.

The demolition of the temporary jetty has the potential to cause turbidity of channel water, noise and vibration during demolition work, spillage of demolition waste and may potentially impact some slow-moving river organisms attached to the base of the structure. The demolition work will also potentially impact river traffic as the Meghna river channel is mainly used by small boats/vessel from nearby areas for ferrying of people & goods. The other impacts identified with demolition activities are:

- Generation of demolition wastes including rubbles, reinforcements, metal wastes etc which if not collected, stored and disposed adequately could impact the surface water quality and the soil quality of the area.
- Damage of the stone-pitched slope stabilization structures.

Dredging may lead to increase in turbidity of the water in Meghna Branch Channel if proper mitigation measures are not adopted. Increased turbidity has the potential to reduce dissolved oxygen (DO) in and around the dredged area thereby impacting the aquatic life in that zone of the water body. Dredging may also result in alterations in the pattern of flow and sedimentation in Meghna River Channel.

Impact can be further specifically addressed when the detailed dredging plan comprising dredging quantity, specific areas of dredging, dredging schedule is available. The dredged material is proposed to be handed over to M/s Meghna Enterprise for handling and appropriate disposal in line with applicable regulations. M/s Meghna Enterprise is a BIDA approved vendor who has been entrusted for solid waste collection, processing or disposal of the project. Considering the demolition work will be of short duration and UMPL will manage the demolition wastes & dredged material as per the prevalent regulations as a Good Practice, the impact due to demolition of Jetty is considered to be low.

• Intensity of Impact	2	• Extent of Impact	1	• Duration of Impact	1
Impact Significance = 2 i.e. Low					

Mitigation Measures:

- It is imperative to obtain written permission from the concerned Authority (BIWTA) prior to dismantling work for removal of the temporary Jetties
- In order to manage the impacts due to dredging, UMPL is recommended to prepare a specific Dredged management plan which comprise of quantity of dredged material, dredging location, dredging schedule and chain of activities following capital dredging operation during the construction activities. Dredging is to be carried out and dredged material managed as per the Dredged Material Management Plan. Indiscriminate dumping of dredged material would be strictly prohibited.
- The decommissioning plan to be developed elaborating the details on the process for demolition, time required, management of wastes, OHS aspects, etc would be developed and strictly adhered to.
- Demolition Work to be carried out during lean river traffic hours
- The roadway deck should be systematically dismantled in a linear manner and remove in units in a similar manner to avoid spillage of demolition waste.
- Post demolition, restoration should be carried out for the area in an around the jetty to restore and enhance the landscape character, and provide improved public access
- Avoid dismantling work at night to minimize the impact of noise generation
- The demolition wastes generated would be stored at a dedicated storage yard at site and the same would be disposed to authorized disposal facility in trucks. The wastes and dismantled structures should be transported in closed container or covered with tarpaulin to prevent emissions.

- The jetties would be decommissioned as per UMPL approved decommissioning plan to ensure minimum or no damage to the slope protection structures and repairing the same in case any damage occurs.
- UMPL would undertake soil sampling and analysis for Pb and other heavy metals. In case contamination is detected, adequate remediation measures would be undertaken.

Residual Impact Residual Impact

The mitigation measures once implemented during dismantling stage, the residual impact will likely to become negligible.

5.5 Assessment of Environmental Impact-Operation and Maintenance Phase

5.5.1 Impact on Topography and Drainage

Land for proposed power plant has been elevated uniformly up to 7.76 m meters in line with present road level located at the north side of the project boundary to avoid inundation of the plant site.

The Storm water drainage network is designed to collect rainwater from the building / roof, roads, storage tank areas and cooling tower water basin, paved and unpaved areas, drainage for pipe trenches, cable trenches etc., overflow water for clean water tank/basin, other drainages for which water quality meet the standards. The rainfall intensity considered for design of stormwater drain is considered as 110 mm/hr, considering impacts of climate change leading to extreme events of precipitation in the future.

Storm water drainage network would be designed to collect following discharges:

a) Rainwater from building / roof

b) Rainwater from roads

c) Rainwater from storage tank areas and cooling tower water basin

d) Rainwater from paved area and unpaved areas

e) Drainage for pipe trenches, cable trenches etc.

f) Overflow water for clean water tank/basin.

g) other drainages which water quality meet the standards.

Storm ditch or box culverts are the drainage structures to be used for main roads within the proposed plant. Heavy box culverts will be in use where truck movement is envisaged inside the plant. The types of storm drain conduits to be used consists of concrete pipes, concrete boxes, spiral rip metal pipe, corrugated metal pipe, pipe arches, corrugated polyethylene and polyvinyl chloride (PVC). For unfinished areas, where installations are not foreseen, it is assumed that drainage is obtained by natural ground absorption and thus, separate drainage arrangement is not planned for the same. Yard area would be sloped a minimum of 1% to drain away from building and structures towards drainage channels

The design for storm ditches is based on the self-weight of the storm ditch structure, the compaction load of 20 kN/m^2 (as per the Contract), loads due to soil load and ground water load (ground level and ground water level are considered to be same). The storm ditches in the proposed power plant drainage network, varies in width and depth. Depending on their depth, they are categorized into two groups - Group 1 consists of structures with their vertical height between the base slabs and ground level to be within 1 m and those exceeding are grouped under Group 2. Similarly, the box culverts are categorized based on their net depth, first category comprises of net depth within 0.85 m, where the section will be 800 m × 850 m and the remaining under the second category with a of section of 1000 m × 1000 m. The storm ditches would be constructed with M30 grade concrete and Fe 420 steel for both Grades and the construction of the box culverts would be with M40 grade concrete and Fe 420 steel. The freeboard of 0.3 m would be provided throughout as a safety factor against overflowing and steel grating covers to be provided for the concrete channels. The figures below show the cross-section for each storm ditch group.

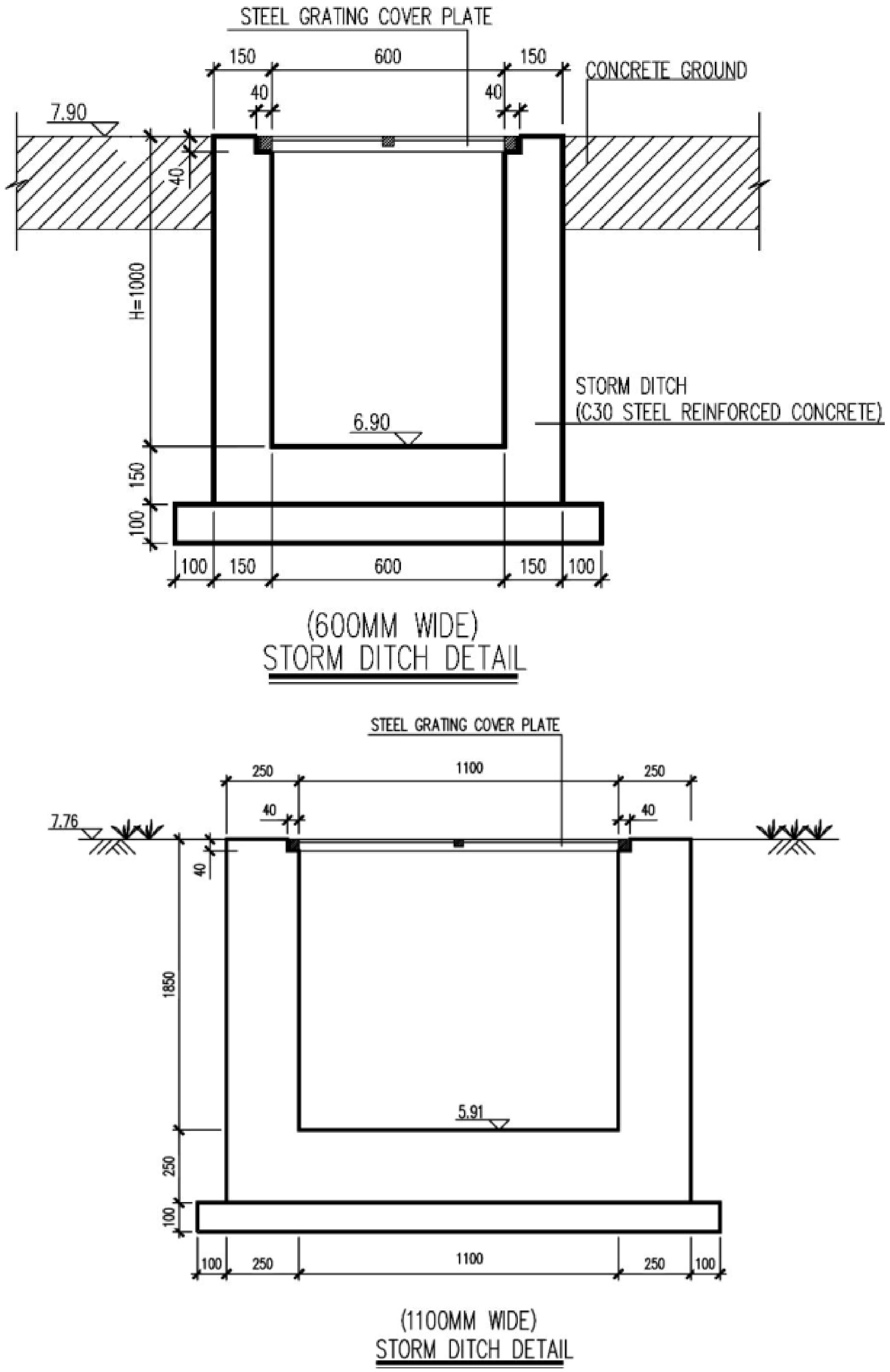


Figure 5.8. Cross section of storm ditches

The yard area of the proposed project would be provided with a 2% slope and the steeper shoulder slope of 2.5 %, to drain away water through the drainage channels. A minimum of 1% slope would be provided for the flow of stormwater under the effect of gravity towards the storm water basins. The slope of the road section has been presented in the ***Figure 5.9.***

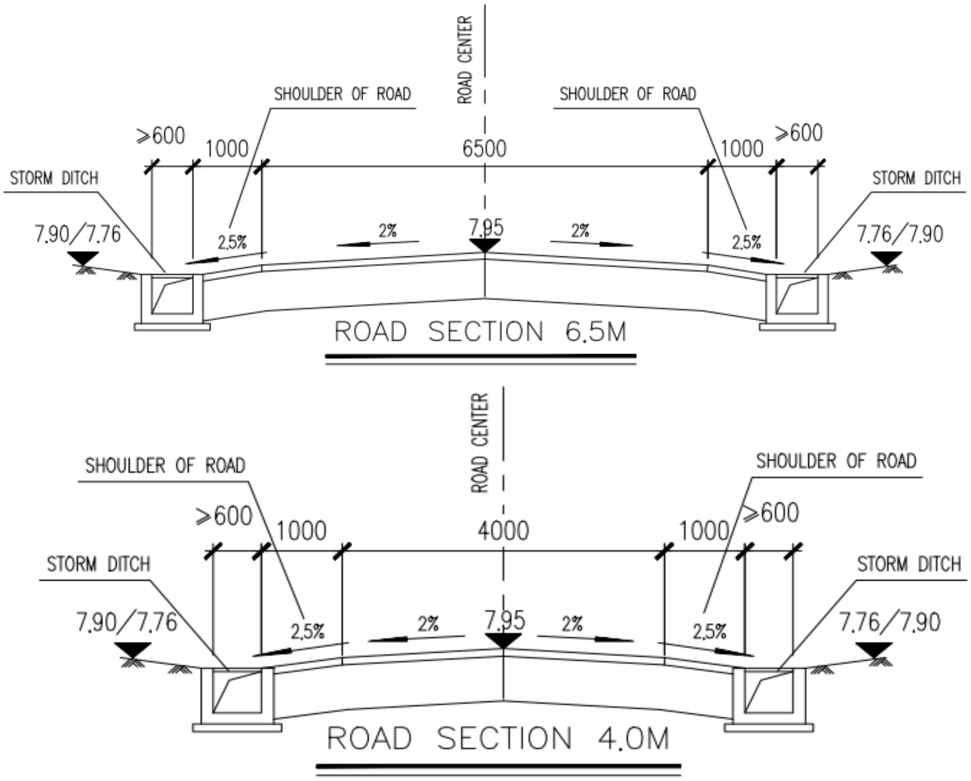
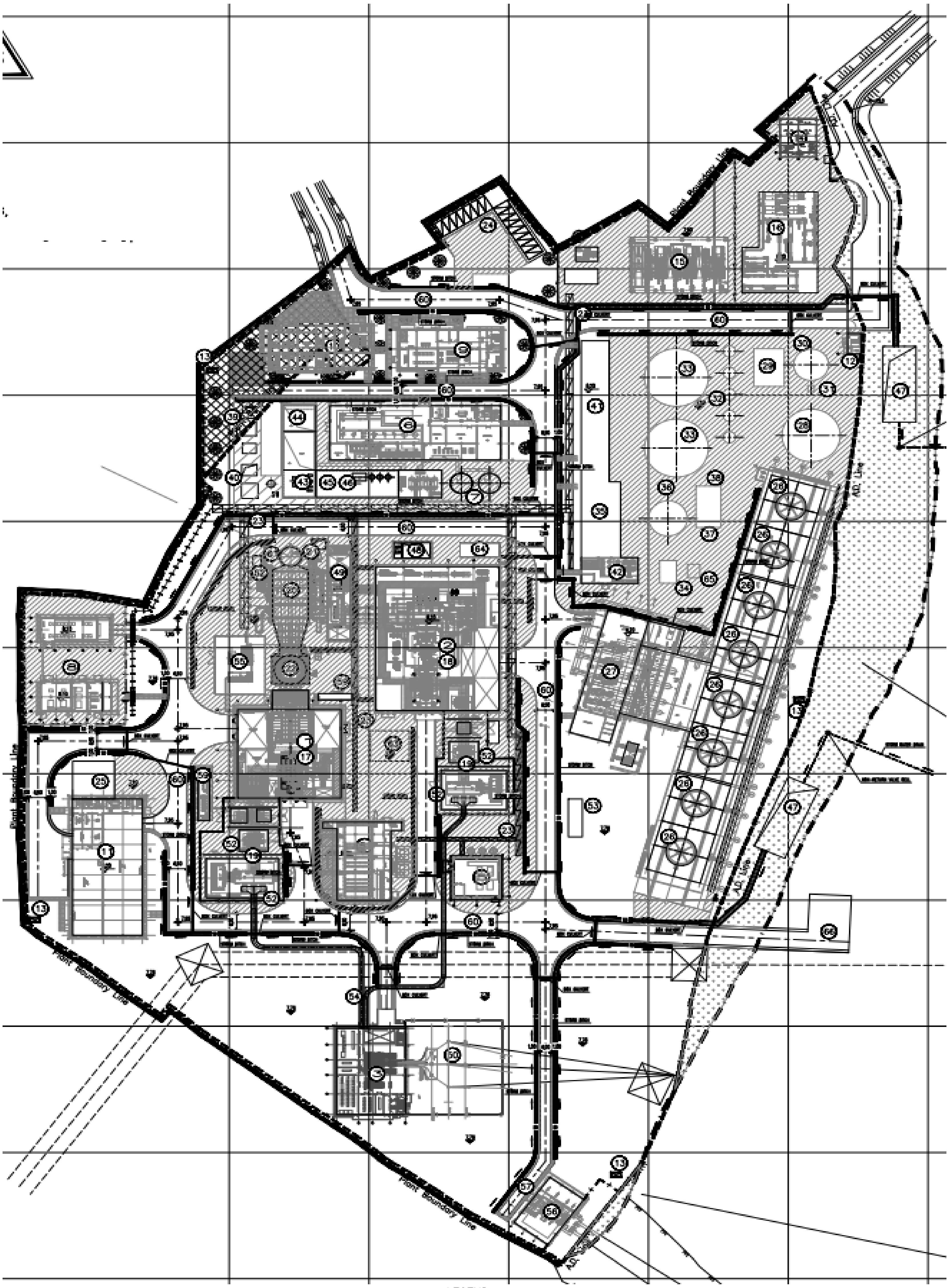


Figure 5.9: Slope of road section

In the project site, two drainage channels would be set up within the plant area as the main drainage. The length of the drainage channel is about 600 m, and the width is 450 mm. Two storm water basins would be arranged at the river side for the storm water drainage of the whole plant, at the south and north of the plant. The catchment area within the boundary wall is about 8.65ha and based on the integrated runoff coefficient of 0.76, the maximum one-hour rainfall of the whole plant is about 6580 m^3/h and the total storage capacity of the two storm water basins would be about 1650 m^3. The total capacity of the two storm water basins will be considered for 15 min storage. The outlets of the two drainage channels are set on the east side of the plant area, which would eventually be discharged by overflow channel to the Meghna River. Non-return valve would be provided, before the stormwater leaves the plant boundary, to ensure one-directional flow and no reversed flow takes place after being discharged into the river channel. The storm water network of the plant is shown in ***Figure 5.10.***



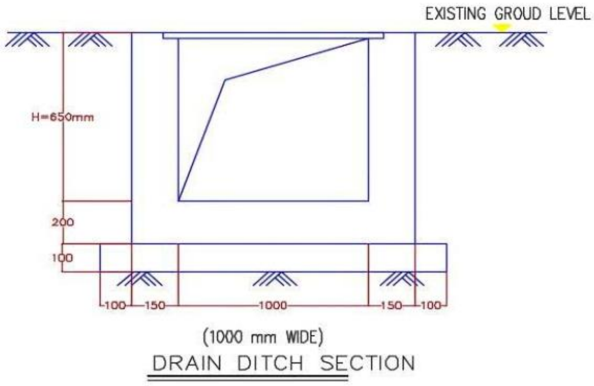
LEGEND

LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
	BUILDING		FENCE
	SINK		PIPE RACK
	ROAD	7.76	OUTDOOR ELEVATION
	HARDENED GROUND	8.20	INDOOR ELEVATION
	BOUNDARY WALL		SIDEWALK
	GREENERY		TRANSMISSION TOWER
	CABLE TRENCH		RETAINING WALL
	PLANT BOUNDARY LINE A.D. LINE	SD	STORM DITCH
	BOX CULVERT		

Figure 5.10: Plant's internal storm water system (Source: Drawing No. UNQ/00/W/UGZ—CEP2P/CE-001provided by UMPL)

As the site has been raised substantially (HFL + 1 m = 7.76 m), the raised site would impede the natural drainage in the lower catchment of the river, including the surrounding village and the approach road. This may lead to water impoundment in the area surrounding the plant (including Approach Road) as the natural slope of the area has changed due to raising of the site.

UMPL would take up the construction of peripheral stormwater Drain based on 110 mm/hr considering impacts of climate change, outside plant boundary to channelize the incoming rainwater water flow from the lower catchment area towards the river to restrict impoundment and flooding within the low-lying areas of the village.. The stormwater drain would be aligned in a manner to ensure stormwater flow by gradient from the villages into the river through stormwater drain constructed around the Proposed Plant at its outer periphery. This would help avoiding the potential chances of inundation as the collected water would be adequately drained. A continuous 200 ft (60 m) wide strip outside the plant boundary at the village side is considered as the catchment area to design the stormwater drainage size outside the plant. The catchment area is calculated as 39647 sq. m. Considering a free board of 150 mm, drain width of 1000mm and Drain height of 650 mm has been determined, as shown below



The outer peripheral drainage network is given in the ***Figure 5.11***

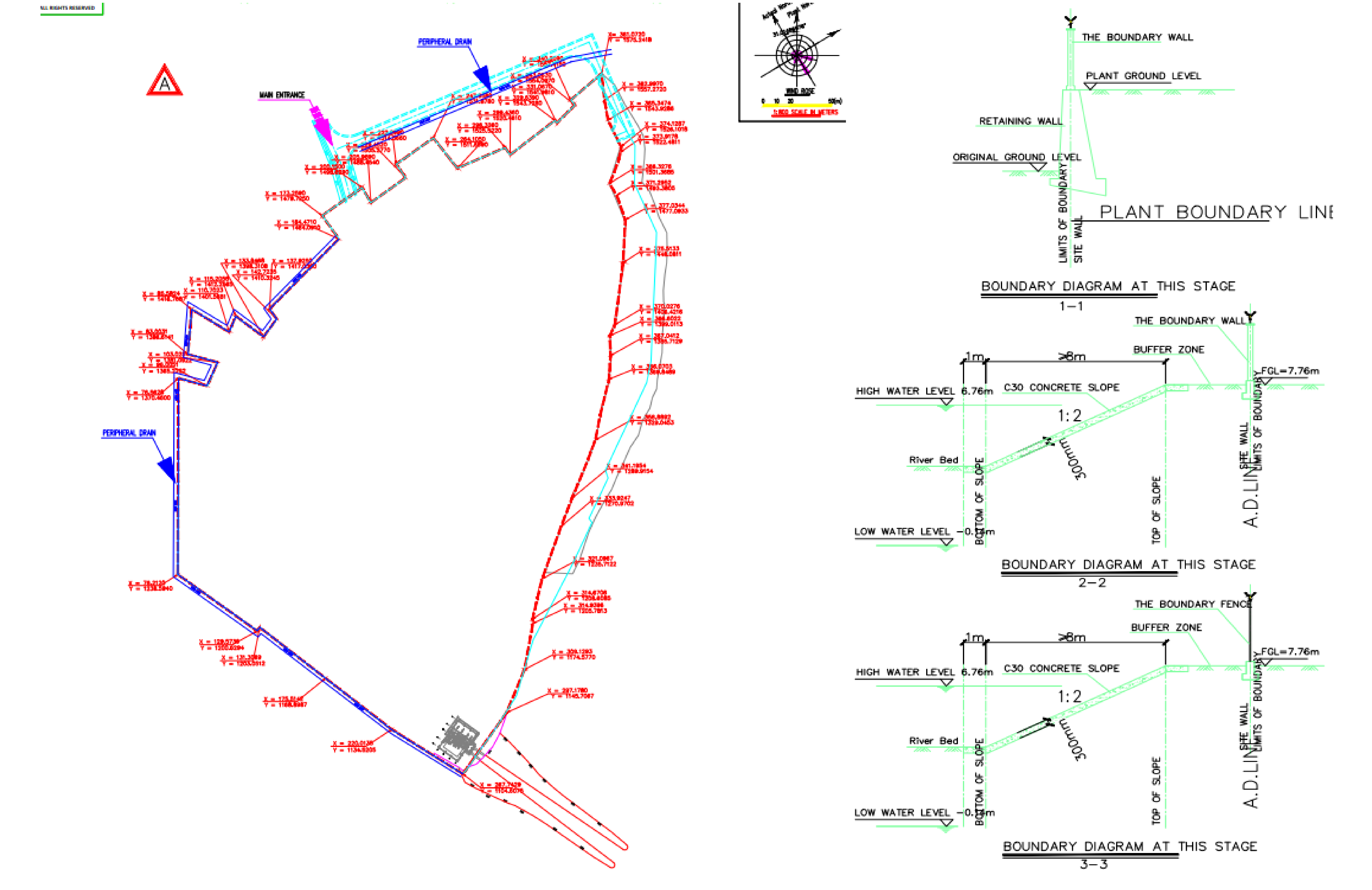


Figure 5.11: Plant's outer peripheral drainage system (Source: UMPL)

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	3
Impact Significance = 3 i.e. Low					

Mitigation Measures:

- Regular cleaning of internal drains would be ensured to restrict the blockage in the drain, ensuring free flow of water.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on soil quality would be negligible

5.5.2 Impact on Soil and Sediment Quality

Impacts associated with soil and sediment quality during operation phase is described below.

- Due to maintenance of Main Plant
- Due to maintenance of Utility
- Storage and Handling of Hazardous and Non-hazardous Waste, spills and leakages

Impact Due to maintenance of main plant and Utility

Any power plant is required through maintenance once in year, when several hazardous and non-hazardous material/chemicals would be used for plant maintenance and several hazardous waste and non-hazardous waste could be generated. Improper handling of such materials and waste could create impact on soil quality and also sediment quality within the plant boundary and outside. However, the plant would be mostly concrete and unpaved areas would be only in Greenbelt & landscaping area. Maintenance would be a routine activity performed by trained staff. Hence the chance of contamination due to improper handling & disposal would be minimal and impact significance would be low.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	1
Impact Significance = 3 i.e. Low					

Impact Due Storage and Handling of Waste and hazardous materials

The potential sources of waste generation during operation of the Power plant are from the following:

- Office and Canteens.
- WTP, ETP and STP.
- Gas Turbines.
- Laboratories.
- Lube oil systems.
- DG sets; and
- Powerhouse and workshop area

Various type of hazardous and non-hazardous wastes would be generated during normal operation of the power plant which have potential to degrade soil quality and sediment quality if not stored and handled properly. There would be storage of High-Speed Diesel (HSD) used as fuel and chemicals like acids/alkali for water treatment purposes during operation phase. Storage, handling and use of these hazardous fuel & chemicals would also have adverse impact on soil quality in case of spillage, improper disposal on soil and mixing with sediment due to indiscriminate disposal.

However, all the wastes would be stored in a designated covered area with impervious floor, bund and secondary containment. The hazardous chemicals would also be stored in designated area in drums, with bunds and concrete floor. Apart from that all the wastes and chemicals would be handled by trained staff and the wastes would be disposed of in environmentally sound manner and as per the international guideline. It is envisaged that UMPL will have a proper spill response plan in place for the operation phase to deal with incidents of spills & leakages. Hence the impact significance is assessed to low.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	1
Impact Significance = 3 i.e. Low					

Mitigation Measures:

- Periodic monitoring of soil quality;
- Implementation of soil management and spill management guidelines and procedures for immediate clean-up actions following any spillages of oils, fuels or chemicals.
- Batteries containing liquid inside would be kept on impervious place
- Fuel tanks, hazardous waste storage area and chemical storage areas would be provided with locks and be sited on paved and sealed areas with bund walls.
- Use of spill or drip trays to contain spills and leaks and refuelling to take place on paved surface.
- The storage areas of oil, hazardous waste, fuel and chemicals would be surrounded by bunds or other containment device to prevent spilled oil, fuel and chemicals from reaching the receiving waters.
- The storage place of wastes would be at least 50m away from the river or other waterbodies
- A spill response plan and emergency plan would be prepared and implemented during the operation phase to address accidental spillages or release of hazardous wastes; and A spill response plan and emergency plan would be prepared and implemented during the operation phase to address accidental spillages or release of hazardous wastes; and
- A proper manifest record would be maintained of waste travelling/ removed from the site.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on soil quality would be negligible

5.5.3 Impact on Surface Water Resource and Quality During Operation Phase

The potential sources of impacts to surface water resources and quality during operation phase are:

- Discharge of untreated liquid wastes generated during operation phase (e.g. Oily effluents from Steam turbine building, Combustion turbine building, Transformer yard of CTG and STG, Compressor and CCW pump house, Emergency DG set area, HSD Storage Tank Farm effluent like cooling tower blow down, boiler blow down, condenser cooling water DM plant backwash; and sewage) is likely contaminate/degrade the surface water quality, when discharged into the adjoining channel of Meghna River. Discharge of untreated liquid wastes generated during operation phase (e.g. Oily effluents from Steam turbine building, Combustion turbine building, Transformer yard of CTG and STG, Compressor and CCW pump house, Emergency DG set area, HSD Storage Tank Farm effluent like cooling tower blow down, boiler blow down, condenser cooling water DM plant backwash; and sewage) is likely contaminate/degrade the surface water quality, when discharged into the adjoining channel of Meghna River.
- Discharge of treated effluent from Common monitoring basin constituting of treated wastewater from the wastewater system of the plant, the treated water from STP and the cooling tower blow-down.
- The water abstraction from the adjoining channel of Meghna River has the potential to have adverse impact on the competing users downstream, local ecosystem and water dependent activities of local people.

Discharges from proposed project's operation activities are likely to have impact throughout the project life, and likely to pose significant impact on the surface water quality, if discharged without adequate treatment and mitigation measures. The design temperature of final outlet is 31.5 °C, which is within the stipulated limit of temperature of discharge water, i.e. 40°C, as per ECR 1997. Also, the outlet temperature is within 3° C of the river water temperature, which is around 28.5 – 29.5 °C as per available data. Considering no thermal discharges occurring from the proposed CCPP due to the closed loop recirculation technology and with treatment techniques already considered in the design, the impact due to discharge of warm water would below.

Prior to discharge, the treated effluent would be monitored for temperature, pH, TSS, oil and grease, total residual chlorine, chromium (total), copper, iron, zinc, lead, cadmium, mercury and arsenic as per Schedule 10 (Standards for Waste from Industrial Units or Projects Waste) of ECR 1997 or IFC's Effluent discharge guidelines for thermal power plants 2008. As a part of design, it would be ensured that in the event of non-compliance with the desired discharge standard, the effluent from CMB would be rerouted to plant's wastewater treatment system. Hence, the impact due to discharge of treated wastewater from common monitoring basin of the plant is envisaged to be low.

The quantitative assessment of impact on surface water resource and quality is presented below:

Assessment of Impact of the proposed project Resource & water quality of Meghna River

Impact on water source of Meghna River

Estimated total consumptive raw water requirement for the plant is about 676 m3/hr (0.1877 m^3/s). The maximum discharge of the Meghna River was estimated to be 34477 m3/sec; while the minimum discharge of 9582 m^3/sec based on data procured from Bangladesh Water Department (BDWD) for Meghna Ferry Bridge Station, which is near the plant.

The minimum discharge or the lean season flow have been considered for impact assessment on water resource of Meghna River. As per the available data, approximately 80% of the available water is used for irrigation purposes, while about 12% cater to domestic & industrial needs. With this consideration, available water (minimum flow) is 766.61 m^3/s.

Total water abstraction quantity of all industrial units, existing as well as proposed constitute about 0.0024% of the available water during at minimum flow conditions in the River and about 0.0001% of the total water flow at minimum flow conditions. The impact of water abstraction for the project from Meghna River would be imperceptible on the water resource of Meghna River.

Impact on water quality of Meghna River due to discharge of treated effluent

In order to evaluate the impact of discharge of effluent on the water quality of Meghna River, load based assessment has been carried out. The pollutant load of the River water, based on baseline monitoring conducted near outfall location (SW1) and the additional load of the effluent discharged from the proposed project is used to calculate the resultant pollutant load in the River water using the following equation:

$QC = Q1C1+Q2C2,$

$(Q1+Q2) * C = Q1C1+Q2C2,$

$C = (Q1C1+Q2C2)/ (Q1+Q2)$

Where, Q = Q1+Q2 = Resultant flow (in m^3/sec) of water in Meghna River post effluent discharge from UMPL,

Q1 = Existing flow rate of Meghna River prior to discharge of the effluent in m^3/sec

Q2 = Effluent discharge rate in m3/sec

C1 = Pollutant concentration of River water in mg/l

C2 = Pollutant concentration of the effluent in mg/l

C = Resultant Pollutant concentration in River water in mg/l post discharge from UMPL

The deviation in the value of resultant concentration from the baseline Pollutant concentration would indicate the impact due to discharge of wastewater to Meghna river water quality.

Calculations:

<u>Flow rate of River (Q1)</u>

The existing flow rate of Meghna River was calculated based on data procured from Bangladesh Water Department (BDWD) for Meghna Ferry Bridge Station[30] located immediately downstream of the site is presented below

Maximum Flow of Meghna River - 34478 m3/sec

Minimum Flow of Meghna River - 9583 m^3/sec

Pollutant load of River water (C1)

The baseline water quality monitored for the two seasons is used to calculate the existing organic & inorganic Pollutant load of the River water. The following concentrations monitored at SW1 at the project location near the effluent discharge point are used for the calculation:

BOD - 3.2 mg/l

TSS - 11 mg/l

COD- 28 mg/l

The Pollutant load under Maximum and minimum flow conditions is presented below ***Table 5.6.***

Table 5.6: Pollutant load under maximum and minimum flow of the river

Pollutant load* under Maximum Flow Condition, kg/s		Pollutant load under Minimum Flow Condition, kg/s	
BOD load	110.32	BOD Load	30.66
COD load	965.37	COD load	268.31
TSS load	379.25	TSS load	105.40

**Pollutant load is calculated as (flow X concentration)*

Effluent flow rate (Q2)

The total treated effluent in the guard pond inside UMPL site boundary (including the treated effluent from the STP) is estimated to be approx. 138.4 m^3/hr, of which about approx. 120 m^3/hr is considered to be discharged to the river while the remaining treated effluent (10-15%) would be used for plantation/green belt within site premises.

Effluent discharge rate - 120 m^3/hr; 0.033 m^3/s

Pollutant load of the discharged effluent (C2)

The concentration of organic & inorganic pollutants in the treated effluent is considered to be within the Standards stipulated in Bangladesh ECR 1997 for industrial wastewater discharged to inland water body and the estimated concentration of the pollutants in the final treated effluent, as per EPC Specification (Volume-IIB; Section 5.8) furnished by the UMPL, is presented below:

BOD – 10 mg/l

TSS - 50 mg/l

COD- 40 mg/l

The pollutant load of the treated effluent is as follows:

BOD Load	0.00033 kg/s
COD Load	0.00133 kg/s
TSS Load	0.00166 kg/s

The resultant concentration of the Pollutants (C) under Maximum and minimum flow conditions of the River is presented below ***Table 5.7***

[30] *Kindly refer to Flood Risk Assessment for location of Meghna Ferry Ghat Station*

Table 5.7: Resultant concentration under maximum and minimum flow

Resultant Pollutant concentration* under Maximum Flow Condition, mg/l		Resultant Pollutant concentration under Minimum Flow Condition, mg/l	
BOD	3.200006	BOD	3.2000024
COD	28.00001	COD	28.00004
TSS	11.00003	TSS	11.00014

From the load-based (mass balance) analysis of the Pollutants, it may be seen that, post discharge of treated effluent into Meghna River from UMPL, the increase in resultant concentration of pollutants in the river water is even less than 0.01% which can be considered as insignificant. However, considering the discharge to be happening regularly throughout the lifecycle of the project, the impact is assessed to be moderate and can be mitigated with following measures.

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**3**
Impact Significance = 6 i.e. Medium					

Impact due to maintenance of water intake channel

It is imperative that there would be siltation in the water intake channel with progress of time. If periodic maintenance of this intake channel & its vicinity is not undertaken, the natural flow into the intake basin would be impeded. In order to maintain unhindered flow of river water with minimum turbidity, periodic cleaning of the water intake channel & its vicinity need to be undertaken. During this periodic cleaning, there is a possibility of sediment getting re-suspended in River water and affecting the quality of water. There would be algal & gastropod growth at the bottom and walls of the intake channel which also needs to be removed periodically.

UMPL has already obtained permission from BIWTA (presented in Appendix S) to carry out dredging in Meghna River Channel for maintaining navigability of the channel for intake of water. The maintenance activities would have adverse impact on water quality, however considering that it is a short-time activity, the impact is envisaged to be of low significance and is expected to be restricted within close vicinity of the cleaning zone.

Intensity of Impact	**2**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 2 i.e. Low					

Mitigation Measures:

- Installing metering system at specific major consumption points to monitor usage and reduce wastage of fresh treated water
- Sewage would be treated in a Sewage Treatment Plant and used for gardening or landscaping.
- Wash water generated from vehicle washing or equipment cleaning on site would be stored in pits and treated before discharge.
- A water management procedure would be prepared for implementation of EMP and management of raw water, wastewater, storm water and surface and ground water quality. Storm water drainage and wastewater of similar nature from different units would be treated in accordance to GoB Environment Conservation Rule (1997) Schedule 10 (Standards for Waste from Industrial Units or Project Waste) and the applicable World Bank Group environmental requirements and World Bank/IFC guidelines.
- Periodic monitoring of surface water quality
- Periodic monitoring of treated sewage and final effluent (once in a month) before discharge to surface water or land for reuse.
- Discharge system shutdown in event that discharge temperature of effluent at any point of time exceeds standard.
- Maintenance activities of the water intake channel would be carried out during the driest period of the year (between November to March) when water level of Meghna Branch Channel recedes to the lowest which would reduce the probability & extent of re-suspension of sediment.

- It would be ensured that the excavation would be carried out using bucket dredgers so that spillage of material is minimum during dredging activity. It would be ensured that dredged material is not disposed into the river.

Growth of algae and gastropod would be cleaned using high pressure water jet or manually through scrapping as per requirement.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on surface water quality would be low.

5.5.4 Impact on Ground Water Resource and Quality During Operation Phase

Ground water abstraction would be undertaken only for drinking purpose in the event of emergency. UMPL would be required to obtain/renew necessary permission from Upazila Parishad, record the volume of abstraction and monitor the ground water quality at periodic interval during the operation phase. Any borewell not in use would be plugged or decommissioned by UMPL to prevent contamination of ground water. Spillage and leakage of high-speed diesel, hazardous chemicals, and mismanagement of hazardous wastes and their subsequent seepage into the ground water aquifer would have potential to impact the ground water quality.

The proposed project during its operational life cycle may contaminate the groundwater through spillage of hazardous fuel, chemicals/wastes. The contamination of groundwater, if occurs would have high impact due to vulnerability of community to drinking water contamination and the damage being long-term in nature may usher major environmental impact if the contaminant finds its way into confined aquifer through borewell. Although, the proposed operational activities for the proposed project do not entail borewell construction; with majority of the work area on site (except for green belt/landscape areas) being paved with PCC/RCC, the overall impact is assessed to be low. The following mitigation measures can prevent/minimize potential for groundwater contamination.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**1**
Impact Significance = 3 i.e. Low					

Mitigation Measures:

- UMPL would ensure that Solid and hazardous waste plan and Material management plan would be prepared, implemented and strictly adhered to during the operation phase.
- UMPL would have a Spill Management plan in place delineating plans and procedures for preventive and corrective actions against any potential spillage of harmful materials and provision of adequate spill kits,
- Prevent indiscriminate discharge of untreated effluent from process, equipment/vehicle washing and chemical/fuel storage areas into the unpaved and open ground. Prevent indiscriminate discharge of untreated effluent from process, equipment/vehicle washing and chemical/fuel storage areas into the unpaved and open ground.
- Periodic monitoring (quarterly) of groundwater quality.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on ground water quality would be negligible.

5.5.5 Impact due to waste handling and storage

Impact from generation and disposal of pigging waste from O&M activities of gas pipeline: Pipeline Pigging would be taken up as O&M practice to perform cleaning, clearing, inspection, testing inside the pipeline. Solid wastes and sludges that are removed from the pipeline are generated. Residues from pigging operations comprising solid wastes & sludges contain solid waxes & condensates. These may include hazardous substances such as BTEX (benzene, toluene, ethyl benzene and xylenes) and NORM (naturally occurring radioactive material). Improper management & indiscriminate disposal of waste can pose serious environmental concerns like contamination of soil and ground water and surface water body (in case sludges find the pathway to the surface water). However, it is proposed that Pigging sludge and solid waste would be analysed for hazardous waste constituents as per the applicable national/international Waste Characterization procedure. Post waste characterisation, it would be stored as per the prevalent waste management practices, including storage in paved and bunded area, properly labelled. With such practices, the impact from generation & disposal of pigging wastes is envisaged to be low.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	2
Impact Significance = 4 i.e. Low					

Impact due to Solid & Municipal Waste: During the operation phases, there would be generation of solid waste and municipal waste including paper, cartoons, bags, boxes, office wastes, etc. along with minor quantity of domestic waste. There would be generation of waste Air filters and waste rugs be occasionally which need to be properly disposed. During operation phase of the project, around 100 workers would be employed. It is estimated that around 40 kg/day municipal solid waste would be generated. Solid and municipal wastes would be collected, segregated and disposed through local waste management bodies. Hence, the impact due to generation, handling and storage of solid waste is envisaged to be low.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	2
Impact Significance = 4 i.e. Low					

Impact of Hazardous Waste: Hazardous waste generated during the operation phase of the proposed project would include waste/spent oil, batteries, lighting lamps, E-wastes and Battery waste. Various types of E-wastes would be generated during the operation of power plant like used and obsolete IT and telecom equipment: electronic and electrical hardware/ components, PC peripherals, Faulty/scrap meters and metering equipment, electronic timers; Faulty/used electronic and electrical equipment, Capacitors i.e., electrolytic capacitors and capacitors containing Polychlorinated Biphenyls.

E-waste contains toxic components that are dangerous to human health, such as mercury, lead, cadmium, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and brominated flame retardants. Improper disposal of e-waste like Direct disposal to landfills without any prior treatment has the potential to contaminate soil and groundwater due to leaching of metals in water and soil. It may further pollute surface water in case it is indiscriminately, and improper e-waste recycling methods open burning and acid baths lead to generation of toxic compounds like dioxins and furans. Battery waste, which is likely to be generated through the project lifetime, when improperly disposed, batteries can leak heavy harmful metals, such as nickel, cadmium and lithium, that has the potential to which contaminate our local soils, groundwater, and streams, similar to e-wastes. UMPL is envisaged to have a proper Waste Management plan for solid wastes and hazardous wastes in place that would ensure that wastes are stored in accordance with safety norms in ventilated enclosures and proper signages, handles as per regulatory instructions and disposed through authorised vendors. Considering the toxicity of the hazardous waste and the types of wastes generated, the significance of impact due to waste generation is envisaged to be medium.

Intensity of Impact	2	Extent of Impact	2	Duration of Impact	2
Impact Significance = 8 i.e. Medium					

Impact from accidental damages to the UG pipeline due to third party activities: The UG pipeline for gas outside the UMPL site would be maintained by Titas Gas. The UG gas pipelines and other utility lines within the plant premises would be provided with Pressure Gauges for detection of any pressure drop due to leakages. These Pressure Gauges would be PLC based and would be controlled using DCS. Additionally, the areas where UG pipelines pass would be adequately demarcated using signages, restricting any excavation activities without work permits; and would have a robust leak detection plan as part of annual maintenance program within the Site. It is also noted that no one w/o valid permit from BIWTA would go for setting up another pipeline or anything else below the river that might intersect or foul with the gas pipeline. Hence, the impact is considered to be low,

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	2
Impact Significance = 2 i.e. Low					

Mitigation Measures:

- UMPL would ensure that the hazardous waste plan is based on national as well as WB/IFC EHS guidelines for all solid and hazardous waste, implemented adequately
- Recyclable Waste will be sold to the authorized recycler and the other solid wastes will be disposed to local designated landfill facility
- Solid waste management plan would include records of waste inventorisation, disposal and transfer.
- Personnel training would be provided to the related plant workers to handle the hazardous waste, storage, reporting and recordkeeping. Post segregation of the waste, characterisation of the wastes would be carried out to determine the next step, i.e., treatment, recycling, reuse or disposal. the appropriate management and handling procedures. Once properly characterized, the wastes would be temporarily stored at the site in appropriate containers and impermeable storage areas according to applicable hazardous waste storage law.
- Oily waste and chemicals would be stored in tank/containers have sufficient secondary containment (~110% more than its capacity). The waste oil thus stored would be sold to Government approved venders.
- All the hazardous waste should be properly levelled with information including Name & type of waste, amount of waste, Date of waste generation, Disposal site and responsible authority. The waste will be removed from the site at regular intervals for safe disposal at designated site through authorised vendors
- UMPL would have a Spill Management plan in place delineating plans and procedures for preventive and corrective actions against any potential spillage of harmful materials and provision of adequate spill kits,
- It would be ensured that activities involving oil handling is carried out at impermeable surfaces and training of workers would be undertaken to manage spill management.
- Prevent indiscriminate discharge of untreated effluent from process, equipment/vehicle washing and chemical/fuel storage areas into the unpaved and open ground.
- Periodic monitoring (quarterly) of groundwater quality.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts due to gas pipeline during the operation phase would be low to negligible.

5.5.6 Impact on Air quality During Operation Phase

The major sources of air emissions and impacts during operation phase would be as follows:

- Emissions of air pollutants (NO2) from HRSG system boiler stack operating continuously during operation of CCPP throughout the project lifecycle have the potential to cause long-term disturbance to air quality would.
- Emissions of air pollutants (i.e., SOx, CO, NO_2, and HC) from emergency DG set stack and vehicles movement to and from the site.
- Emissions from vehicular movement throughout the project life cycle would likely impact ambient air quality on site and areas within close vicinity.

Since the proposed Power Plant would operate using R-LNG which have very low content of sulphur, emissions of sulphur dioxide would be negligible and would not require any interventions. Expected NO_2 level at GT exhaust of advanced class machines would not be higher than 25 ppmvd @ 15% O_2 which is within the pollution control norms. Also, the operation of DG set would be for emergency purpose and would not be a regular operation; hence no significant impact is envisaged.

The existing baseline average concentrations of PM_{10} & $PM_{2.5}$ vary between 46 µg/m3 to 90 µg/m3 and 23 µg/m3to 37 µg/m3, considering monitored data for two seasons. The monitored data is well within Bangladesh NAAQS, though some of the values are higher than WHO guidelines value of 50 µg/m3 and 25 µg/m3 for PM_{10} & $PM_{2.5}$ respectively. Concentrations of SO_2 are within the Bangladesh NAAQS. However, since the project does not envisage significant particulate matter & SO_2 emission, hence significant increase in the concentrations of Particulates in the ambient air is not envisaged due to the operation of the proposed project.

The dispersion of air pollutants for the proposed power plant from the point sources was predicted using AERMOD 9.9.0. Data relating to plant emissions, meteorology and other atmospheric conditions, determined by formulating impact scenarios were used as inputs while carrying out the simulation studies.

The ambient air quality monitoring data used in the prediction is based on field sampling and analysis. The locations of monitoring stations were earlier fixed based on the occurrence of maximum pollutant concentrations using screening models. Besides, these locations were selected considering the receptor points, predominant wind directions and settlements. USEPA approved AERMOD view version 9.9.0 model was used to estimate ground level concentrations generated from the point source emissions from the plant.

The site-specific meteorological data comprising surface meteorological data file & profile meteorological (Met) data was procured from Envitrans India. The model was run for NO_2 considering that most of the other oxides of nitrogen, namely NO is converted to NO_2 and a conservative assumption of 90% conversion to NO_2 is used as a basis of modelling.

The power project would be operated as combined cycle operation in which the exhaust air would be emitted through 75 m high stack. The parameters and corresponding values are summarized in the below ***Table 5.8.***

Table 5.8: NO2 Standards in Bangladesh as well as WHO

Pollutant	Averaging Period	Unit	WHO Standard	Bangladesh Standard
NO2	1 hour	µg/m^3	200	-
	Annual	µg/m^3	40	100

INPUT DETAILS:

For AERMOD running point source-controlled emission, input details of HRSG stack is given below in Table 5.9

Table 5.9: Input details

Parameters	Stack Emission Details
Stack height (m)	75*
Stack tip inside diameter(m)	7.4
Stack gas exit velocity (m/s)	20.2
Exhaust temperature (K)	364.4
Exhaust flow rate (m^3/sec)	868.7
NO_2 emission rate as NO_2 (g/sec)	41**

**Stack height is 75 meter is considered as per detailed design. Emission modelling results at grid intervals of 150 m spacing have been carried out – results do not show any variation; isopleth maps for UMPEL only and for cumulative assessment are presented in Appendix K.*
*** NOx emission concentration would be within 25 ppm at 15% oxygen'.*

Table 5.10: GLC at various points for NO_2 (µg/m^3)

24-Hourly Basis			
Pollutant Maximum	Distance	Direction	75meter stack height Incremental 24hourly Concentration for Proposed project (1st highest value) (µg/m3)
NO_2	0-2km	North North-East	3.2-4.1
		South South-West	2.3-2.9
	2-5km	North North-East	1.4-1.8
		South South-West	1.4-1.7
1-Hourly Basis			
Pollutant Maximum	Distance	Direction	75meter stack height Incremental 1 hourly

			Concentration for Proposed project(1st highest value) (µg/m3)
NO_2	0-2km	North North-East	15.0-20.0
		South South-West	14.0-22.0
	2-5km	North North-East	13.0-20.0
		South South-West	15.0-19.0
Annual Basis			
Pollutant Maximum	Distance	Direction	75meter stack height
			Incremental 1 hourly Concentration for Proposed project (1st highest value) (µg/m^3)
NO_2	0-2km	North North-East	0.42-0.54
		South South-West	0.38-0.50
	2-5km	North North-East	0.18-0.32
		South South-West	0.18-0.30

Table 5.11: Resultant concentration at various points for NO_2 (µg/m^3)

Location	Direction	Distance	Max value of Baseline monitoring (µg/m^3) A	Maximum Incremental value due to UMPL only, 24-hourly (µg/m3) B	Resultant maximum value due to UMPEL only (µg/m3) C(A+B)	Bangladesh Standards	IFC/WHO Standard
AQ1	North side of the project boundary	0.75 km	31.4	3.8	35.2	-	200 (1hr average)
AQ2	North east side of the project boundary	1.48 km	28.7	3.4	32.1		
AQ3	NNW side of the project boundary;	3.06 km	28.4	2.4	30.8		
AQ4	West side of the project boundary	4.46 km	18.4	1.4	19.8		

Dispersion Modelling results summary (24hr average)

The maximum (1st highest value) of 24-hourly concentration of NO_2 is predicted to be 4.1 µg/m^3 at 0.80km NNE from the project boundary.

Dispersion Modelling results summary (1hr average)

The maximum (1st highest value) of 1-hourly concentration of NO_2 is predicted to be 22.0 µg/m^3 at 1.48km SSW from the project boundary.

Dispersion Modelling results summary (Annual)

The maximum (1st highest value) of annually concentration of NO_2 is predicted to be 0.54 µg/m^3 at 0.80 km NNE from the project boundary.

Figure 5.12 to ***Figure 5.14*** presents predicted 24-hr average Ground Level concentration of NO_2, predicted 1-hr average Ground Level concentration of NO_2 and predicted annual Ground Level concentration of NO_2 respectively. The total resultant values of NO_2 are not beyond the limits of Bangladesh standard. This indicate that the expected power plant does not have any significant adverse impact on the prevailing air quality of that area.

The project would also have a bypass stack of 60m high which would be used when HRSG is not working and prior to venting through the by-pass stack, the flue gas would be passed through a gas burner. Air dispersion modeling has been carried out in the scenario of using bypass stack only. The maximum (1st highest value) of 24-hourly concentration of NO_2 is predicted to be 1.25 μg/m³ at 0.8km NNE from the project boundary. The maximum (1st highest value) of 1-hourly concentration of NO_2 is predicted to be 11.5 μg/m³ at 3.0km SSW from the project boundary. It was found that the incremental GLC from the bypass stack was lower than the main stack, although the area of impact was found to be more. This is due to better dispersion of pollutant from the bypass stack as the exit temperature (better buoyancy) and exit velocity is higher than the main stack. The details of air dispersion modelling considering the bypass stack is presented in **Appendix J.**

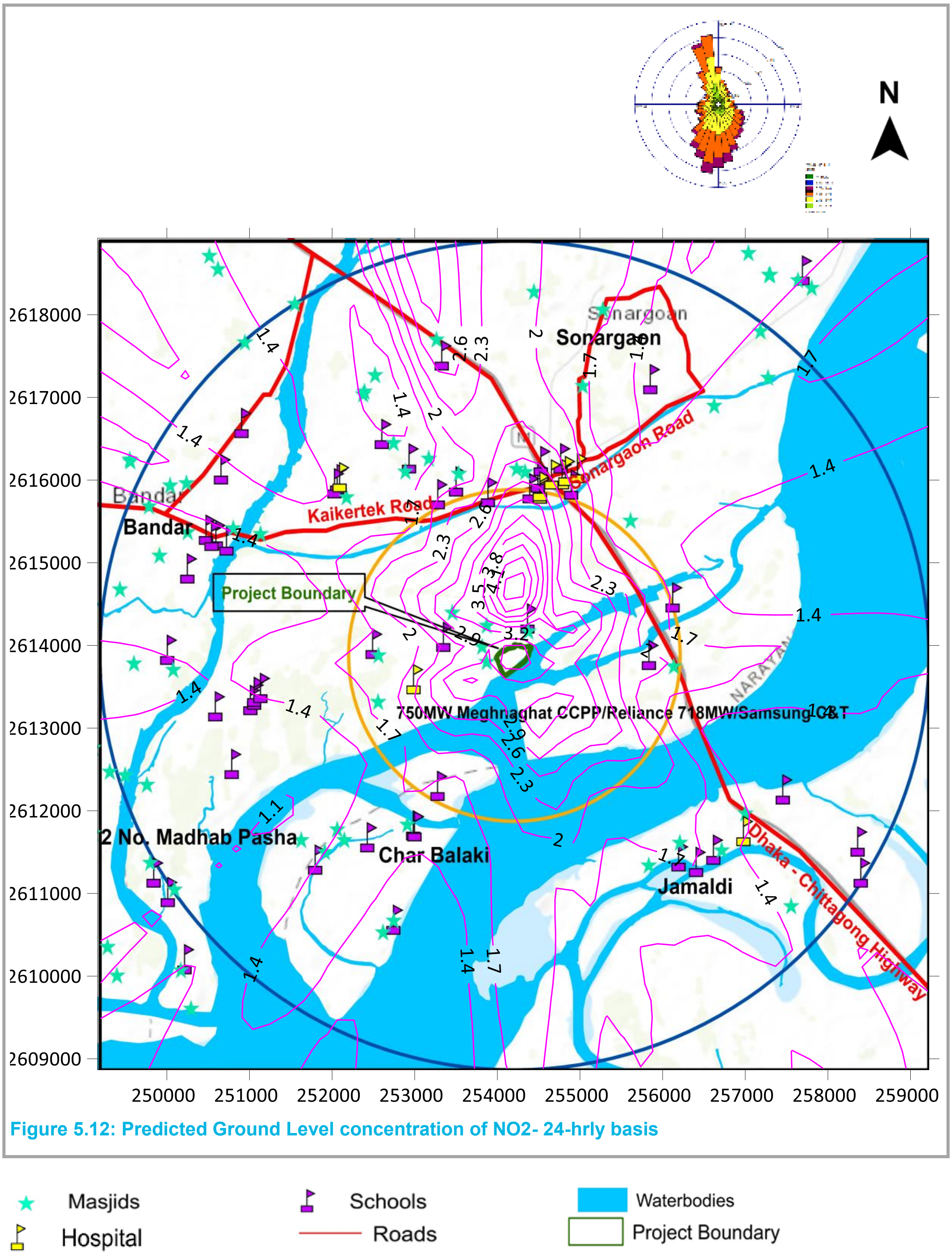


Figure 5.12: Predicted Ground Level concentration of NO2- 24-hrly basis

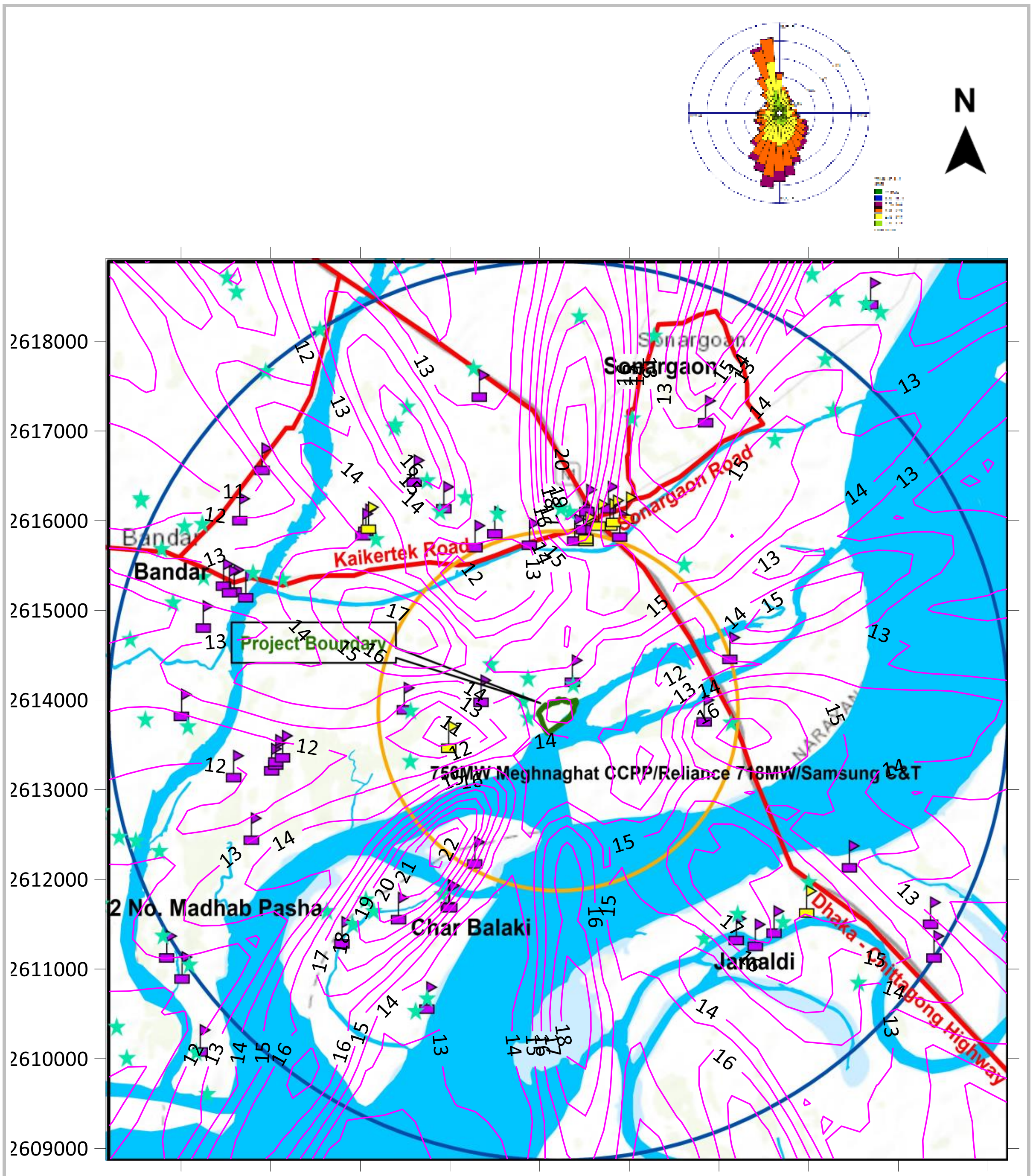


Figure 5.13: Predicted Ground Level concentration of NO2- 1-hrly basis

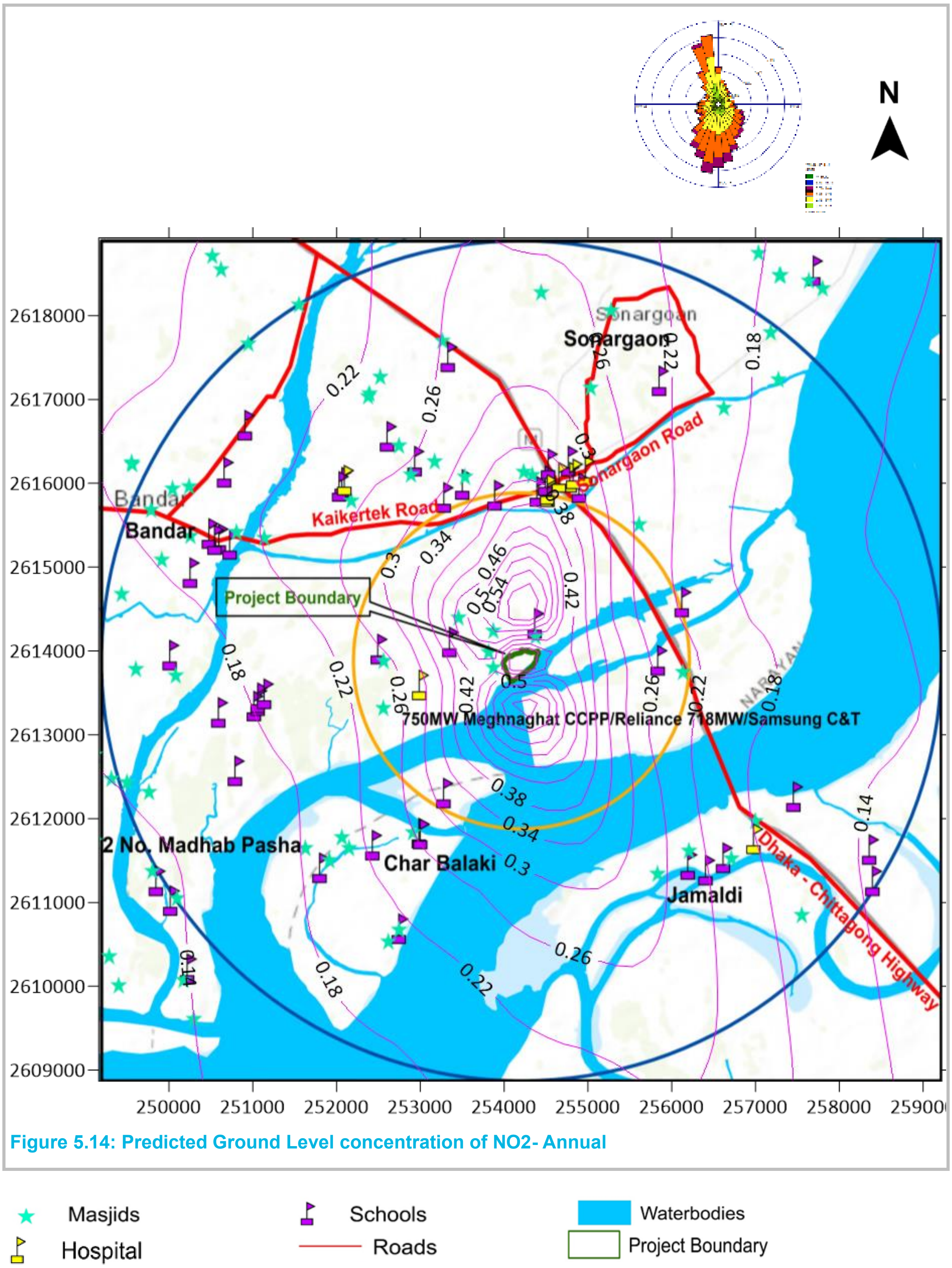


Figure 5.14: Predicted Ground Level concentration of NO2- Annual

Based on the above prediction and estimation and based on the nature of the fuel and gas turbine used for the proposed CCPP, impact due to emissions of air during the operation phase is envisaged to be low.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	2
Impact Significance = 4 i.e. low					

Mitigation Measures:

- Periodic monitoring of the ambient air quality and stack emissions
- Work zone air quality monitoring would be carried out at periodic intervals.
- Periodic maintenance and monitoring of air pollution control equipment would be ensured
- Preparation and implementation of Air Quality Management Procedure as part of EMP implementation.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on air quality would reduce further. Particulate matter is not an air pollutant of concern for a CCGT project. PM from other sources during the O&M phase like vehicles would be negligible. Although the baseline PM10 and PM2.5 exceeded the WHO standards, this project as such would not increase the prevailing PM concentration in the ambient air of the project region,

5.5.7 Impact Due to Noise Generation During Operation Phase

Noise prediction modelling has been carried out using SoundPLAN 8.2 to predict noise levels that would result from the plant's operational phase, as input to the Environmental and Social Impact Assessment (ESIA) study of the project. This assessment is attentive to evaluating the noise contributions from the operational phase of the plant to the sensitive receptors in the adjoining area.

The main sources of noise during the operational phase would comprise of Gas Turbines, Pumps and motors, Stand-by Diesel Generator (EDG), Steam Turbine, Cooling Tower and Compressed Air Unit would generate noise during the operation phase. Other sources of noise generation source during the operation include workers' commutation, traffic of vehicles for carrying the periodic inspection materials.

5.5.8 Basis of SoundPLAN Modelling Software

SoundPLAN is a software for modelling and a presentation tool that helps to optimize the noise control measures and visualize the effects of noise propagation throughout complex systems. This model is very useful to calculate sound pressure levels and generate noise maps. The output of this software is a graphical representation of the calculated sound pressure levels, considering reflections and diffractions of sound, and considering the geometry of buildings at the site and topography. The pressure level calculated or interpolated for each point within the modelling domain are shown as a grid of sound pressure, from which a contour map is generated showing isophones (lines of equal sound pressure).

Accumulated levels of sound pressure can be calculated by combining the sound contribution generated during the operational phase considering the conditions of existing background noise. The elevation of the study area was obtained and calculated from Google Map or OSM, which most closely approximates the actual topography. For the proposed project, the elevation of the site is considered to be about 7.76 m above MSL while the adjoining areas are taken to be 4.8 m high above MSL.

The Industrial Noise Propagation module of SoundPLAN 8.2 consists of two main components, the emission calculation and the propagation calculation. The emission calculation is performed internally within the noise source database, where operational equipment's sound power (SP) or pressure (SPL) level, sound generation height, their positions are defined. The propagation calculation is performed inside the calculation core of SoundPLAN. The performance of this module is further enhanced when used in conjunction with Wall Design to design and optimise the location and extent of noise barriers. Implemented calculation standards include BS 5228-1:2009, CoRTN, CoRTN Lden, NORD 2000 and RLS-90, amongst many others. Initially, there was the provision of a 3m high concrete boundary wall and noise modelling was carried out based on a 3 m high boundary wall. However, based on the results of the simulation and subsequent discussion with UMPL, initially, UMPL has agreed to raise the boundary wall height by additional 3m i.e. 6 m. The noise simulation exercises during the operation phase consist of both the scenarios i.e. with two different wall heights (3m & 6m) was performed and presented in our previous version of the Report.

After submission of that report, UMPL has decided not to raise the boundary wall up to 6 m due to its non-compatibility in the project site. The effectiveness of these additional components including additional boundary materials and height has been computed using computer noise modelling software (SoundPLAN), based on information on plant layout, the operating conditions and the levels of noise generated by plant items.

5.5.9 Additional Noise impact Assessment

The additional assessment presented in this report covers the following items

- Measure baseline sound levels at locations representative of the closest noise-sensitive receptors to the site.
- Carry out acoustic modelling work to quantify the noise impacts to surrounding sensitive receptors from the operation of the proposed plant considering different plant boundary materials and different heights.

5.5.9.1 Sources of Noise:

The main noise sources in the proposed power plant are presented in ***Table 5.12.***

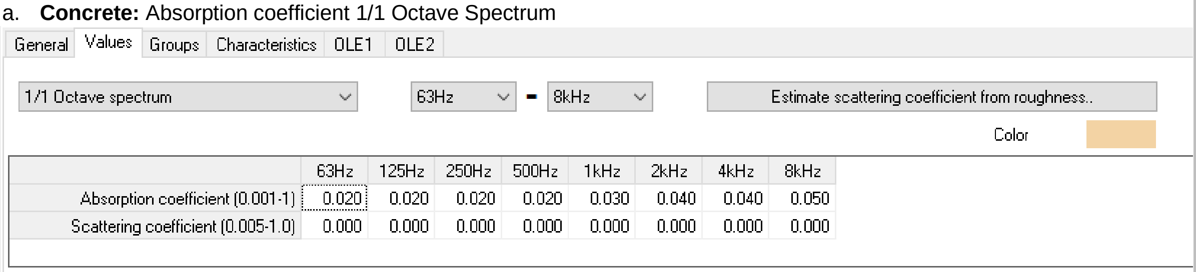
Table 5.12: Noise Level of Main Equipment in This Project Unit:

No.	Noise Sources	Noise Level dB(A)	Comments
1.	Gas Turbine (GT)	85	1m Outside the Cover
2.	Steam Turbine (ST)	85	1m Outside the Cover
3.	Generator	85	1m Outside the Cover
4.	GT Diffusion Section	85	1m Away
5.	GT Suction Outlet	85	1m Away
6.	GT/ST Room Roof Fan	85	1m Away
7.	GT/ST Room Composite Wall (Outside)	72	1m Outside the Wall
8.	GT/ST Room Door and Window (Outside)	72	1m Outside the Door
9.	GT/ST Room Air Inlet Louver (Outside)	82	1m Outside the Louver
10.	HRSG Proper	80	1m Away
11.	Boiler Feed Pump	85	1m Away
12.	Pressure Regulating Station	70	1m Away
13.	Pressurization Station	85	1m Away
14.	Circulating Water Pump	85	1m Away
15.	Transformer	75	1m Away
16.	Cooling Tower Air Inlet	88	1m Away
17.	Cooling Tower Air Outlet	85	1m Away

(Source: UMPL)

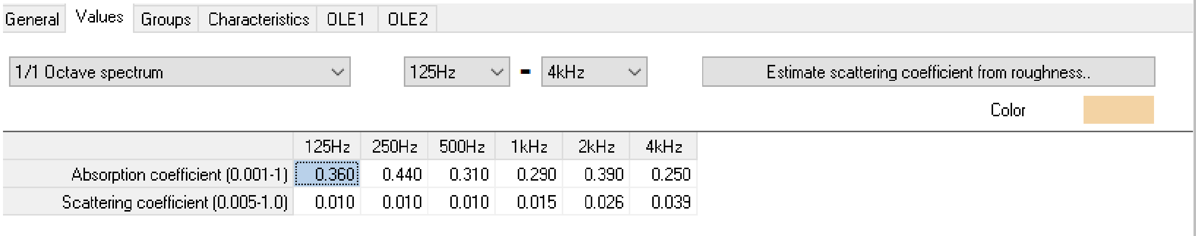
Three types of materials are considered for the boundary of the plant as shown below:

a. **Concrete:** Absorption coefficient 1/1 Octave Spectrum



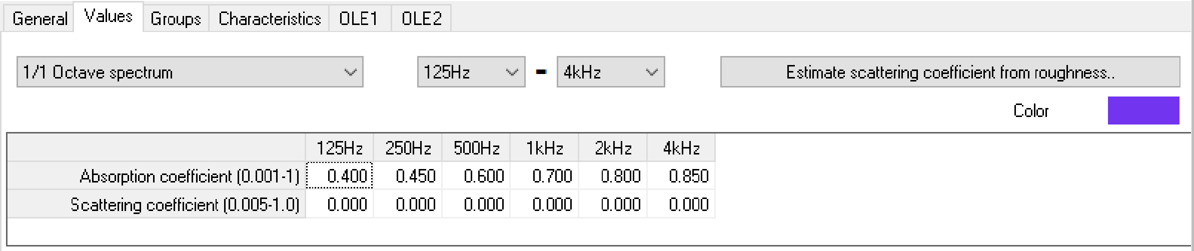
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Absorption coefficient (0.001-1)	0.020	0.020	0.020	0.020	0.030	0.040	0.040	0.050
Scattering coefficient (0.005-1.0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

b. **Rough Concrete:** Absorption coefficient 1/1 Octave Spectrum



	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Absorption coefficient (0.001-1)	0.360	0.440	0.310	0.290	0.390	0.250
Scattering coefficient (0.005-1.0)	0.010	0.010	0.010	0.015	0.026	0.039

c. **NPW Sheet:** Absorption coefficient 1/1Octave Spectrum



	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Absorption coefficient (0.001-1)	0.400	0.450	0.600	0.700	0.800	0.850
Scattering coefficient (0.005-1.0)	0.000	0.000	0.000	0.000	0.000	0.000

Figure 5.15: Absorption coefficient of plant boundary materials

The sources of noise generation and receptors of the proposed project within the area of influence is presented below:

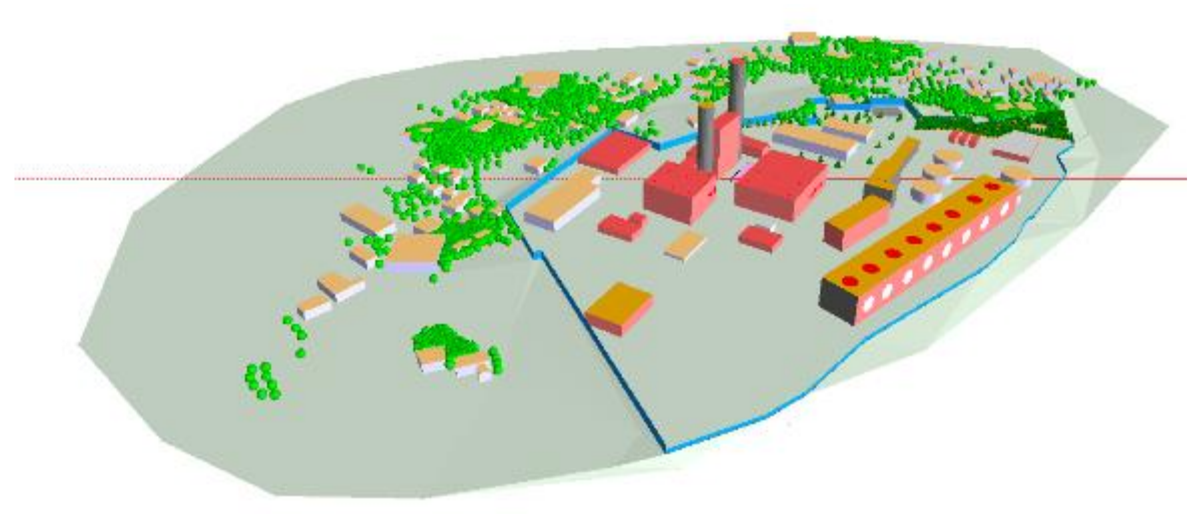


Figure 5.16: Noise generating sources and receptors of the proposed project

5.5.9.2 Different Scenarios:

Under this assignment, the modeler has developed different testable predictions (boundary wall height and materials) then gathered data from several secondary sources. After gathering the data the modeler has prepared different situations to run the model. Major numbers of situations were not that effective to reduce the noise level at the receptor ends. Three most effective situations which were found most effective to reduce the noise level are presented below:

Situation 1:

- Normal Concrete wall 3 m (Absorption spectrum presented in ***Figure 5.15 a***
- Noise protection wall 3m on and above the concrete wall (Absorption spectrum presented in ***Figure 5.15 c***
- Except for Industrial building, road and the mandatory concrete plant floor, the rest all remaining floors are covered with grass
- Proposed greenbelt within the plant boundary considered
- All noise sources were assumed to be operating continuously throughout the daytime
  and night-time periods.

Figure 5.17: Normal Concrete Wall

- Stand-by units were not considered in the model as noise sources.
- Small elements, such as structures, pipes and racks, were not included as noise sources or sound barriers.

Situation 2:

- Rough Concrete (Roughness >1cm) wall 3 m (Absorption spectrum presented in ***Figure 5,15 b***)
- Noise protection wall 3m on and above the concrete wall (Absorption spectrum presented in ***Figure 5.15 c***)
- Except for Industrial building, road and the mandatory concrete plant floor, the rest all remaining floors are covered with grass

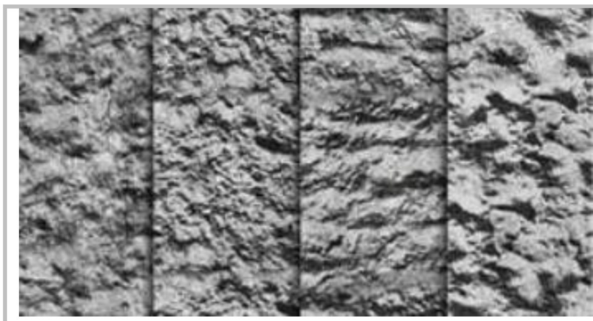


Figure 5.18: Rough Concrete Wall

- Proposed greenbelt within the plant boundary considered All noise sources were assumed to be operating continuously throughout the daytime and night-time periods.
- Stand-by units were not considered in the model as noise sources.
- Small elements, such as structures, pipes and racks, were not included as noise sources or sound barriers.

Situation 3:

- Noise protection wall 6m (Absorption spectrum presented in Figure 5.15c)
- Except for Industrial building, road and the mandatory concrete plant floor, the rest all remaining floors are covered with grass
- Proposed greenbelt within the plant boundary considered
- All noise sources were assumed to be operating continuously throughout the daytime and night-time periods.
- Stand-by units were not considered in the model as noise sources.
- Small elements, such as structures, pipes and racks, were not included as noise sources or sound barriers.

In our previous study we have considered following situations:

Situation 1 of Previous Study:

- Plant Boundary of Concrete 3m (Absorption spectrum presented in Figure 5.15 a)
- Except for Industrial building, and road, the rest all remaining floors are concrete within the plant boundary
- All noise sources were assumed to be operating continuously throughout the daytime and night-time periods.
- Stand-by units were not considered in the model as noise sources.
- Small elements, such as structures, pipes and racks, were not included as noise sources or sound barriers.

Situation 2 of Previous Study:

- Plant Boundary of Concrete 6m (Absorption spectrum presented in Figure 5.15 a)

- Except for Industrial building, and road, the rest all remaining floors are concrete within the plant boundary
- Proposed greenbelt within the plant boundary considered
- All noise sources were assumed to be operating continuously throughout the daytime and night-time periods.
- Stand-by units were not considered in the model as noise sources.
- Small elements, such as structures, pipes and racks, were not included as noise sources or sound barriers.

5.5.9.3 Model Results and Discussion

The results of the model run for two baseline case and three (3) new scenarios are presented as noise contour maps in ***Figure 5.19*** to ***5.24*** below. These were generated from a colour-coded noise level distribution grid. The colour scale was chosen so that cool colours (green) represent low values of sound pressure and warm colours (deep blue) represent elevated values of sound pressure. Contour lines (isophones) are representative of noise pressure intervals of 5 dB(A).

The noise contour maps only represent the SPLs predicted in the calculated area as a result of the operational phase. For this reason, the existing background SPLs are considered and were added to the SPLs predicted from the operation of the plant for 100% for 24 h Time Histogram to calculate the cumulative noise levels.

The noise absorption level of a rough concrete wall is much higher compared to the plain concrete wall. Further, mineral fibre acoustic panels of 200 mm have a higher absorption capacity compared to rough concrete and plain concrete walls. The noise simulation studies indicate that the boundary wall and homestead vegetation in the adjoining scattered village area around the plant site also acts as a noise protection barrier. Further, we can see from ***Table 5.13*** that the effects of material of construction of Boundary wall are less in case of the nearby receptors. Although, increasing wall height has a positive impact on that receptor. This is due to the elevation difference of the Project Site and Adjoining Ares (i.e., >1m). On another side, the effects of Boundary Material are found higher in the noise level at farther receptors. In the operation phase, increasing the height of the boundary wall by 3 m with the NPW and proposed greenbelt within the plant would definitely reduce the SPL in the adjoining area.

The estimated noise level with different situations at the sensitive receptors in the vicinity of the plant is shown below ***Table 5.13.***

Table 5.13:Estimated noise level in the receptors

Sensitive Receptor Name	Direction	Distance from Boundary, m	Operation Phase Estimated noise level, L_{dn} dB (A)		Operation Phase Estimated noise level, L_{dn} dB (A) (Additional Studies)			IFC/WHO standards			
								Residential		Industrial	
			With 3 m boundary wall height (Concrete)	With 6 m boundary wall height (Concrete)	With 3 m Concrete wall and 3 m NPW above that	With 3 m Rough Concrete wall and 3 m NPW above that	With 6 m NPW boundary wall height	Day*, dB(A)	Night**, dB(A)	Day, dB(A)	Night, dB(A)
Korbunpur Jamia mosque	West	67	56.53	55.05	54.54	54.33	54.00	55	45	70	70
Sardarbari Mosque	North-west	112	57.91	53.54	53.11	50.44	49.62				
Purbapara Jame Masjid	North-east	26	62.47	51.4	49.84	49.84	49.84				
Madhya Para Jame Masjid	North-east	135	59.38	57.10	55.64	54.62	50.44				
Dudhghata Govt Primary School	North-east	142	54.61	52.89	54.79	52.80	52.11				

*- Day time 6.00 am – 10.00 pm

** Night-time 10.00 pm – 6.00 am

$L_{dn:}$ equivalent noise level for day and night (24hrs)

The baseline noise level recorded at the monitoring station nearest to the plant was 49 dB(A) to during daytime and 43 dB(A) during the night-time.

NPW: Noise Protection Wall

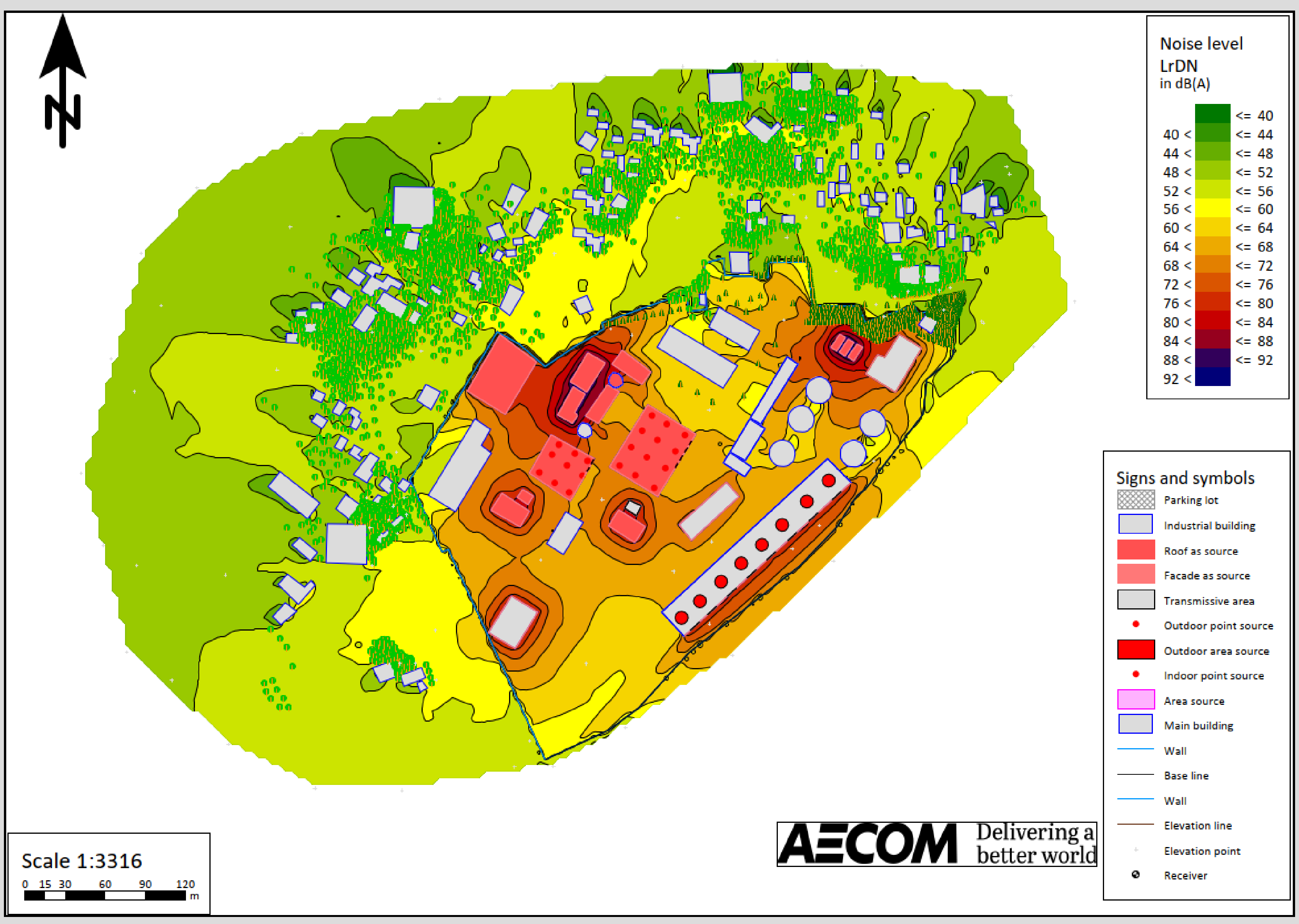


Figure 5.19: Noise level contours in operation phase (With 3 m Normal Concrete wall and 3 m NPW above that)

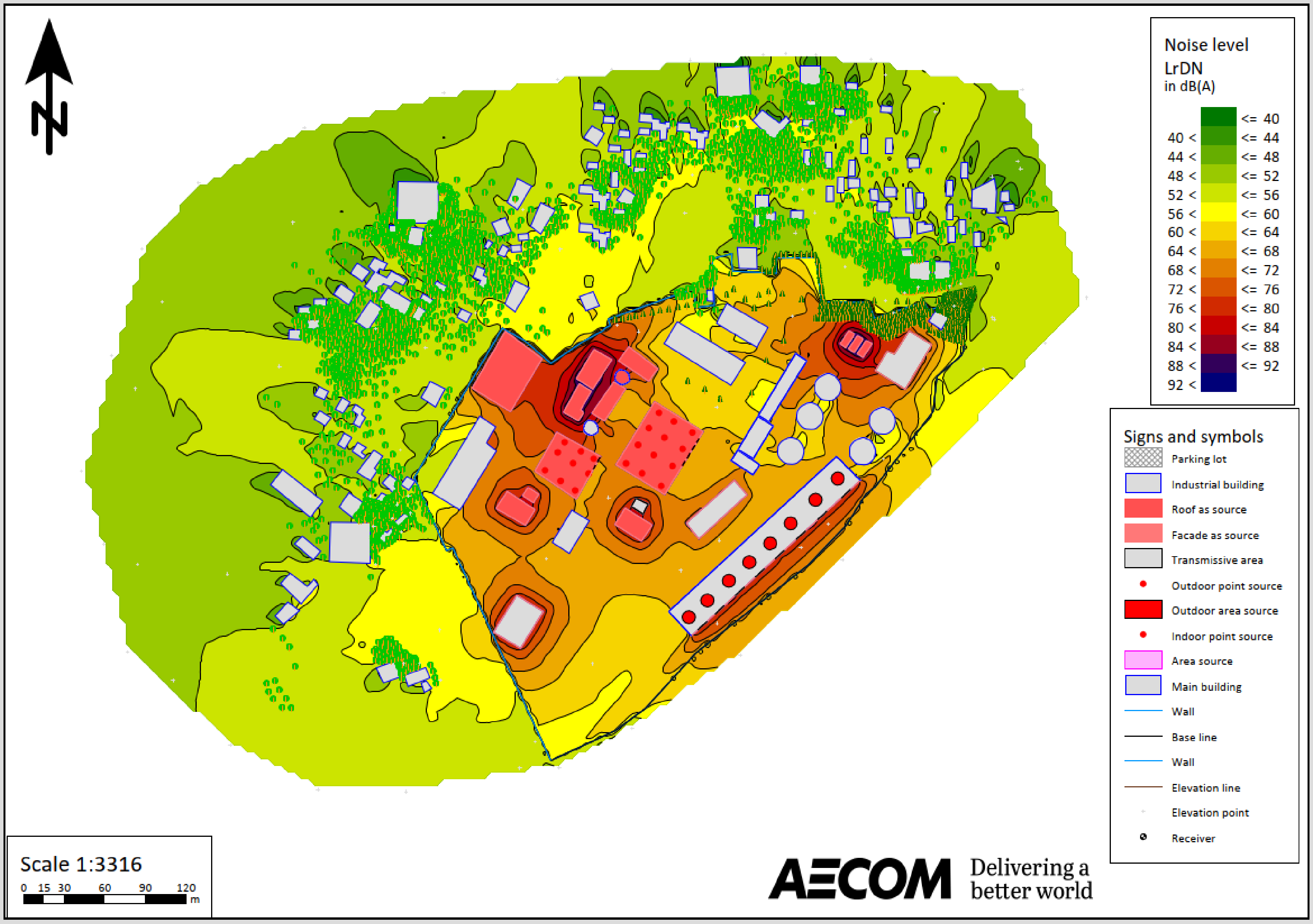


Figure 5.20: Noise level contours in operation phase (With 3 m Rough Concrete wall and 3 m NPW above that)

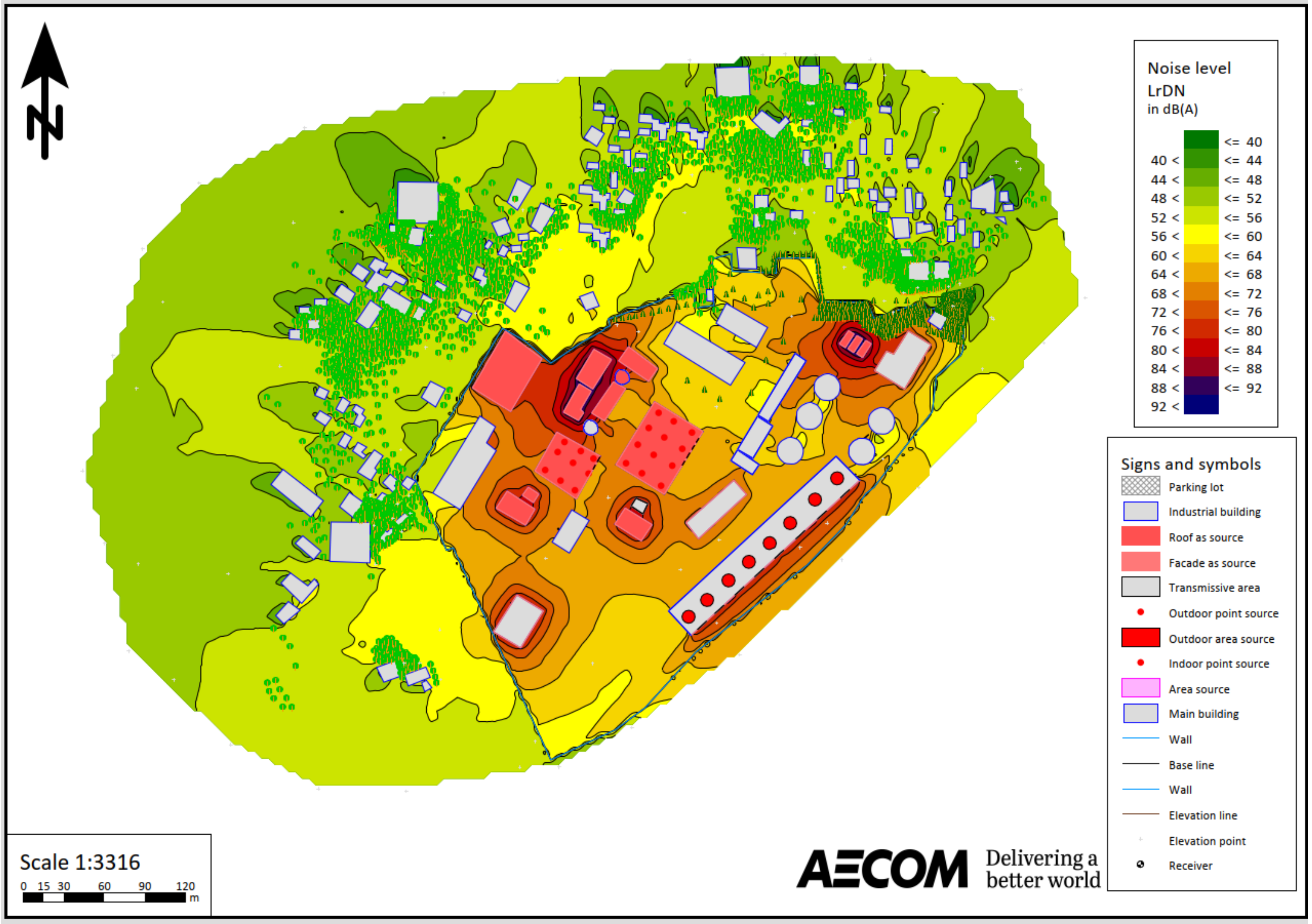


Figure 5.21: Noise level contours in operation phase (With 6 m NPW as boundary wall)

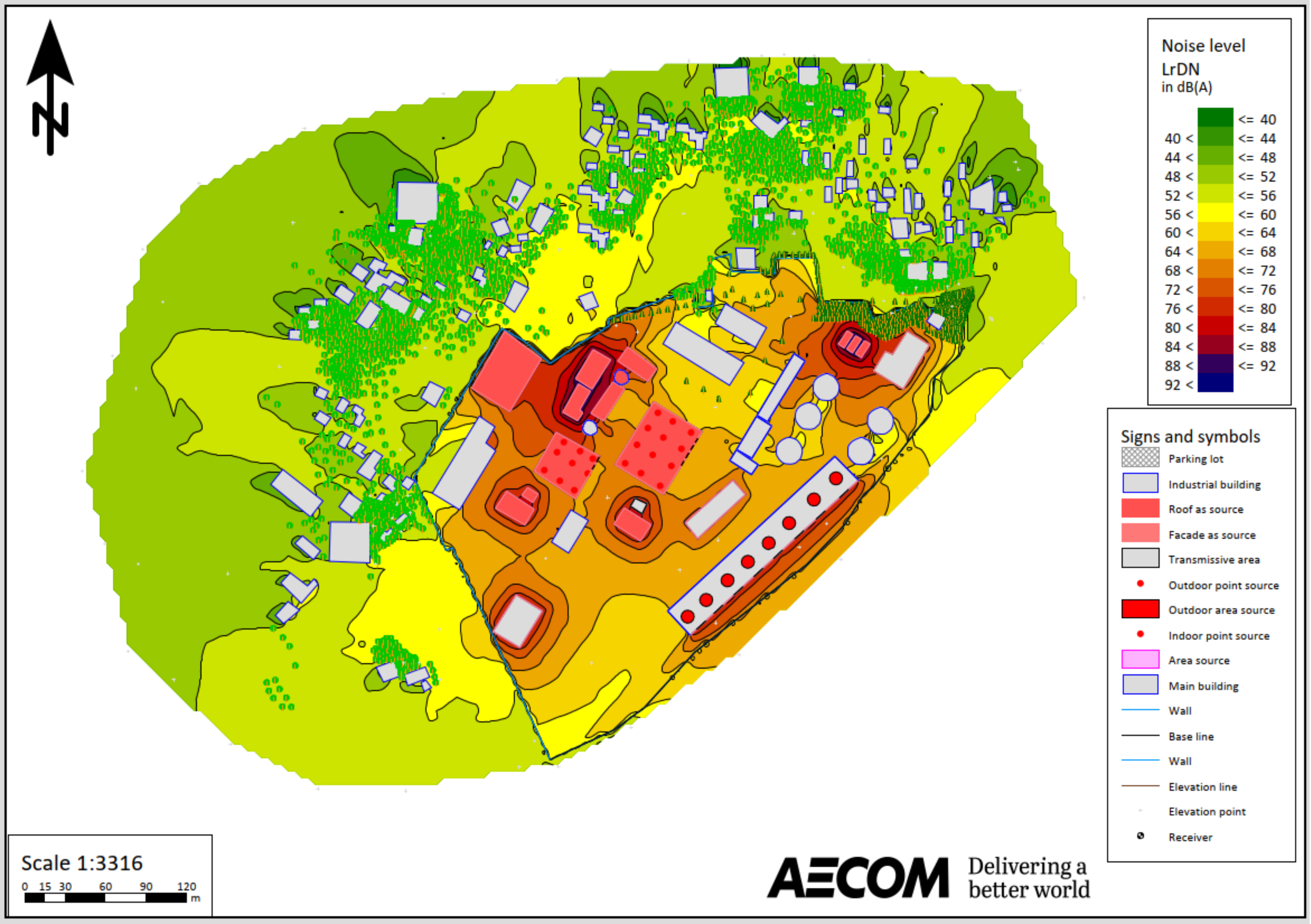


Figure 5.22: Noise level contours in operation phase (With 3 m Rough Concrete wall and 3 m NPW above that)

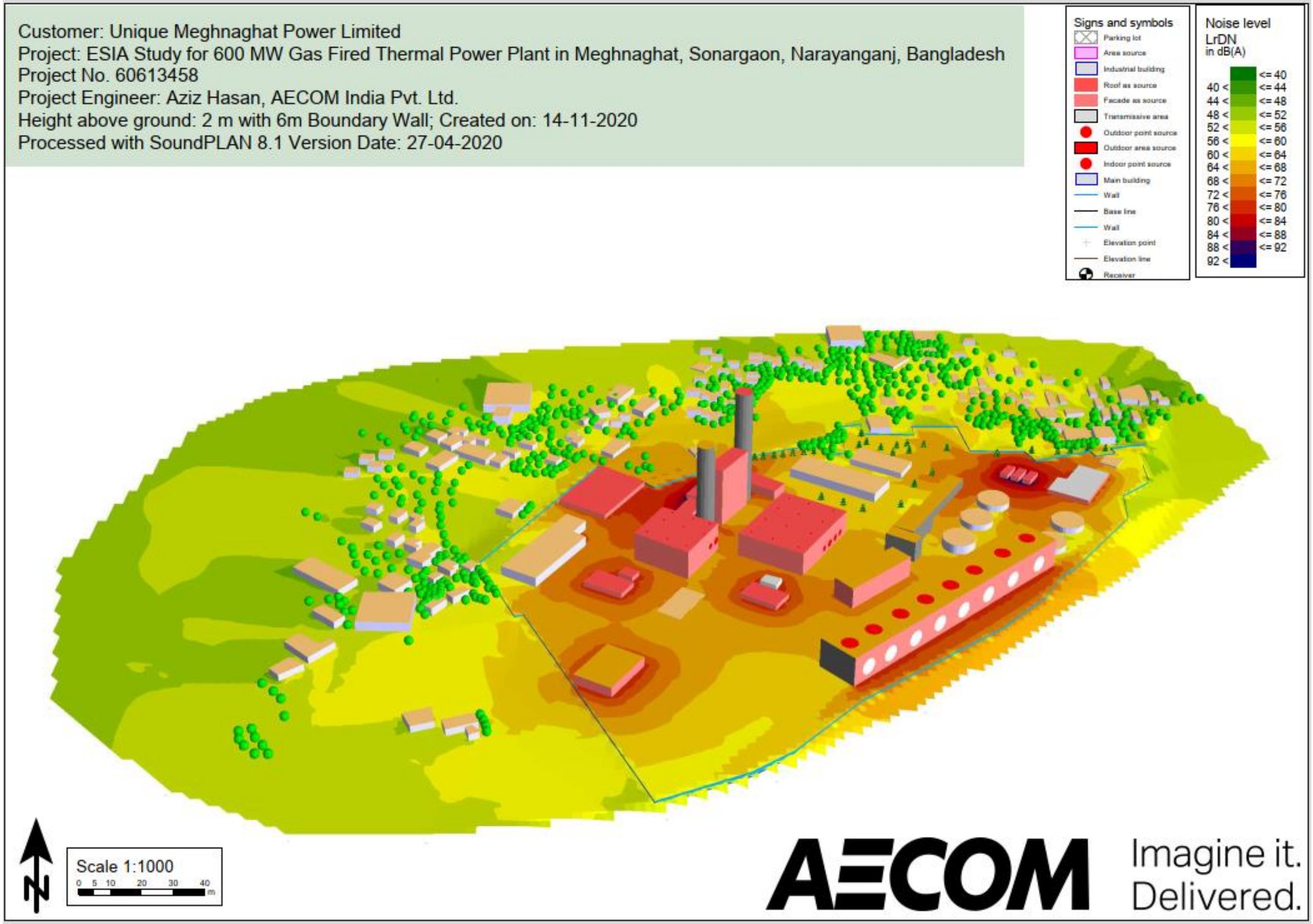


Figure 5.23: Noise level contou rs in operation phase (With 3 m Concrete Boundary Wall boundary wall) :Previous Study

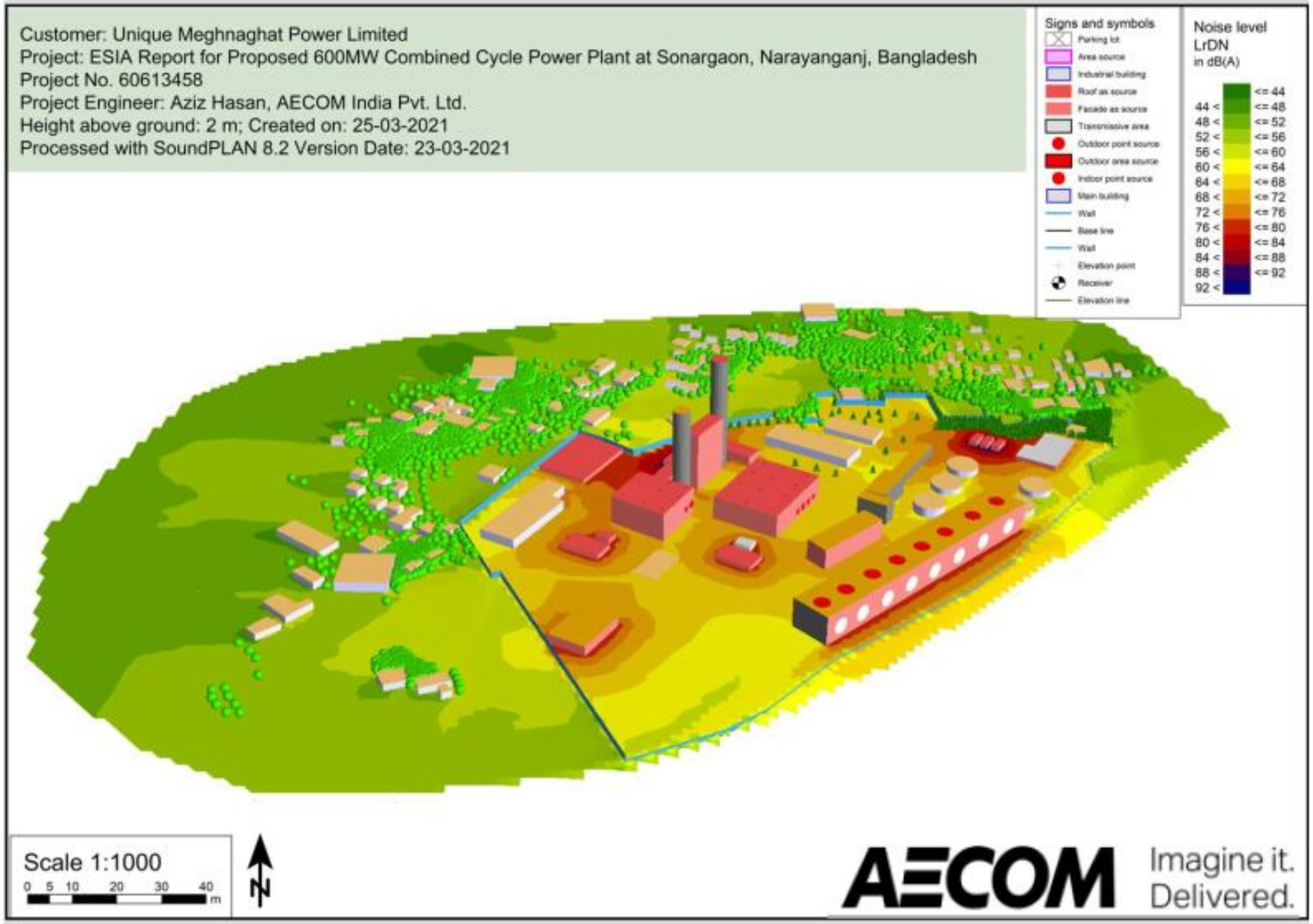


Figure 5.24: Noise level contours in operation phase (With 6 m Concrete Boundary Wall boundary wall): Previous Study

Recommendations:

Since power generating auxiliary equipment, cooling tower, and traffic would generate considerable noise throughout the project lifecycle, noise generated during the operational phase may be significant; however, with adequate additional management/mitigation measures, the impact of noise on the environment can be minimized.

During operation, the management measures would include in the first place, use of state-of-the-art low-noise generating equipment wherever feasible. Vehicles would strictly adhere to traffic management plans and techniques for reducing noise generation including engineering control mechanisms such as installation of mufflers and speed reduction in the residential area etc, to ensure reduction of noise impact. Other principal mitigation measures would include a mix of the following options to be undertaken:

- Periodic monitoring of work-zone and ambient noise during the operation phase.
- In case there is exceedance with the standard, adoption of practical mitigation measures to attenuate noise at source level. Source-specific noise reduction would be the best mitigation measure. Padding with noise absorbent materials inside/outside in each industrial building of principal noise generating sources, wherever feasible would enhance attenuation and minimize the noise levels at the receptor at Plant boundary and beyond. Apart from this UMPL would adopt all initiatives to put any high noise generating equipment within robust acoustic enclosures.
- In case it is not sufficient, UMPL would consider additional increase in height of the boundary wall by another 3 m with Noise Protection wall (NPW), with a total height of boundary wall as 6 m on all sides except the riverside boundary.
- On the riverside, no NPW has been considered.
- Based on the land availability, the development of a greenbelt (Plantation of Trees with broad leaves and dense foliage) along the entire periphery of the plant would be undertaken. This would help to further reduce the noise level at the receptor end.
- Use of PPEs like ear mufflers, earplugs etc. by the workers working in high noise zone.
- Exposure to noise of the workers would be limited to 85 dB(A) for 8 hours as per OSHA guidelines.
- For workers who may be exposed to noise level higher than 85dB(A), time of exposure would be restricted as per OSHA guidelines.

Residual Impact

With implementation of the precautionary and the additional mitigation measures mentioned above, impacts due to noise generation from project during construction and operational period would be much lesser.

5.5.10 Impact on Traffic and Transportation During Operation Phase

Impacts during operation phase include:

- Community disturbance and potential safety hazards, with pedestrians and cyclists using local roads would have to exercise more care with increase of vehicular traffic on the said roads;
- Increased wear and tear of local roads thus reducing lifespan of affected roads;
- Increase of exhaust emission from vehicles, which would pollute local atmospheric air.
- Increase of dust due to traffic movement.
- Increase in probability of accidents of human as well as domestic animals.
- Increase of community disturbance due to the increase of traffic related noise and vibration.
- However, movement of traffic during operation would be very minimum only restricted to movement of staffs and Contractual workers only. Traffic due to the project would be mainly due to plying of UMPL and O&M contractor personnel and would include around 3 Nos. of Sedan Car, 7 Nos of Micro Bus and 2 Nos. of Pick up Vans, which would ply to & fro the project site in the Approach Road.

It may be seen that the net contribution due to the operation of UMPL on daily average traffic load is not expected to be significant, considering this road will be used mainly for conveyance of personnel working at site. Use of water transportation for personnel movement is also under consideration. Based on the above factors, the impact on UMPL project on the traffic is envisaged to be low.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	3
Impact Significance = 3 i.e. Low					

Mitigation Measures

Mitigation measures include:

- Preparation and implementation of a detailed Traffic and Transport Management Plan during operation phase of the project.
- Ensure all vehicles with valid pollution fitness certificates are used.
- Enforce local road and river traffic rules.
- Formulation and implementation of a safety program (signage, speed restrictions, lights on trucks, truck load restrictions etc.) and sensitize all the vehicle drivers.
- Provide drivers training on safe driving.
- Installation of vehicle tracking system (VTS) in cars to monitor adherence to speed limit.
- Regulate speed limit of vehicles to 20 km/hr in the village road.
- Restrict night time movement of vehicles
- Restrict use of horns when passing through village roads, and especially at night.
- Adoption of Stakeholder measures for avoidance of traffic incidents like display of educational materials and signboards to ensure elderly and children are aware of the increased traffic risk and safety measures

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts due to traffic movement would be negligible.

Impact due to maintenance of Transmission line

The Right of Way or transmission corridor is the land that sets two transmission line centre paths. And the transmission tower is located centrally of the ROW. The width of ROW varies according to the voltage of the Transmission line and increase for higher voltages for better clearance due to safety reasons. Vegetation clearance is also done for the same. For UMPL project, the width of ROW for 440 KV is 33 m. The maintenance of ROW in transmission lines is a significant aspect considering the safety factor.

For UMPL project, the Transmission line is connected through two tower footings, one located within the plant boundary towards the eastern periphery of the plant and the other within PGCB substation. TL crosses the river and passes through the land for about 500 m to PGCB substation for power evacuation. The area has industrial land use and presence of vegetation is minimum. However, for the existing vegetation cleared & trimmed for installing the TL, it is crucial to keep the growth of vegetation in check. Unchecked growth of vegetation, especially tall trees and accumulation of vegetation within rights-of-way may cause impacts like power outages due to contact of branches with transmission lines; blocking of equipment access and interference with critical grounding equipment. Hence, impact due to maintenance activities is presumed to be of medium significance

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	2
Impact Significance = 6 i.e. Medium					

- Maintenance of TL entails handling and use of insulated oils that are used to cool transformers. They also provide electrical insulation between live components. Insulated oils may contain Sulphur Hexafluoride (SF6) which is a Greenhouse gas having Global Warming potential higher than Carbon dioxide. It is recommended to minimize the use of SF6. Use of Polychlorinated Biphenyls (PCB) as a dielectric fluid for providing electrical insulation will be avoided due to potential adverse impact on human health and environment. Maintenance of TL entails handling and use of insulated oils that are used to cool transformers. They also provide electrical insulation between live components. Insulated oils may contain Sulphur Hexafluoride (SF6) which is a Greenhouse gas having Global Warming potential higher than Carbon dioxide. It is recommended to minimize the use of SF6. Use of Polychlorinated Biphenyls (PCB) as a dielectric fluid for providing electrical insulation will be avoided due to potential adverse impact on human health and environment.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	3
Impact Significance = 3 i.e. Low					

- Occupational health and safety hazards are inherently associated with maintenance of TL. Specific occupational health and safety hazards involves hazards associated with working with live power lines, Working at height, Electric and magnetic fields (EMF) and Exposure to chemicals. Impact due to EMF has been discussed separately. UMPL have in place a well drafted OHS plan for Construction stage and will formulate an OHS plan to safeguard occupational health & safety of all working personnel. OHS plan would include aspects related to safe working practices during maintenance of the TL for prevention of hazards associated with working with live power lines, working at height, and exposure to chemicals. Considering that maintenance activities would be conducted as per the safe practices indicated in the OHS plan, the impact significance is envisaged to be medium.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	3
Impact Significance = 9 i.e. Medium					

O&M of transmission line will be responsibility of PGCB. However, to facilitate PGCB in carrying out the task safely, UMPL will adopt following mitigation measures and share with PGCB to suggest the same in tandem with any other additional measures formulated by PGCB.

- OHS plan would include provisions as per the national regulations and IFC EHS Guidelines for Electric Power Transmission and Distribution.
- Planning & implementation of periodic maintenance activity to keep check on the vegetation from growing back into the lines and address other operation aspects including restoring of proper signages as required.
- Implementation of vegetation management system involving removal of tall-growing tree species and the encouragement of low-growing grasses and shrubs in transmission line ROW.
- It is imperative to implement strict management control to ensure adherence with the OHS plan while conducting maintenance work of TL ROW. It is also crucial to ensure that live-wire work is carried out by trained personnel with strict adherence to safety & insulation standards.
- It is to be ensured that Deactivating and properly grounding of live power lines before work is performed on, or in close proximity, to the lines.
- Workers working with live wires would be properly insulated from the energized part with gloves or other appropriate insulation
- It is recommended that Testing of structures is done for integrity prior to commencing maintenance work; It is to be ensured that maintenance activities are conducted by personnel with knowledge of fall protection system.
- OHS plan would incorporate crucial aspects to prevent fall while working at height like Installation of fixtures on tower components, use of safety belts I two-in-one nylon or material of equivalent strength and in good condition (not aged or frayed), use of second safety strap while working with power tools at height, removal of signs & other obstructions prior to work.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts due to operation of TL would be low to negligible.

5.5.11 Impact Due to Electric and Magnetic Field (EMF)

Types of Hazards: There are essentially three major potential hazards associated with electromagnetic radiation

- Electrical hazards
- Fire hazards
- Biological hazards

Electrical Hazards: Strong electromagnetic fields have the capacity to generate electric current in other metal objects by electromagnetic induction. The induced current can cause an electric shock to all living forms. It can also overload and destroy electrical equipment. The overloading of transformers in the living areas can be of particular concern. This can be especially hazardous in the vicinity of military ordnance, since an electrical overload can cause ordnance to discharge or explode.

Fire Hazards: Electromagnetic induction resulting from a strong electromagnetic field can cause electric currents to flow across an air gap to ground and produce sparks. These sparks can then ignite flammable materials or gases, leading to an explosion or a fire.

Biological Hazards: Generation of heat is the main biological effect produced by electromagnetic fields. This in fact is the principle behind the operation of a microwave oven. The heating effect varies with the frequency of EMR. The eyes are particularly vulnerable to RF energy in the microwave range, and prolonged exposure to microwaves can lead to cataracts. Each frequency in the electromagnetic spectrum is absorbed by living tissues at a different rate, called the specific absorption rate, SAR, which has units of watts per kilogram (W/kg). The Health and Safety Institutions of many national governments have established safety limits for exposure to various frequencies of electromagnetic energy based on SAR. However electromagnetic radiation would be limited to some part of the entire plant like switchyard.

[31]Low Frequency (LF) fields are mainly related to the electric power supply, through the generation, distribution and use of alternating current (AC) and the frequency used for this purpose is usually 50 or 60 Hz. When people are exposed to LF fields, electric fields and currents are generated inside the body which can interfere with the body's own electric fields and current flows related to normal biological functioning. Additionally, LF electric field also interacts with the surface charge of the body. At low levels, these interactions do not cause significant health impacts.

However, above threshold level of exposure, the induced internal fields provoke reversible effects on excitable cells in the body including stimulation of nerves and muscles experienced as a tingling sensation.

The threshold exposure limits of non-ionizing radiation from EMF were developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) - an organization formally recognised by WHO. The standards are based on evaluations of biological effects that have been established to have health consequences. It is concluded that EMF exposures below the limits recommended in the ICNIRP international guidelines do not have any known consequence on human health. ICNIRP exposure limits for occupational exposure to electric and magnetic fields is presented below ***Table 5.14***

Table 5.14: ICINRP Exposure Limits

Frequency[32]	Electric Field (V/m)	Magnetic Field (μT)
50 Hz	10,000	500
60 Hz	8300	415

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	2
Impact Significance = 4 i.e. Low					

Mitigation Measures

Working in Electric and Magnetic Fields (EMF): Occupational EMF exposure would be prevented or minimized through the preparation and implementation of an EMF safety program including the following components:

- Identification of potential exposure levels in the workplace.

[31] *(www.icnirp.org)*
[32] *(www.icnirp.org)*

- For addressing exposure levels exceeding ICNIRP levels, it is required to implement action plan to ensure that occupational exposure limit is within the ICNIR guidelines
- EMF Safety program would be adopted which would include the following:
  - Training of workers in the identification of occupational EMF levels and associated hazards.
  - Establishment and identification of safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting approach to high-risk zones. Appropriate signages would be put up elaborating the dangers associated with exposure to EMF radiation.
  - Personal exposure monitoring equipment would be set to warn of exposure levels that are below occupational exposure reference levels (e.g. 50 percent). Action plans to address occupational exposure may include limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, or the use of shielding materials.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts due to EMF would be negligible.

5.5.12 Impact on Ecology During Operation Phase

The impact on operation phase would be primarily from:

- Physical presence and operation of transmission system
- Physical Hindrance by On-ground Installations
- Impacts from Illumination from power plant
- Impact due to intake and discharge of water

Physical presence and operation of transmission system

Physical presence of permanent structures, such as the transmission towers and their ancillary components, as well as the transmission line system would persist throughout the operation phase of the project. The principal direct risk posed by operational transmission line and its ancillary structures to avifauna is the potential for individuals to be injured or killed, either by collision with erected towers or by entanglement with power cables, leading to electrocution. Bird mortality due to collision with ground wire and conductors of transmission lines and electrocution are common issues. In case of 400 kV lines, which has length of 800m, and electrical separation is above 4m, which is more than the wingspan of observed large birds e.g. Egret, Black Kite, Open billed stork etc. The wingspan of these birds varies between 1m-2.5m. Therefore, the electrocution risk due to direct contact with conductors is considered low. Further, Bangladesh falls under East Asian–Australasian Migratory Flyway and as per consultation with local people during the primary survey and review of publications and reports of Bangladesh, no records of presence of migratory birds found in and around the 10km radius of the project area. Thus, the overall significance is considered low.

Intensity of Impact	**1**	**Extent of Impact**	**1**	**Duration of Impact**	**3**
Impact Significance = 3 i.e. Low					

Mitigation Measures

- To further minimize the collision of birds with the transmission line installation of Bird Diverter[33] would be installed for safe passage of avian species.
- It is recommended that Bird flight diverter is made up of Polyvinyl chloride (PVC) having high resistance against chemicals, high tensile strength and durable against high temperatures. Bird flight diverters would retain good physical conditions within a range of harsh conditions for an extended period. The recommended spacing between bird flights diverter is 10 to 15 m.

[33] *Avian Power Line Interaction Committee (APLIC). 2012. Reducing Avian Collisions with Power Lines: The State of the Art in 2012. Edison Electric Institute and APLIC. Washington, D.C.*

Physical Hindrance by On-ground Installations: The physical presence of the different installation of gas based combined cycle power plants would hinder faunal movement within and through the area, affecting their current approach to habitats and resources. This impact is of low significance as there are similar habitats in the vicinity and the species can easily relocate to those areas and change their aerial route.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	3
Impact Significance = 3 i.e. Low					

Mitigation Measures

- Construction of boundary wall around the power plant area premises to stop any accidental incident of faunal species.in
- Green belt development would be initiated with plantation of local species for stabilization of the filled in material and engage with local forest department and Upazila administration for plantation activities outside the project area.
- Regulation of traffic speed, especially during the night to prevent accident of wild and domesticated animals.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on ecology would be negligible

Impacts from Illumination from substation

Use of artificial lighting to illuminate the Power plant area and during night-time would lead to unnatural illumination in the area during the natural dark part of the day. Use of vehicles during night may also lead to artificial illumination. Interruption of the natural night period by light is known to disrupt the natural biological cycles of many floristic and faunal species. This impact is of low significance owing to the location of the Project Site in faraway to any wildlife habitats.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	3
Impact Significance = 3 i.e. low					

Mitigation Measures

- Opt for low-intensity artificial lighting, such as LED, to prevent insects from being attracted to the Substation area. Ensure that lights are provided with downward-facing shades to limit the dispersion of the illumination.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on ecology would be negligible

Impact due to intake and discharge of water

Water is mainly required for cooling purposes in the project which would be sourced from adjacent Meghna River and discharged after treatment. At total of 49 species of fish species were listed in the Meghna river. Also, this river area falls under migratory path of adult Hilsha fish but does not fall within designated 4 spawning ground and 5 designated nursery sites as identified by GoB. Though, the intake of water would be done from Meghna River channel, not directly from Meghna river, however, there would be a chance of intake of aquatic organisms with water to power plant. Also, improper management of effluent that may lead to impact on aquatic ecosystem of the Meghna River. So, any treated surplus wastewater discharge after ensuring various reuse/recycle options are exhausted would comply to wastewater discharge standards as per ECR, 1997 and IFC EHS guidelines for thermal power plants and general guidelines.

The impact significance on aquatic ecology due to discharge of treated wastewater during operation phase is assessed to be low as the treated wastewater would strictly abide by the prescribed standards and the extent of impact is local as the elevated water would equalize at a short distance from discharge. Also, during intake of water would be followed as per the IFC-EHS guideline. The impact magnitude thus arrived is low.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	3
Impact Significance = 3 i.e. Low					

Mitigation Measures

- Options of utilizing the treated wastewater to other uses would be explored to reduce the quantity of discharge as much as possible.
- As far as possible the treated wastewater would be used for green belt development.
- The water intake structure would have multiple size screen barriers to avoid impingement or entrainment of aquatic organism.
- Usage of barrier nets (seasonal or year-round), fish handling and return systems, fine mesh screens, and wedge-wire screens, and aquatic filter barrier systems would be explored in the water intake system.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on ecology would be negligible

Impact due to maintenance of water intake channel

It is imperative that there would be siltation in the water intake channel with progress of time. In order to maintain unhindered flow of river water with minimum turbidity, periodic cleaning of the water intake channel & its vicinity need to be undertaken. There would be algal & gastropod growth at the bottom and walls of the intake channel which also needs to be removed periodically. During dredging of sediments for cleaning of the water intake channel & its vicinity, there is possibility of generation of plume of dredge materials resulting in increase in turbidity of water in and around the water intake channel. This may subsequently adversely impact the aquatic life during the period of cleaning. However, it is anticipated that fishes would usually avoid the working zone due to disturbance. Gradually the plume of dredge material would settle within close radius of 5-10 m. Considering these, this activity would not have any significant impact on the aquatic ecology.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	1
Impact Significance = 2 i.e. Low					

Mitigation Measures

- It would be ensured that the excavation would be carried out using bucket dredgers so that spillage of material is minimum during dredging activity.
- It would be ensured that dredged material is not disposed into the river.
- UMPL would ensure that regularly maintained dredger is used for the dredging activity, so that there is no oil spillage from dredger during the dredging.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above, impacts on ecology especially on aquatic ecosystem would be negligible

5.5.13 Potential Aesthetic and Visual Impact During Operation Phase

UMPL project site is located in village settings of Dudhghata mouza where the residing community adjoining the proposed project can see the river front from their respective houses. However, the operation of power plant would not only obstruction their view of the river front and the branch channel of river but also create aesthetics and visual impact on the local population. However, Dudhghata mouza is located in the boundary of Meghnaghat Industrial area, and it is presumed that the local people are already adapted to the visual façade of industrial set up. Hence impact significance of aesthetic and visual impact would be negligible. The transmission line that passes through an open terrain and crosses Meghna channel would also have impact on landscape and visual aspects. The landscape impact of the transmission line would remain very local as it does not pass through a densely populated or built-up area. Hence, the overall impact due to operation of the plant on the aesthetics point of view would be low.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	3
Impact Significance = 3 i.e. Low					

5.5.14 Impact Related to Gender Based Violence (GBV)/ Sexual Exploitation, Abuse and Harassment (SEAH) during Operation Phase

During operation phase, O&M contractor and UMPL may employ women workers for various work. However., as per the workplace scenario in Bangladesh, majority of the workers are male. In this scenario, incidents of Gender Based Violence and Sexual exploitation, Abuse and Harassment may be likely and UMPL does not have any Gender Policy. Hence significance of impacts related to GBV and SEAH is envisaged to be medium.

Intensity of Impact	2	Extent of Impact	1	Duration of Impact	3
Impact Significance = 6 i.e. Medium					

Mitigation Measures

- UMPL is recommended to formulate and implement Gender Policy in the workplace for all the worker working directly under UMPL or their sub-contractor.
- UMPL is recommended to formulate a sexual harassment committee headed by woman member of UMPL management and formulate SOP for daily working procedure of the committee and formulate and implement code of conduct related to GBV and SEAH for every employee and worker.
- Regular training programme should be carried out during induction of new worker and employee and yearly for the worker and employee working in power plant.
- Complaint Box should be installed in various places of the power plant and worker accommodation soliciting any related issues and concerns in this regard
- Developing a system of analysing any reported incidents and implementing remedial measures to prevent any recurrence

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on GBV and SEAH would be low.

5.5.15 Impact on Community Health and Safety During Operational Phase

Community health and safety may be impacted during operation phase due to noise generation and air pollution. Deterioration of surface water quality due to discharge of wastewater would also impact local community. However, gas-based power plant is comparatively cleaner than coal-based power plant so air quality impact on the surrounding community would be less. Planned green belt within the plant & immediate surrounding also reduce the noise and air pollution impact on surrounding environment significantly. In case of water quality, UMPL would install ETP and STP for treatment of waste water generated in their plant before discharge. Hence impact on community health safety due to plant operation would be medium.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	3
Impact Significance = 9 i.e. Medium					

Mitigation Measures

- Periodic maintenance of the plant machinery would be carried out to reduce the noise and air pollution impact
- Periodic Air pollution, noise monitoring and treated wastewater sample analysis would be carried out to assess the impact level.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on community health and safety would be low.

5.5.16 Impact on Cultural Resources During Operational Phase

There are four (4) mosques located in and around the plant boundary, Korbunpur Jamia mosque located west of the plant (67 m), Sardarbari Mosque located north-west of the plant (112 m), Purbapara Jame Masjid and Madhya Para Jame Masjid located north-east of the plant (26 m and 135 m). Due to their location in close vicinity of the plant, these mosques may be impacted from noise generated from the operation of the power plant. Safety related issue is also envisaged from the project operation including leaks and rupture of natural gas, fire and explosion which has potential to impact these mosques. Considering that the receptor sensitivities are high, the impact on cultural heritage site is assessed as medium.

Intensity of Impact	3	Extent of Impact	1	Duration of Impact	3
Impact Significance = 9 i.e. Medium					

Mitigation Measures

- Thick greenbelt would be developed along the part where the Masjids are located to prevent noise propagation and fugitive dust emission. It is also suggested to build a boundary wall of height 6 m to restrict noise propagation from the Plant.
- The plant would have Emergency Preparedness plan in place that would include adequate training and regular mock drills, safety procedures, elaborate firefighting system to cater to emergency events. There would be signages about the risks and emergency response plans near the vulnerable areas where sensitive receptors are located, such that immediate response is activated.
- Awareness programs, training and mock drills can be extended to residents in the immediate vicinity to raise awareness of the risks and build their capability to adopt immediate response measures.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above, impacts on cultural resource would be low.

5.5.17 Benefit to Local Enterprises

The project is likely to influence development of entrepreneurs in the area. The local enterprises particularly involved in production and sale of construction materials are expected to be potential benefactors of the civil works to be undertaken for the project. Similarly, local transporters of construction materials would also benefit from the project. The significance of the benefit to local enterprises is summarized below:

Positive Impact ++

5.5.18 Employment Generation

The construction and operational phase of the project is likely to generate both direct and indirect opportunities for employment. The estimated average direct employment would be approximately 900 personnel including 400 un-skilled workers which would primarily be sourced locally. In-direct employment would be primarily in the supply chain as vendors which are anticipated to be set up to support the construction. The local people are expected to be having options for such in-direct employment, even if they are not directly involved as construction labourers. Overall construction activity would have positive impact on developing the socio-economic conditions in general and employment generation within the study area. There would be moderate direct employment generation of about 130 personnel of skilled and semi-skilled nature during the operational phase apart from many more indirect employment generations, which would benefit the socio-economic status of this region.

Positive Impact ++

5.5.19 Demand for Lodging, Housing and Civic Services

Employment opportunities created by the project is expected to attract large number of people from outside the district. The in-migration of long term or permanent staff would create demand for long-term housing and other support services. There would be requirement of housing and other amenities even though the project would provide on-site lodging facility. This is expected to drive up the demand for housing and supply of other support services in turn resulting in the development of adjoining areas and having a positive impact on the quality of life in the area.

Positive Impact ++

5.5.20 Benefits of Community Development Activities and CSR Activity

Once the proposed power plant has established its social license to operate in the community, the continued sustenance of community relations would require the project proponent to engage in community development initiatives among the project affected villages as per needs and priorities identified by opinion leaders of the community. The Upazila and Union Parishad administration can also identify priority areas for social investment that the company would plan to contribute. The initiatives of the project proponent are likely to be focussed on providing good education and health facilities which can further improve the quality of life of the community in the vicinity.

Positive Impact ++

5.5.21 Impact on Occupational Health and Safety During Operational Phase

Occupational health and safety impacts associated with power plant operations include fire and explosion, contact with hot surfaces, Chemical hazards, working in confined spaces, non-ionizing radiation, Heat, Noise, Confined spaces, Fire hazards and Particulate matter.

The project embedded control measures are as follows:

- A Permit to Enter system would be established to ensure that only authorised persons gain entry to the site;
- Personal Protective Equipment (PPE) would be worn at all times on the Site. This would include appropriate safety shoes, safety eyewear and hard hats. Non-slip or studded boots would be worn to minimize the risk of slips.

Fire and explosion hazards at gas-based power plant may result from the presence of combustible gases and liquids, oxygen, and ignition sources during loading and unloading activities, and /or leaks and spills of flammable products.

Confined space entry (storage tanks, secondary containment areas, storm water/wastewater management infrastructure etc.) by workers and the potential for accidents may vary among power plant facilities depending on design, onsite equipment, and infrastructure.

These risks could create long term impacts to the health and safety of the operation workforce and therefore the impact severity is assessed to be medium. Measures would be implemented to ensure that these risks are considered prior to the commencement of operation, and that all risks are communicated to the workforce. Appropriate PPE would be provided, and equipment maintained and inspected regularly. Taking this into account, the impact to the health and safety of workers is assessed to be medium.

Intensity of Impact	**3**	**Extent of Impact**	**1**	**Duration of Impact**	**3**

Impact Significance = 6 i.e. medium

Mitigation Measures

- Occupational Health & Safety Plan would be prepared by UMPL/O & M Contractor engaged by UMPL that would cover aspects of health & safety hazards, their prevention & control procedure and identify training needs and frequency.
- OHS Manual will be prepared and stringently followed during the operation of the plant
- The Project would adopt a total safety control system, which aims to prevent the probable accidents such as fire accidents or chemical spills.
- Firefighting systems, such as sprinklers, portable extinguishers (appropriate to the flammable hazard in the area) and automated fire extinguishers would be provided at strategic locations with clear labelling of the extinguisher type.
- Plant equipment at hot temperatures that can pose risk to workers would be identified and protected to prevent accidental contact. Training on handling, hazard due to contact with hot surfaces would be provided; PPEs (gloves, insulated clothing would be used)
- Constant monitoring of pressure, density and temperature of gas pipeline; installation of pressure safety valves to prevent any explosion.
- Material Safety Data Sheets (MSDS) for each chemical used would be available and readily approachable at the facility
- A safety manual for storage and handling of Hazardous chemicals would be prepared and implemented.
- The staff would be trained for first aid and firefighting procedures. The rescue team would support the first aid and firefighting team.
- A first-aid centre with the trained personnel.
- Training and rehearsal of the emergency response procedures by the emergency team members and personnel on site would be completed periodically.
- A safe assembly area would be identified, and evacuation of the premises would be practised regularly through mock drills.
- Safe work practices would be developed to provide for the control of hazards during operation and maintenance.
- In the material storage area, hazardous materials would be stored based on their compatibility characteristics.
- A near miss and accident reporting system would be followed and corrective measures would be taken to avoid / minimize near miss incidents.
- Safety measures in the form of Dos and Don’ts would be displayed at strategic locations.
- Safety audits would be conducted periodically as per the regulatory requirements.
- Firefighting system would be tested periodically; and
- All hydrants monitor and valves would be visually inspected every month.
- Fire safety certificate from the competent Govt. Fire Authority has to be obtained on periodic basis.
- Monitoring of occupational hazards in the working environment designed and implemented by accredited professionals as part of an Occupational health and safety monitoring program.
- Maintaining the record of occupational accidents and diseases.

Residual Impact

With implementation of the precautionary and the mitigation measures mentioned above impacts on occupational health and safety would be low.

5.5.22 Impact on Climate Change

Greenhouse gases produced from natural as well as anthropogenic activities absorb and radiate infrared radiation emitted by Earth, and reradiate in all directions, some to space and some back toward the surface, where it further warms the surface and the lower atmosphere eventually contributing to global warming and finally climate change. In order, the most abundant greenhouse gases in Earth's atmosphere are Water vapor, Carbon dioxide, Methane, Nitrous oxide, Ozone, Chlorofluorocarbons.

For the operation phase of the proposed 600 MW CCPP project of UMPL, some specific potential GHGs emissions sources identified are as follows:

- Emissions from RLNG combustion
- Vehicular emission for commuting
- Air conditioning.

The total green-house gas emission from various emission sources, during the operation phase is estimated to be about 1727452 tonnes of $CO_{2\ eq}$. Detailed GHG estimation is presented in Section 6.4 of this report. Considering the above, the impact due to the operation of the proposed plant is assessed to be significant.

Intensity of Impact	3	Extent of Impact	3	Duration of Impact	3
Impact Significance = 27 i.e. High					

Mitigation Measures

- UMPL is recommended to explore technologies for Carbon Capture, Storage & Sequestration (CCSS) and implement the same onsite or offsite.
- Avoid use of Ozone Depleting Substances having significantly higher Global Warming potential (GWP).

Residual Impact

With implementation of the mitigation measures mentioned above, impacts would be moderate to low.

5.6 Impact during Post-project Decommissioning Phase

The plant has been designed to be in operation for 25 years. Decommissioning of the plant would involve the following aspects:

- Dismantling of the power plant structures and all associated electrical infrastructure and site buildings.
- Removal of hard standings and restoration of soil

The following impacts are envisaged to be associated with decommissioning activities:

- Improper disposal of demolition waste and obsolete machineries may lead to contamination of soil and discontent of community
- Generation of demolition wastes including rubbles, paver blocks, coal tars, dismantled macadam, metallic wastes and spoils and their disposal.
- Emissions of dust from demolition activities
- Disturbance due to noise generated from dismantling activities

However, these impacts are likely to be short-term and temporary in nature (approx. 4-6 months). Hence the overall impact of decommissioning activities is assessed to be low.

Intensity of Impact	1	Extent of Impact	1	Duration of Impact	2
Impact Significance = 2 i.e. Low					

The following mitigation measures will further alleviate the impacts of decommissioning activities.

- The demolition wastes would be recycled where feasible. The mixed wastes, rubbles and metallic wastes would be disposed to authorized waste disposal facility.
- Dismantling activities would be avoided at nigh time to reduce impact of noise on the community.
- Periodic sprinkling of water on deposited rubbles and spoils would reduce the fugitive dust emissions. Movement of vehicles removing dismantled materials from the site will be restricted with a speed limit of 20km/hr when passing through the village roads, the materials would be carried with tarpaulin covers, and vehicles shall have a valid emission compliance certificate to ensure vehicular emissions are within the prescribed norms.
- Soil testing would be carried out to assess any contamination, if any, from the project. In case, soil contamination is reported, its extent would be evaluated and required remediation measures would be adopted by UMPL.

The dismantling activities will involve engagement of local semi-skilled and unskilled labours; hence this phase is likely to generate sustainable income generation among the local population.

It is anticipated that with all the above mitigation measures in place, the impact of decommissioning activities on the environment will be negligible.

5.7 Cumulative Impact Assessment (CIA)

Cumulative impact on water resource and quality, air quality and noise are being assessed considering major industrial activities located within the Area of Influence. For cumulative assessment, the area of influence would encompass the spatial extent of all the nearby industrial activities. Based on the information gathered from extensive desktop research, verified during communication with Department of Environment (DOE) Narayanganj, the list of industrial activities in & around the project site have been obtained and is listed below. It was seen that the industrial activities which are majorly polluting are mostly limited to the immediate buffer area of 5 km from the project site. AOI for air pollution is 5km as the maximal GLC is not expected to be beyond 5km from UMPL. AOI of water resources and quality extends up to 5 km from the project site. Hence, the AOI for cumulative assessment impacts is considered as 5 km from the proposed project boundary.

The CIA study was carried out in reference to IFC Good Practice Handbook: Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets (2013)[34]. The approach adopted for the CIA is in line with the afore-mentioned handbook and included Scoping for identification of Valued Environmental Components[35] (VEC), establishment of environmental baseline (the baseline assessed for the ESIA report has been used) followed by Impact Assessment and formulation of Mitigation measures and their reporting the environmental components that are considered for cumulative impact assessment has been selected based on the severity of impacts identified during assessment of impact due to the proposed UMPL power plant and the impacts anticipated directly or indirectly by the existing, proposed and future projects. Since most of the industrial activities in the vicinity is generation of power from gas-based fuel, similar to the configuration of the proposed UMPL project, it is envisaged that they would cause impacts of similar nature of the proposed project. Based on the aforementioned rationale and the baseline environmental scenario, the cumulative impacts assessment has been conducted onthe VEC namely air quality, water quality and ambient noise quality. The cumulative impact is not predicted on other VECs like ground water resources, ground water quality and soil quality as these are not considered based on the following rationale: The cumulative impact is not predicted on other VECs like ground water resources, ground water quality and soil quality as these are not considered based on the following rationale:

- Ground water resource: Most of the existing projects are not using ground water as the primary source of water. Due to the availability of water supply, river water is used by the industries for their use. No groundwater abstraction is envisaged for proposed developments on regular basis and limited abstraction of groundwater is envisaged only for domestic purpose only. Hence, cumulative impacts are not anticipated on this VEC.
- Ground water quality: Baseline GW quality conforms to the standards and the projects do not have direct impact on ground water quality and cumulative impact is not expected to arise from other proposed projects.

[34] *The Good Practice Handbook for Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets (2013) of IFC*

[35] *Valued environmental components (VECs) are defined as fundamental elements of the physical, biological, or socioeconomic environment, (including the air, water, soil, terrain, vegetation, wildlife, fish, birds, and land use) that are likely to be the most sensitive receptors to the impacts of a proposed project or the cumulative impacts of several projects)*

- Soil quality: Impact on soil quality is also localised in nature and with mitigation measures and regular monitoring for trigger in case of deviation, it is not supposed to have cumulative impacts.

5.7.1 Industries in the AoI

The list of existing industries is presented in Section 4.3 of this report. The list of proposed industries in the area of influence is presented below ***Table 5.15.***

Table 5.15: List of proposed industries in the AoI

Name of Industry	Capacity	Configuration
Reliance Bangladesh LNG and Power Limited	750MW	Natural gas based CCPP
Majesty Power Jamaldih	600 MW	Natural gas based CCPP
Summit Meghnaghat II Power Company Ltd.	590 MW (Gas/RLNG) / 541 MW (HSD)	Natural gas & Liquid fuel based CCPP
Orion Power Sonargaon Ltd.	104 MW	HFO based
Unique Meghnaghat Power Limited	600MW	Natural gas based CCPP

Source: DOE Narayanganj & Desktop Research

The above mentioned five (5) industries including UMPL are the only proposed projects in the AOI, while the other industries, like cement plant, steel mill, and paper mill (as delineated in Section 4.3) are existing factories, the impacts of which have already been captured in the baseline monitoring.

5.7.2 Cumulative Air Quality Impact Assessment

The key air polluting industries situated in the Meghnaghat Industrial Area are power plants, cement plants and steel mills. The cumulative impact on air quality due to the present operational and proposed power plants and key air polluting industries were assessed by modelling projected emission rates using the USEPA approved AERMOD 9.9.0 view dispersion model.

Information of stack details for the power plants and industries, have been collected from the available secondary sources. However, due to unavailability of all requisite information, certain assumptions considering the type of industries & their configuration were done during the modelling study. The standard values of the modelled parameter are presented below ***Table 5.16.***

Table 5.16- Bangladesh Standard values and WHO guideline value of NO_2

Pollutant	Averaging Period	Unit	IFC/WHO Standard	Bangladesh Standard
NO_2	1 hour	µg/m^3	200	-
	Annual	µg/m^3	40	100

Note: NO_2 standard for 1 hr is not available in ECR 1997 and its subsequent amendments

INPUT DETAILS:

For modelling of air dispersion of NO2 in AERMOD, point source-controlled emission details of various projects in the AoI are given below in ***Table 5.17*** and ***Table 5.19.***

Table 5.17 : Inputs details of proposed Industrial Emissions for Air Quality Modelling

Name	Capacity	Distance	Direction From UMPEL project	Stack height (m)	Stack inside diameter (m)	NO2 Emission(g/s)
Reliance Bangladesh LNG and Power Limited	750 MW	825m	SE	70m	6.30m	39.0
Summit Meghnaghat II Power Company Ltd.	590 MW	1.03km	SE	75m	4.85m	52.0
Project Majesty power, Jamaldih	600 MW	3.0km	SE	75m	7.4m	41.0
Orion Power Sonargaon Ltd.	104 MW	1.91	SE	45m	1.1m	20.0
UMPL project-	600 MW	-		75m*	7.4m	41.0

Emission modelling results at grid intervals of 150 m spacing have been carried out – results do not show any variation; isopleth maps at 150 m interval for cumulative assessment are presented in Appendix K.

Table 5.18 : GLC at various points for NO2 (µg/m3) on 24-hrly and 1-hrly basis

Pollutant Maximum	Distance	Direction	Only for UMPL project		Cumulative Study	
			Incremental 24hourly Concentration for Proposed project (µg/m^3)	Incremental 1 hourly Concentration for Proposed project (µg/m^3)*	Incremental 24hourly Concentration for Proposed project (µg/m^3)	Incremental 1hourly Concentration for Proposed project (µg/m^3)
NO_2	0-2km	East	3.2-4.1	15.0-20.0	8.1-12.1	51.0-66.0
		West	2.3-2.9	14.0-22.0	6.5-11.3	56.0-76.0
	2-5km	East	1.4-1.8	13.0-20.0	5.7-6.5	41.0-56.0
		West	1.4-1.7	15.0-19.0	5.7-7.3	41.0-66.0

For UMPL project Incremental Annual Concentration value is 0.54 µg/m3 and for cumulative project assessment incremental concentration value is 3.4 µg/m^3. However, it is not possible to provide any projection of resultant GLC for the annual period as baseline monitoring was conducted for two seasons only (October 2019-November 2019 and June 2020).

The predicted concentration at the nearest sensitive receptors is presented below:

- Korbunpur Jamia mosque (Nearest Masjid) distance from boundary 67 m, W -12.1 µg/m^3 and 51 µg/m^3 24 hourly and 1 hourly NO_2 emission
- Nearest Hospital distance from boundary 1.2 km, E - 11.2 µg/m^3 and 54.0 µg/m^3 24 hourly and 1 hourly NO_2 emission
- Dudhghata Govt Primary School distance from boundary 140 m, NE - 11.3 µg/m^3 and 66.0 µg/m^3 24 hourly and 1 hourly NO_2 emission.

The predicted level of NO_2 in the ambient air due to cumulative growth of the industries considered is presented below. The isopleths showing the contribution due to the proposed projects on 24-hourly and 1 -hourly and annual basis is presented in the ***Figure 5.25*** & ***Figure 5.26*** respectively.

Table 5.19: Predicted air quality within the AOI

Location	Direction	Distance	Max value of Baseline monitoring (µg/m^3) A	Incremental value due to UMPL only, 24-hourly (µg/m^3) B	Resultant value due to UMPL only (µg/m^3) C(A+B)	Incremental value for Cumulative assessment, 24-hourly (µg/m3) D	Resultant value for cumulative, 24-hourly (µg/m^3) E (A+D)
AQ1	North side of the project boundary	0.75 km	31.4	3.8	35.2	9.2	40.6
AQ2	Northeast side of the project boundary	1.48 km	28.7	3.4	32.1	7.2	35.9
AQ3	NNW side of the project boundary;	3.06 km	28.4	2.4	30.8	4.9	33.3
AQ4	West side of the project boundary	4.46 km	18.4	1.4	19.8	6.5	24.9

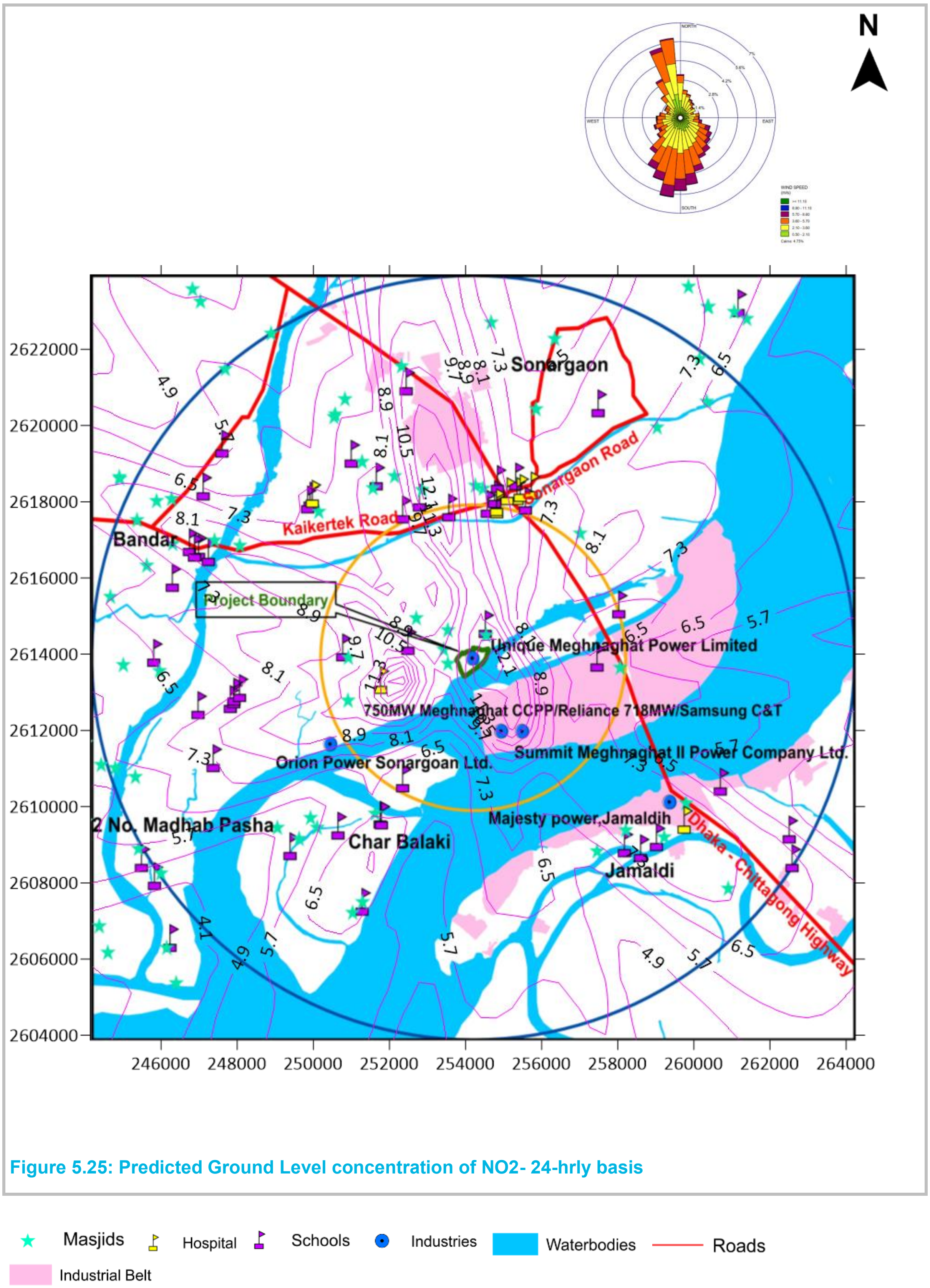


Figure 5.25: Predicted Ground Level concentration of NO2- 24-hrly basis

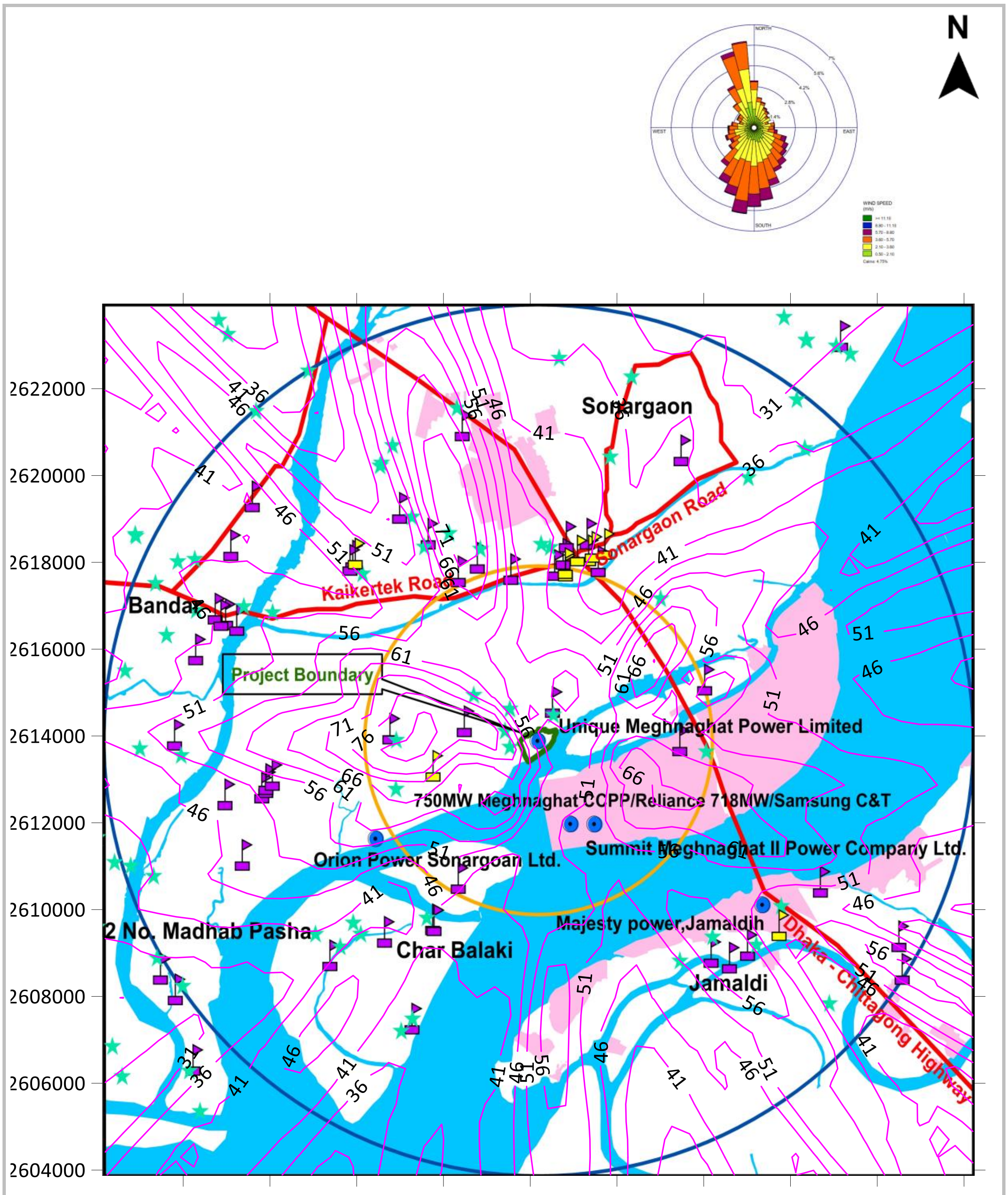


Figure 5.26: Predicted Ground Level concentration of NO2- 1-hrly basis

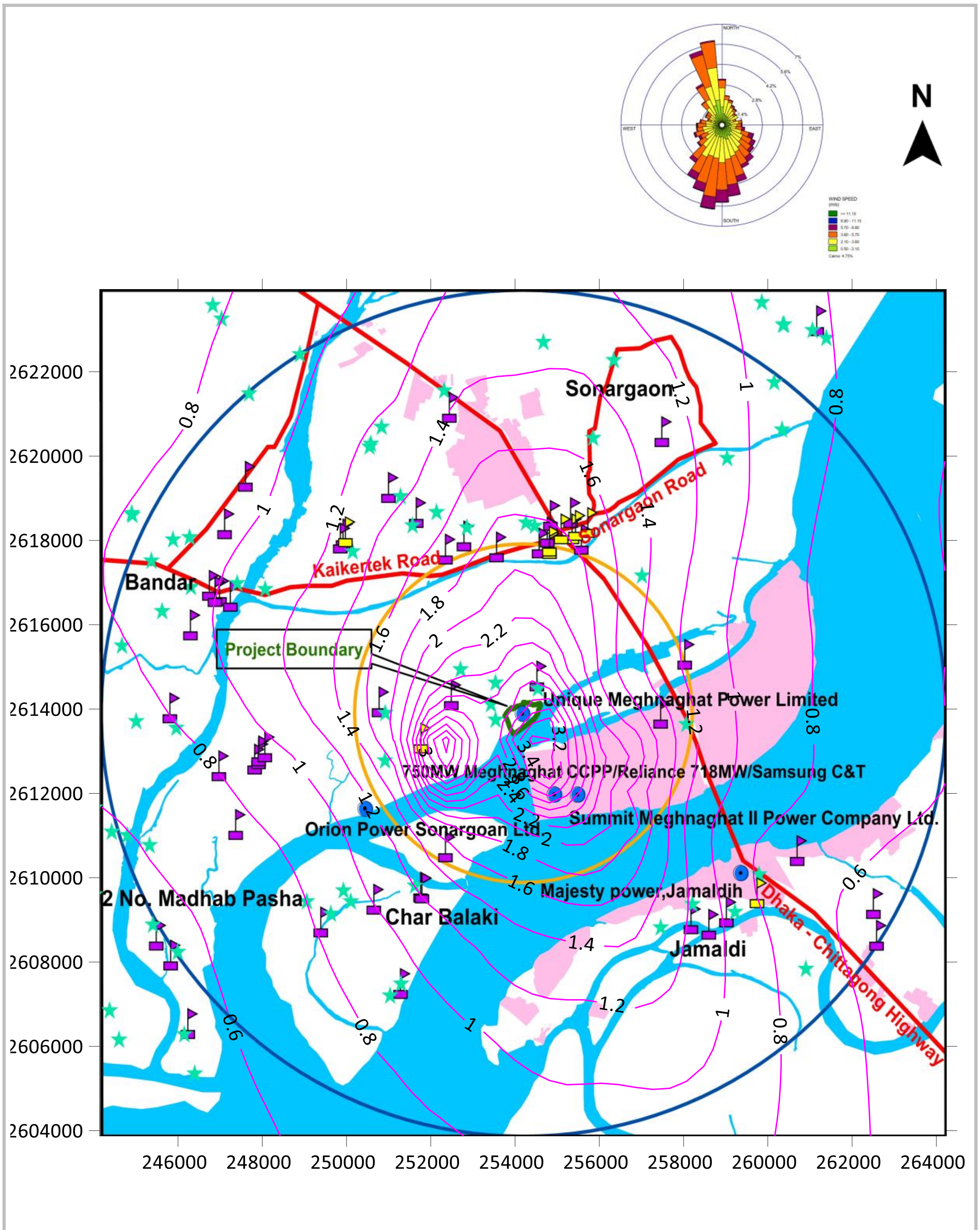


Figure 5.27: Predicted Ground Level concentration of NO2- Annual basis

Masjids Hospital Schools Industries Waterbodies Roads
Industrial Belt

Limitation for Cumulative impact for Air:

For preparation of cumulative study, the projects considered are based on available information from secondary sources and DOE Narayanganj. No information regarding upcoming projects was available from Bangladesh Investment Development Authority (BIDA). The results of air dispersion modelling and subsequently the cumulative impact on air may vary significantly if the configuration & details for the proposed projects vary.

5.7.3 Cumulative Impact Assessment on Water resource of Meghna River

The existing and proposed Industrial units are located on both the banks of Meghna River. Majority of these industries situated in this area use the water from Meghna river water for consumptive purposes and also use it as a sink for their effluent, post suitable treatment. Besides industrial use, the river water is consumed for other activities and serve as means of livelihood for the local people through fishing and ferrying in the river. In order understand the stress on the water resource of Meghna River, the water requirement of the existing industries have been tabulated below. The information of water source & consumption of these industrial units is collected from the available veritable secondary sources[36] and information collected during the site reconnaissance in combination with data of similar projects.

Table 5.20. Water requirement of Exiting Industries situated in the AOI

Industries	Water requirement, cum/hr
Existing Industries	
Power Plant:	
100 MW HFO based Power Plant of Orion Group	80
337 MW Duel Fuel CCPP of Summit Group	390
450 MW Meghna CCPP of Pendakar Energy;	500
Paper Mill:	
Basundhara Paper Mill Unit-1 and Unit-2	1000
Magura Paper Mill,	200
Multi Paper Mill,	200
Tanveer Paper Mill;	200
Shipyard:	
Ananda Shipyard,	1.5
Islampur Shipyard,	1.5
Meghna Shipbuilding & Dockyard,	1.5
T K Shipyard,	1.5
Khan Brother Shipbuilding;	1.5
Steel Mill:	
Tanveer Steel Mill	15
Cement Plant:	
Tiger Cement Plant Unit 1 and Unit 2,	15
Holcim Cement Plant Unit 1 and Unit 2,	15
Fresh Cement Plant, Anwar Cement Plant;	15
Chemical Industry:	
Meghna Chemicals	3.5
Meghna Group of Industry,	3.5
Samuda Chemicals;	3.5
Textile / RMG Unit:	
Esquire Colour Coating Mill,	17

750 MW Combined Cycle Power Plant (October 2017)
https://www.jbic.go.jp/ja/business-areas/environment/projects/pdf/61566_1.pdf
Environmental and Social Impact Assessment (ESIA) Report of SUMMIT NARAYANGANJ POWER UNIT II LIMITED - Prepared by: BCAS, Environment and Social Consultant
CEIA Study for Siddhirganj Power Hub
http://documents1.worldbank.org/curated/fr/156701482397807775/pdf/Final-CEIA-Siddhirganj-Power-Hub.pdf
Environmental and Social Impact Assessment Report of Reliance Meghnaghat 750 MW Combined Cycle Power Plant, Prepared by Adroit Environment Consultants Ltd, Bangladesh

Industries	Water requirement, cum/hr
Esquire Approachories	17
Proposed Industries	
Reliance Meghnaghat	1100
Summit Meghnaghat Power Ltd. II-	600
Majesty power, Jamaldih	600
Orion Power Sonargaon Ltd.	80
Unique Meghnaghat Power Limited	676

Source: Secondary sources

It is estimated that total consumption of river water by the existing & proposed industries in the AoI is about 6000 m^3/hr or 1.7 m^3/s. Based on water discharge data calculated for Meghna Ferry Bridge Station[37] of Bangladesh Water Department (BDWD), the maximum discharge of the Meghna River was measured as 34478 m^3/s while the minimum discharge of 9583 m^3/s. To The minimum discharge or the lean season flow have been considered for impact assessment on water resource of Meghna River. As per the available data, approximately 80% of the available water is used for irrigation purposes, while about 12% cater to domestic needs. With this consideration, available water (minimum flow) is 766.61 m^3/s. The minimum discharge or the lean season flow have been considered for impact assessment on water resource of Meghna River. As per the available data, approximately 80% of the available water is used for irrigation purposes, while about 12% cater to domestic needs. With this consideration, available water (minimum flow) is 766.61 m^3/s.

Total water abstraction quantity of all industrial units, existing as well as proposed constitute about 0.0022% of the available water during at minimum flow conditions in the River and about 0.0001% of the total water flow at minimum flow conditions. Hence, there would be insignificant or negligible impact cumulatively by all the existing & proposed projects on the water resource of Meghna River.

5.8 Cumulative Impact Assessment on Water quality of Meghna River

In order to evaluate the impact of discharge of effluent on the water quality of Meghna River, load based assessment has been carried out. The pollutant load of the River water, based on baseline monitoring conducted at downstream of project location in Meghna River (SW2) and the additional load of the effluent discharged from the proposed projects are used to calculate the resultant pollutant load in the River water using the following equation:

$$C = \frac{Q_1 C_1 + \sum_{n=1}^{\infty} Q_n C_n}{Q_1 + \sum_{n=1}^{\infty} Q_n}$$

Where, C = Resultant Pollutant concentration in River water in mg/l post discharge from proposed industries in Meghnaghat industrial area

Q_1 = Existing flow rate of Meghna River prior to discharge of the effluent in m^3/sec

Q_n = Effluent discharge rate each proposed industries in m^3/sec

C_1 = Pollutant concentration of River water in mg/l

C_n = Pollutant concentration of the effluent of each industry in mg/l

The deviation in the value of resultant concentration from the baseline Pollutant concentration would indicate the impact due to discharge of wastewater to Meghna river water quality.

Flow rate of River (Q_1) Flow rate of River (Q_1)

The existing flow rate of Meghna River obtained for Meghna Ferry Bridge Station[38] of Bangladesh Water Department (BDWD) is as follows: Maximum Flow of Meghna River - 34478 m^3/s

[37] *Kindly refer to Flood Risk Assessment for location of Meghna Ferry Ghat Station*
[38] *Kindly refer to Flood Risk Assessment for location of Meghna Ferry Ghat Station*

Minimum Flow of Meghna River - 9583 m^3/s

Pollutant load of River water (C_1)

The baseline water quality monitored for the two seasons is used to calculate the existing organic & inorganic Pollutant load of the River water. The following concentrations are used for the calculation:

BOD - 5 mg/l

COD- 40 mg/l

TSS - 6 mg/l

The Pollutant load under maximum and minimum flow conditions is presented below ***Table 5.21***

Table 5.21: Pollutant load

Pollutant load*	Under Maximum Flow Condition, kg/s	Under Minimum Flow Condition, kg/s
BOD load	172.38	47.91
COD load	1379.10	383.31
TSS load	206.86	57.46

< **Pollutant load is calculated as (flow X concentration)*>

Effluent flow rate (Qn)

For this assessment proposed plant wise total treated effluent considered to be discharged in the river water are presented below ***Table 5.22:***

Table 5.22: Quantity of discharged water in the river

Proposed Industries	Treated Effluent from ETP (m^3/hr)	Effluent discharged to River Water (m^3/hr)*	Flow Rate of Effluent discharge to River Water (m^3/s)
Reliance Meghnaghat	250	212	0.058
Summit Meghnaghat Power Ltd. II	140	120	0.033
Majesty power, Jamaldih	140	120	0.033
Orion Power Sonargaon Ltd.	50	42	0.011
Unique Meghnaghat Power Limited	138.4	120	0.033

**Note: It is assumed that 15% of treated effluent would be used for plantation/green belt within the site premises*

Total Effluent discharge rate from all proposed plants in their operation phase - 611 m^3/hr; 0.171 m^3/s

Pollutant load of the discharged effluent (C_n)

The concentration of organic & inorganic pollutants in the treated effluent is considered to be within the Standards stipulated in Bangladesh ECR 1997 for industrial wastewater and the assumed concentration of treated effluent is presented below:

BOD – 50 mg/l

COD- 200 mg/l

TSS – 150mg/l

The pollutant load of the treated effluent from each industry are as follows:

Table 5.23: Pollutant load of Industries

Proposed Industries	BOD Load to be discharged to the river (kg/s)	COD Load to be discharged to the river (kg/s)	TSS Load to be discharged to the river (kg/s)
Reliance Meghnaghat	0.00294	0.01177	0.00883

Proposed Industries	BOD Load to be discharged to the river (kg/s)	COD Load to be discharged to the river (kg/s)	TSS Load to be discharged to the river (kg/s)
Summit Meghnaghat Power Ltd. II-	0.00167	0.00666	0.005
Majesty power, Jamaldih	0.00167	0.00666	0.005
Orion Power Sonargoan Ltd.	0.00058	0.00233	0.00175
Unique Meghnaghat Power Limited	0.00167	0.00666	0.005

The resultant concentration of the Pollutants (C) under Maximum and minims flow conditions of the River is presented below: The resultant concentration of the Pollutants (C) under Maximum and minims flow conditions of the River is presented below:

Table 5.24: Pollutant concentration in river under maximum and minimum flow

Pollutant Concentration in River Water*	Under Maximum Flow Condition, mg/l	Under Minimum Flow Condition, mg/l
BOD load	5.000024734	5.00008899
COD load	40.00042048	40.00107802
TSS load	6.00021766	6.000435267

From the load-based (mass balance) analysis of the Pollutants, it may be seen that, post discharge of treated effluent into Meghna River from the proposed industries of Meghnaghat Industrial Area, the increase in resultant concentration of pollutants in the river water is even less than 0.1% and can be considered as insignificant. Thus, it can be concluded that discharge of treated wastewater from the proposed industries of Meghnaghat Industrial Area would have insignificant or no impact on the water quality of Meghna river.

5.8.1 Cumulative Noise Quality Impact Assessment

The project area can be considered to be situated in the mixed land use area where the major noise generating sources are from industrial, commercial and anthropogenic activities and traffic of the existing roads. Industries generating high noise levels (e.g., power plants, cement plants, etc.) are normally equipped with acoustic control measures. Other industries identified in this industrial area like shipyards act as noise generation sources from open work areas. Also, major highway pass through the study area which, in addition to the noise from the traffic of other internal roads, also contribute to the overall noise level in this region.

To assess the baseline noise level Noise monitoring was carried out for 24 hours during monitoring period with 1-min equivalent sound pressure levels. The equivalent noise levels have been converted to hourly equivalent noise levels. Finally, the measurements were carried out by dividing the 24 hours into two parts, i.e. daytime, which is considered from 0600 to 2100 hours and night from 2100 to 0600 hours. At each location, daytime Leq has been computed from the hourly sound pressure level values measured between 0600 to 2100 hours and nighttime Leq has been computed from the hourly sound pressure level values measured between 2100 to 0600 hours.

The recorded noise levels in the Project Area of Influence (AOI) during October 2019 and June 2020 are summarized in Table 16 of Chapter 4 of this report. Ambient daytime noise level (L_{eq} Day) was recorded in the range of 47.8 to 54.8 dB (A) in first season and 52.54 to 71.19 in second season. Whereas ambient night-time noise level (L_{eq} Night) in the study area varied in the ranged of 38.6 to 48.4 dB (A) and 38.02 to 60.58 dB (A) in first and second season respectively.

Modelling of Noise propagation during construction and operation phase has been conducted and incorporated in Section 5.3.7 and in 5.5.9 respectively. The noise assessment only represent the SPLs predicted in calculated area as a result of the construction and operation phase. The existing background SPLs are considered and were added over and above the SPLs predicted from the construction and operation of plant for 100% for 24h Time Histogram to calculate the cumulative noise levels.

The noise simulation studies indicate that the boundary wall and homestead vegetation in the adjoining scattered village area around the plant site acts as a noise protection barrier. In the operation phase increasing height of the boundary wall by 3m and proposed greenbelt within that would be definitely reduced the SPL in adjoining area.

Impact on noise quality due to industrial activity would be mostly localized, i.e. experienced within the premises of the various industrial units and its immediate vicinity. Noise generated from the equipment would be controlled using conventional noise control measures, such as insulation, lagging, ear protection, and enclosures to restrict the propagation of noise outside the boundary of the industries.

5.8.2 Cumulative Impact on Socio-Economic Condition of the AOI

The project area is presently situated on the fringe of Meghnaghat Industrial Area. With the development of the proposed UMPL project and other power projects around the project site in the AOI, the AOI would be facing surge of industrial growth. This would largely cause beneficial impact on the existing socio-economic condition of the area. There would be rise in opportunities for direct and indirect employment due to the proposed developments considered in the AOI, leading to improvement of living conditions of people, especially labourers, Along with direct employment, there would be considerable opportunities for development of auxiliary and ancillary business opportunities, ranging from small scale trade to establishment of large scale business like hospitality, healthcare, retail, residential, etc. Cumulative development would also lead to approach to improved healthcare facilities, education facilities and physical infrastructure. The project activities are expected to have large scale impact in the whole region due to production of power for meeting the increasing energy demands. Another aspect of cumulative development would be the peripheral social developmental activities from the CSR by these industries. Considering that the Industries would carry out CSR activities based on Need assessment of the area, there would be upliftment in socio-economic condition along with improvement of physical and social infrastructure of the area.

5.9 Summary of Assessment and Mitigation Measures

Table 5.25: Assessment of mitigation measures

Sl No	Aspects	Construction Phase		Operation Phase	
		Impact Significance before Mitigation Measures	Residual Impact after Mitigation Measures	Impact Significance before Mitigation Measures	Residual Impact after Mitigation Measures
1	Impact on Land use	Low	Negligible	--	--
2	Impact on Topography, Hydrology and Drainage	Low	Negligible	Low	Negligible
3	Impact on Soil and Sediment Quality	High	Moderate	Low	Negligible
4	Impact of water intake station and unloading jetty	Medium	Low	-	-
5	Impact due to laying of gas pipeline	Medium	Low	-	-
6	Impact due to waste handling and storage	Low	Negligible	Medium	Low
7	Impact on Air Quality	Medium	Low	Low	Negligible
8	Impact Due to Generation of Noise and Vibration	Medium	Low	Medium	Low
8	Impact on Surface Water Quality & resources	Low	Negligible	Medium	Low
9	Impact on Ground Water Quality	Low	Negligible	Low	Negligible
10	Impact on Terrestrial Flora and Fauna	Low	Negligible	Low	Negligible
11	Impact on Aquatic Flora and Fauna	Low	Negligible	Low	Negligible
12	Aesthetics and Visual Impact	Low	Negligible	Low	Negligible
13	Impact on Traffic and Transportation	Low	Negligible	Low	Negligible
14	Impact Due to Land Procurement	Medium	Low	-	-
15	Impact Due to Access Restriction	Low	Negligible	-	-
16	Impact on Economy and Livelihood of the Local Community	Medium	Low	-	-
17	Impact on fishing livelihood	Low	Negligible		
18	Conflict with Local People	Low	Negligible	-	-
19	Impact due to Increment in Cost of Living	Low	--	Low	Negligible

Sl No	Aspects	Construction Phase		Operation Phase	
		Impact Significance before Mitigation Measures	Residual Impact after Mitigation Measures	Impact Significance before Mitigation Measures	Residual Impact after Mitigation Measures
20	Impact on Community Health and Safety	Medium	Low	Medium	Low
21	Impact on Cultural Resources	Medium	Low	Medium	Low
22	Benefit to Local Enterprises	Positive	-	Positive	-
23	Employment Generation	Positive	-	Positive	-
24	Demand for Lodging, Housing and Civic Services	Positive	-	Positive	-
25	Benefits of Community Development Activities and CSR Activity	Positive	-	Positive	-
26	Impact on Occupational Health and Safety	Low	Negligible	Medium	Low
27	Impact Due to Electro Magnetic Field	-	-	Low	Negligible
28	Impact related Gender Based Violence (GBV) and Sexual Exploitation, Abuse and Harassment (SEAH)	Medium	Low	Medium	Low
29	Demolition of temporary jetties (2 nos)	Low	Negligible	-	-
30	Decommissioning if temporary labour camp and sewage pipeline	Low	Negligible	-	-
31	Decommissioning of Plant on completion of project life-cycle	-	-	Low	Negligible
32	Operation of gas pipeline	-	-	Low	Negligible
33	Impact of climate change	Low	Negligible	High	Medium

	Medium negative impact
	High negative impact
	Low negative impact
	Negligible negative Impact
	Positive impact

6 Green House Gas Emission

The predictive quantification of green-house gases (GHGs) from the proposed 600 MW combined cycle power plant project during the construction phase is based on United States Environmental Protection Agency's "Greenhouse Gas Inventories, 2018", "The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol)" developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The quantification of GHGs emissions is also validated using calculation tools of GHG Protocol, which establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions. The predictive quantification of green-house gases (GHGs) from the proposed 600 MW combined cycle power plant project during the construction phase is based on United States Environmental Protection Agency's "Greenhouse Gas Inventories, 2018", "The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol)" developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The quantification of GHGs emissions is also validated using calculation tools of GHG Protocol, which establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions.

6.1 Methodology for GHG Quantification during Construction Phase

According to EPA, sources of green-house gas emission could be divided in three different scopes:

- Scope 1: Scope 1 emission is referred to those sources, which directly emits potential amount of green-house gas, due to project activity.
- Scope 2 and 3: Scope 2 and 3 refers to those emission sources, which are not directly associated with the project activity, but has an impact on the project. The Scope 2 includes GHG emissions from the generation of purchased electricity consumed by a company; while Scope 3 emissions are such emissions which are consequence of the company's activities but occur from sources which are not owned or controlled by the company.

For the construction phase of the proposed 600 MW CCPP project of UMPL, some specific potential GHGs emissions sources based on planned construction activities have been identified and those activities have been separated under different scopes as per EPA guidelines.

Scope 1 activities include:

- Emissions from DG sets.
- Vehicular emission in the project boundary.
- Air conditioner in Porta cabins.
- Construction equipment and machinery operations.

Scope 2 activities include:

No electricity will be sourced from the nearby power grid during the construction period. Only DG sets will be used as main source of power.

Scope 3 Emissions is not being considered due to non-availability of information.

The potential sources of GHGs emissions are broadly classified into following categories:

Stationary Combustion Sources:

The three (3) main greenhouse gases comprising carbon di-oxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are emitted during the combustion of fuels. CO_2 accounts for the majority of the GHG emissions from stationary combustion sources. CH_4 and N_2O emissions together represent less than one percent of the total CO_2-equivalent emissions from the same sources. In the proposed project, emissions from DG sets, some construction equipment could be considered as potential stationary combustion sources, and as per EPA, the amount of green-house gas could be calculated by this equation below:

Emissions = Fuel x HHV x EF2
Where:
Emissions = Mass of CO2, CH4, or N2O emitted
Fuel = Mass or volume of fuel combusted
HHV = Fuel heat content (higher heating value), in units of energy per mass or volume of fuel
EF2 = CO_2, CH_4, or N_2O emission factor per energy unit.

No electricity supply from Power Grid is envisaged in the construction phase; hence emissions from electricity consumption in KW/hr is ruled out from the construction phase emissions. Emission factors and heat content are obtained from the "Greenhouse gas inventories, 2018" by EPA. To represent the CH4 and N2O emissions in terms of equivalent amount of CO2 emissions in tonnes, the emission from CH4 and N2O, would be multiplied by the global warming potential of CH4 and N2O.

Transportation Source

Major transportation emissions during construction would be caused by transporting of raw materials and heavy construction equipment to the site and the commuting of labour and employees during both pre-construction and construction phases. In case of raw material and heavy equipment transport, the unit tonne-mile would be considered, which can be defined as the multiplying the total weight of raw materials with the distance covered by the vehicle.

According to the vehicle type, the emission factors for three major green-house gas CO_2, CH_4, and N_2O would be determined, and emissions quantity would be calculated by multiplying the emission factors, with the tonne mile unit.

The other transportation would be of labour and employee commuting, for which total distance covered by the vehicle would be multiplied by the emission factor of CH_4 and N_2O, but in case of quantifying CO_2, the fuel quantity would be multiplied by the emission factor of CO_2, for that specific fuel. Also, the value of the emission factors for CO_2, CH_4, and N_2O would vary depending on the vehicle type and fuel type.

Fugitive Emission

All the emissions from Air Conditioners (AC) and other refrigerants equipment could be considered as fugitive emission. Emissions from the refrigeration and air conditioning system result from the manufacturing process, from leakage and service over the operational life of the equipment, and from disposal at the end of the useful life of the equipment. These gases have 100-year global warming potentials (GWPs), which are typically greater than 1,000 times that of CO_2, so their Impact on climate change can be significant. By the same token, any reductions of these gases can have a large potential benefit. Considering refrigerant R 410-A (GWP- 2088) as per the information available, it is the safest refrigerant used in Air conditioning system. Considering construction phase existing for a period of 6 months, and only 1 AC present in the portable cabin at site, the emissions are considered to be insignificant.

6.2 Quantification & Impact of GHGs Emissions During Construction Phase

The total green-house gas emission from various emission sources, during the three years construction phase is provided in ***Table 6.1*** and ***Figure 6.1*** below.

Table 6.1: Total Green House Gas Emission During Construction Phase[39]

Activity	Total emission in terms of equivalent of CO_2 (tonne)	Number of equipment/vehicles
Scope 1 Emission		
Mobile Sources		
DG set emission	2039.958	Considering 3x500KVA DG sets operating at half load and consuming approx. 18.5 gal/hr of diesel and assuming operating 300 hrs per month as during construction phase
Construction equipment	667.175	Excavator -3, Dump truck-3, Crawler crane -3, Mobile crane – 2, Payloader-2, Rig-1, Transit Concrete mixer 2, batching plant-1. assuming all diesel fed
Vehicles inside plant for commuting	188.222	5
Air Conditioners	1.2006	10
Total GHGs Emissions	**2896.555**	-
Scope 2 Emission		
Electricity consumption from the Grid	0	0
Total GHGs Emissions	**2896.555**	-

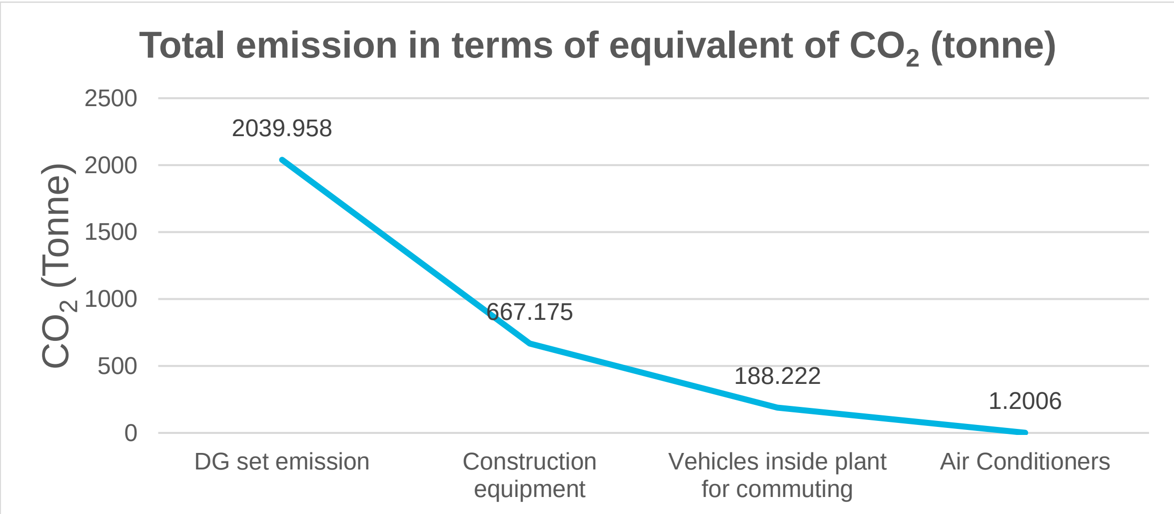


Figure 6.1: Total GHG Emission During Construction Phase In terms of CO_2

During the calculation of Scope 1 emission for the construction phase, only mobile sources have been considered as no emissions from the stationary sources has been envisaged.

In the construction phase, 17 number of construction equipment would be operating at site, which include three Excavators, three Dump trucks, three Crawler cranes, two Payloaders, one Rig, Two Transit Concrete Mixtures and one Batching plant. Total estimated emissions from the construction equipment would be 667.175 tonne equivalent of CO_2 per year. The calculation for the GHG Emission was done by considering the fuel consumption of 198 Gallon per day. The emission of CO_2 was deduced as 2021.58 kg/day, equivalent CO_2 for Methane was found as 0.1128 kg/day and for N_2O it was 0.05148 kg/day.

Ten air conditioning system would be present, in portable cabin during the construction phase. It has been assumed that, as a refrigerant R- 410 A would be used, as is the most common refrigerant used in air conditioner. The

[39] *The number of DG sets, AC, Construction Equipment and Construction Vehicles for transportation of raw materials, equipment and labours are tentative at this stage based on the information furnished by UMPL; and are subject to considerable variation when the actual construction activities commence with full momentum.*

estimated total emissions from the air conditioner would be 1.2 tonne equivalent of CO_2 per year calculated based on the equation for Emissions from Operation = C × (x/100) x T, where C is the Refrigerant capacity (1.15 kg), x is the annual leak in percent capacity (10%) and T is time in years used during the reporting period (0.5 when used only during half of the reporting period and then disposed, whereas GWP for Refrigerant is 2088.

Three DG sets would be operating during the construction phase for power supply and the estimated total emissions would be 2039.958 tonne equivalent of CO_2 per year[40], considering a running period of 300 hours/month with 18.5 Gallon/hr fuel consumption.

During the construction phase, the vehicular emission within the plant boundary would be limited to 188.22 tonne per year for 5 Nos. of vehicles. CNG is considered as a source of Fuel where Total CNG requirement for a day is 2090.53 scf/day. The total distance travelled by the vehicles is considered as 200 km and based on these factors the total CO_2 emission was calculated as 113.8 kg/day, emission of CH_4 was 0.24 eq CO_2 in kg/day and emission of N_2O was 0.021 eq CO_2 in kg/day.

The total GHG Emissions estimated for Scope 1 is 2896.555 tonnes of CO_2 equivalent per year.

The Scope 2 emission has been excluded during the estimation of GHG as no electricity will be consumed from nearest power grid.

6.3 Mitigation Measures

- Use of construction equipment and vehicles only with appropriate pollution fitness certificates.
- Periodic maintenance of DG sets and air compressors
- Avoid use of Ozone Depleting Substances during construction phase.

6.4 Green House Gas Emissions – Operation Phase

The predictive quantification of green-house gases (GHGs) for the proposed 600 MW combined cycle power plant project during the operation phase is based on United States Environmental Protection Agency's "Greenhouse Gas Inventories, 2018", "The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol)" developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The quantification of GHGs emissions during operation phase are also validated using calculation tools of GHG Protocol, which establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions.

6.5 Methodology for GHG Quantification during Operation Phase

Sources of green-house gas emission could be divided into Scope 1, Scope 2 and Scope 3.

During the operation and maintenance phase of the proposed project, emissions from the power generation system has been considered, along with the other direct and indirect sources under the following scopes:

Scope 1 activities includes:

- Emissions from heat recovery system (Heat Recovery Steam Generator).
- Vehicular emissions within in the project boundary.
- Emissions from ACs used in office buildings.
- DG Sets

[40] The current GHGs emissions during construction phase has been derived based on information furnished by UMPL; and would change if there is any addition/deletion of potential GHGs emitting sources on site.

Scope 2 activities include:

Electricity consumption in Kilo-watt Hour (KW/hr) from nearest power grid during the operation phase has been excluded from the scope of GHGs emissions calculation as the UMPL Representative confirms that the electricity consumption from the nearest grid would be “NIL”.

Scope 3 activities include:

- The GHGs emissions associated with business related travel (road, air and train) by UMPL employees during operational phase has not been considered in this assessment as this is an indirect and optional scope as per IFC’s Carbon Neutral Commitments.

Apart from that some other aspects have also been excluded from the scope of estimation. These are-

- The proposed cooling tower in the CCPP premises is designed to generate and release approx. 460 m3/hr of water vapour into the atmosphere. Although water vapour is considered to be one of most abundant and major green-house gases, is not considered to be a cause of man-made global warming because it does not persist in the atmosphere for more than a few days; hence not considered for the estimation.

With all the possible emissions sources have been identified and green-house gas emissions would be calculated from the nature of emissions, by the emitting sources.

The potential sources of GHGs emissions are broadly classified into following categories:

Stationary Combustion Sources:

The three (3) main greenhouse gases comprising carbon di-oxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are emitted during the combustion of fuels. CO_2 accounts for the majority of the GHG emissions from stationary combustion sources. CH_4 and N_2O emissions together represent less than one percent of the total CO2-equivalent emissions from the same sources. In the proposed project; emissions from the RLNG combustion and heat recovery system (Heat Recovery Steam Generator) and ACs are considered as potential stationary combustion sources during the operational phase, and as per EPA, the amount of green-house gas could be calculated by this equation below:

Emissions = Fuel x HHV x EF2
Where:
Emissions = Mass of CO_2, CH_4, or N_2O emitted
Fuel = Mass or volume of fuel combusted
HHV = Fuel heat content (higher heating value), in units of energy per mass or volume of fuel

No electricity supply from Power Grid is envisaged in the operation phase; hence emissions from electricity consumption in KW/hr is ruled out from the operation phase emissions. Emission factors and heat content are obtained from the “Greenhouse gas inventories, 2018” by EPA. To represent the CH_4 and N_2O emissions in terms of equivalent amount of CO_2 emissions in tonnes, the emission from CH_4 and N_2O, would be multiplied by the global warming potential of CH_4 and N_2O.As per EPC Contract, Performance Guarantee for Combined Cycle Operation @100 percent load efficiency is 60.29 percent.

Transportation Source

Major transportation emissions during operation phase would be caused by transporting of labour and employees during both operation and maintenance phase (emissions from both the road and jetty).

According to the vehicle and fuel type, the emission factors for three major green-house gas CO_2, CH_4, and N_2O would be determined, and emissions quantity would be calculated by multiplying the emission factors, with the tonne mile unit.

Fugitive Emission

All the emissions from Air Conditioners (AC) and other refrigerants equipment could be considered as fugitive emission. Emissions from the refrigeration and air conditioning system result from the manufacturing process, from leakage and service over the operational life of the equipment, and from disposal at the end of the useful life of the equipment. These gases have 100-year global warming potentials (GWPs), which are typically greater than 1,000 times that of CO_2, so their Impact on climate change can be significant. By the same token, any reductions of these gases can have a large potential benefit. Considering refrigerant R 410-A (GWP- 2088) as per the information available, it is the safest refrigerant used in Air conditioning system. Based on information furnished, 68 ACs would be present at site during operational phase.

In the present context, emissions of GHGs during operational phase of the air conditioning system has been considered, and calculated by the equation as followed by EPA, given below:

Emissions from Operation = C × (x/100) x T

where:

C = refrigerant capacity of the piece of equipment

x = annual leak rate in percent of capacity

T = time in years used during the reporting period (e.g., 0.5 if used only during half of the reporting period and then disposed).

By calculating all the scopes in operation phase, the total estimated quantity of the green-house gas emitted by various activities of the proposed project has been derived.

6.6 Quantification and Impact of GHGs Emissions During Operation Phase

Estimation of GHGs emissions during the operation phase considers the emissions from the main power generation system, from the combustion of liquified natural gas with heat recovery mechanism, along with other emission sources like vehicular emission, commuting of labours and employees etc. Approx. 96192 Mscf natural gas would be obtained from Titas Gas Transmission and Distribution Company Limited (TGTDCL) through underwater pipeline.

The total green-house gas emission from various emission sources, during the operation phase is provided in ***Table 6.2*** and ***Figure 6.2*** below:

Table 6.2: Total GHG Emission During Operation Phase in terms of CO_2[41]

Activity	Total emission in terms of equivalent of CO2 (tonne) per year (330 operating days/year)	Number of equipment/vehicles42
Scope 1 Emission		
Stationary Sources		
Emission from RLNG combustion	1726944	1 Heat recovery system
Air conditioning	9.58	68
DG Set	453.324	4
Mobile Sources		
Vehicles within Plant Boundary	45.24	4
Total GHGs Emissions (Scope 1)	1727452.144	-
Scope 2 Emission		
Electricity consumption from the Grid	0	-

[41] As mentioned above, Electricity consumption in Kilo-watt Hour (KW/hr) from nearest power grid during the operation phase has been excluded from the scope of GHGs emissions and from the Scope 2 Emission as well
[42] The number of DG sets, AC, Operating units, Vehicles for transportation of labours/employees are tentative at this stage based on the information furnished by UMPL; and are subject to considerable variation when the final operating procedures get finalized and actual operation activities commence on site.

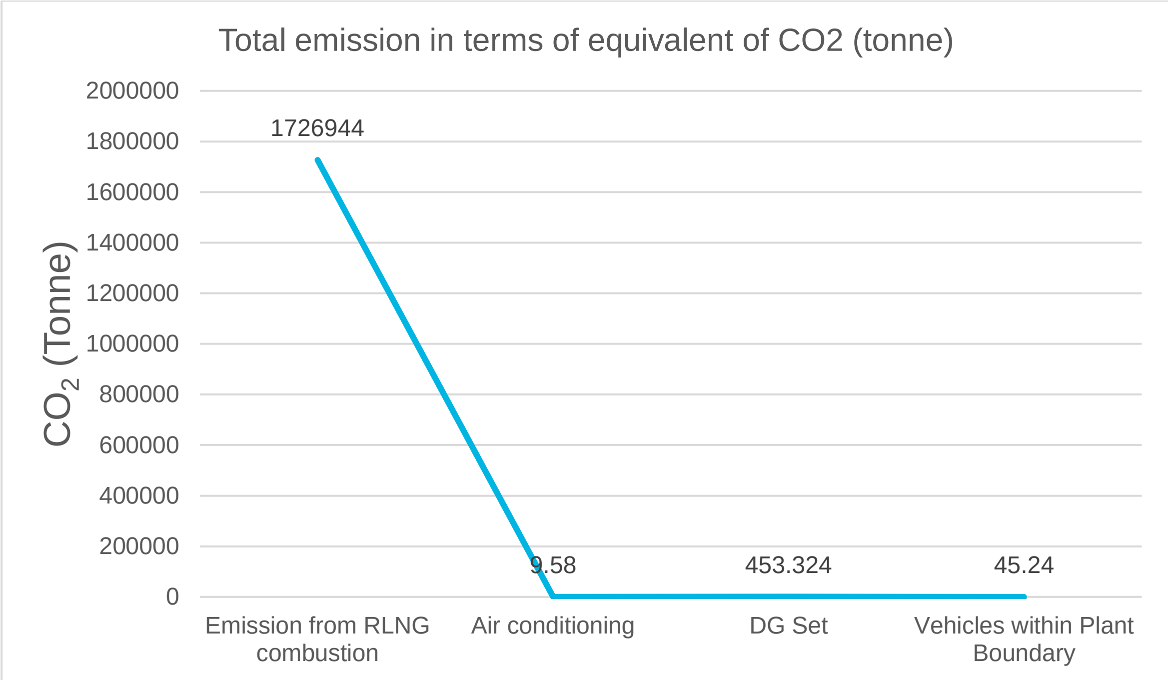


Figure 6.2: Total GHG Emission During Operation Phase in terms of CO2

It has been assumed that total operating days per year would be 330 days throughout operational life cycle. In the operation phase, the total emission from both Scope 1 and Scope 2 sources was estimated as 1727452.144 tonne per year.

There are two sources have been considered for Scope 1 Emission, these are – stationary sources and mobile sources. The Stationary Sources include emission from HRSG, Air Conditioners and emission from the DG Sets. The mobile sources include Vehicles operating within the Plant Boundary.

The total estimated GHG emissions every year throughout the operational life-cycle of the project is estimated to be 1727452 tonnes of CO_2 equivalent. This amounts to 0.37-ton CO_2eq per MWh of power generation (the average grid emission factor in Bangladesh is 0.67 tons CO2/MWh[43]).

The calculation of GHG emission for construction and operation phases is presented in **Appendix U.**

6.7 Mitigation Measures

- Green belt development within the plant and around its outside periphery.
- Adopt recycling/reuse of water to minimize freshwater consumption. This could be achieved by adopting various initiatives e.g., recycling treated wastewater for toilet flushing, landscaping, recycling of treated effluent in boiler, cooling tower etc.
- Use of machines, DG, equipment and vehicles only with appropriate pollution fitness certificates. Also carry out periodic maintenance of equipment and vehicles.
- Design and construct rainwater harvesting structure to retain the rainwater/stormwater and minimize freshwater consumption.
- Estimate, and maintain carbon footprint (month wise) during operation phase and reduce vehicular movement where possible. Publishing of carbon footprint would be annual.
- Recommend use of non-Ozone-Depleting Substances in chillers and air conditioners.

[43] *Grid Emission Factor (GEF) of Bangladesh published by DOE, GOB (Reference No. DOE/International Convention /2012/ 21/07)*

7 Flood Risk Assessment

7.1 Study Area

Ganga-Brahmaputra-Meghna (GBM) Basin is one of the largest river basins (1.7 Million sq. Km) in South East Asia passing through various countries such as India (64%), China (18%), Bangladesh (7%), Bhutan (9%) and Nepal (3%) (BWDB, 2006). Bangladesh is at the confluence of three rivers-Ganga, Brahmaputra and Meghna. Meghna River is one of the most important rivers in Bangladesh and the area of Meghna River basin is more than half of the country's area. Meghna River is divided into two parts-Upper Meghna River and Lower Meghna River. Upper Meghna River is from Bhairab Bazar (24.0555° N, 90.9802° E) up to Chandpur (23.2321° N, 90.6631° E) and Lower Meghna River is from Chandpur to the end point in the sea. The upper Meghna River basin occupies the total area of 82000 km2. The area is divided into Bangladesh (43%) and India (57%). (Ali et al 2016). The study area is shown in the ***Figure 7.1***

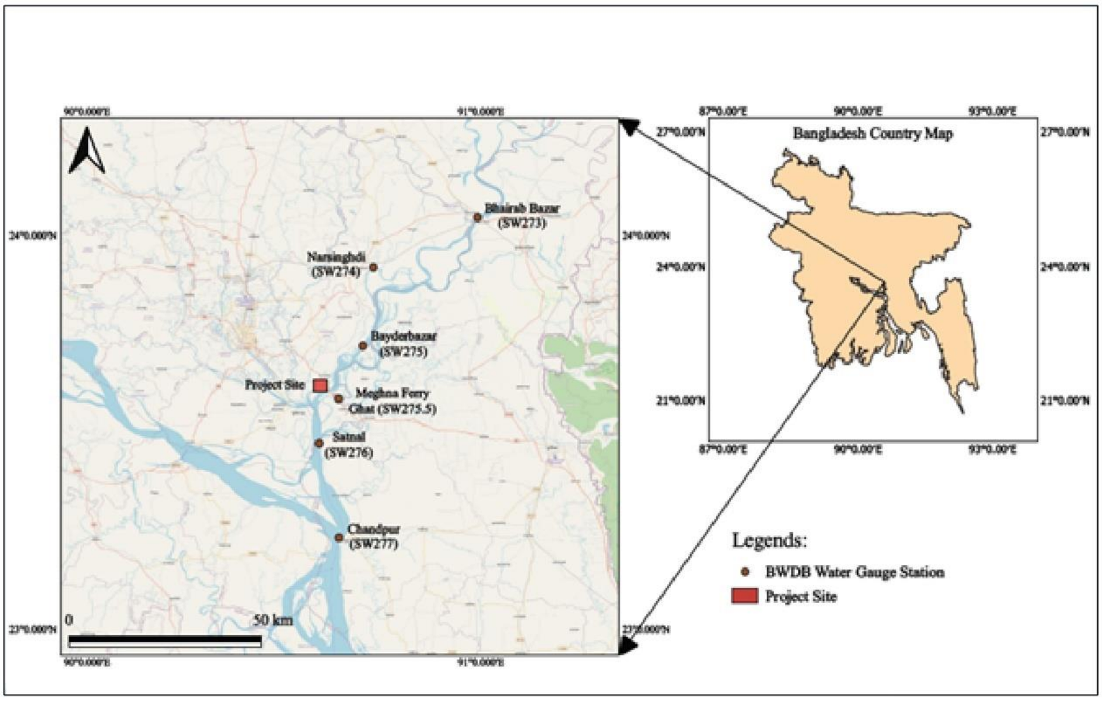


FIGURE NO.	Project name: ESIA STUDY FOR 600 MW GAS FIRED THERMAL POWER PLANT IN MEGHNAGHAT, SONARGAON, NARAYANGANJ, BANGLADESH					Title: Study Area Map for Flood Risk Assesment	AECOM
	Date: 09/12/2019	Drawn By: Moumita Dey	Checked By: Souvik Basu	Approved By: Avijit Sarkar	Client Name: Unique Meghnaghat Power Limited	Source: Google Earth, Esri Digital Globe, GeoEye, Earthstar Geographics,CNES /AirbusDS,USDA, USGS, AeroGRID, IGN, and the GIS User Community.	

Figure 7.1: The Upper Meghna River Basin. (Ref: Ali et al., 2016)

There are four different types of floods encountered in the Bangladesh-Flash floods, river floods, tidal floods and storm surges. (Hoffer and Messeri, 2006) as shown in ***Figure 7.2***. However, the upper Meghna River basin is subjected only to flash floods and river floods. Flash floods are restricted to the far eastern and far northern portion of the basin and therefore the area is mainly subjected to river floods.

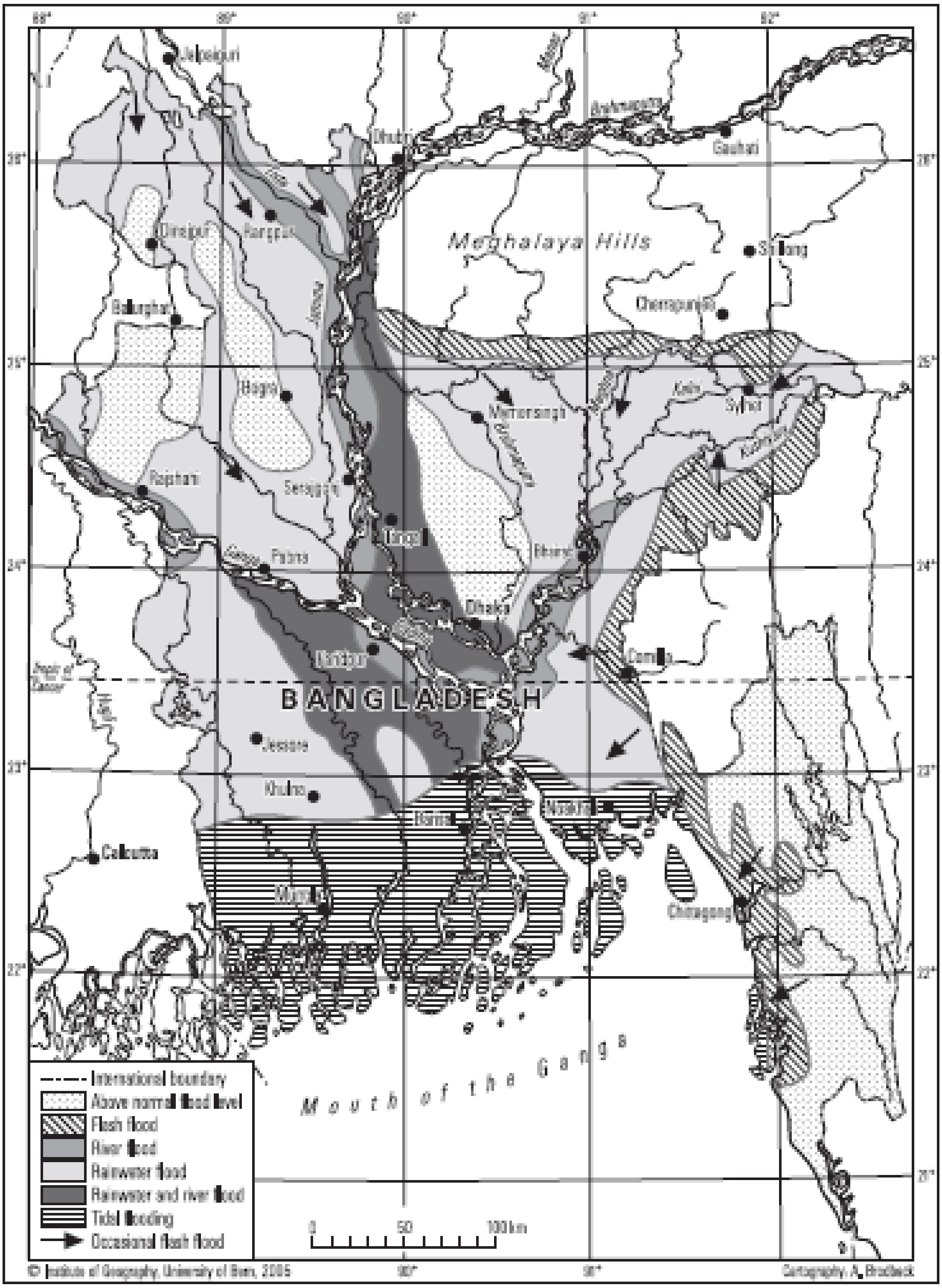


Figure 7.2: Different types of Flood in Bangladesh

In order to better understand the inundation due to floods in Bangladesh, it is essential to understand the physiography of the area. The physiography of the area is divided into seven major divisions- Hills, Pleistocene Upland, piedmont plain, flood plain, deltaic plain, coastal plain and deltaic plain (Hasan, 2015). The physiography of the area is shown in the ***Figure 7.3***. The upper Meghna River basin is largely flood plain with some portion of it is Pleistocene Upland in the western region and a very small percentage area is Hills in the Northeastern part.

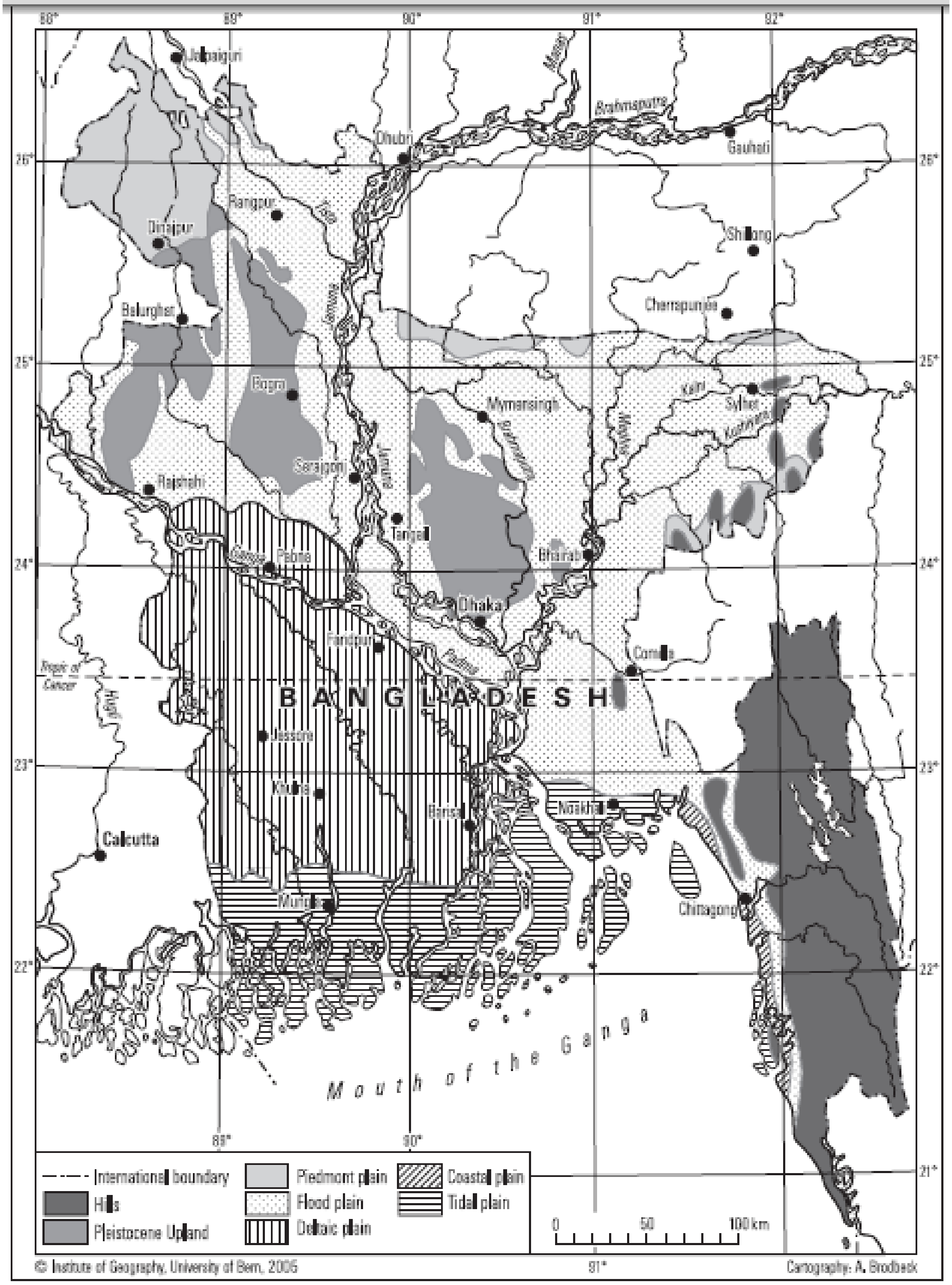


Figure 7.3: Physiography in Bangladesh

There are four distinct climatic seasons in the Upper Meghna basin. (i) Winter- December to February (ii) Pre-Monsoon- March to May (iii) Monsoon- June to September (iv) Post-Monsoon- October to November. More than 80% of rainfall occurs in the Monsoon season from June to September which is also known as flood season.

The Meghna River is a part of Surma-Kushiyara River system. The river system originates in the hills of Shillong and Meghalaya of India. The main source is Barak River which has major portion of its catchment in Eastern Assam which borders Myanmar. When it reaches Bangladesh border at Amalshid in Sylhet District, it bifurcates into Surma and Kushiyara Rivers. The Surma, flowing on the north of Sylhet basin receives Right bank Tributaries from Khasia and Jaintia hills of Shillong. These are the steep highly flashy rivers originating from Cherrapunji at Meghalaya which is one of the wettest regions of the world. The Kushiyara has main tributary as Manu originating from Tripura hills but are less flashy due to lesser elevation and rainfall of Tripura hills as compared to the northern tributaries. The two rivers re-join at Markuli and flow via Bhairab Bazar as the Upper Meghna River. The major tributaries of Meghna River are Gumti, Dhaleshwari and Feni. The Upper Meghna river has a tidal influence at the downstream side.

7.2 Primary Data Analysis

UMPL has provided the datasets of water level and discharges at tidal as well as non-tidal stations of Bhairab Bazar as shown in ***Figure 7.4*** and ***Figure 7.5*** and water level stations at Meghna Ferry Bridge as shown in ***Figure 7.6*** and Chandpur as shown in ***Figure 7.7***.

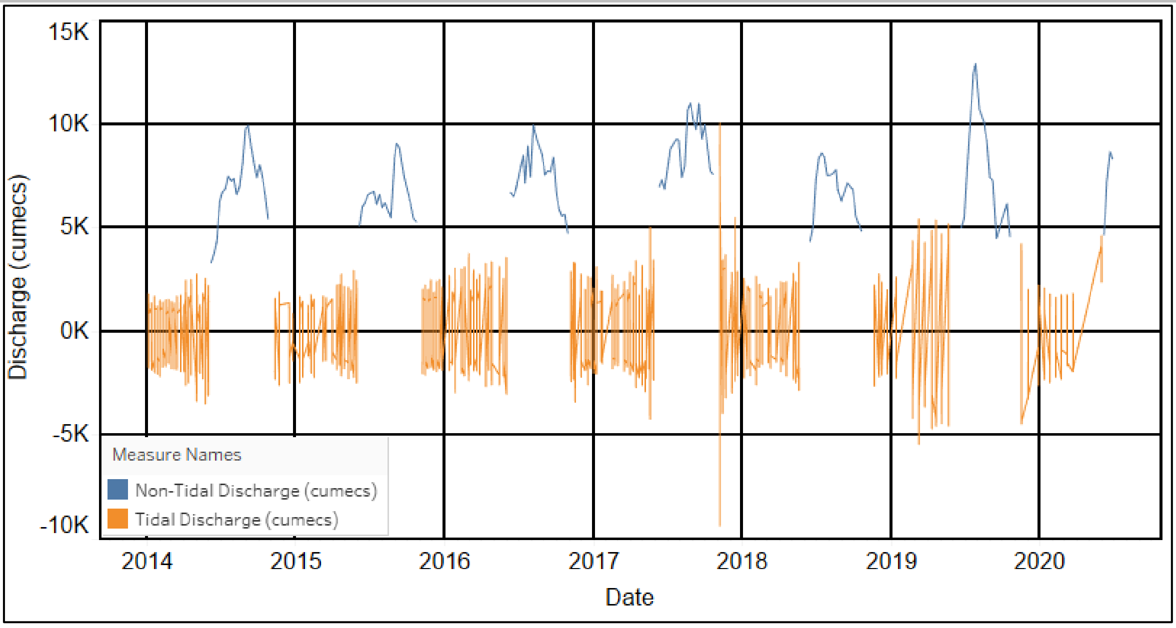


Figure 7.4: Comparison of Tidal vs Non-Tidal Discharge at Bhairab Bazar (2014-2020)

There are two stations at Bhairab Bazar, one is Tidal and other is non-Tidal. The tidal station works from Nov- May and non-tidal station works from June- October. As it can be seen from the ***Figure 7.4***, the flood flow due to non-tidal flow is higher than the tidal flow. This indicates that non-flood flow is critical in the estimation of maximum inundation level in the region.

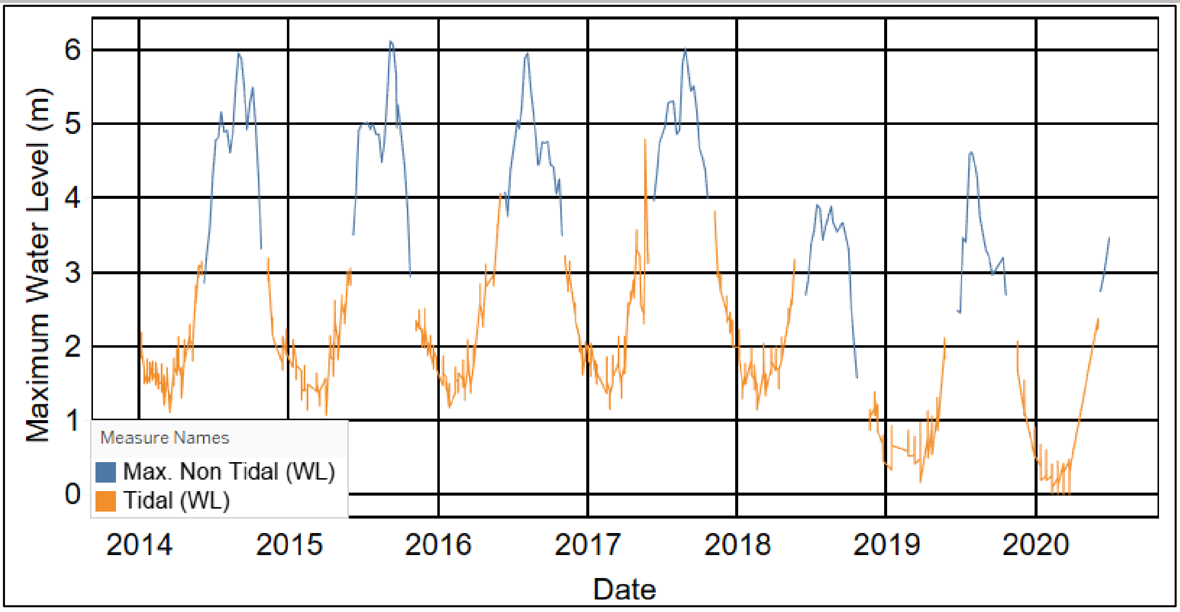


Figure 7.5: Comparison of Tidal and Non-Tidal Water Level at Bhairab Bazar (2014-2020)

The comparison of water level for tidal flow as well as non-tidal flows shows that in the most time periods the water levels due to tidal flow is well below the non-tidal flows. The water levels due to tidal flows varies from 0.1 m to 4 m and the water levels from non-tidal flows varies from 1.6 m to 6.1 m. This indicates that the river is perennial and the water level throughout the year the water level in the river is greater Mean Sea Level due to the presence of tidal flows.

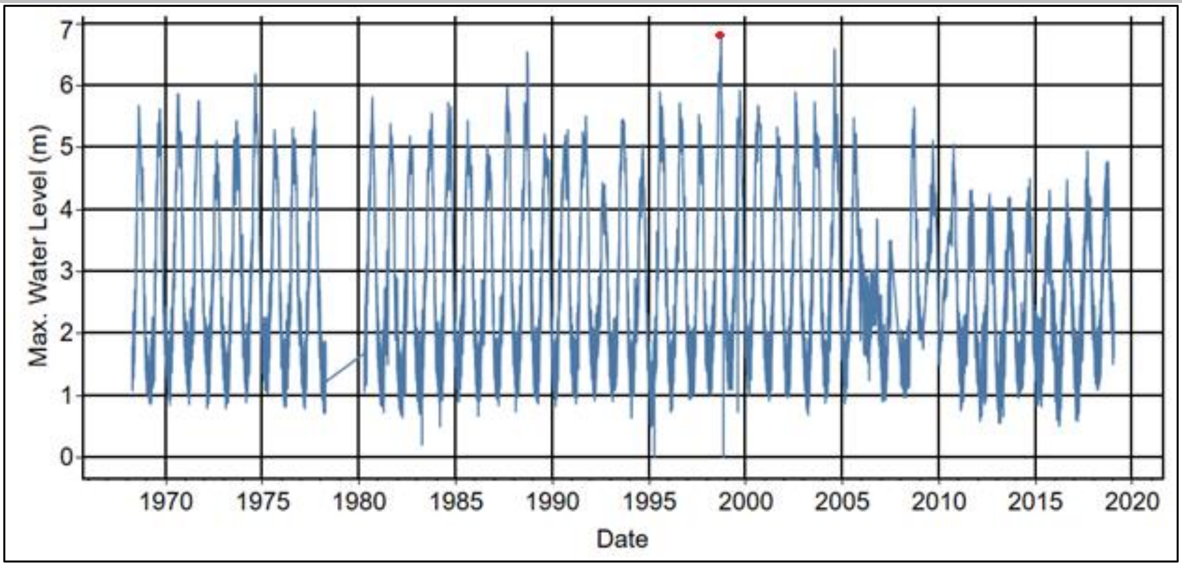


Figure 7.6: Maximum Daily Water Level-Meghna Ferry Bridge (1968-2018)

The maximum daily water level for the water gauge near Meghna Ferry Bridge is shown in ***Figure 7.6***. The minimum water level in the most cases during the entire period from 1968-2020 is around 1 m. It can be seen that maximum water level at Meghna Ferry Bridge during the entire period is 6.76 m for the year 1998.

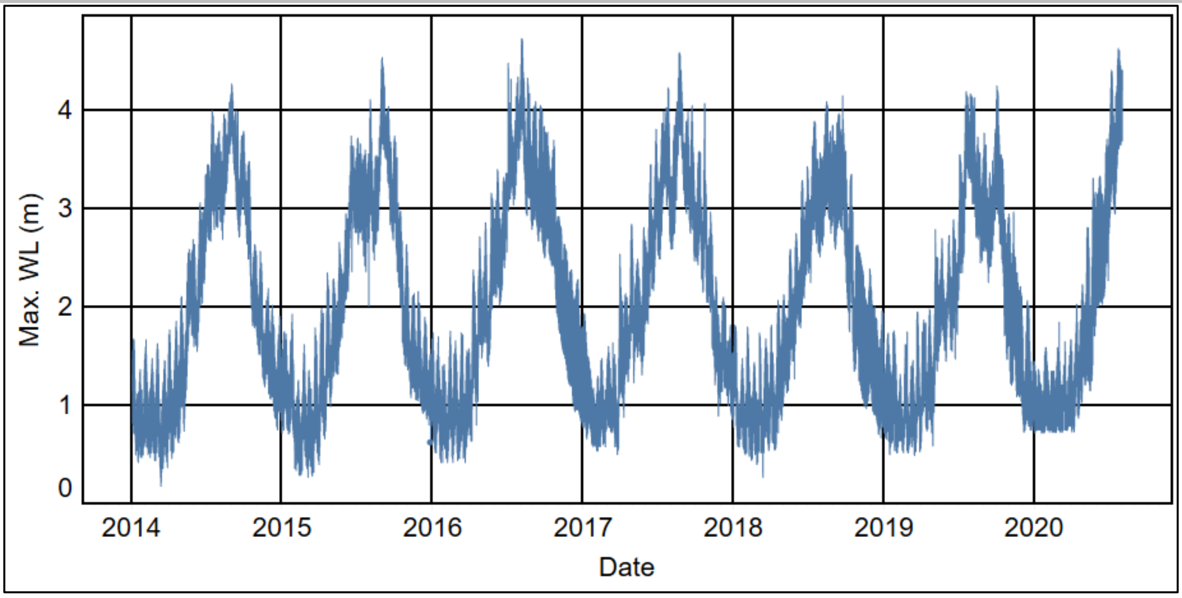


Figure 7.7: Maximum Daily Water Level - Chandpur (2014-2020)

The maximum daily water level at Chandpur station is shown in ***Figure 7.7***. Chandpur station is the last point of the Upper Meghna River. At Chandpur station, not only there is a confluence of the Meghna River and Padma River, but it is also starting point of the lower Meghna River which is actively dominated by tidal flows.

7.3 Secondary Data Analysis

The water level data for Baidyer Bazar as well as Satnal for 30 years (1982-2012) was obtained from available database procured in past from Bangladesh Water Development Board and are shown in ***Figure 7.8*** and ***Figure***

7.9. The water level at Baidyer Bazar was converted to discharge using the rating curve developed using the conveyance method as explained below.

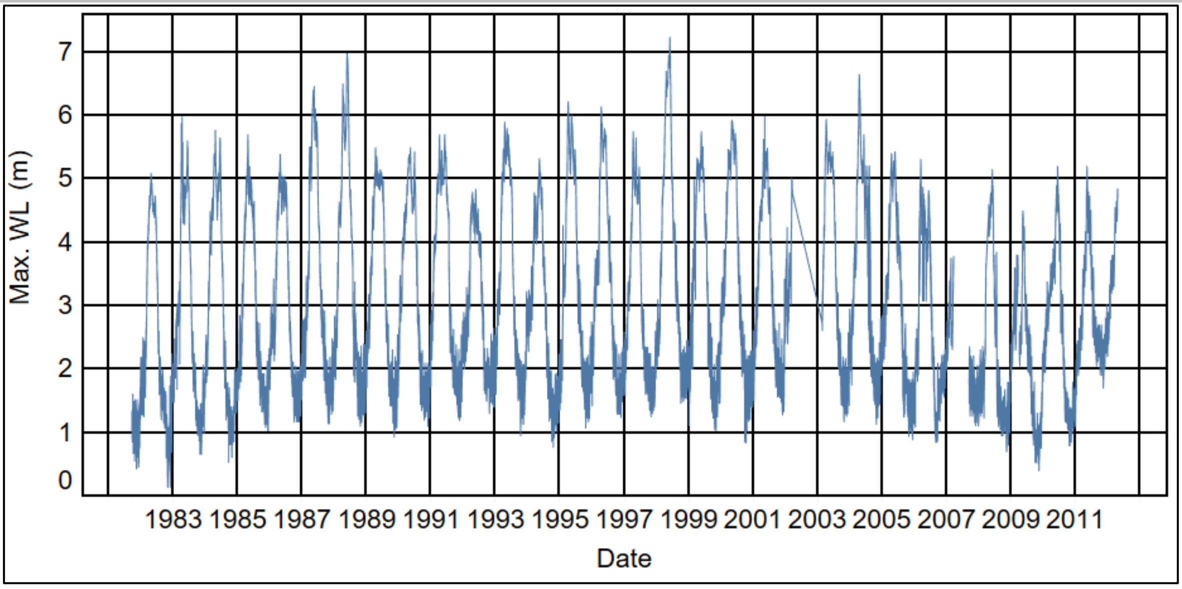


Figure 7.8: Maximum Daily Water Level (WL) at Baidyer Bazar (1982-2012).

It can be observed from the ***Figure 7.8*** that there is a greater variation in the troughs as well as the crests of the water level time series. The reason for this variation can be explained that the variation in troughs is due to the tidal flows and the variation in the crest is due to the flood flows and the flood flows are higher than the tidal flows. There is only station which records both the tidal as well as non-tidal flows at Baidyer Bazar.

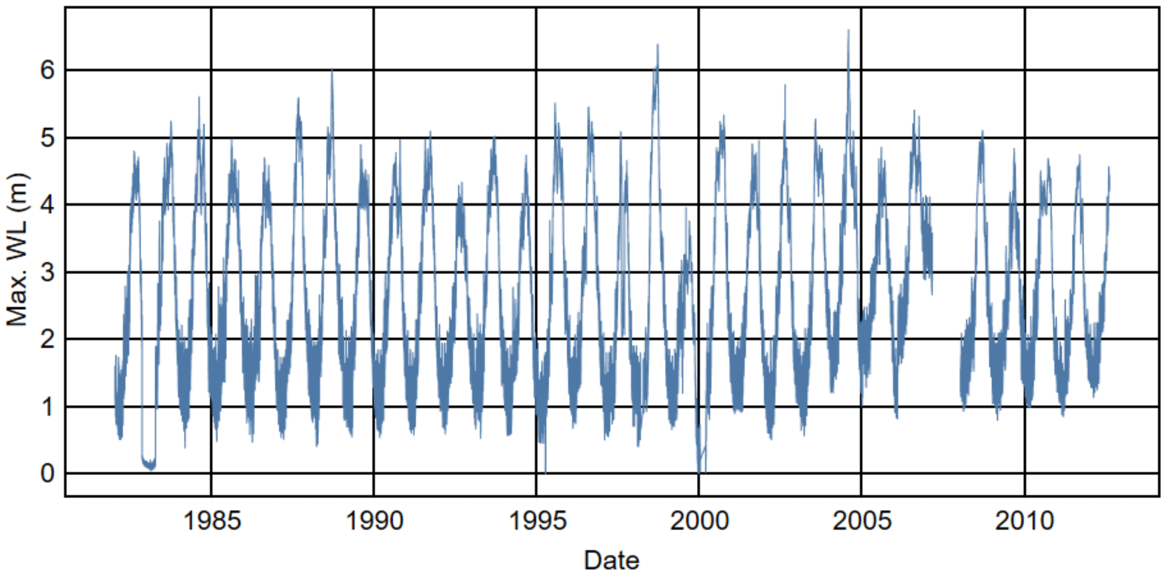


Figure 7.9: Maximum Daily Water Level (WL) at Satnal (1982-2012)

The water level at Satnal as shown in **Figure 7.9** is taken as the downstream boundary condition for the hydraulic model. The maximum water level at Satnal was recorded as 6.62 m in the year 2004.

7.4 Development of Discharge stage relationship for Baidyer Bazar

The discharge stage relationship at Baidyer Bazar was developed using the standard Conveyance Slope method. In this method, conveyance and energy slope are extrapolated separately. It is based on Manning's equation.

$Q = K \times S^{1/2}$(1)

Where, K is the conveyance.

K = (1/n) x $R^{2/3}$ x A (2)

Assuming, channel is rectangular with B= 1680 m from the cross-section data, and width B>> d so with R ~ d. Also, assuming n =0.03 and slope S =1/2000 considering the average slope between the upstream station and downstream station. The slope is based on the average change of bed level from upstream station to downstream station and the distance between them. The manning's number assumption is based on the recommendation for n values in streams and flood plain given in V.T Chow (1959)-Open Channel Hydraulics text book.

We get

Q = (1/0.03) x $(1/2000)^{0.5}$ x 1680 x $d^{1.67}$

Q = 1252 x $d^{1.67}$ (3)

7.5 Secondary Data Analysis

The extreme value analysis is carried out to estimate the upstream water level for the design life of the project which is 50 years. The analysis was carried out using various probability distributions such as Generalized Extreme Value Distribution, Normal distribution, Log-Normal distribution, Gumbel distribution and Weibul Distribution and goodness of fit was estimate using K-S fitting approach.

It was found that Generalized Extreme Value distribution closely matched the upstream discharge and gives the best fit as shown in ***Figure 7.10.*** This distribution was used to estimate the design water level for the project which was then converted to discharge using the rating curve.

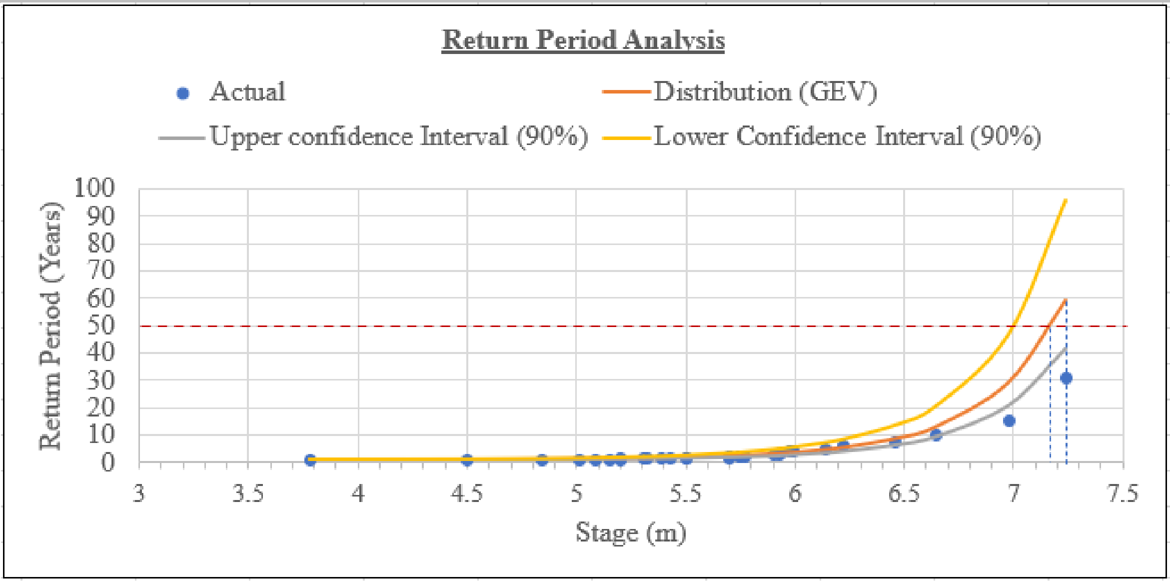


Figure 7.10: Return Period Analysi

It can be observed from Figure 10 that the Generalized Extreme Value (GEV) Distribution matches closely with the observed data. Moreover, it can be observed that the highest value in the observed data corresponds to 60 years return period and it is observed for the year 1998 as shown in Figure 8. Moreover, the 50 years return period flood corresponding to the calculated value (7.18 m) from the distribution is quite close to the highest value observed (7.24 m) in the actual data. However, based on available data and considering 30 years of data of water level and discharge, it can be observed that the year 1998 flood could be considered the 50 years return period flood and the inundation corresponding to the 1998 flood can be considered as the 50 years return period inundation in the project area. Moreover, the analysis of 50 years of water level data (1968-2018) at Meghna Ferry Bridge also shows that the highest water level recorded was for year 1998 which further supports the consideration.

7.6 HEC-RAS Model

The Hydrologic Engineering Center's (HEC) River Analysis System (RAS) is a hydraulic flow model to perform 1D and 2D steady and unsteady river hydraulics analysis. It is developed by U.S. Army Corps of Engineers (USACE).

The HEC-RAS is comprised of graphical user interface, separate hydraulic analysis components, data management and storage, graphics and reporting facilities. The software supports steady and unsteady flow water surface profile calculations, sediment transport calculations, and water quality as well as inundation mapping within the software.

The model takes the three types of input-geometry data, flow data and friction data. The geometry data consists of the cross-section information as well as the river thalweg line and streambanks –left and right floodway. The flow data consists of discharge/water level/ rating curve at the boundary conditions as well as any lateral flow data. The friction data consists of the bed friction in terms of Manning's coefficient. The friction could be given a global value as well as local values for each reach.

HEC-RAS uses a number of input parameters for hydraulic analysis of the stream channel geometry and water flow. These parameters are used to establish a series of cross-sections along the stream. In each cross-section, the locations of the stream banks are identified and used to divide into segments of left floodway, main channel, and right floodway. At each cross-section, HEC-RAS uses several input parameters to describe shape, elevation, and relative location along the stream such as:

- River station (cross-section) number.
- Lateral and elevation coordinates for each (dry, unflooded) terrain point.
- Left and right bank station locations.
- Reach lengths between the left floodway, stream centreline, and right floodway of adjacent cross-sections.
- Manning's roughness coefficients.
- Channel contraction and expansion coefficients.
- Geometric description of any hydraulic structures, such as bridges, culverts, and weirs.

HEC-RAS performs both steady flow analysis as well as unsteady flow analysis. The steady flow analysis is based on the steady gradually varied flow and solves the 1D energy equation evaluating energy loss through Manning's friction as well as contraction and expansion loss. However, in the unsteady flow computations there are changes in flow velocity and depth with time, that causes accelerations and forces that cannot be adequately represented using the Energy Equation The unsteady flow computations are governed by the full equations of motion, called the St. Venant Equations. HEC-RAS employs a solver adapted from the UNET (Unsteady Network Model) developed by Dr Robert Barkau, 1992 and modified by HEC. This unsteady flow program is used because of its unique ability to handle complex stream networks (dendritic to full looped networks); a wide variety of hydraulic structures (bridges, culverts, spillways, weirs, and gated structures); and high computational speed (Brunner, 2004). It basically solves the 1-D set of equations presented below:

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} - q = 0 \quad (4)$$

$$\frac{\partial Q}{\partial t} + \frac{\partial QV}{\partial x} + gA\left(\frac{\partial z}{\partial x} + S_f\right) = 0 \quad (5)$$

Where,

Q= longitudinal flow,

A= cross section area,

V= Flow velocity,

Sf = slope of energy grade line

g = acceleration due to gravity,

q = lateral inflow,

x= distance along the length of river, and

z = free surface elevation

In the present study, the HEC-RAS model is used to perform 1D-unsteady flow analysis for the extreme events. In such cases, the river and its flood plain behave a single channel and the flow in the flood plain is assumed to be parallel to the river centreline to give a good understanding of the flood inundation extents. The flow can be reasonably assumed to be 1D flow however detailed analysis of flow in the flood plain for specific problems could be modelled only through the 2D models and 3D models which are data intensive, computation expensive as well as subjected to numerical instabilities.

7.6.1 Model Set Up Details

Model Domain

The model domain was taken as the river reach between the Baidyer Bazar level gauge station (SW 275) and Satnal level gauge station (SW 276) is shown in ***Figure 7.11***. The level gauge station near the project area is Meghna Ferry Bridge station (SW 275.5) lies between the reach considered. The reach length is 30.2 km. The green lines in the ***Figure 7.11*** represents the cross section, the blue line represents the river centreline and red dots represents the riverbank stations.

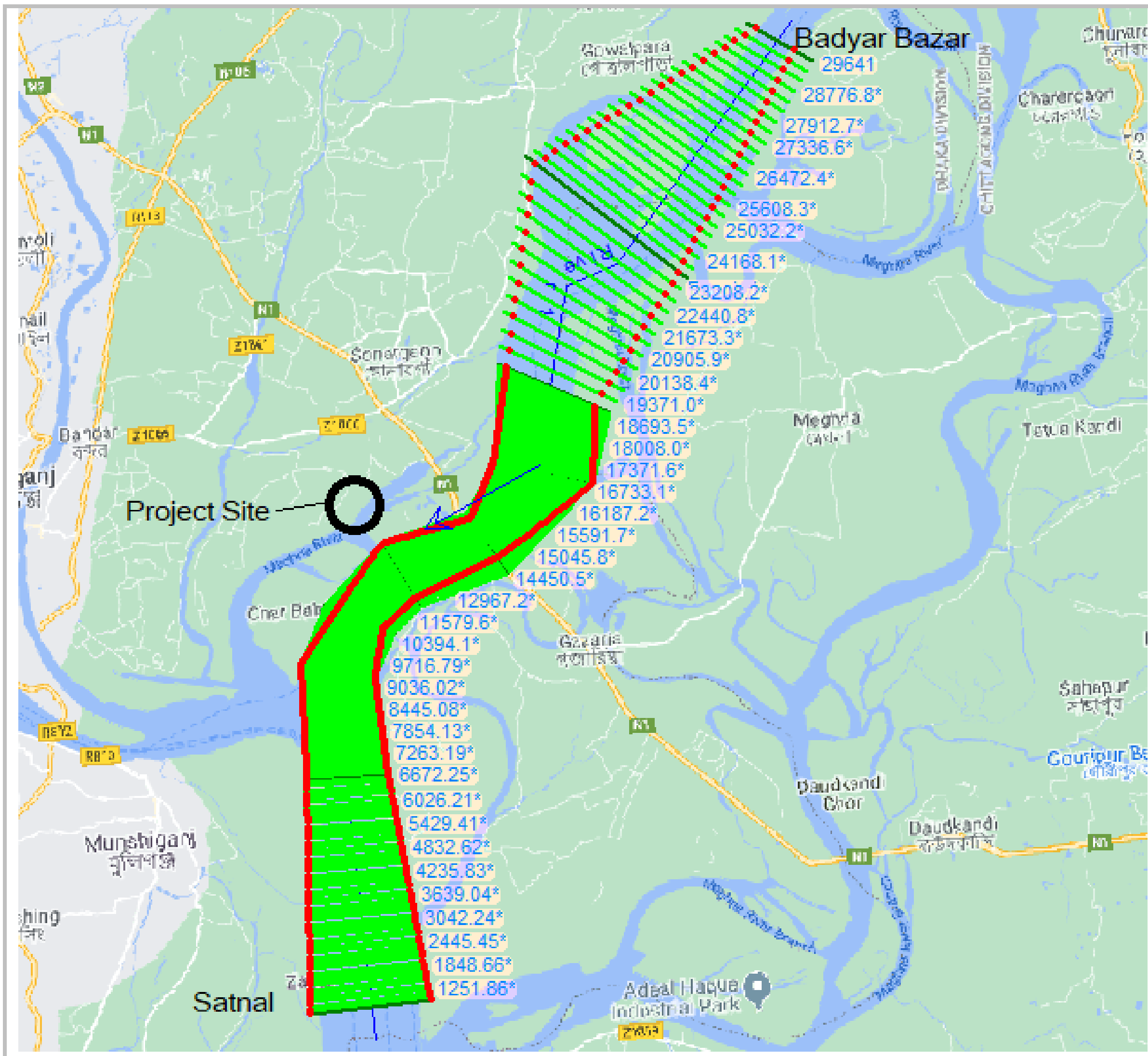


Figure 7.11: Model Domain considered in HEC-RAS model

The cross-section information was obtained from the archive database of the consultants which was previously procured from the Bangladesh Water Development Board's field data collection program. The cross sections locations along the reach are shown in the toposheet with Project number (BGD-88-054 WRIS) as shown in the ***Figure 7.12*** and the cross-section IDs are M10, M9, M8, M6, M5.1 and M4.1. The cross-section information for the year 1998 was considered in the present study. This year is chosen since the flow in the reach for the year 1998 is quite close to the 50-year return period required in the present study.

Since these locations are located distant apart, the cross sections were interpolated between these locations with the help of cross section interpolator tool in the HEC-RAS such that the maximum distance between cross sections is between 50m -100 m. The cross sections were placed closer for the river stretch near to the study area. Since 1D flow is assumed therefore, the flow around the islands in the river stretch is neglected. Moreover, the flow area around the islands is quite less as compared to the main channel so it could be appropriate to neglect the flow in absence of any gauge data in the area around the islands. The topography of the flood plain was extracted from SRTM DEM 3 arc second (USGS, 2000).

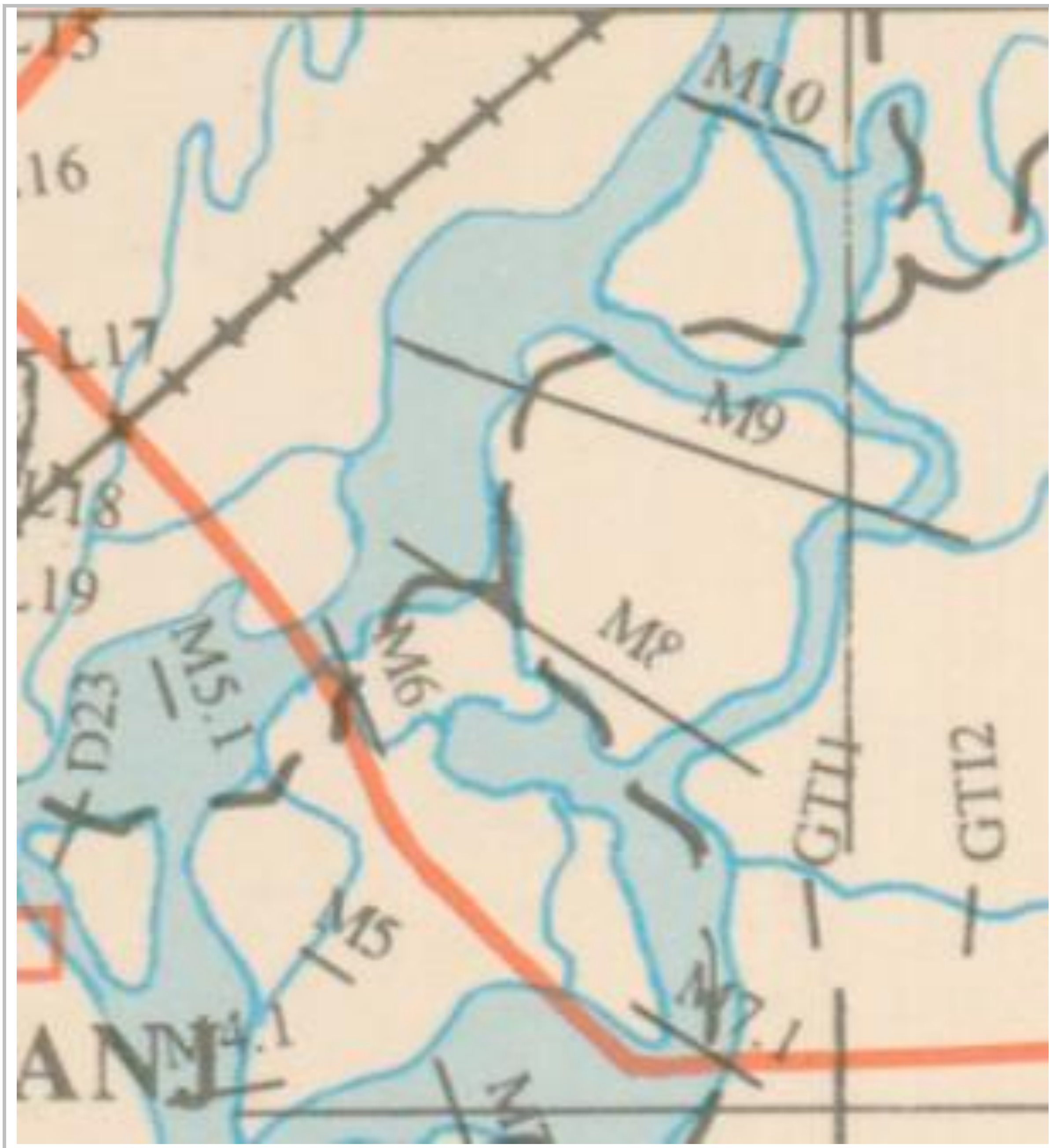
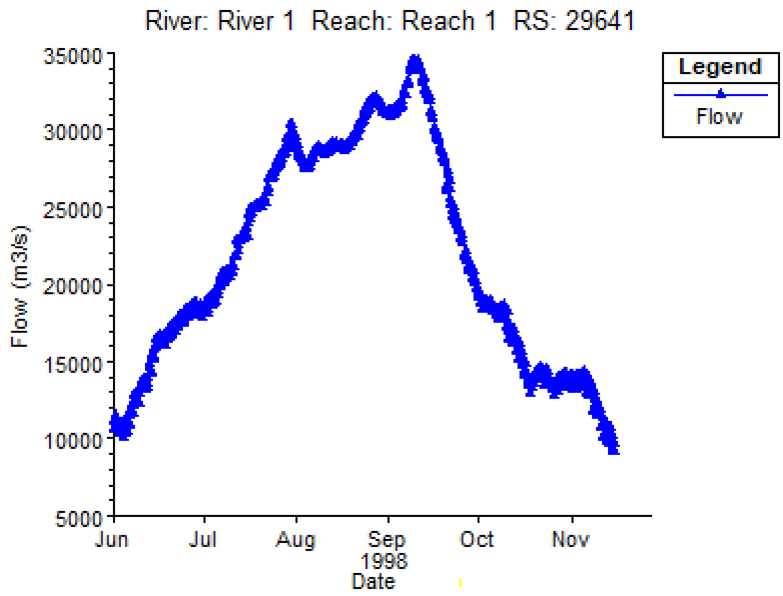


Figure 7.12: Cross section location for the reach considered

Boundary Conditions.

The boundary conditions considered during calibration of the model are upstream boundary condition was taken as discharge boundary condition at Baidyer Bazar (RS 29641) and water level time series at Satnal (RS 854) was taken as downstream boundary condition as shown in figures below.

(a)



(b)

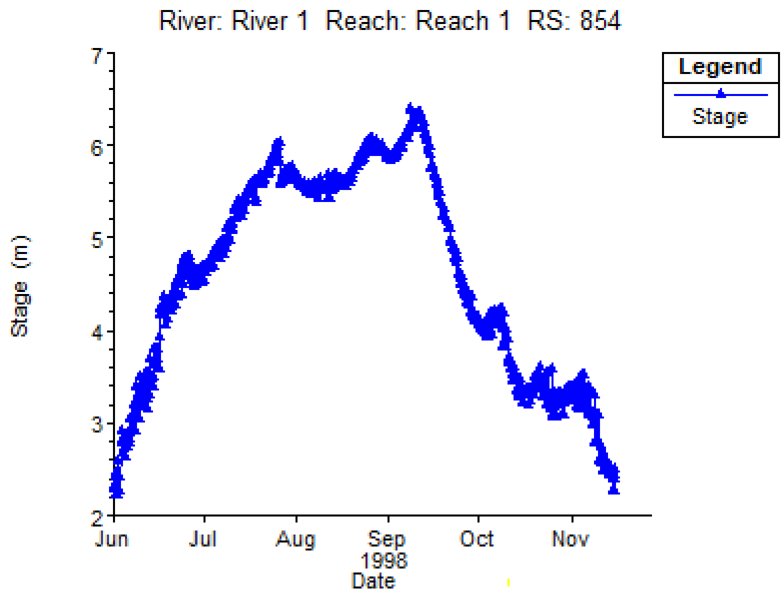


Figure 7.13: Boundary Conditions- (a) Upstream BC at Baidyer Bazar; (b) Downstream BC at Satnal

Calibrating Parameters

The bed friction is the main calibrating parameter for the model. The bed friction is modelled using Manning's coefficient. The value was defined for the main channel as well as the flood plain. Slightly higher value is defined for the flood plain as compared to the main channel owing to the presence of possible obstructions in the flood plain. The Manning's n given in the model varied between 0.03-0.055. Higher Manning's number was taken for the stretch of river near the site due to the braiding nature of the channel as well as due to presence of various obstructions in the channel.

Calibration of the model

The model was calibrated against the available field measurement of the water level at Meghna Ferry Bridge (SW 275.5) for the year 1998. This particular year was chosen since this is the year of the highest recorded water level at the Meghna Ferry Bridge which is closest to the site in last 50 years (1968-2018). The comparison of the water level obtained from the model with the measurements at the water level gauge at Meghna Ferry Bridge is shown in the ***Figure 7.14.***

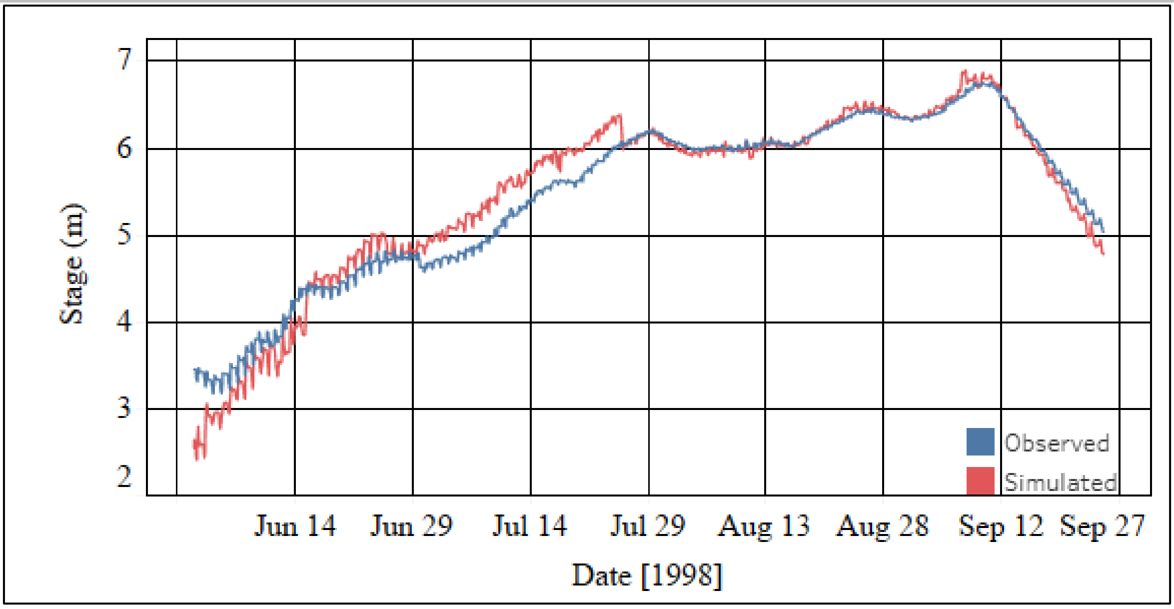


Figure 7.14: Calibration of the model

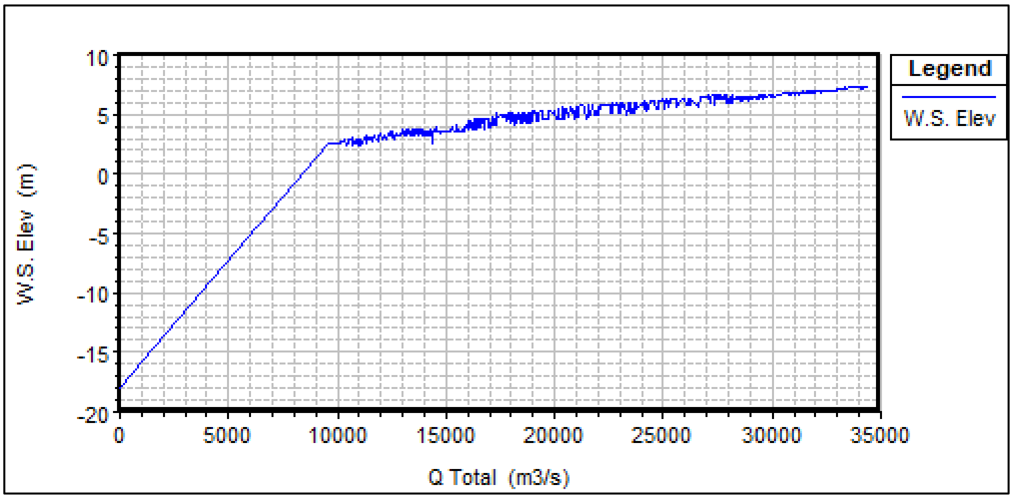
It can be observed from the ***Figure 7.14*** that there is a close match between the observed water level and the match obtained through the model. There is a strong correlation between simulated results and observations.

Results and Discussion

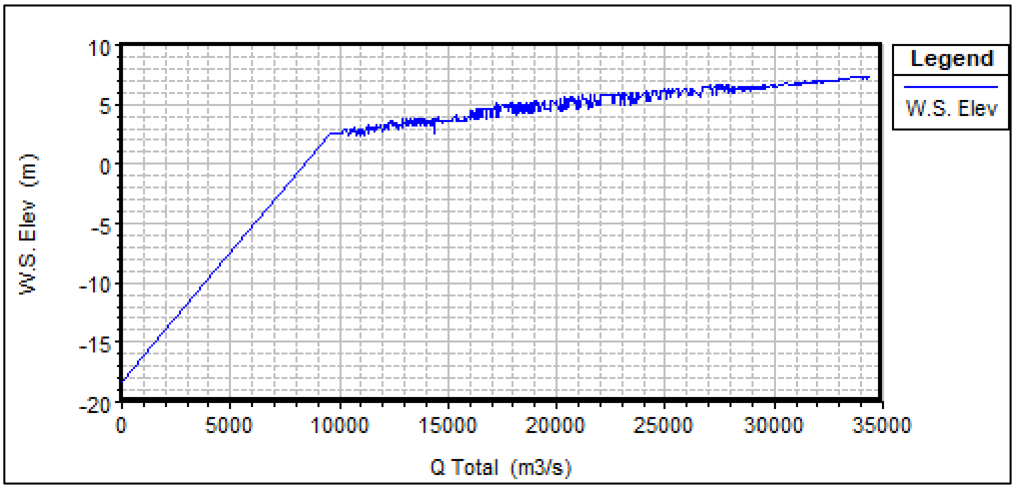
For the sake of better clarity, this study has considered the 10 km length channel in front of project site. The channel considered as well as cross sections used for the analysis of results are shown in the ***Figure 7.15.***

Figure 7.15: Channel in front of project site as well as its cross sections

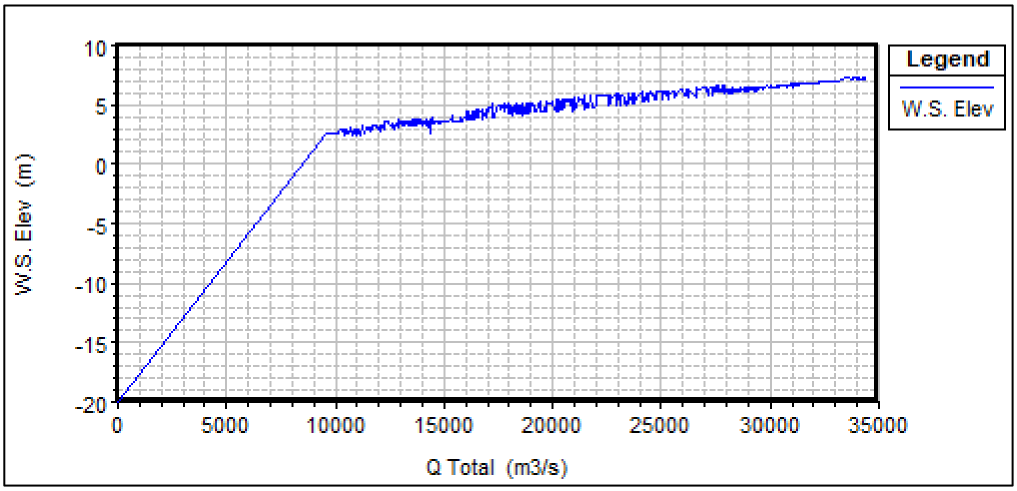
The rating curves are the plot of stage vs discharge for a particular cross section and these plots are useful to determine the continuous river measurement for particular discharge information. It depends largely on the geometry of the channel cross section as well as topography of its associated flood plain. The rating curves for the cross sections shown in ***Figure 7.15*** and are shown in the figures below:



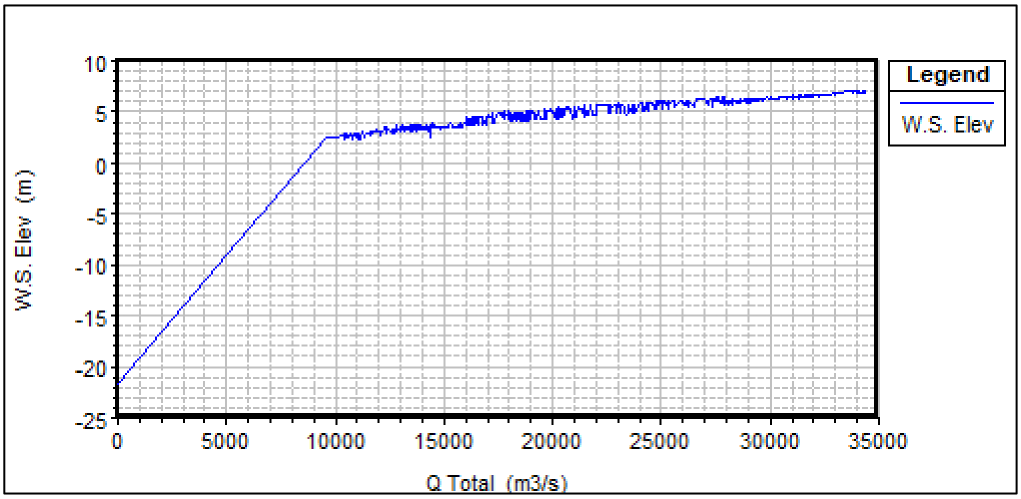
(a)Cross section (17763.2)



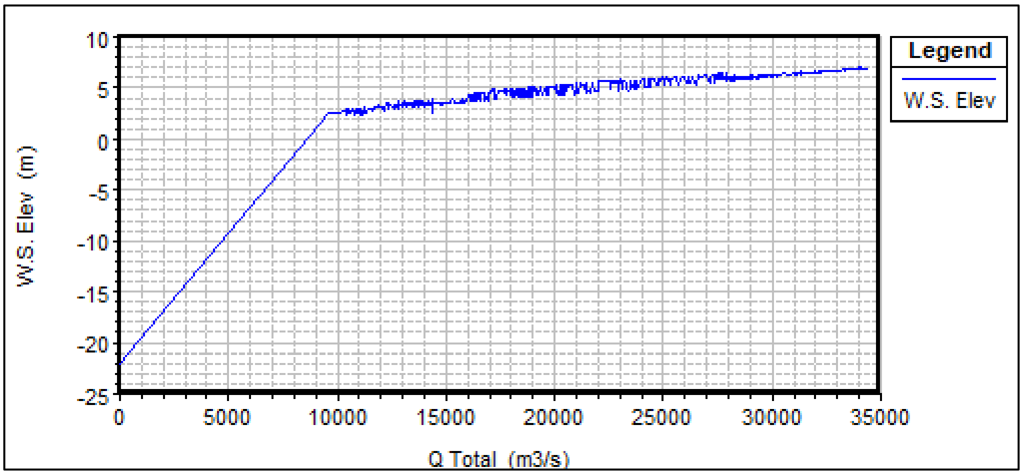
(b)Cross section (16733.1)



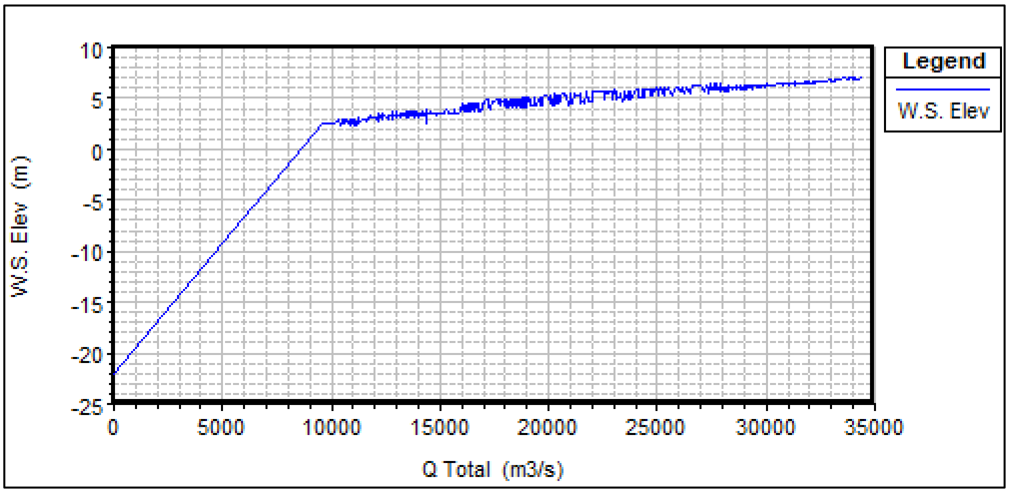
(c)Cross section (15740.6)



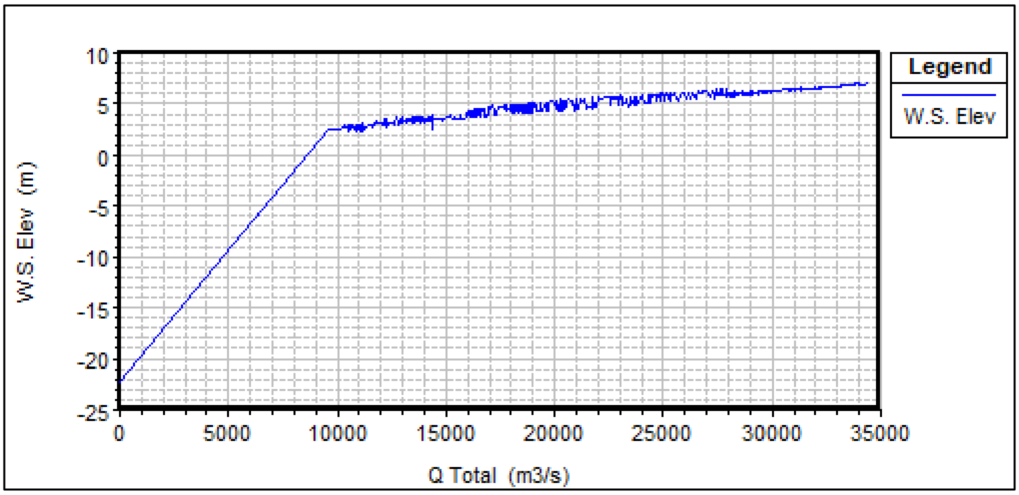
(d)Cross section (14748.1)



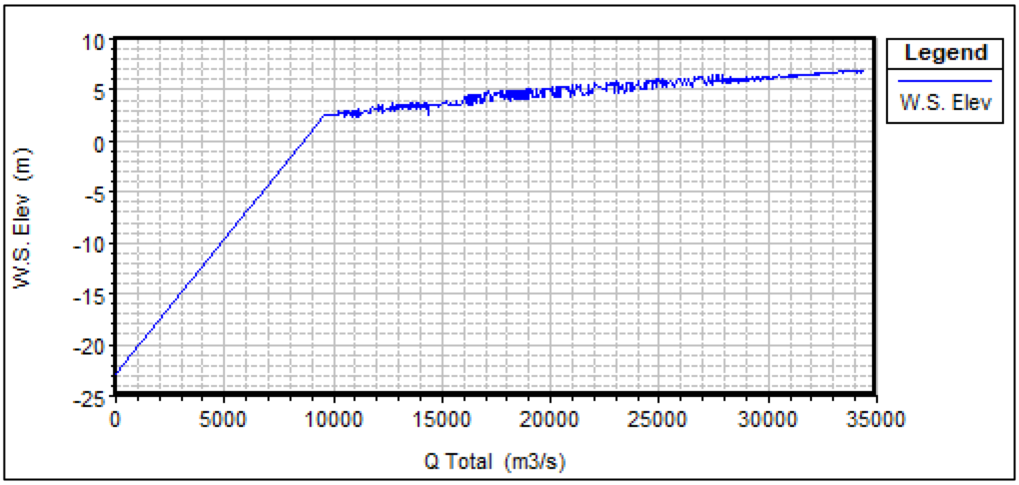
(e)Cross section (13758.3)



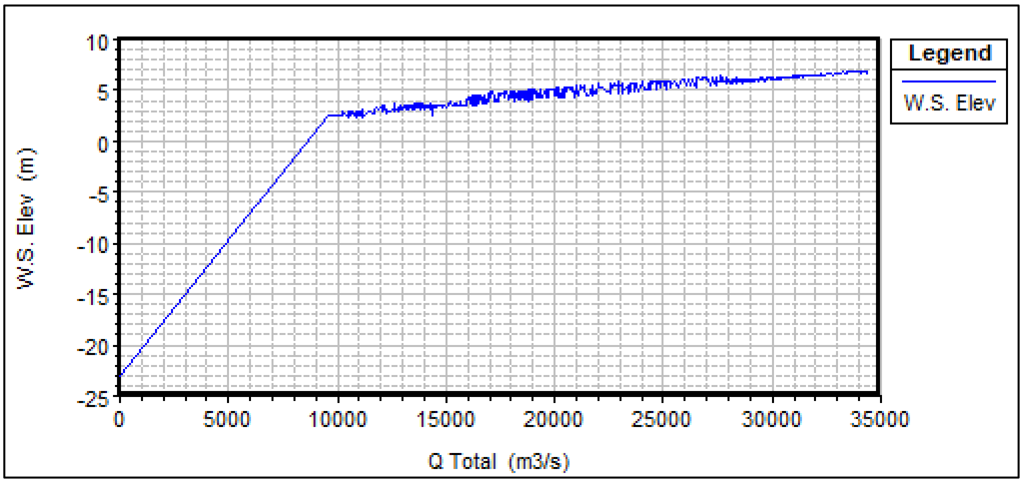
(f)Cross section (12769.4)



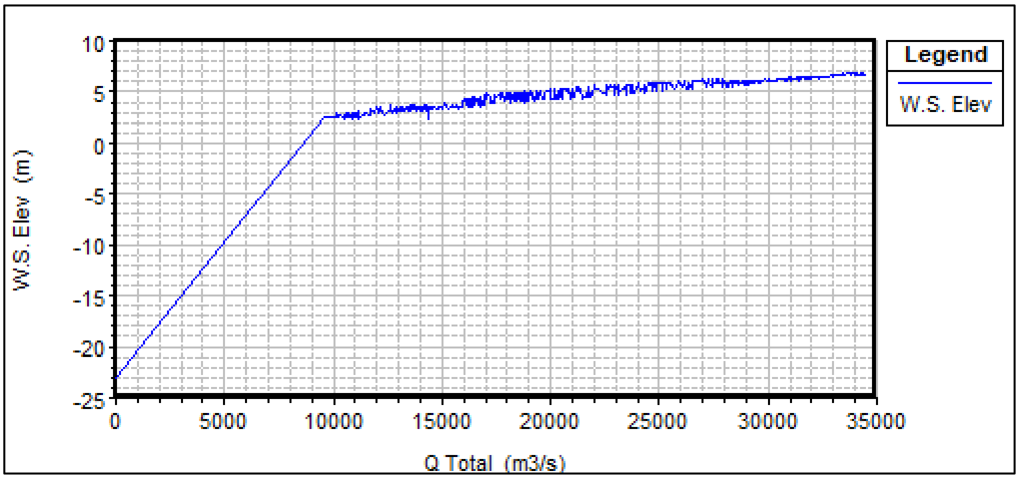
(g)Cross section (11778.3)



(h)Cross section (10785.0)



(i)Cross section (9765.17)



(j)Cross section (8740.55)

The maximum flow depths in terms of water surface elevation (WSE) with respect to mean sea level in the river channel in front of project site are shown in ***Figure 7.17***. It can be seen from the Figure 16 that the water surface elevation varied from 6.78 m to 7.4 m.

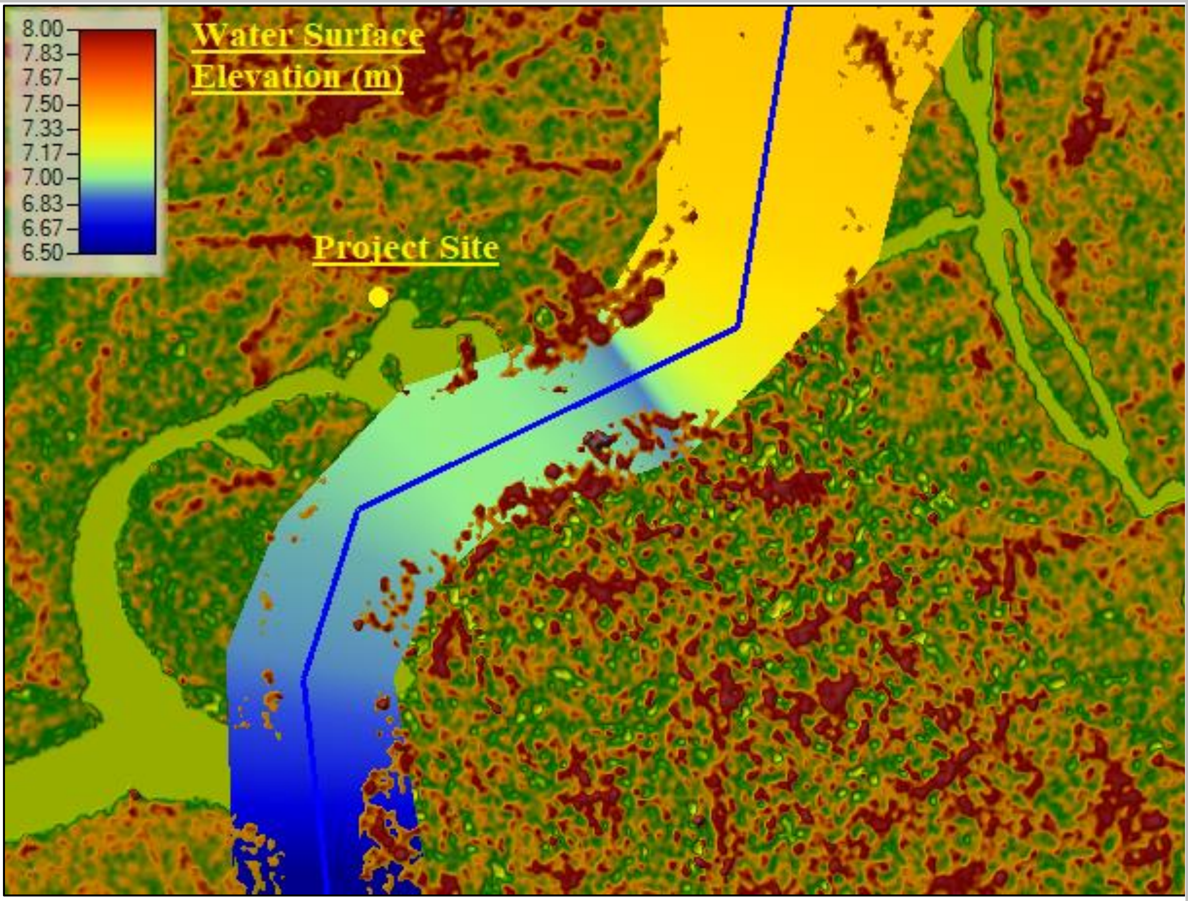


Figure 7.16: Flow Depths in the channel

The maximum flow velocities in the channel in front of project site is shown in the ***Figure 7.18***. It can be observed from the figure that velocities varied between 0.9 m/s to 2.7 m/s along the centreline of the channel and the velocity varied between 0.3 m/s to 2.7 m/s across the channel. Moreover, it is observed that for any cross section there is higher velocity near the centreline and the velocity reduces as one moves farther from the centreline. The reason behind such occurrence is that near the sides of the channel there is retardation of flow due to friction from the side walls of the channel apart from the bed friction and its effect keeps reducing with the distance.

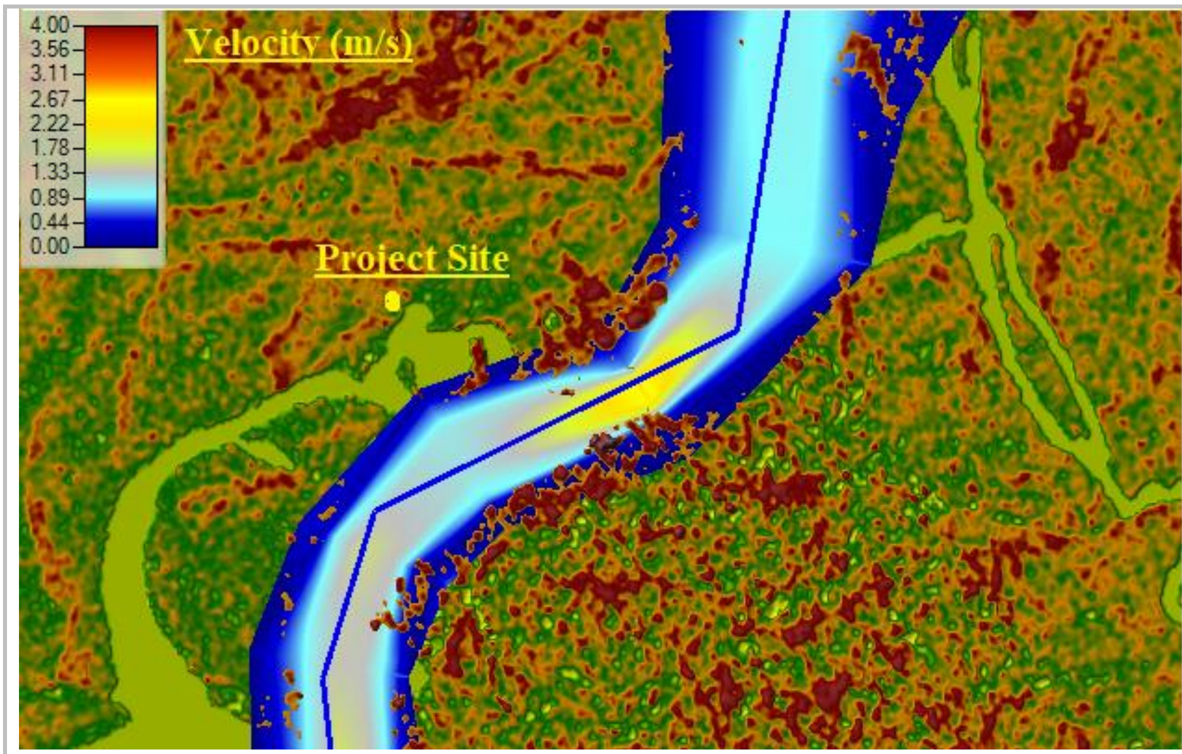


Figure 7.17: Flow velocities in the channel

The Flow Area, Top Width and Volume in the channel are shown in the following figures, respectively. The plots are made considering the downstream side of the channel as reference origin in the graphs. The flow areas, top width as well as volume are higher in upstream and lower in the downstream.

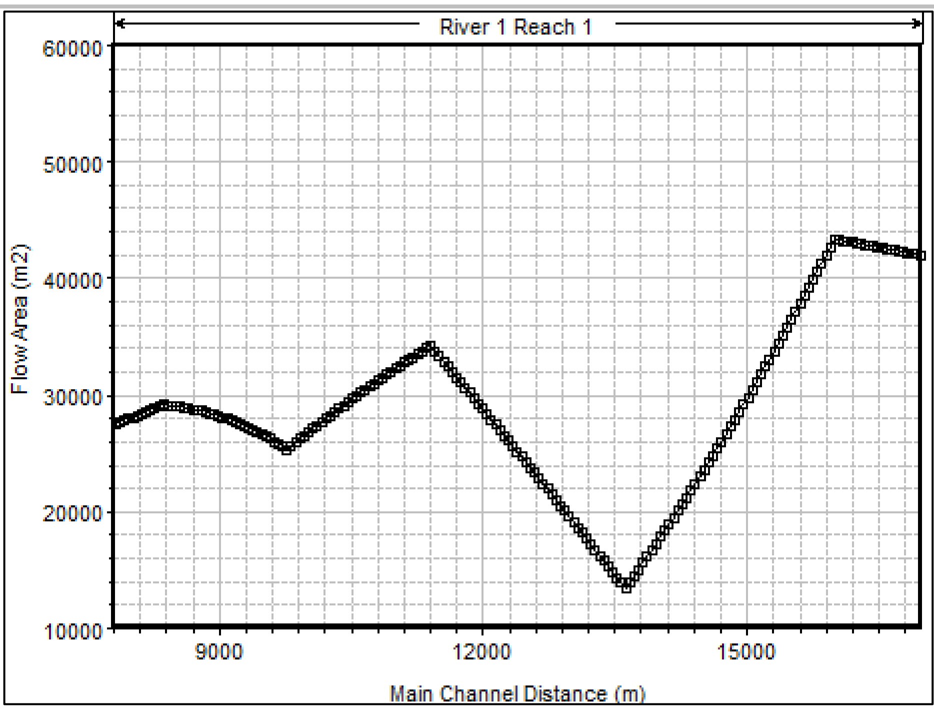


Figure 7.18: Flow Area in the Channel

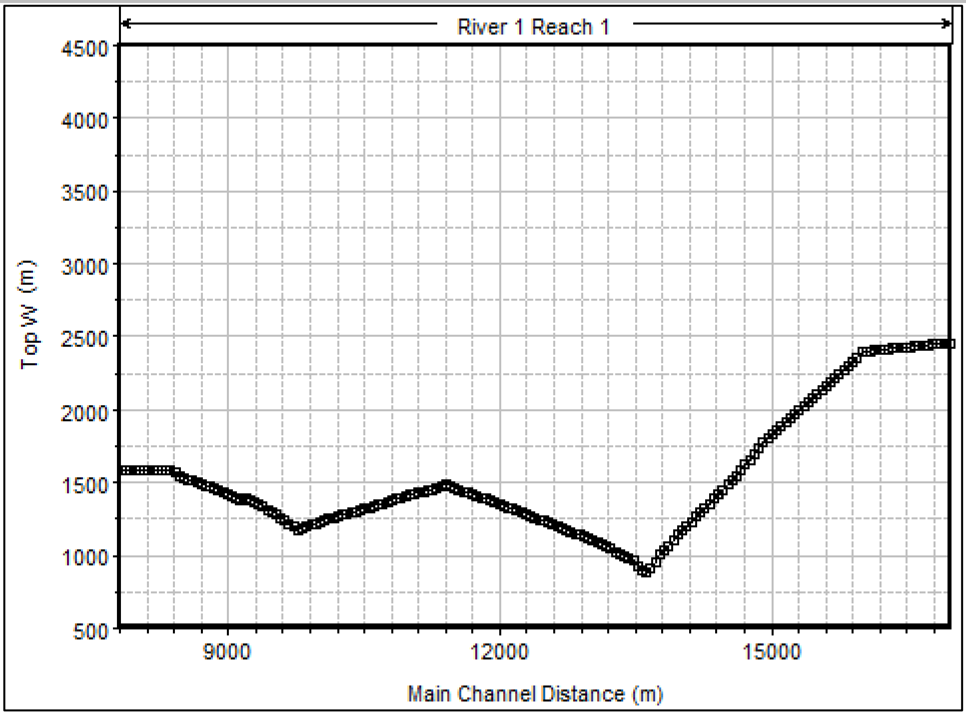


Figure 7.19: Top Width in the Channel

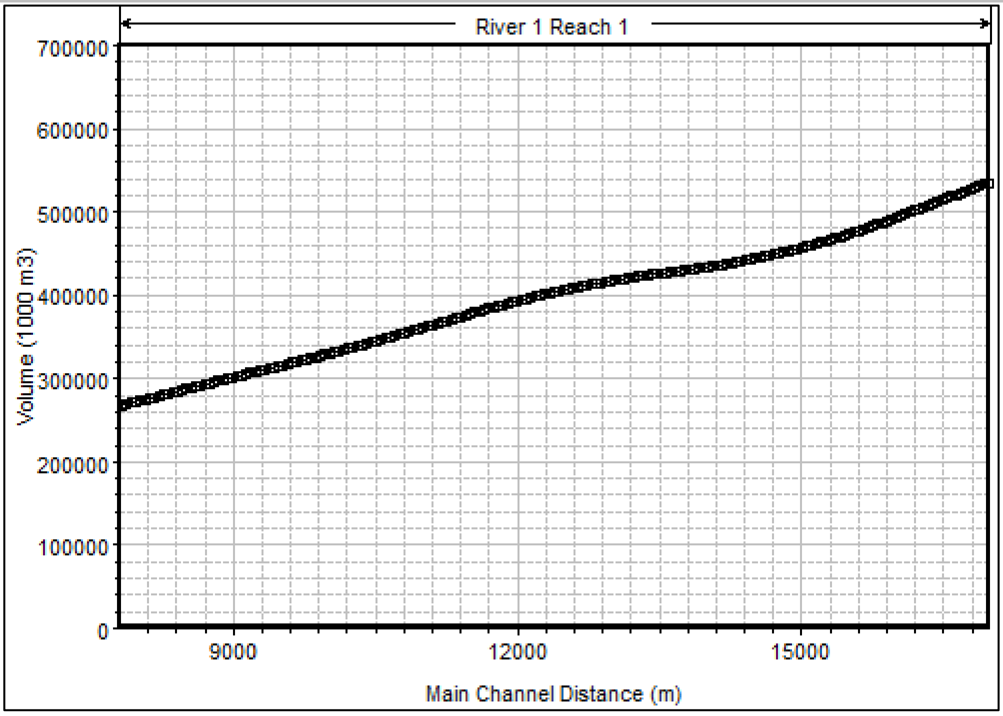


Figure 7.20: Volume in the Channel

The summary of results shown above are presented in form of a table in

Table 7.1.

Table 7.1. Summary of flow and current characteristics in the channel

S. No.	Variable	Range
1	Flow Depth (wrt MSL)	6.78 m -7.4 m
2.	Velocity	0.3 m/s -2.7 m/s

S. No.	Variable	Range
3.	Flow Area	7871.87 m^2- 16877.66 m^2
4	Top Width	1581.81 m – 2453.48 m
5.	Volume	269277.38 m^3- 530855.31 m^3

The water surface area of the channel in 3 D view is shown in the ***Figure 7.22*** and the profile plot of the water surface in the channel is shown in the ***Figure 7.23.*** It can be observed from the 3D view that the channel is curvy S-shaped, and the cross section are largely trapezoidal in shape. For the purpose of better viewing, the vertical axis is scaled with the horizontal axis by a factor of 100. However, the depth of river is quite small in comparison to the width of the river. From the profile plot it can be observed that the relative change in bed gradient is larger in upstream section as compared to the downstream section. In the profile plot, the variation in water surface elevation is from 6.78 m in the downstream section to the 7.4 m in the upstream section.

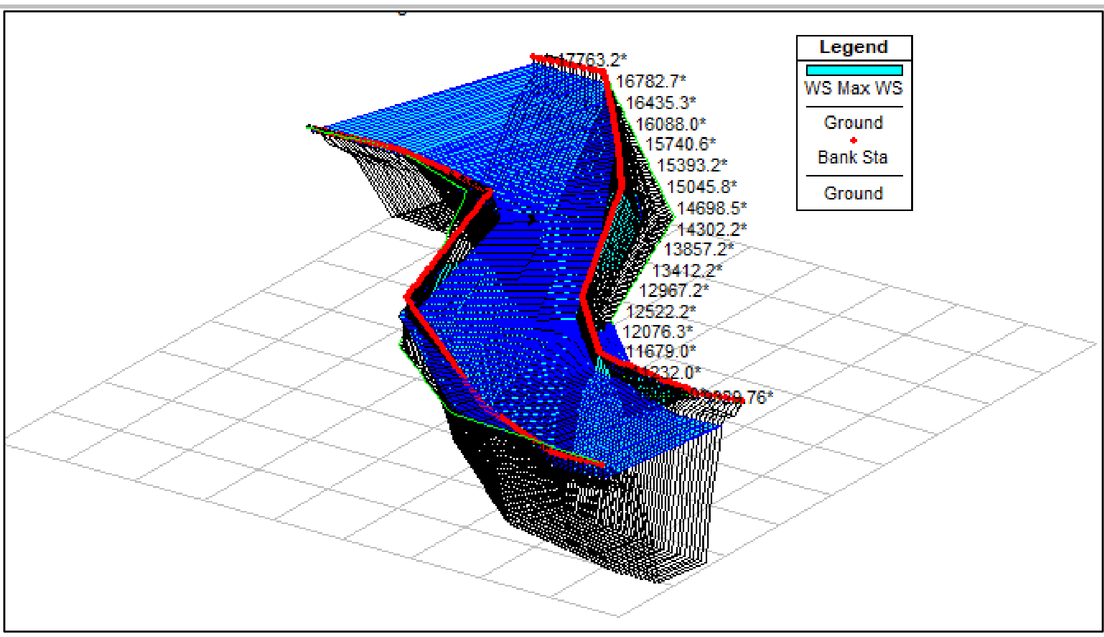


Figure 7.21: Water surface area (3D View)

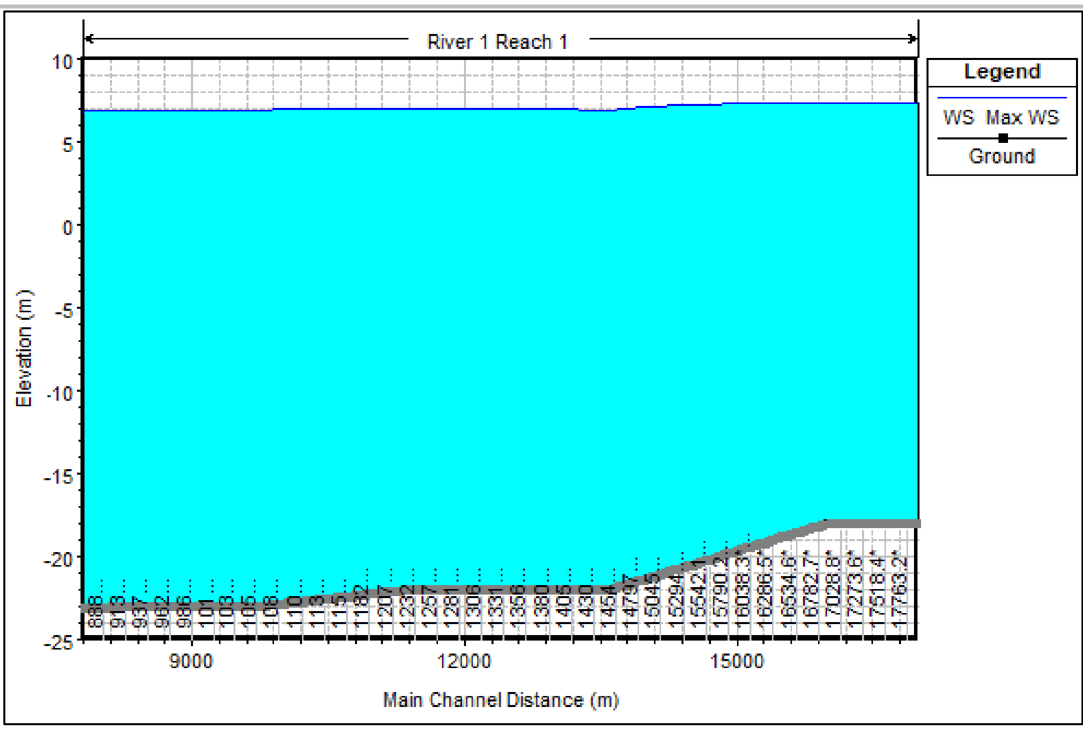


Figure 7.22: Water Surface Profile Plot

The ***Figure 7.23*** shows the flood vulnerability map around the project site. Flood vulnerability ma along 10 Km channel length in front of the project site as shown in the ***Figure 7.23.***

There can be 2 methods to estimate the flood inundation map. One is through the use of inundation map produced by RAS mapper and other could be the use of maximum water level in the reach to develop the flood inundation map. The second approach is better than the formed due to 2 reasons. First reason is that the reach is S-shaped and therefore the cross sections if extended to flood plain may intersect with each other leading to erroneous results. Second reason it that the former will not give the maximum extent possible which can only be represented through considering the maximum water level in the reach and this has been considered in the present approach. Therefore, the best way to get the conservative estimate of the flood inundation extent is to estimate the inundation corresponding to the maximum water level obtained through modelling for 50-year return period in the channel under consideration. This approach has been used in the study to develop the flood vulnerability map shown in ***Figure 7.23*** according to the hazard classification as shown in ***Table 7.2.***

Table 7.2: Hazard classification

S.No	Class	Depth
1	River	<=0 m
2	Low Impact	0 m -2.04 m
3	Moderate Impact	2.04 m – 4.08 m
4	High Impact	4.08 m – 6.12 m
5	Severe Impact	6.12 m -8.15 m
6	No Impact	>= 8.15 m

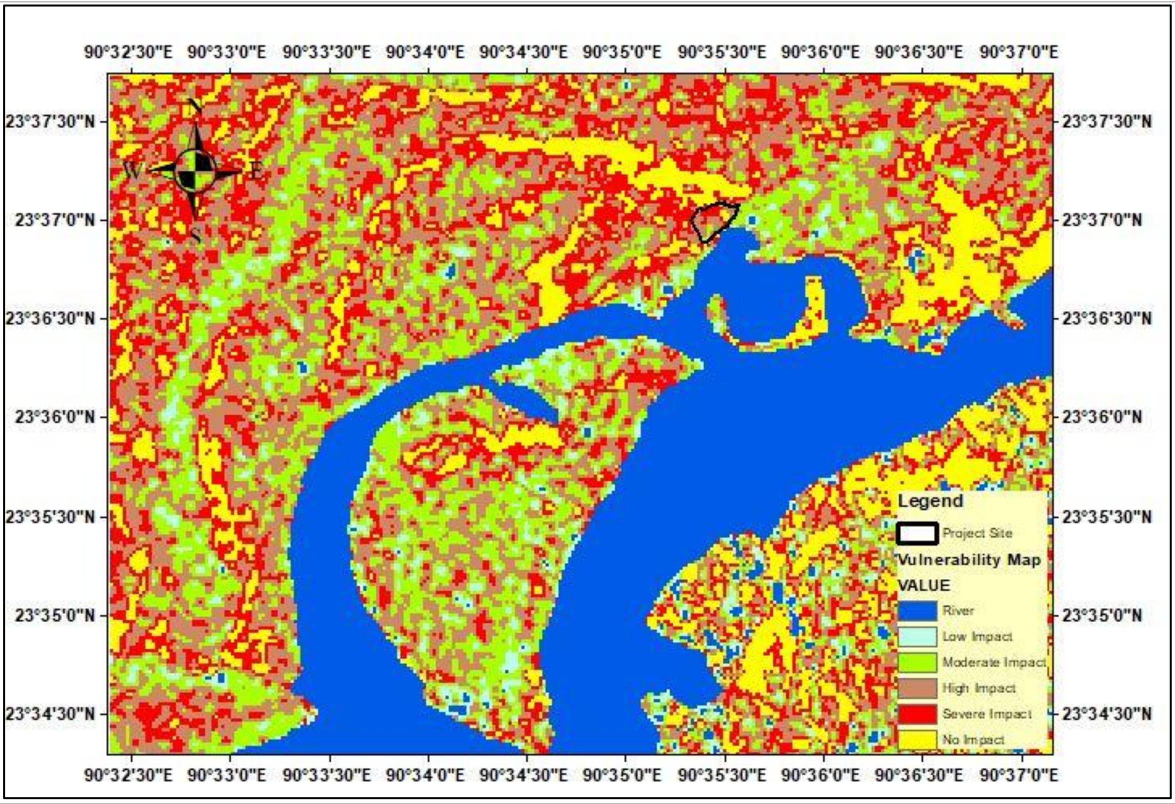


Figure 7.23: Flood Vulnerability Map

The flood vulnerability map indicates the area which is vulnerable to get submerged in case of a 50-year return period flood. Suitable drainage arrangement must be provided in the area to manage the potential damage which can occur due to flooding.

To avoid the potentially harmful effects of flooding, flood control measures, such as the development of flood protection embankments and dikes, as well as the improvement of storm water drainage in flood plains, must be implemented.

7.7 Conclusions[44]

The study was carried out to investigate the flood vulnerability assessment at a project site near Meghna Ferry Ghat due to rise in river water due to floods in a 5 km channel of Meghna River in front of the project site. The design period for the project is 50 years and the vulnerability of the area corresponding to 50-year return period flood is considered.

The detailed literature review revealed that there are primarily four types of floods in Bangladesh- Riverine floods, flash floods, tidal floods and floods due to storm surge. However, the area under study is only subjected to riverine floods, whereas tidal floods and storm surge is near the coastal areas and the flash floods occur in the northern as well as northeastern parts of Bangladesh.

The primary and secondary data analysis revealed that the Meghna river is subjected to both tidal as well as non-tidal monsoon flows. However, the intensity of monsoon flows is greater than the pure tidal flows. Therefore, for the preparation of flood risk assessment maps, only monsoon flows were considered. The extreme value analysis was carried out to estimate the 50-year return period flows at Baidyer Bazar which was considered as upstream Boundary condition for the model. The extreme value analysis results revealed that 50-year return period flows matched closely with the flood flows in the year 1998. The flood flows in the year 1998 were therefore considered for estimation of design flood flows in the area.

The hydrodynamic model was developed using HEC-RAS 1D unsteady flow module considering the upstream boundary condition at Baidyer Bazar and downstream Boundary condition at Satnal covering a channel length of around 30 km. The model was calibrated with the help of water level measurements at Meghna Ferry Bridge. The model closely matched the trend as well as peak flood levels with the measurements whereas there was some mismatch in the beginning of the simulation time. The output model results were reported in the 10 km channel in front of project site. The output results such as rating curves at the cross sections, flow depth and velocities profile, profile curves of flow areas, top width and volumes profile, 3d view of water surface area as well as profile plot of water surface area were then reported as well as discussed.

The flood hazard map was then presented which gives the inundation extent as well as water depths divided into 6 classes around the project site which might get submerged during the flooding condition in the Meghna River.

As the site has been raised substantially (HFL + 1 m = 7.76 m), the raised site would impede the natural drainage in the lower catchment of the river, including the surrounding village and the approach road. This may lead to water impoundment in the area surrounding the plant (including Approach Road) as the natural slope of the area has changed due to raising of the site.

The Storm water drainage network is designed to collect rain water from the building / roof, roads, storage tank areas and cooling tower water basin, paved and unpaved areas, drainage for pipe trenches, cable trenches etc., overflow water for clean water tank/basin, other drainages for which water quality meet the standards. Storm ditch or box culverts are the drainage structures to be used for main roads within the proposed plant. Heavy box culverts will be in use where truck movement is envisaged inside the plant. The types of storm drain conduits to be used consists of concrete pipes, concrete boxes, spiral rip metal pipe, corrugated metal pipe, pipe arches, corrugated polyethylene and polyvinyl chloride (PVC). In the project site, two drainage channels would be set up within the plant area as the main drainage. The length of the drainage channel is about 600 m, and the width is 450 mm. Two storm water basins would be arranged at the river side for the storm water drainage of the whole plant, at the south and north of the plant. The total capacity of the two storm water basins will be considered for 15 min storage and the capacity of the two storm water basins will be about 1400 m^3. The outlets of the two drainage channels are set on the east side of the plant area, which would eventually be discharged by overflow channel to the Meghna River. Non-return valve would be provided, before the stormwater leaves the plant boundary, to ensure one-directional flow and no reversed flow takes place after being discharged into the river channel.

As the site has been raised substantially (HFL + 1 m = 7.76 m), the raised site would impede the natural drainage in the lower catchment of the river, including the surrounding village and the approach road. This may lead to water

[44] *Ali, M. M., Narzis, A., & Haque, S. (2016). Impacts of Climate Changes on Peak Flow of Upper Meghna River Basin. PRESIDENCY, 3(2), 54-63.*
BWDB., 2006. Rivers of Bangladesh, Report by Bangladesh Water Development Board (BWDB), Dhaka, Bangladesh
HEC-RAS, "Hydraulic Reference Manual," US Army Corps of Engineers, Hydrologic Engineering Center, Davis Version 5.0, 2016.
Hofer, T., & Messerli, B. (2006). Floods in Bangladesh: History, dynamics and rethinking the role of the Himalayas. UNU Press/FAO.
Imran Hasan, M. (2015). Modelling the flood behaviour of upper Meghna river. Master's Thesis. Bangladesh University of Engineering and Technology, Bangladesh.

impoundment in the area surrounding the plant (including Approach Road) as the natural slope of the area has changed due to raising of the site.

UMPL would take up the construction of peripheral stormwater Drain outside plant boundary to channelize the incoming rainwater water flow from the lower catchment area towards the river to restrict impoundment and flooding within the village land. The stormwater drain would be aligned in a manner to ensure stormwater flow by gradient from the villages into the river through stormwater drain constructed around the Proposed Plant at its outer periphery.

UMPL is considering constructing peripheral drain to divert the run-off generated from the outer catchment and channelize the flow towards the river. This would help avoiding the potential chances of inundation as the collected water would be adequately drained. A continuous 200 ft (60 m) wide strip outside the plant boundary at the village side is considered as the catchment area to design the stormwater drainage size outside the plant. The area is calculated as 39647 sq. m. The precipitation considered for design of the outer peripheral drain includes the extreme precipitation event due to impacts of Climate Change.

8 Climate Change Assessment

Climate change is a major concern in the recent years due to global warming. As per IPCC (2014)45, the necessity of comprehensive information about the regional and local climate changes has been emphasized mainly due to the interest of different nations and economic groups. Precipitation is changing on both global and regional scales by the influence of global warming mainly rise in temperature46. The unbalanced distribution of precipitation and temperature could yield to excess or scarcity of water resources. Not only precipitation and temperature, sea level rise also contributes to society and environmental impacts such as coastal flooding and inundation of the low-lying coastal areas. Rising sea level rise could pose similar vulnerability risk to the concern region. In addition to this, increasing heavy precipitation days also leads to possible frequent flash floods, riverbank erosion and landslides.

Bangladesh is generally a low-lying alluvial plain in the delta of three biggest rivers of Asia. It occupies an area of 147,570 km2 and geographically extends from 20°34' N to 26°38' N and from 88°01' E to 92°41' E. Most of the population lives in rural areas and are directly or indirectly depends on agricultural activities2. The country is favored with sub-tropical monsoon climate and experiences vast amount of rainfall annually. The highest rainfall occurs during the summer monsoon season (78%) and the concentration of precipitation varies within the country. Higher mean rainfall from 1400 mm in the west to more than 4200 mm in the east have been captured47. The country is also characterized by moderately warm temperature where average temperature ranges from 7.2° C to 12.8° C during winter season and 23.9° C to 31.1° C during summer season3. The country's flat geographical topography with low elevation, extreme climate variability that is governed by monsoon and temperature distribution resulting in acute water distribution over space and time, high population density, poverty, etc are some of the factors making it more vulnerable due to climate change48. The climate of Bangladesh is changing and becoming more unpredictable with time49. Changes in rainfall and temperature over the region50, extreme precipitation days51 and sea level rise52 over the Bay of Bengal have been studied where intra-annual, interannual and intra-seasonal variations are found.

Future climate change may involve changes in climatic variability as well as changes in mean which is particularly important for area such as Bangladesh where hydrological disasters is very common. Therefore, it is utmost important to understand the vulnerability and the associated risk poses to adapt the climate change impacts mainly over the project site. For this, planning and management in the context of climate change in terms of temporal as well as spatial variations of rainfall, maximum and minimum temperature, extreme precipitation events and sea level rise is necessary mainly because of the geographical nature of the region. Understanding the nature of these climatic parameters would give us a brief idea on the likely change in future climate over the project site. Since climate change is dynamic in nature with respect to time and space, understanding its state of nature could be possible with the help of already available general circulation model with defined scenarios.

8.1 Objective

The objective of the study is to prepare a concrete report on climate change issues that could likely be faced by the project location. To take notes of all the important findings in a general form for the readership for better understanding of the nature of the climate change over the specific site. The report could form a baseline to help create awareness among the stakeholders in decision making in terms of the development of the project without being harm to both the project as well as the surroundings vulnerable areas in near future.

[45] Chambwera, M., et al., 2014: Economics of adaptation. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC [Field, C.B., et al. (eds.)]. Cambridge University Press, UK pp. 945-977

[46] Mondal et al. 2018. Precipitation concentration in Bangladesh over different temporal periods. Adv. Meteorol. DoI: 10.1155/2018/1849050

[47] Shahid, S, 2011. Trends in extreme rainfall events of Bangladesh, Theor. Appl. Climatol. 104(3-4): 489-499

[48] Ahmed, A. U, 2006. A synthesis report on Bangladesh: Climate Change Impacts and Vulnerability. Climate Change Cell, DoE, Bangladesh

[49] Rahman, Md. R, H. Lateh, 2017. Climate change in Bangladesh: a spatio-temporal analysis and simulation of recent temperature and rainfall data using GIS and time series analysis model. Theor. Appl. Climatol. 128:27–41.

[50] : Basak, et al. 2013. Climate change in Bangladesh: A Historical Analysis of Temperature and rainfall Data. J. Environ. 2: 41–46

[51] Shahid, S, 2011. Trends in extreme rainfall events of Bangladesh, Theor. Appl. Climatol. 104(3-4): 489-499

[52] Ghosh et al. 2017. Trends of sea level rise in the Bay of Bengal using altimetry and other complementary techniques. J Spat Sci. pp.49–62.

8.2 Datasets and Methodology

8.2.1 Datasets used

Station datasets of precipitation, maximum temperature and minimum temperature derived from Bangladesh Meteorological Department (BMD) of 0.25° x 0.25° resolution for the period 1990 to 2014 has been used. Note that the observation datasets are available for this time period only. To estimate the historical (1985 to 2014) for 30 years and future projections (2015 to 2050) for 36 years of the climatic parameters mentioned over the project site, high resolution (0.25° x 0.25°) gridded data from Atmospheric General Circulation Model (CMCC) generated by Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici, Italy under the aegis of CMIP6 have been used. The future scenario used for this study of the parameters mentioned above is close to RCP8.5. Only this scenario for future projection data is used because the set of experiments being run for CMIP6 particularly for these datasets are available only for this scenario and that RCP4.5 is not available.

As for the sea level rise assessment, gridded reanalysis data of 1° x 1° resolution developed by ECMWF ORAS5 (European Centre for Medium-Range Weather Forecasts, Ocean Reanalysis System 5) for the period 1985 to 2005 have been used. This dataset has been generated using NEMO ocean model version 3.4.1 (European Model developed by France, Italy and UK) and biased corrected with the help of ocean observation datasets including satellite-based AVISO altimetry data along with other observation datasets. Sea level rise coupled model (atmospheric-ocean) gridded data (MIROC) of 1.4° x 1.4° resolution developed by Japan Agency for Marine-Earth Science and Technology, Kanagawa; Atmospheric and Ocean Research Institute, The University of Tokyo, Chiba and National Institute for Environmental Studies, Ibaraki, Japan under the aegis of CMIP5 for historical period (1985 to 2005) and future projection (2006 to 2050) for both RCP4.5 and RCP8.5 have been used. The sea level rise data from CMIP5 have been used over CMIP6 sea level rise data as CMIP6 data is found to be unsuitable to study the sea level rise over the Bay of Bengal region probably due to the ocean dynamics involved over the Bay of Bengal and also due to the initial boundary conditions of the models. Note that the model experiment set up for CMIP5 model runs till 2005 for historical and starts from 2006 for future scenarios hence the period is taken from 1985 to 2005 as historical period (30 years) and 2006 to 2050 as future scenarios (36 years) for this study. Same applied to CMIP6 model, historical experiment set up is till 2014 and future starts from 2015 so 1985 to 2014 (30 years) as historical period while 2015 to 2050 (36 years) as future scenarios.

For extreme precipitation events, daily precipitation data (1985 to 2014) converted from ERA5 hourly reanalysis precipitation data at 0.25° x 0.25° resolution is used for bias correcting the model data. The Copernicus Climate Change Service (C3S) at ECMWF produced ERA5, which is the fifth generation ECMWF atmospheric global reanalysis data. Similar CMIP6 CMCC AGCM at 0.25° x 0.25° resolution daily precipitation data have been used for present simulation (1985 to 2014) and future projections (2015 to 2050).

8.2.2 Methodology

For this study, the historical simulations of the model are validated by comparing the mean model with observed mean precipitation, maximum temperature, minimum temperature and sea level rise patterns. As for the sea level rise data, the reanalysis datasets and the model datasets are resampled into the same resolution (0.25° x 0.25°) using a bilinear interpolation method in Climate Data Operator tool. This is required as the datasets are of different resolution. Then, the annual variations (both inter and intra) and seasonal variations of the climatic parameters are explored. For time series area-averaged trend statistical analysis including annual mean and seasonal mean, the region bounded by 23.125° N – 23.625° N through 90.25° E – 90.5° E have been taken as the Meghnaghat project location as the gridded data is of two-dimensional data, these coordinates are the nearest to the project location. The slope of the area-averaged trend is tested by applying a linear trend analysis “Least square linear fit”[53] on the observed as well as the model simulated datasets[54]. Then the statistical significance of the trend is evaluated using two-tailed Student t-test, a method of testing hypothesis whether to accept or reject it based on critical value, t-value and p-value. Critical value is the point on the test distribution that is compared to the test statistic to determine whether to reject the null hypothesis, T-value is the absolute value calculated difference represented in units of standard error and p-value is the probability of how likely the data could have occurred under the null hypothesis. According to this test, if the t value is larger than the critical value and p value is smaller than the critical value then we say that the null hypothesis is rejected, and the trend is statistically significant and vice versa. The significance test is run at 95% confidence level (percentage of probability) on time series area-averaged data.

[53] *Jain, S. K, and V. Kumar, 2012. Trend analysis of rainfall and temperature data for India. Curr. Sci. 102:37-49.*
[54] *Dubey, D. P, and G. Krishnakumar, 2014. Trends in precipitation extremes over Central India. MAUSAM, 65, 1:103-108*

While for spatial distribution analysis (climatology and trend), the region bounded by 20.625° N – 25.125° N through 88° E – 93.25° E have been used with the project location bounded by a box. This is mainly because of the distribution of the climatic parameters which means that larger the region more accuracy will be there when visualized. If the region is taken for a smaller area, then it would be difficult to interpret when the shades of colour scales and increments are provided. The difference between future climatological and historical climatological have also been computed to find out how much changes have occurred during the future period over the region. This is done by subtracting the historical climatology (A) of the climatic parameter from the future climatology (B) of the corresponding climatic parameter i.e., $\Delta C = B - A$.

For extreme precipitation events analysis, the month of June, July, August and September are considered for this study as higher amount of precipitation occurs during these months. The model daily precipitation data during 1985 to 2014 have been bias corrected with the help of reanalysis data using percentage method[55]. This method calculates the relative volume difference between modelled and observed volume. A negative value indicates under-prediction whereas a positive value indicates over-prediction. Then extreme precipitation events are defined as those exceeding 95th percentile as very heavy precipitation and those exceeding 99th percentile as extremely heavy precipitation[56]. 95th percentile indicates the peak highest 5% precipitation value and 99th percentile indicates the peak highest 1% precipitation value. The frequency and intensity of the extreme precipitation events based on these two percentiles are estimated for historical (1985 to 2014) and future projections (2015 to 2050) over the project location.

All the analysis including annual cycle, climatology, trend and extreme events are being carried out using Climate Data Operator (CDO) and GrADS in linux shell.

8.3 Results

8.3.1 Annual mean cycle of precipitation from observation and model

In the Figure 8.1 the climate model simulated annual mean precipitation during 1990 to 2014 have been validated against the observed annual mean precipitation over the Meghnaghat project location (23.125° N – 23.625° N through 90.25° E – 90.5° E). The model simulates a similar pattern of annual mean precipitation though the magnitude of the simulated precipitation underestimates the annual mean precipitation when compared to the observed annual mean. Note that underestimating or overestimating by the climate model data is very common and natural as the gridded data are being interpolated when generated. June month shows the highest mean precipitation while December month with the lowest mean precipitation in both the observation as well as the model simulation. This shows the reliability of the model for further analysis. Then in figure 1b, the annual mean precipitation for historical period (1985 – 2014) and future projections (2015 – 2050) are being shown. Here, the annual mean simulated precipitation during future projection shows no changes during January, February, June, July, September and December or slightly decrease in March, April, October and November while slightly increase in the month of May and August indicating that less precipitation variation as seen from most of the months.

[55] *Mendez, et al. 2020. Performance Evaluation of Bias Correction Methods for Climate Change Monthly Precipitation Projections over Costa Rica. Water, 12- 482*
[56] *Varikoden, H, J. V. Revadekar, 2020. On the extreme rainfall events during the southwest monsoon season in northeast regions of the Indian subcontinent. Meteorol. Appl. 27-1822.*

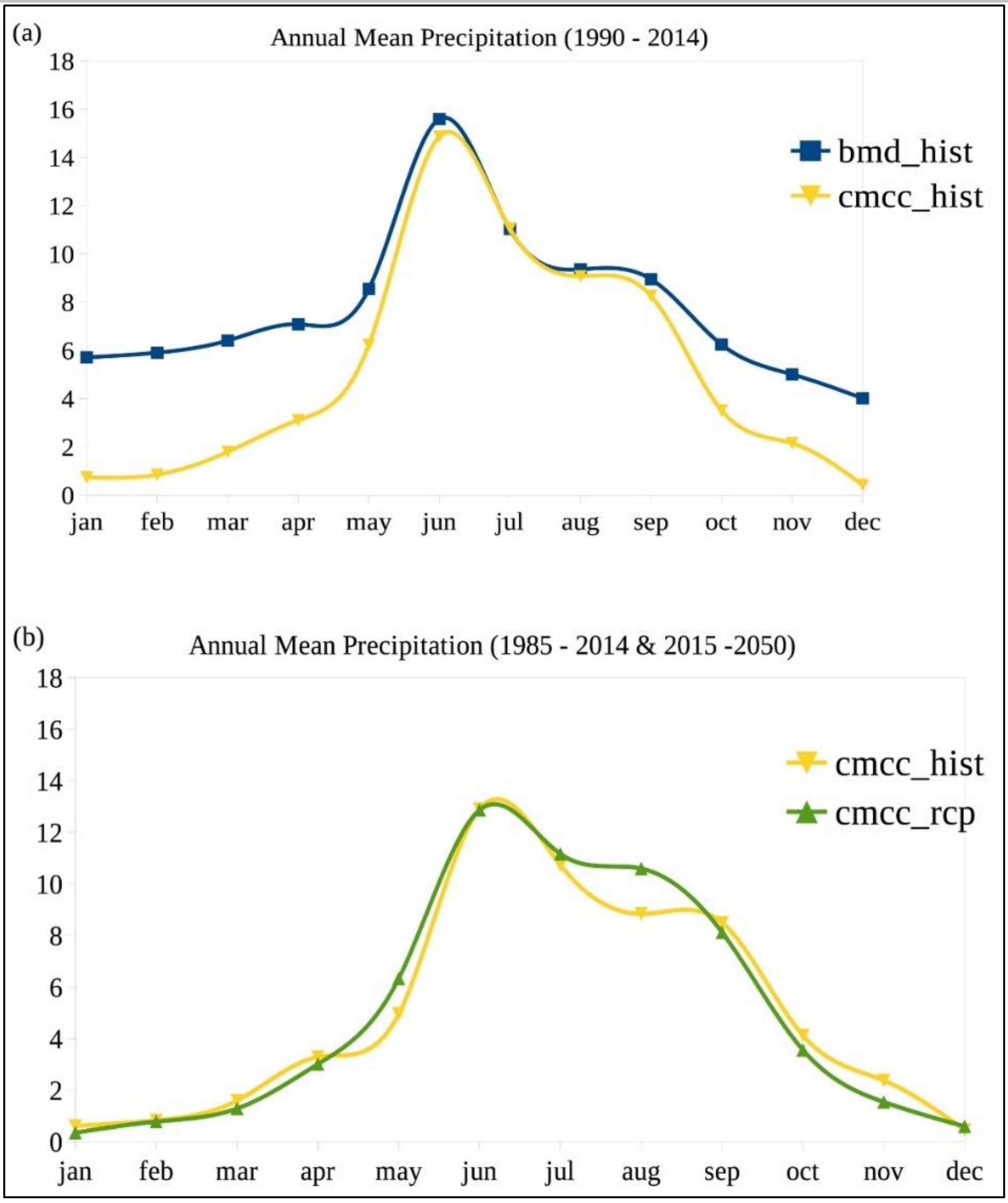


Figure 8.1: Annual mean cycle of precipitation (mm/day) over the project location

8.3.2 Historical area-averaged trend of annual mean precipitation from observation and model

In Figure 8.2, the month January, February, March, April May, October and December show significant decreasing trend at 95% confidence level as captured by both observation and model during historical period (1990 to 2014). While June and November show significant increasing precipitation trend at 95% confidence level though the observation data shows no trend during November. On the other hand, July, August and September months show no trend i.e., neither increasing nor decreasing trend as per the observed data though model captured a slightly increasing trend during July and September.

Most of the months show decreasing precipitation trend during the historical period as captured by both observation and model except for July, August and September.

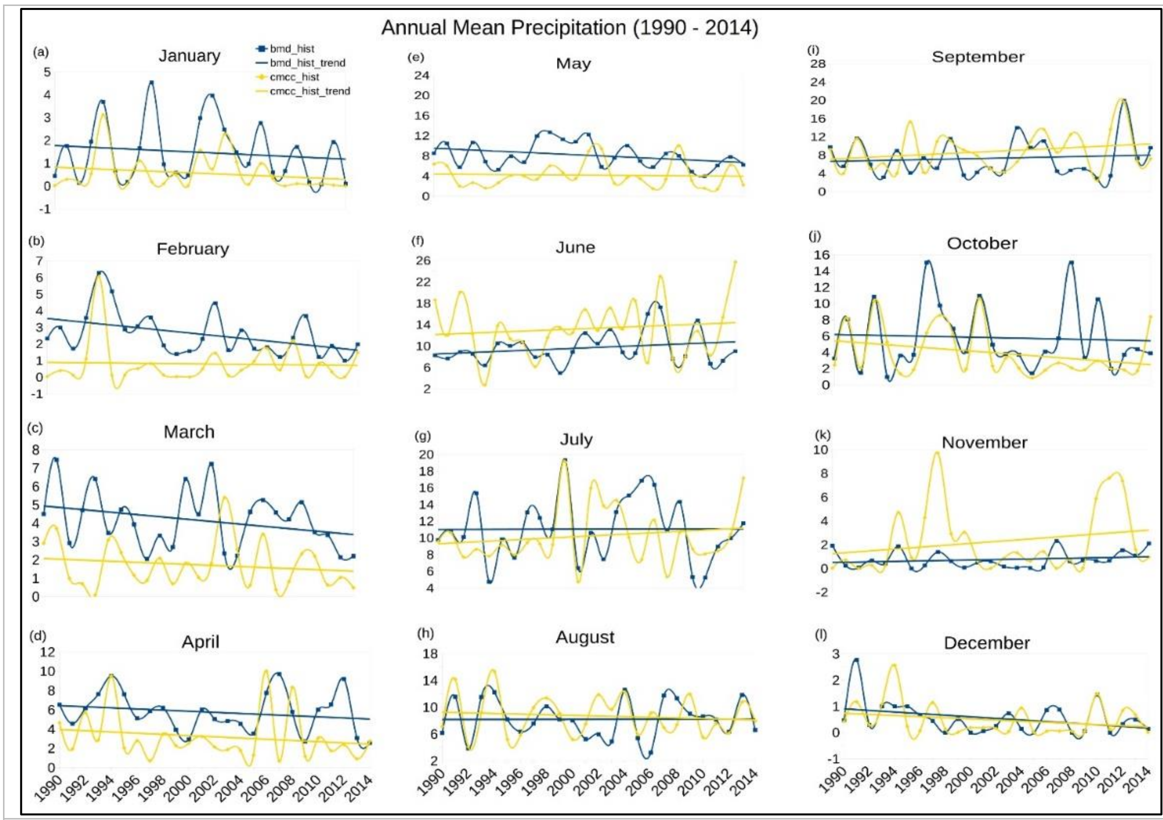


Figure 8.2: Area-averaged trend of annual mean precipitation (mm/day) from 1990 to 2014

Note: Observation data (BMD) and model (CMCC) over the Meghnaghat project location (23.125° N – 23.625° N through 90.25° E – 90.5° E).

8.3.3 Model future projected area-averaged trend of annual mean precipitation

Five months i.e. January, May, June, July and August show significant decreasing inter-annual precipitation trend at 95% confidence level in future projections (figure 3). While February, March, April, September, October, November and December months show no trend towards the future projections. The interannual monthly mean precipitation over the project location indicates that the precipitation is either decreasing in some of the months or show any changes in future projections.

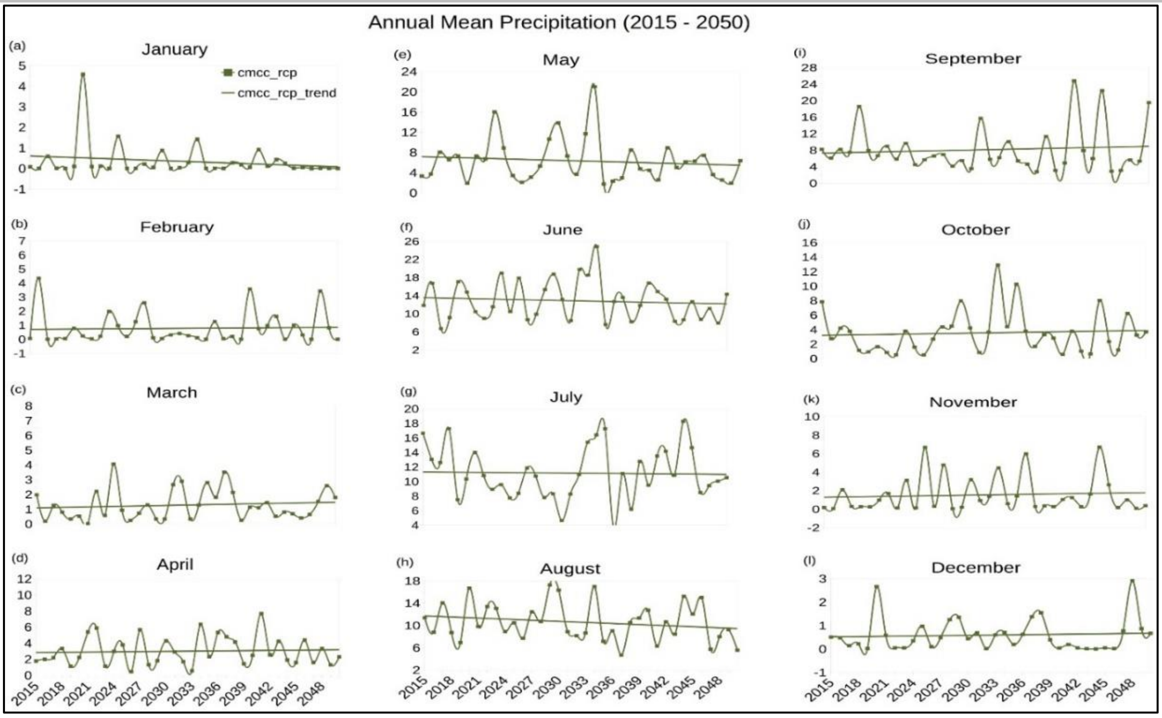


Figure 8.3: Area-averaged trend of annual mean precipitation (mm/day) during future projection (2015 to 2050)

Note: *Sourced from Model (CMCC) over the Meghnaghat project location (23.125° N – 23.625° N through 90.25° E – 90.5° E).*

8.3.4 Seasonal precipitation climatology during historical and future projections

In summer monsoon precipitation climatology slightly increases significantly during historical period (1985 to 2014) while slightly decreases significantly at 95% confidence level during future projection. Winter monsoon precipitation climatology shows no trend meaning that the precipitation neither increases nor increases during both the period. During pre-monsoon season, precipitation climatology decreases significantly at 95% significance level while shows no trend during future projections. Coming to post-monsoon season, precipitation climatology shows no trend during both the periods indicating no changes in precipitation over the region.

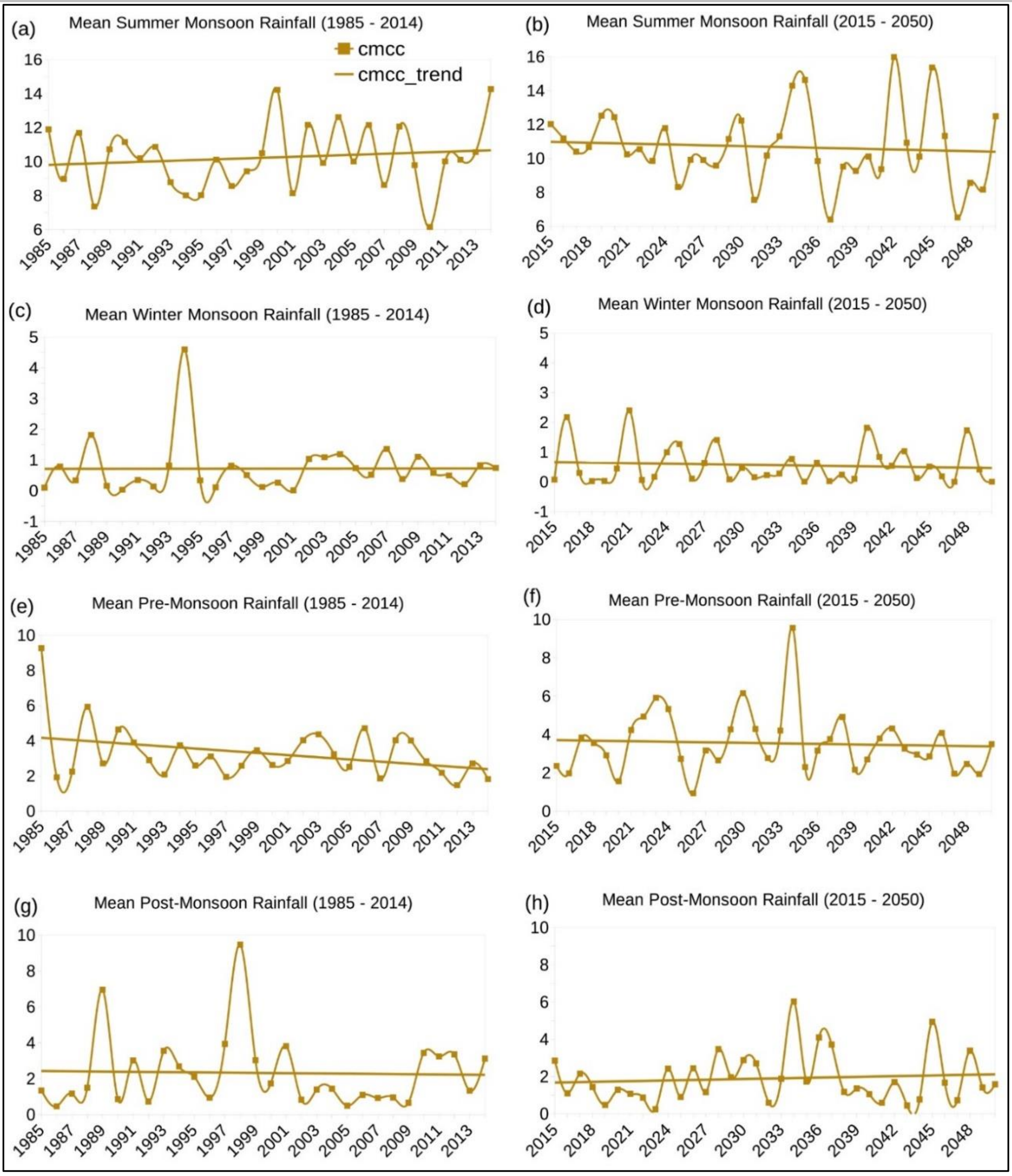


Figure 8.4: Area-averaged trend of seasonal precipitation climatology (mm/day) during historical period (1985 to 2014).

8.3.5 Spatial distribution of precipitation climatology (summer monsoon and winter monsoon) for historical and future projections

In Figure 8.5, the region bounded by black box is the project location and the nature of precipitation explained here is based on for this region only and why large region is being taken is already explained in the methodology section. The climatological precipitation ranges between 11 mm/day to 13 mm/day during historical summer monsoon season (JJAS) in figure 5a. During the future summer monsoon projection (5b), it shows similar precipitation climatological range with more of decreasing mean value. The difference between the future precipitation climatology and historical precipitation climatology (5c) shows that almost the entire project location ranges between 0.6 mm to 0.7 mm indicating a slight change during the future period, with few exceptions ranging between 0.4 mm to 0.5 mm. During winter monsoon season (5d & e), the future projected precipitation climatology shows lower mean value than the historical simulation ranging between 0.5 mm/day to 0.6 mm/day (future projection) and

0.7 mm/day to 0.8 mm/day (historical simulation). The difference between them (5f) also show lower mean value ranging between -0.15 mm to -0.1 mm indicating decreasing precipitation climatology during this season.

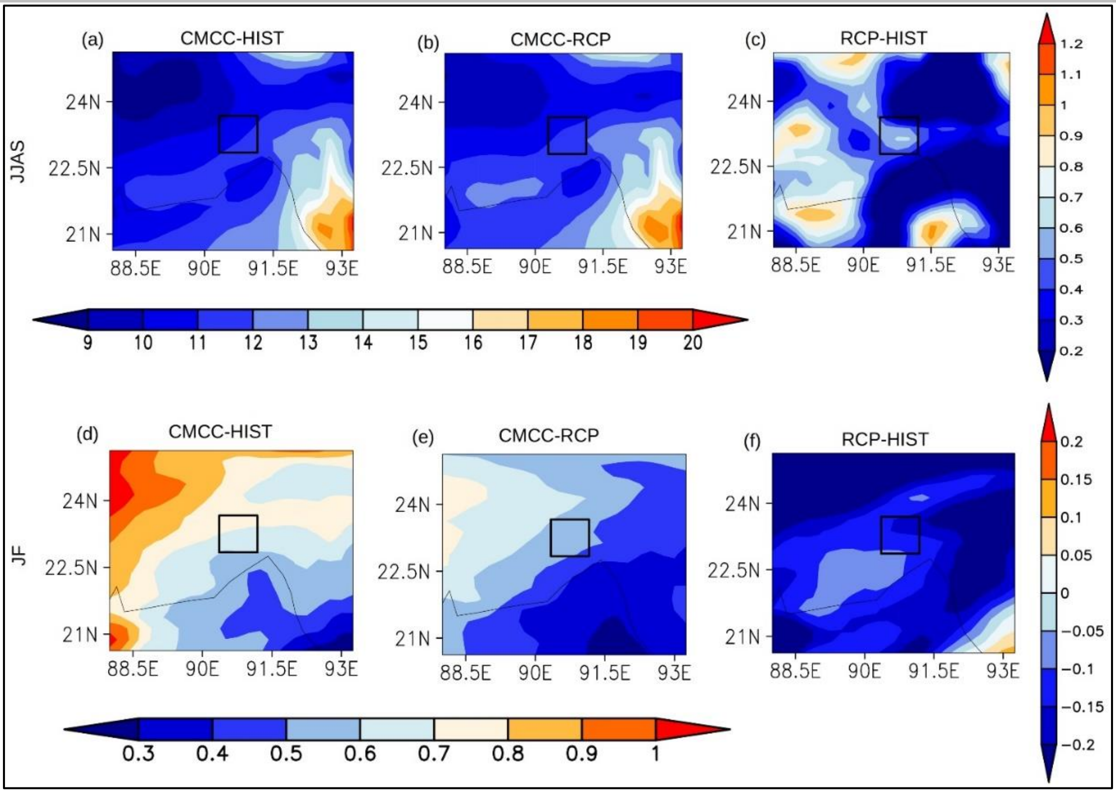


Figure 8.5: Spatial distribution of precipitation climatology (mm/day) for summer monsoon season

8.3.6 Spatial distribution of precipitation climatology (pre-monsoon and post-monsoon) for historical and future projections

In ***Figure 8.6***, the precipitation climatology pre-monsoon season ranges between 3.5 mm/day to 4 mm/day during historical period with a slight increase mean value of 4 mm/day during the future projections (6b). The difference between them shows higher climatological precipitation of 0.2 mm (6c). During the post-monsoon season, the precipitation climatology ranges between 2.4 mm/day to 2.6 mm/day (historical) in figure 6d while decreases during future projections (6e) ranging between 2 mm/day to 2.2 mm/day. The difference between these two periods (6f) also show a decreasing precipitation climatology ranging between -0.4 mm to -0.2 mm.

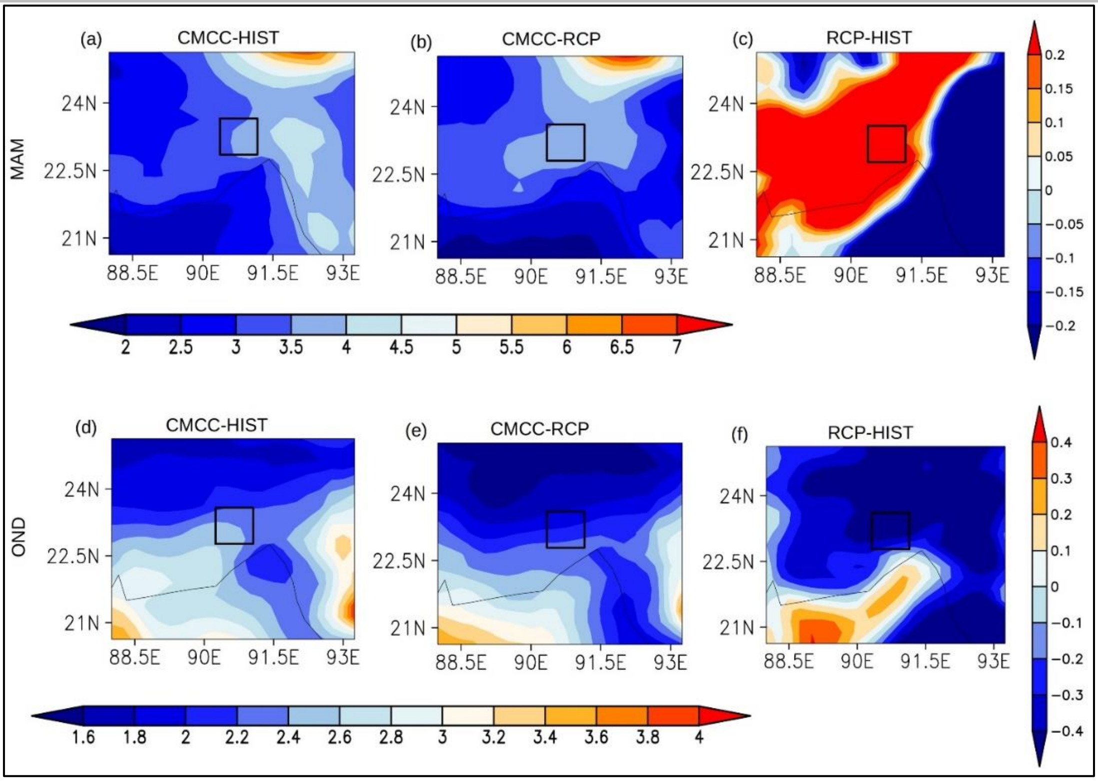


Figure 8.6: Spatial distribution of precipitation climatology (mm/day) for pre-monsoon season (MAM)

8.3.7 Annual mean cycle of maximum temperature from observation and model

In, the observed annual mean maximum temperature is validated against the model simulated annual mean maximum temperature for historical period (1990 to 2014) precipitation over the Meghnaghat project location (23.125° N – 23.625° N through 90.25° E – 90.5° E). The model simulates similar pattern of maximum temperature as in the observation pattern though the model slightly underestimates the magnitude of the maximum temperature. The highest maximum temperature is found in the month of April followed by the lowest in January month by both the observation data as well as the model. The mean maximum temperature is found to be slightly increasing during future projection in the month of April, June, July, August, September and October (7b).

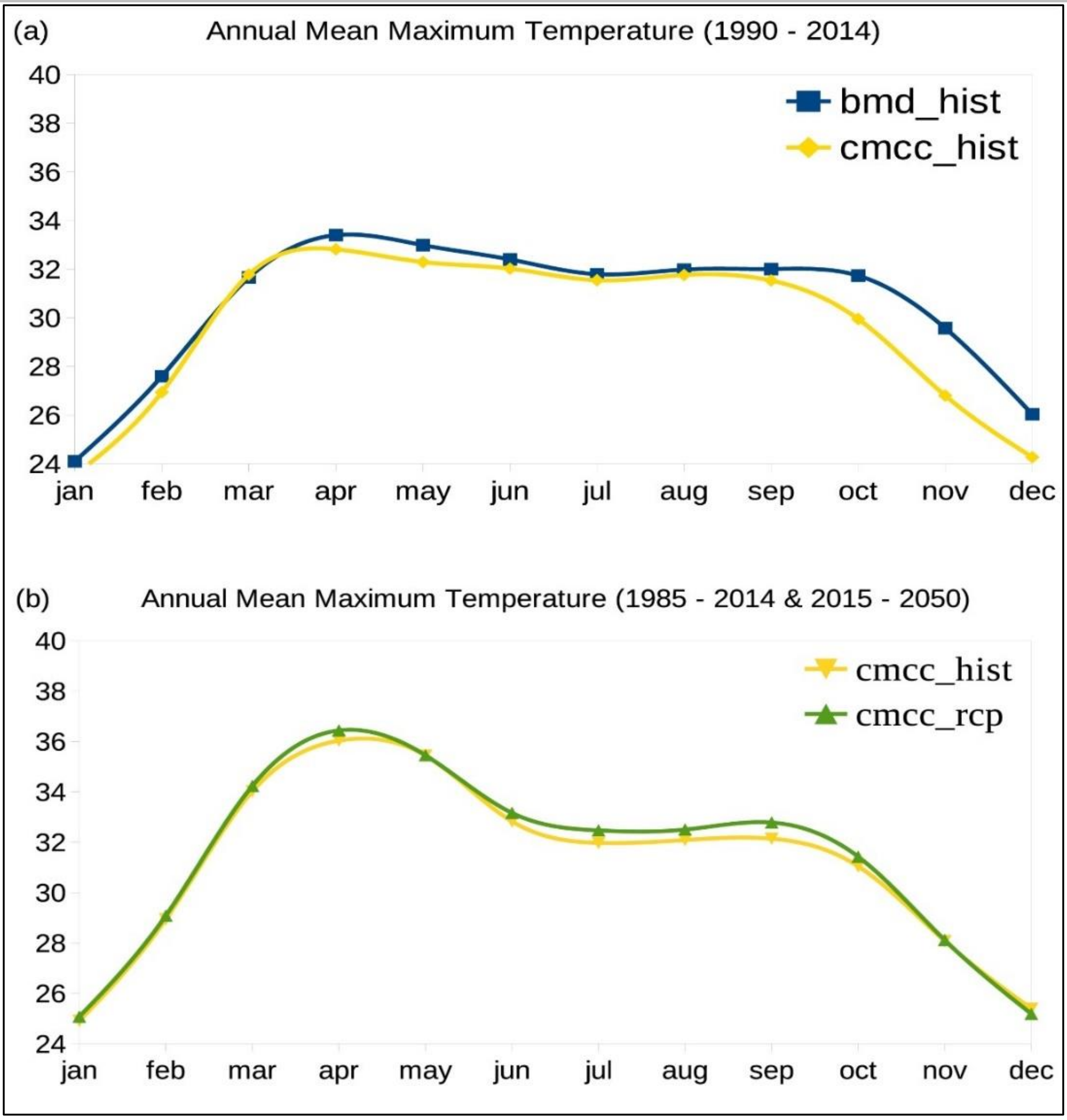


Figure 8.7 Annual mean cycle of maximum temperature (°C) over the project location

8.3.8 Historical area-averaged trend of annual mean maximum temperature from observation and model

In ***Figure 8.8,*** January, March, April, September and October months show significant increasing trend of maximum temperature from both the observation and model during historical period (1990 to 2014). While the month of June, July and August show slightly increasing trend significantly at 95% confidence level. November month shows no trend in both the observation as well as the model simulation while in February month, observation shows slightly increasing trend and slightly decreasing simulated maximum temperature trend but significantly at 95% confidence level. December is the only month showing significant decreasing trend of maximum temperature.

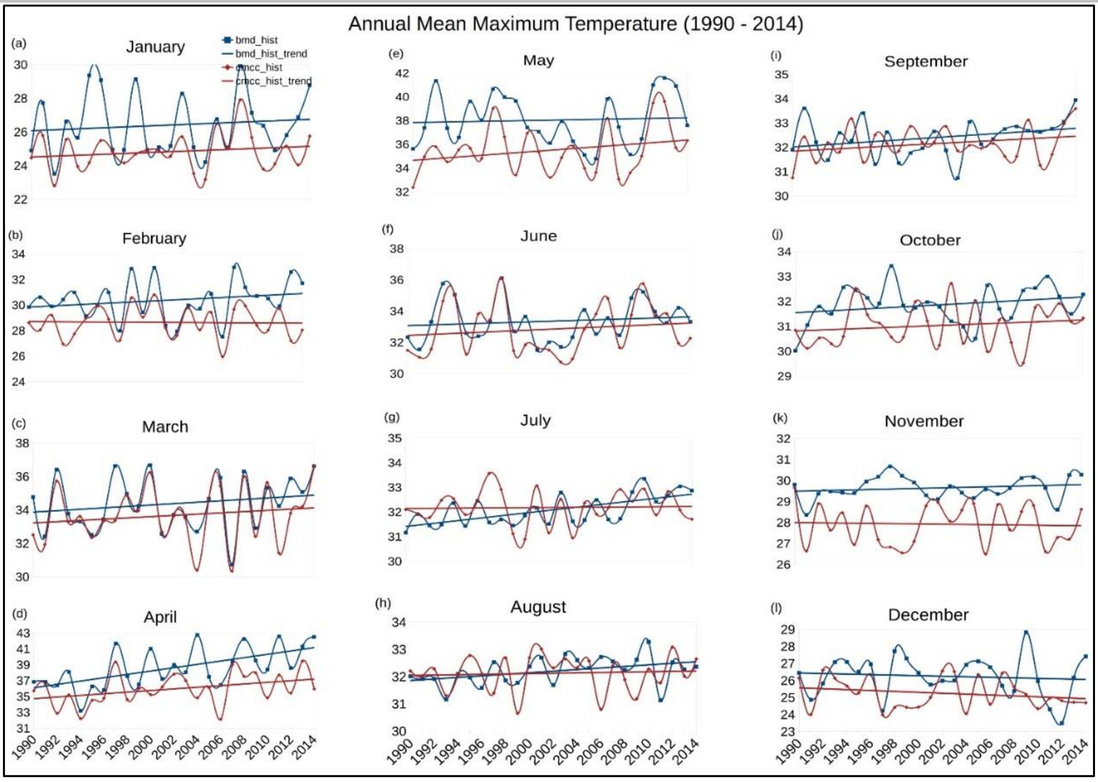


Figure 8.8: Area-averaged trend of annual mean maximum temperature (°C) during historical period (1990 to 2014)

8.3.9 Model future projected area-averaged trend of annual mean maximum temperature

The maximum temperature, over the project location, in all the months increases significantly at 95% confidence level towards the future projection (2015 to 2050) except for March and April month as both show no trend (***Figure 8.9***).

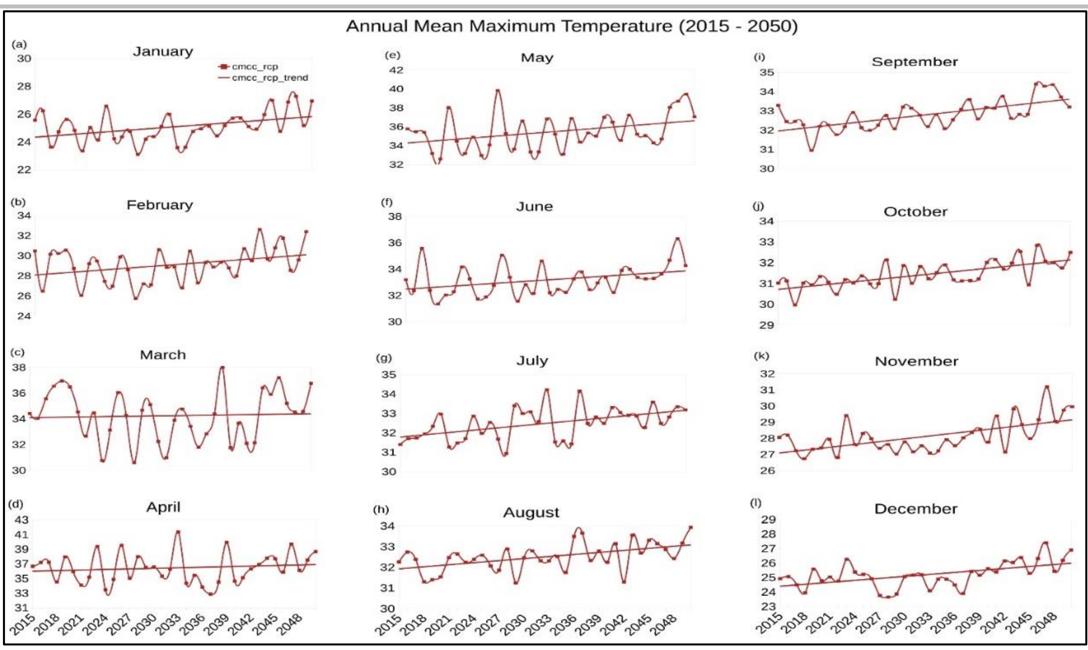


Figure 8.9: Area-averaged trend of annual mean maximum temperature (°C) during future projection (2015 to 2050)

8.3.10 Seasonal maximum temperature climatology during historical and future projections

In ***Figure 8.10***, maximum temperature during summer monsoon season for historical as well as for future projection increases significantly at 95% confidence level. As for winter monsoon season, the maximum temperature climatology decreases during historical period while increases during future projections significantly at 95% confidence level.

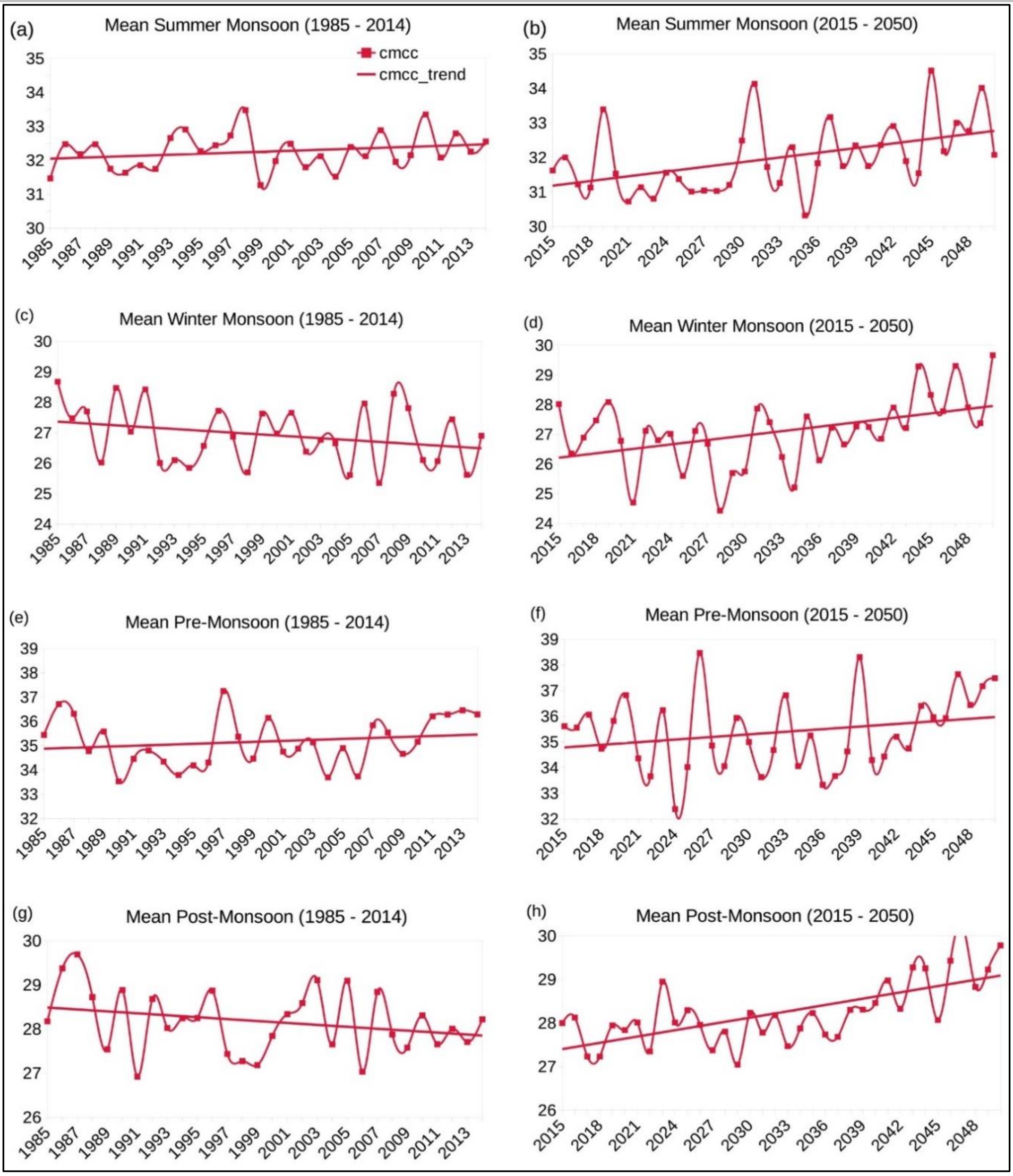


Figure 8.10: Area-averaged trend of seasonal maximum temperature climatology (°C) during historical period (1985 to 2014)

8.3.11 Spatial distribution of maximum temperature climatology (summer monsoon and winter monsoon) for historical and future projections

In ***Figure 8.11***, the summer monsoon maximum temperature climatology (11a) during historical period (1985 to 2014) ranges between 31.5° C to 32.5° C with an increasing maximum temperature climatology (11b) ranging between 32.5° C to 33° C in future projection. The difference between these two periods also shows an increasing maximum temperature climatology ranging between 0.3° C to 0.4° C. During winter monsoon season, the maximum temperature climatology ranges between 26.5° C to 28° C in historical period (11d) with an increasing maximum temperature climatology ranging between 27° C to 28.5° C in future projection (11e). The difference between them shows a slight increasing maximum temperature climatology ranging between 0.2° C to 0.6° C in most of the area (8.11f).

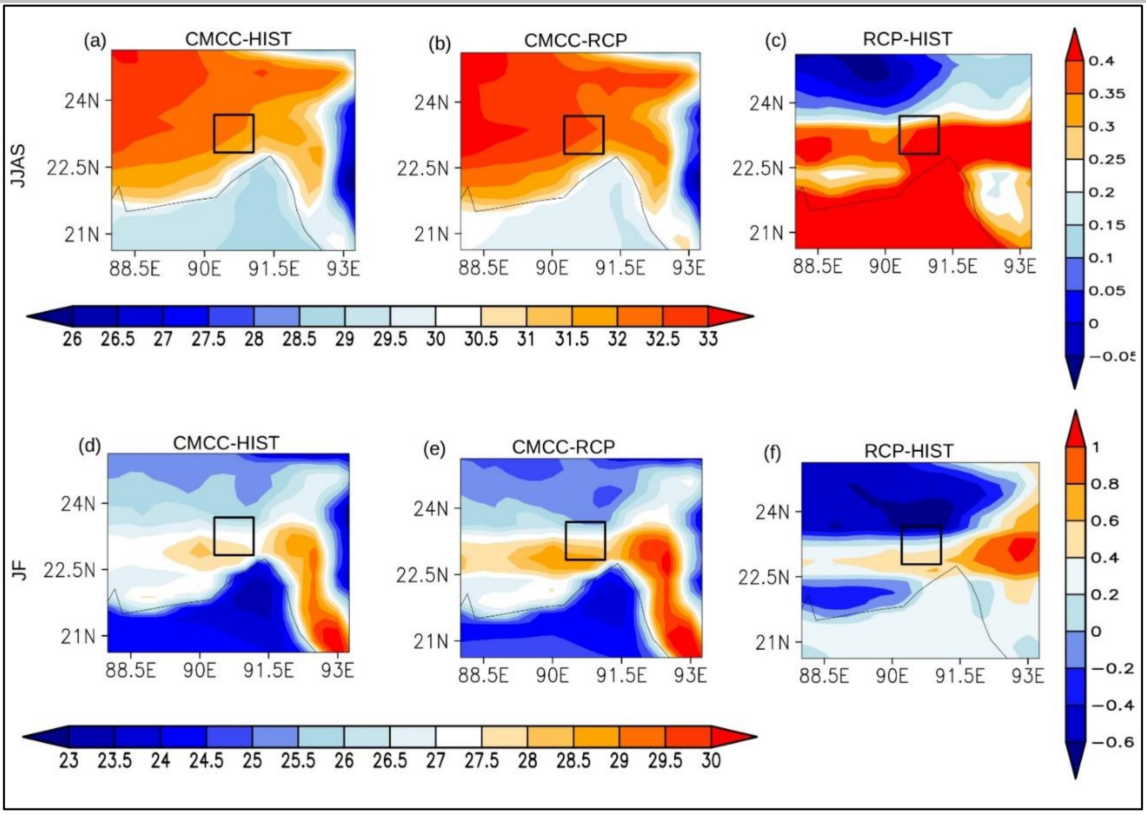


Figure 8.11: Spatial distribution of maximum temperature climatology (°C) for summer monsoon season (2015 to 2050).

8.3.12 Spatial distribution of maximum temperature climatology (pre-monsoon and post-monsoon) for historical and future projections

In **Figure 8.12**, the maximum temperature climatology for pre-monsoon season during historical period (1985 to 2014) shows lower mean value ranging between 34° C to 35° C (12a) with an increasing maximum temperature climatology during future projection (2015 to 2050) ranging between 35° C to 36° C (12b). The difference between these two periods shows a slight increasing maximum temperature climatology ranging between 0.2° C to 0.4° C in most of the area (12c). During post-monsoon season, the maximum temperature climatology is lower than the future projection ranging between 28° C to 29° C (12d) and higher maximum temperature climatology ranging between 28° C to 29.5° C in future projection (12e). The difference between these two periods shows a slightly higher maximum temperature climatology ranging between 0.2° C to 0.4° C with few exceptions of lower temperature ranging between -0.4° C to -0.2° C.

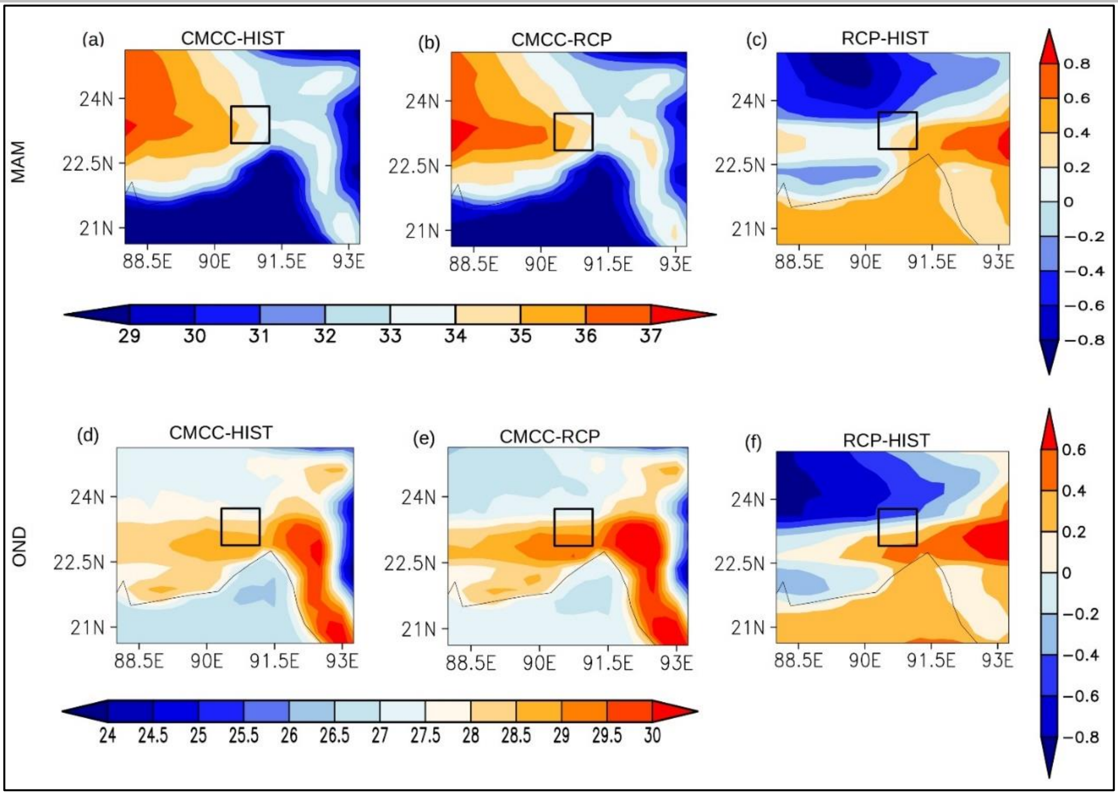


Figure 8.12: Spatial distribution of maximum temperature climatology (°C) for pre-monsoon season (2015 to 2050).

8.3.13 Annual mean cycle of minimum temperature from observation and model

In ***Figure 8.13,*** the simulated annual mean minimum temperature is validated against the observed annual mean minimum temperature for historical period (1990 to 2014). The model simulates a similar pattern of annual mean minimum temperature as in observation data with highest minimum temperature in August month and lowest during January month. The simulated magnitude of the minimum temperature is more or less similar to that of the observed minimum temperature. The annual mean minimum temperature during future projection is slightly higher than the annual mean minimum temperature from April to October months.

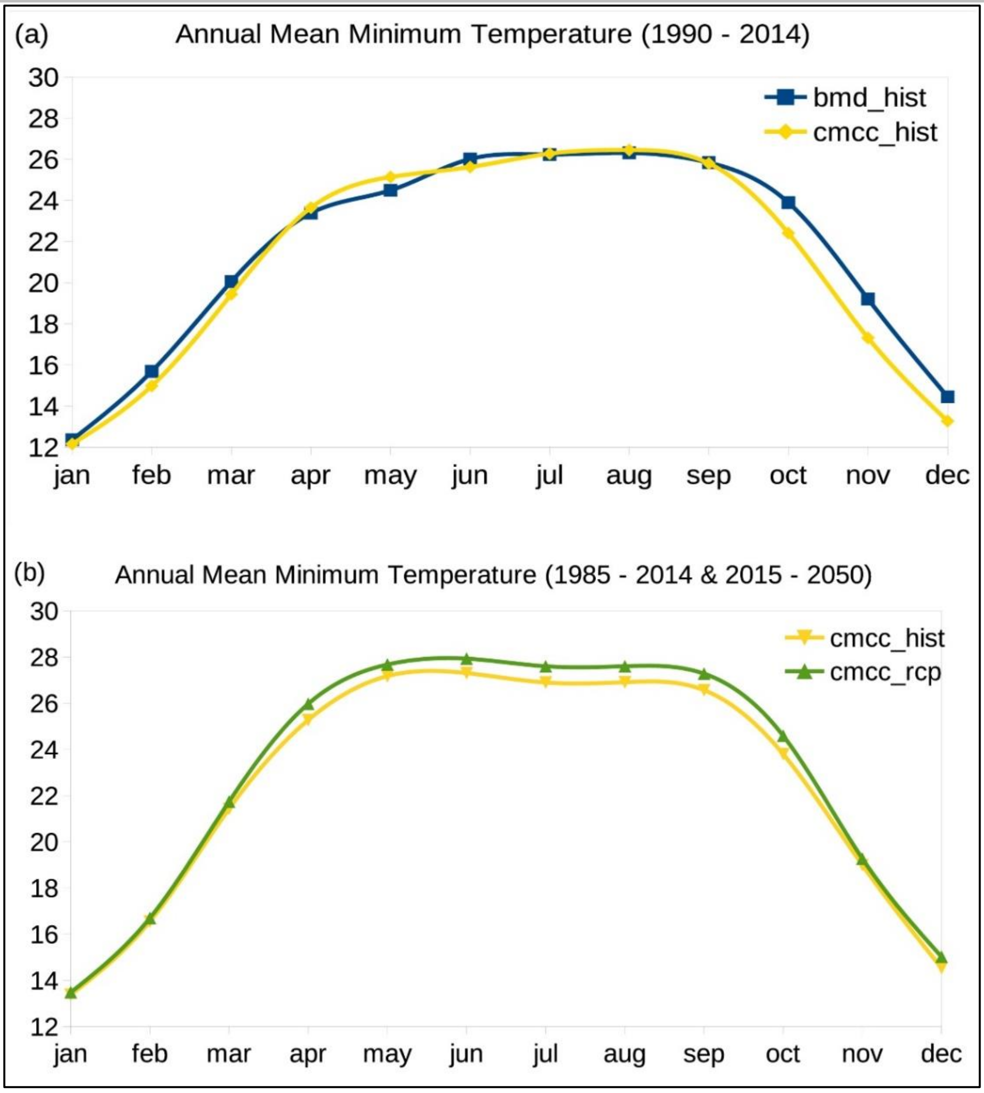


Figure 8.13: Annual mean cycle of minimum temperature (°C) over the Meghnaghat project location

8.3.14 Historical area-averaged trend of annual mean minimum temperature from observation and model

In ***Figure 8.14***, mean simulated as well as observed minimum temperature shows significant increasing trend at 95% significance level in all the months except in February month with no trend during the historical period (1990 to 2014) indicating a rise in temperature over the project location.

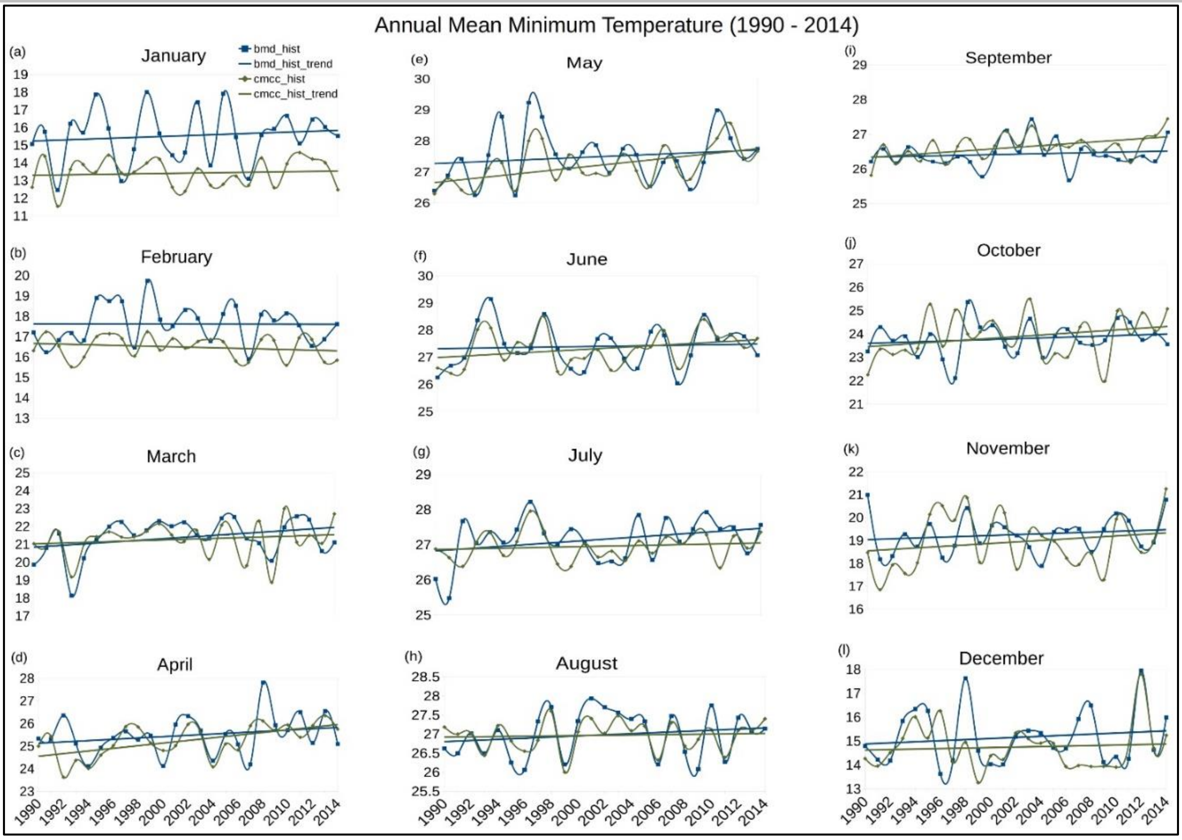


Figure 8.14: Area-averaged trend of annual mean minimum temperature (°C) during historical period (1990 to 2014)

8.3.15 Model future projected area-averaged trend of annual mean minimum temperature

In ***Figure 8.15,*** mean minimum temperature increases significantly at 95% confidence level in all the months during the future projection over the project location indicating a sharp rise in temperature.

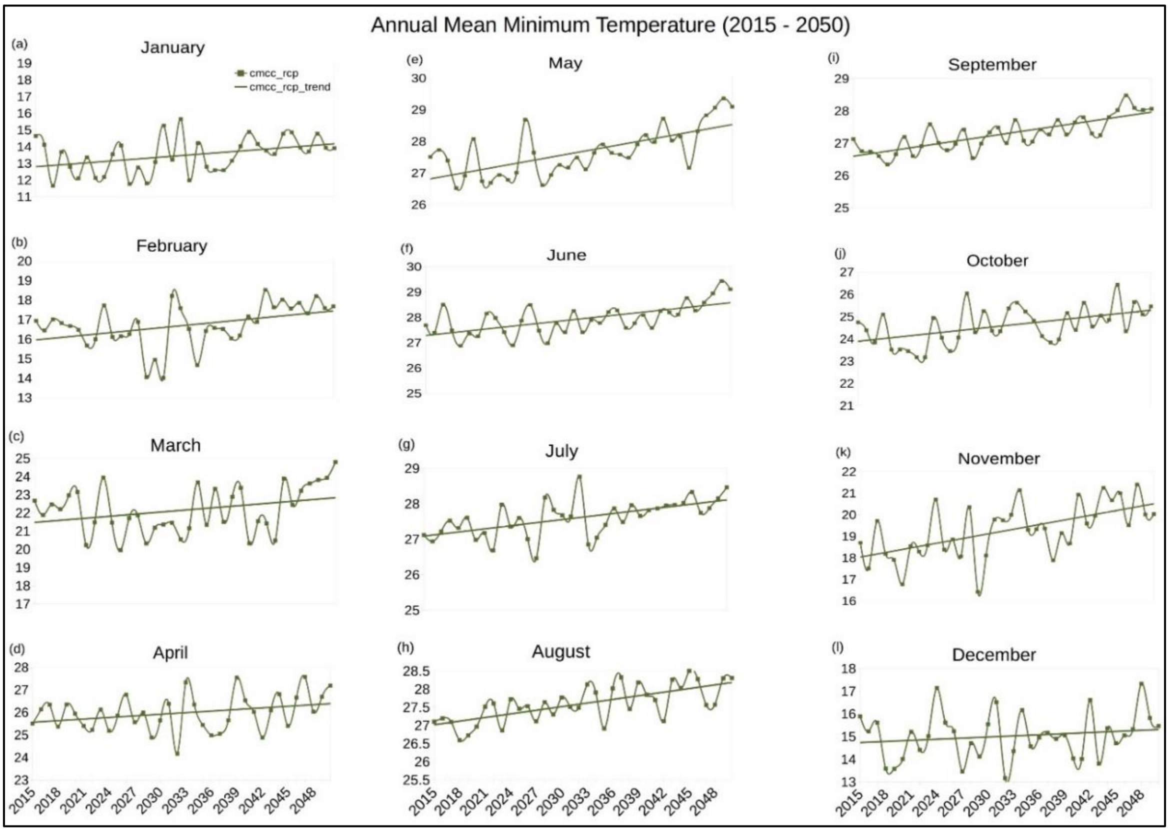


Figure 8.15: Area-averaged trend of annual mean minimum temperature (°C) during future projection (2015 to 2050)

8.3.16 Seasonal minimum temperature climatology during historical and future projections

In ***Figure 8.16,*** the minimum temperature climatology during the summer monsoon season increases significantly at 95% confidence level in both historical as well as future projection. The winter monsoon season shows a significant decreasing minimum temperature climatology during historical period while increasing trend significantly at 95% confidence level towards the future projections. As for pre-monsoon and post-monsoon season, the minimum temperature climatology slightly increases significantly at 95% confidence level during the historical period while sharply increases significantly towards the future projection at 95% confidence level.

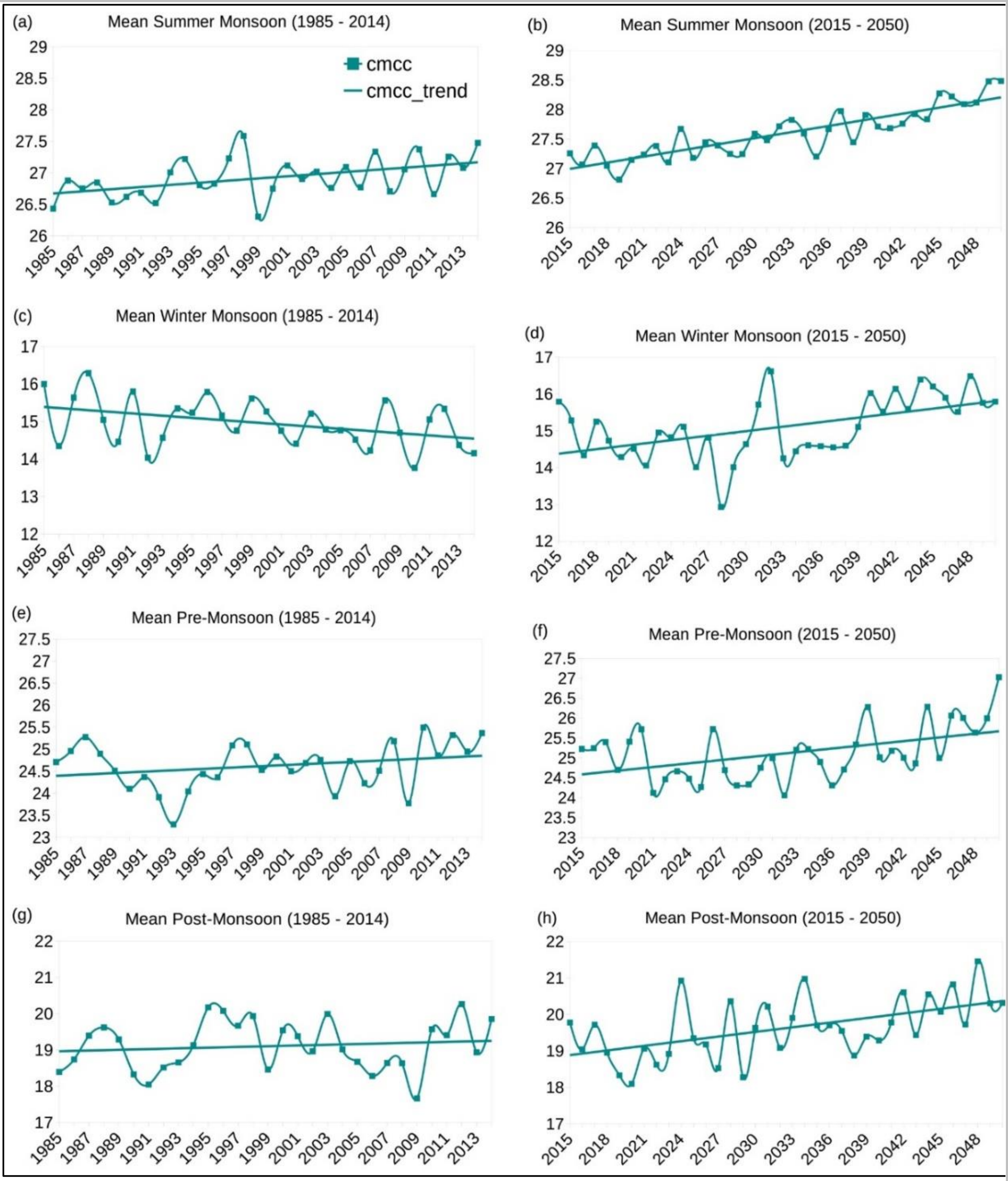


Figure 8.16: Area-averaged trend of seasonal minimum temperature climatology (°C)

In ***Figure 8.17***, the minimum temperature climatology during the historical summer monsoon season (17a) shows lower mean value of 27° C with an increasing minimum temperature climatology of 28° C during the future projection (17b). The difference between these two periods (17c) shows higher minimum temperature climatology ranging between 0.55° C to 0.6° C. For winter monsoon season, the minimum temperature climatology shows lower temperature of 15° C (17d) than the future projections with an increase minimum temperature climatology ranging between 19° C to 20° C (17e). The difference between them shows both decreasing (northern part) as well as increasing (southern part) temperature ranging between -0.1° C to 0.4° C (8.17f).

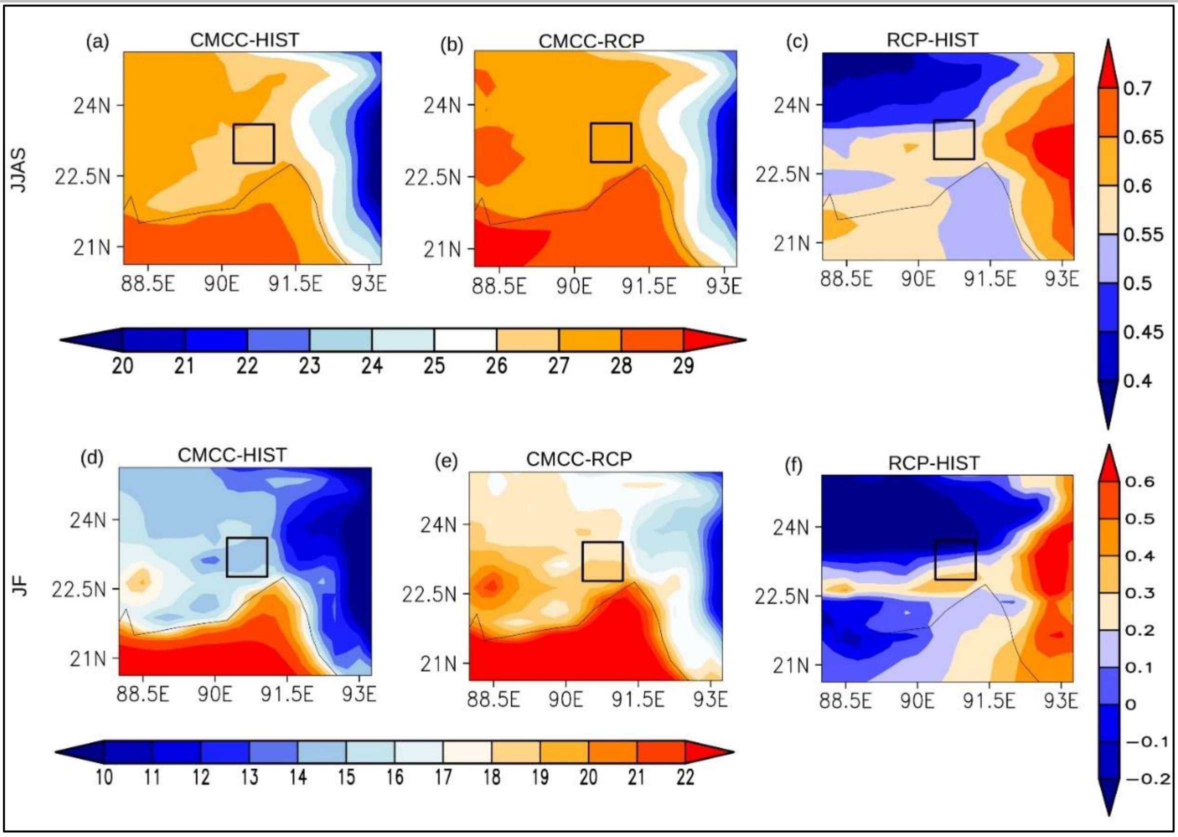


Figure 8.17: Spatial distribution of minimum temperature climatology (°C) for summer monsoon season

8.3.17 Spatial distribution of minimum temperature climatology (pre-monsoon and post-monsoon) for historical and future projections

In ***Figure 8.18***, the minimum temperature climatology during the historical pre-monsoon season (18a) shows lower temperature of 25° C with an increasing minimum temperature climatology ranging between 25° C to 26° C in future projection (18b). The difference between these two periods shows higher temperature ranging between 0.3° C to 0.6° C indicating rise in temperature in future projection (18c). During post-monsoon season, the minimum temperature climatology shows higher temperature in future projection (20 C) while in historical ranging between 19° C to 20° C (18d & e). The difference between the future projection and historical period shows increasing minimum temperature ranging between 0.5° C to 0.7° C in most of the entire area (8.18f).

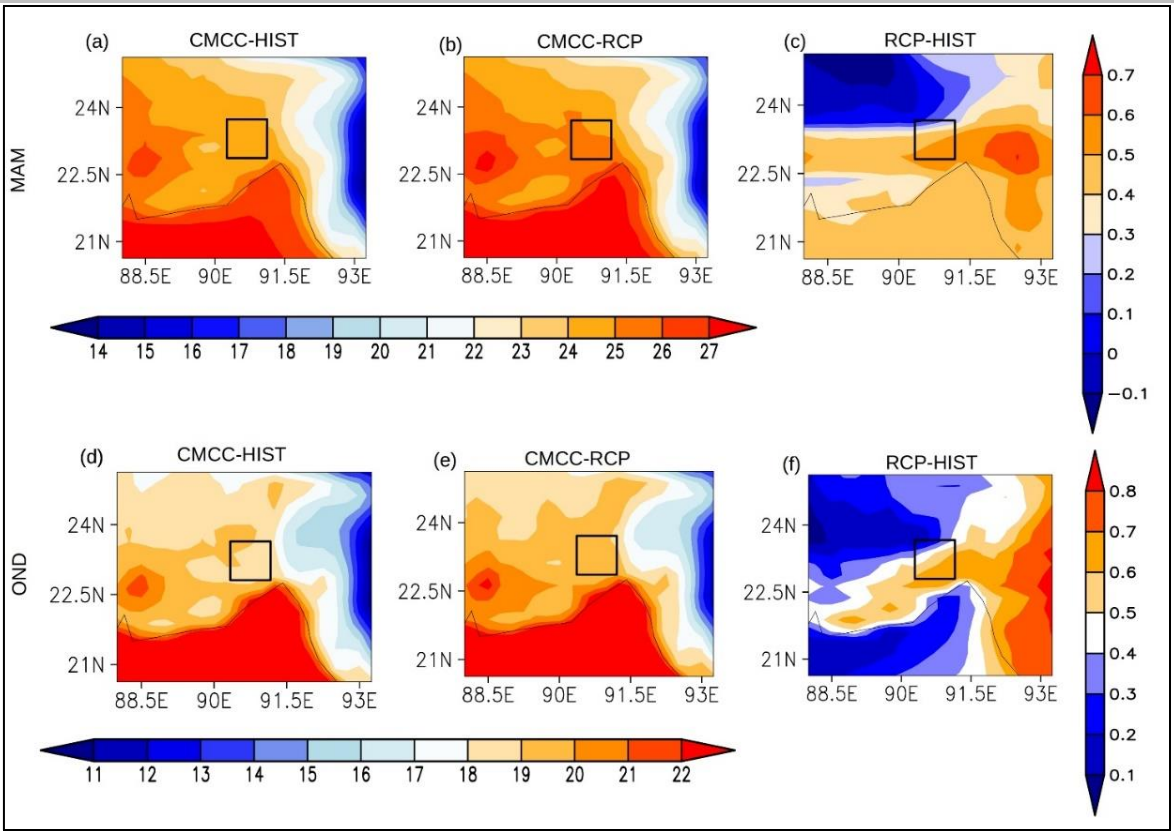


Figure 8.18: Spatial distribution of minimum temperature climatology (°C) for pre-monsoon season

8.3.18 Annual mean sea level rise for historical and future projections over the north of Bay of Bengal

In ***Figure 8.19***, the model (MIROC_HIST) simulated annual mean sea level rise is validated against the reanalysis (ECMWF_HIST) annual mean sea level rise data for historical period (1985 to 2005). Details of reanalysis data have been explained in the methodology section. From the figure, the magnitude of the model simulated sea level rise overestimates when compared to the reanalysis sea level rise data. However, the model simulates a similar pattern of the annual cycle of the sea level rise. The annual mean sea level rise in both RCP4.5 and RCP8.5 show higher mean values than the historical mean value indicating rise in sea level over the northern part of Bay of Bengal.

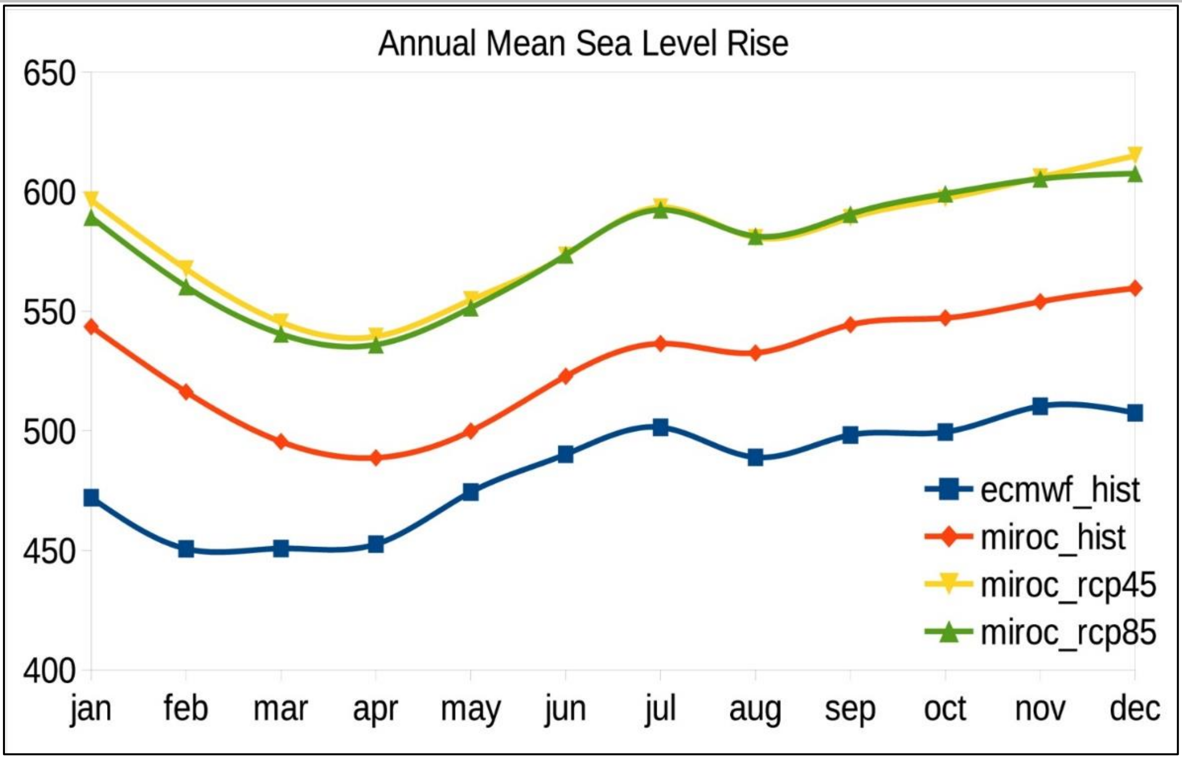


Figure 8.19: Annual mean cycle of sea level rise (mm) over the north Bay of Bengal for the period 2006 to 2050.

8.3.19 Historical area-averaged trend of annual mean sea level rise from observation and model

In ***Figure 8.20***, all the months show significant sharp increase in mean sea level rise at 95% confidence level except for June month with the magnitude of the sea level rise is slightly lesser compared to rest of the months even though it also shows increase in mean sea level rise. This could be probably due to set up of similar scales and intervals for all the months indicating that the rest of the months exhibit higher magnitude in the rise than the June month.

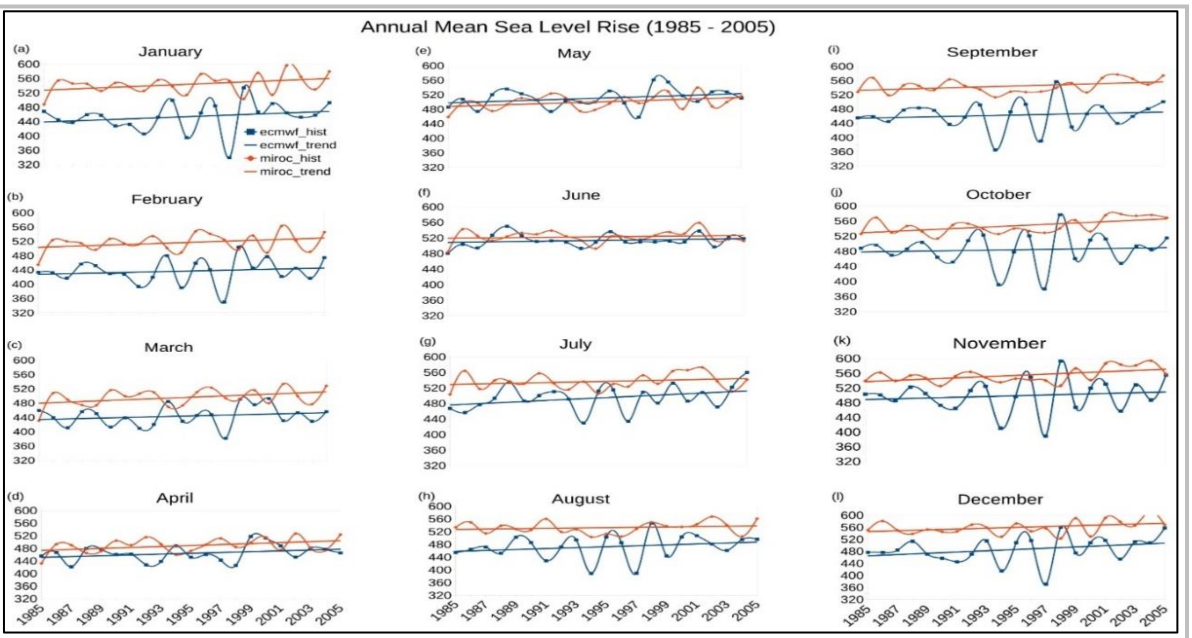


Figure 8.20: Area-averaged trend of annual mean sea level rise (mm) during historical period (1985 to 2005) from reanalysis data (ECMWF) and model (MIROC) over the northern part of Bay of Bengal.

8.3.20 Future projected area-averaged trend of annual mean sea level rise

In ***Figure 8.21***, the mean sea level rise increases significantly at 95% confidence level in all the months in future projection (2015 to 2050) over the northern part of Bay of Bengal.

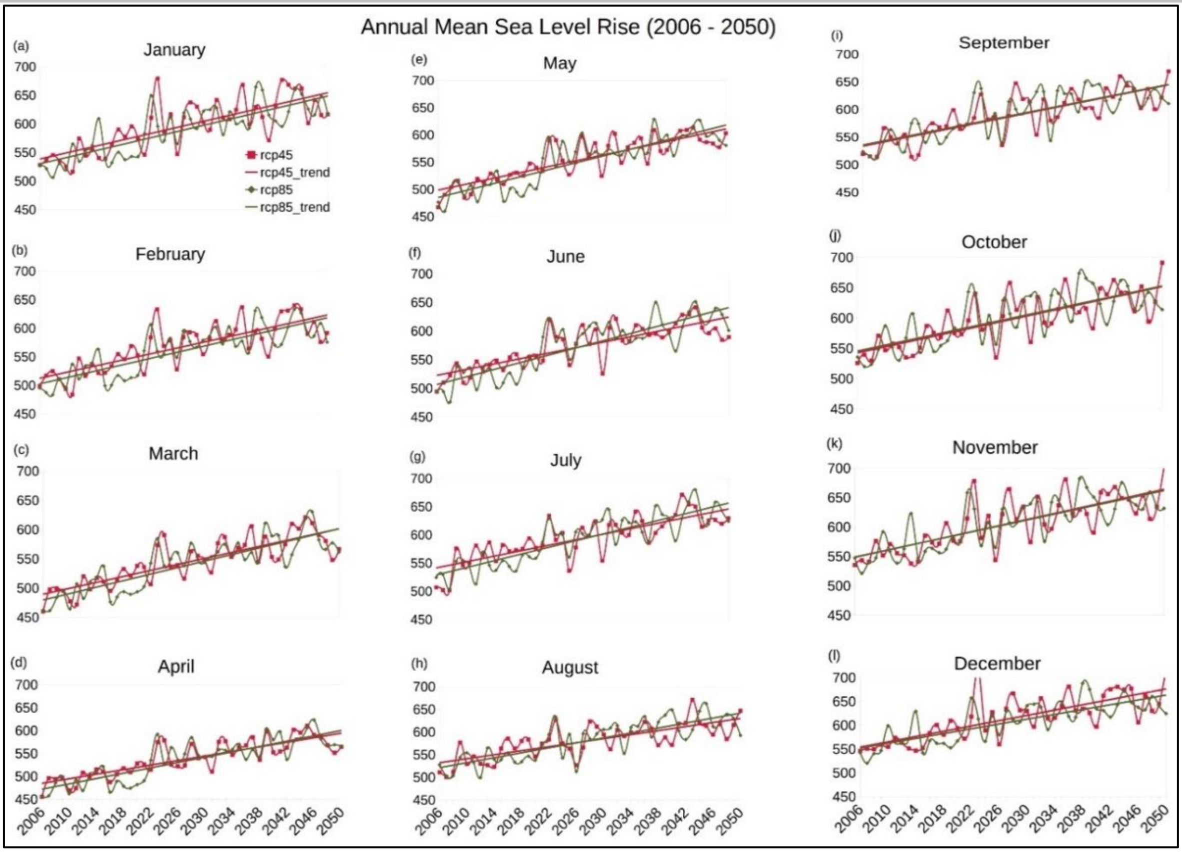


Figure 8.21: Area-averaged trend of annual mean sea level rise (mm) for future projection (2015 to 2050) over the north Bay of Bengal as simulated by MIROC model. over the northern part of Bay of Bengal.

8.3.21 Spatial distribution of sea level rise climatology (January, February, March and April) for historical and future projections

In ***Figure 8.22,*** the sea level rise climatology distribution over the northern part of Bay of Bengal during the historical period depicts a rise ranging between 540 mm to 580 mm in January and February months while during the future projections, the overall sea level rise increases with 560 mm to 580 mm in both the months. In March and April, increase in sea level rise climatology, 510 mm to 540 mm, is also seen though a bit weaker in magnitude than the previous months in historical period. However, these two months also show a rise in the sea level ranging between 540 mm to 580 mm in future projection.

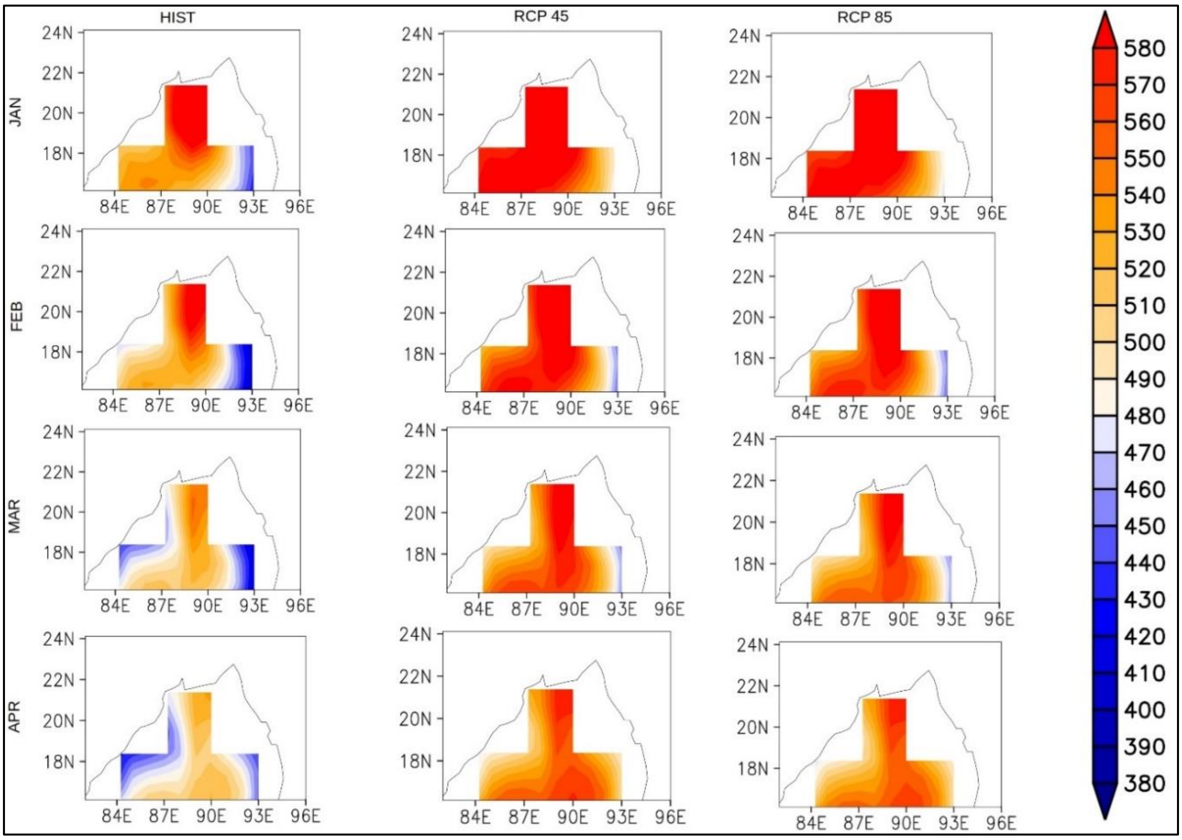


Figure 8.22 : Spatial distribution of sea level rise climatology (mm)

8.3.22 Spatial distribution of sea level rise climatology (May, June, July and August) for historical and future projections

The sea level rise climatology distribution in May shows slightly weaker in magnitude, 510 mm to 540 mm, than rest of the months in ***Figure 8.23.*** However, in most parts of the northern Bay of Bengal, in all the months it shows a rise in the climatology ranging between 540 mm to 580 mm in June, July and August during the historical period. In future projection also, similar pattern is found in the month of May though it increases with 550 mm to 580 mm while rest of the months show sharp increase ranging between 570 mm to 580 mm.

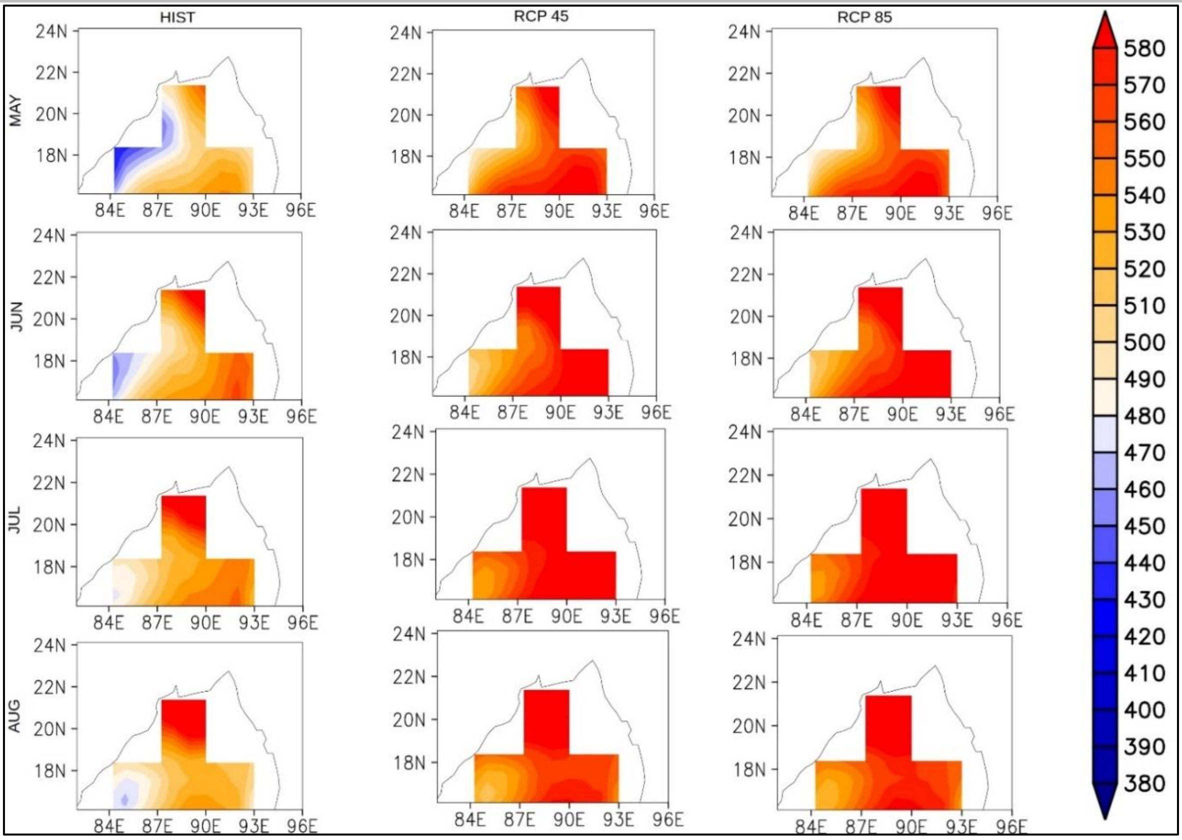


Figure 8.23: Spatial distribution of sea level rise climatology (mm)

8.3.23 Spatial distribution of sea level rise climatology (September, October, November and December) for historical and future projections

The sea level rise climatology distribution in all the months show rise in the historical period ranging between 540 mm to 580 mm in ***Figure 8.24***. During the future projection also, all the months depict sharp increase in the sea level rise climatology distribution in the entire northern part of Bay of Bengal ranging between 560 mm to 580 mm.

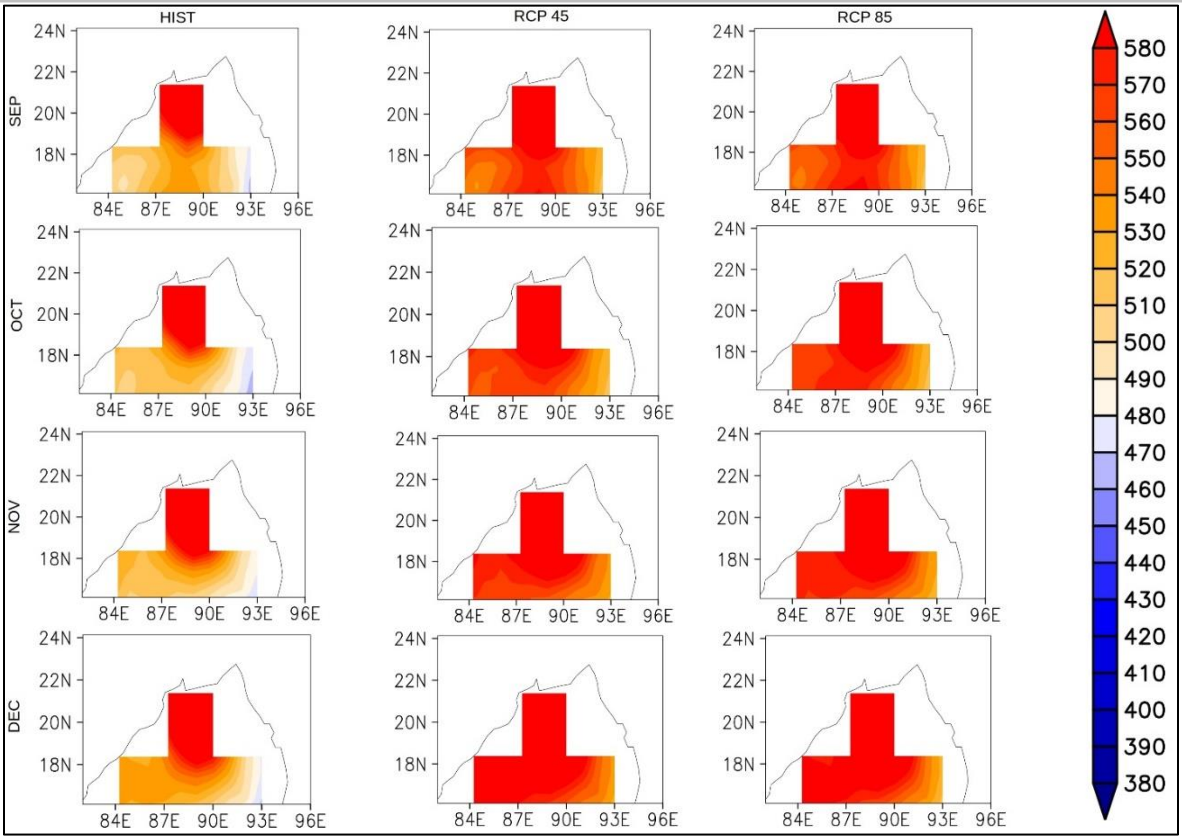


Figure 8.24: Spatial distribution of sea level rise climatology (mm).

8.3.24 Spatial distribution of sea level rise trend (January, February, March and April) for historical and future projections

In ***Figure 8.25***, the distribution of sea level rise shows an increasing trend of 1.8 mm/year to 2 mm/year towards the northern part of Bay of Bengal in the month of January, February and March during the historical period. April month also show an increasing trend of 1.7 mm/year to 1.9 mm/year. In future projection, RCP8.5 shows higher magnitude of trend than RCP4.5. In January and February months, though the sea level rise is slightly weaker towards the northern part of Bay of Bengal than rest of the months, both depict an increasing trend (RCP4.5) of 1.9 mm/year to 2.3 mm/year as compared to historical period. The sea level rise in March shows an increasing trend of 2.2 mm/year to 2.5 mm/year in RCP4.5 while in April month, it shows an increasing trend of 2.4 mm/year to 2.5 mm/year in RCP4.5. In RCP8.5, except for January month, rest of the months show an increasing trend of 2.8 mm/year to 3 mm/year while in January month, it shows an increasing trend of 2.9 mm/year to 3 mm/year in overall northern parts of the Bay of Bengal.

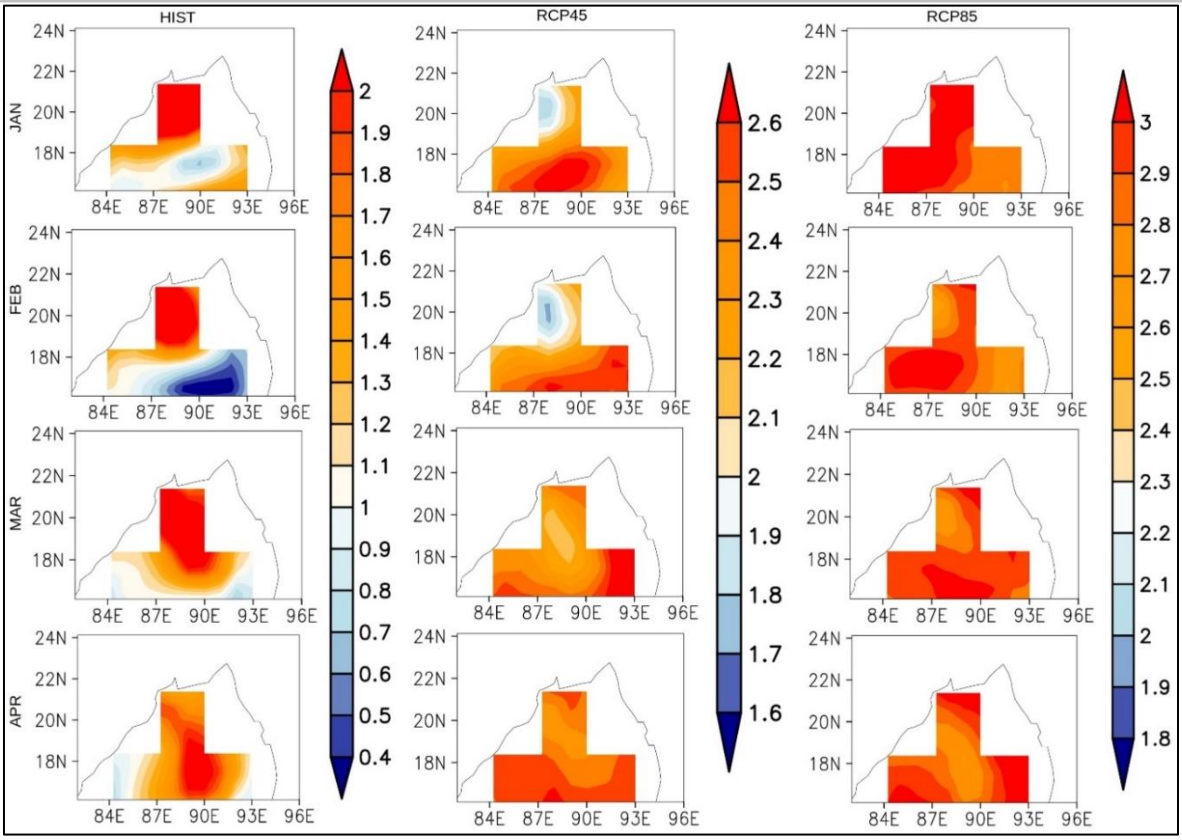


Figure 8.25: Spatial distribution trend of sea level rise (mm).

8.3.25 Spatial distribution of sea level rise trend (May, June, July and August) for historical and future projections

In ***Figure 8.26,*** May month shows higher sea level rise distribution in the magnitude with an increasing trend than rest of the months ranging between 1.3 mm/year to 1.5 mm/year in the historical period. July month also shows slightly higher sea level rise magnitude of trend with slightly variation in the distribution than June and August ranging between 0.5 mm/year to 1.3 mm/year. June and August months show weaker sea level rise magnitude of trend ranging between 0.5 mm/year to 0.9 mm/year. In RCP4.5, the sea level rise in May month shows highest than rest of the months with an increasing trend of 2.5 mm/year to 2.6 mm/year in most part of the northern Bay of Bengal. This is followed by July month with an increasing trend of 2.2 mm/year to 2.6 mm/year though the distribution of the sea level rise decreases towards the northern part of Bay of Bengal. June and August months also show an increasing trend of 2.1 mm/year to 2.4 mm/year in RCP4.5. In RCP8.5, May and June months show highest increasing trend of 2.9 mm/year to 3 mm/year than rest of the months. While July and August show slightly weaker distribution of sea level rise towards the northern part of Bay of Bengal but with an increasing trend of 2.6 mm/year to 2.9 mm/year as compared to historical simulations.

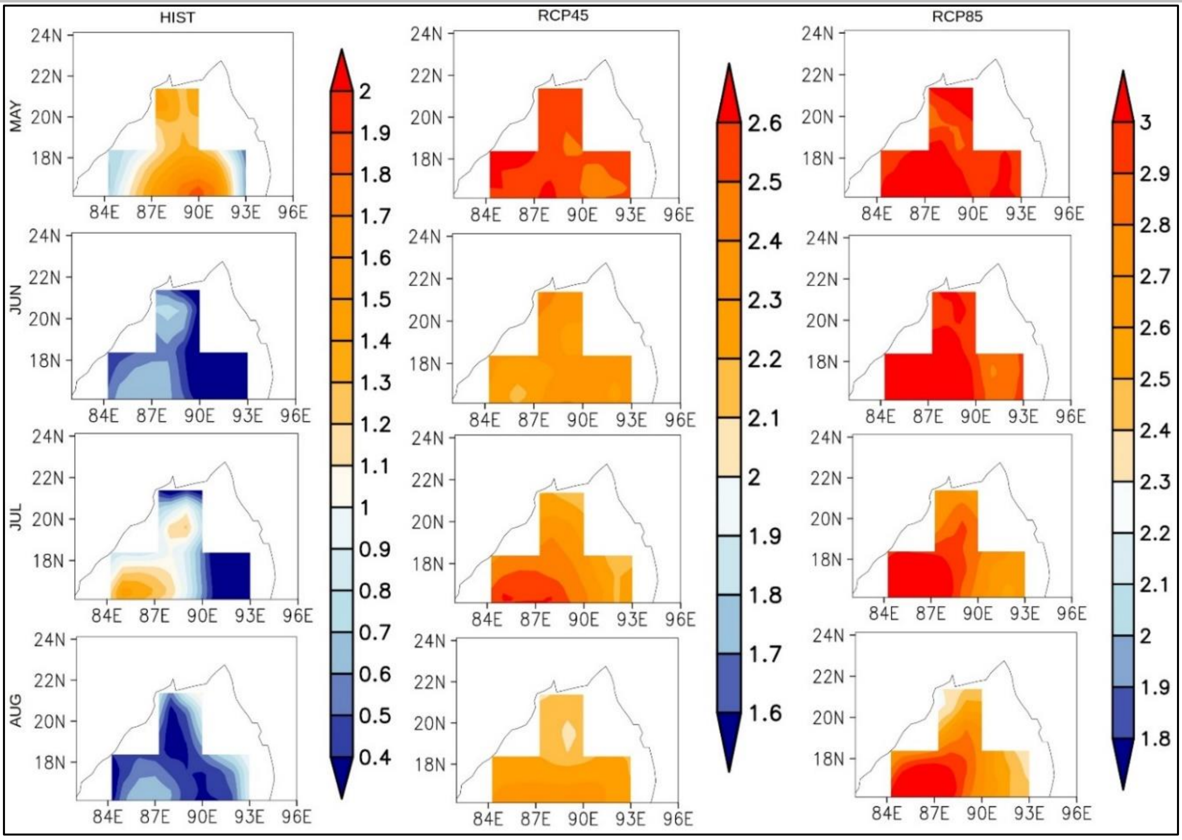


Figure 8.26: Spatial distribution trend of sea level rise (mm).

8.3.26 Spatial distribution of sea level rise trend (September, October, November and December) for historical and future projections

In **Figure 8.27**, September month shows slightly weaker trend of sea level rise distribution than rest of the months towards the northern part of Bay of Bengal with 1.3 mm/year to 1.6 mm/year with more lower trends in the north-central Bay of Bengal in historical period. October and November months show increasing trend of 1.6 mm/year to 2 mm/year towards the northern part of Bay of Bengal. December month shows an increasing trend of 1.8 mm/year to 2mm/year towards northern part of Bay of Bengal with lower distribution of sea level rise trends in rest of the region. In RCP4.5, May month shows slightly higher trend than rest of the months with an increment of 1.9 mm/year to 2 mm/year though the distribution of sea level rise is higher towards the central part of Bay of Bengal. October, November and December months show slightly weaker trends ranging between 1.6 mm/year to 2 mm/year in RCP4.5 with similar higher distribution of magnitude towards central part of the region. In RCP8.5, September and October months show slight lesser magnitude of trends than rest of the months though it increases between 2.4 mm/year to 2.9 mm/year with similar distribution as in RCP4.5. This is followed by November month, where the sea level rise shows slightly increasing trend than the previous months with 2.8 mm/year to 3 mm/year. As for the December month, it shows the highest magnitude of sea level rise with an increasing trend of 3 mm/year in almost all the entire region in RCP8.5.

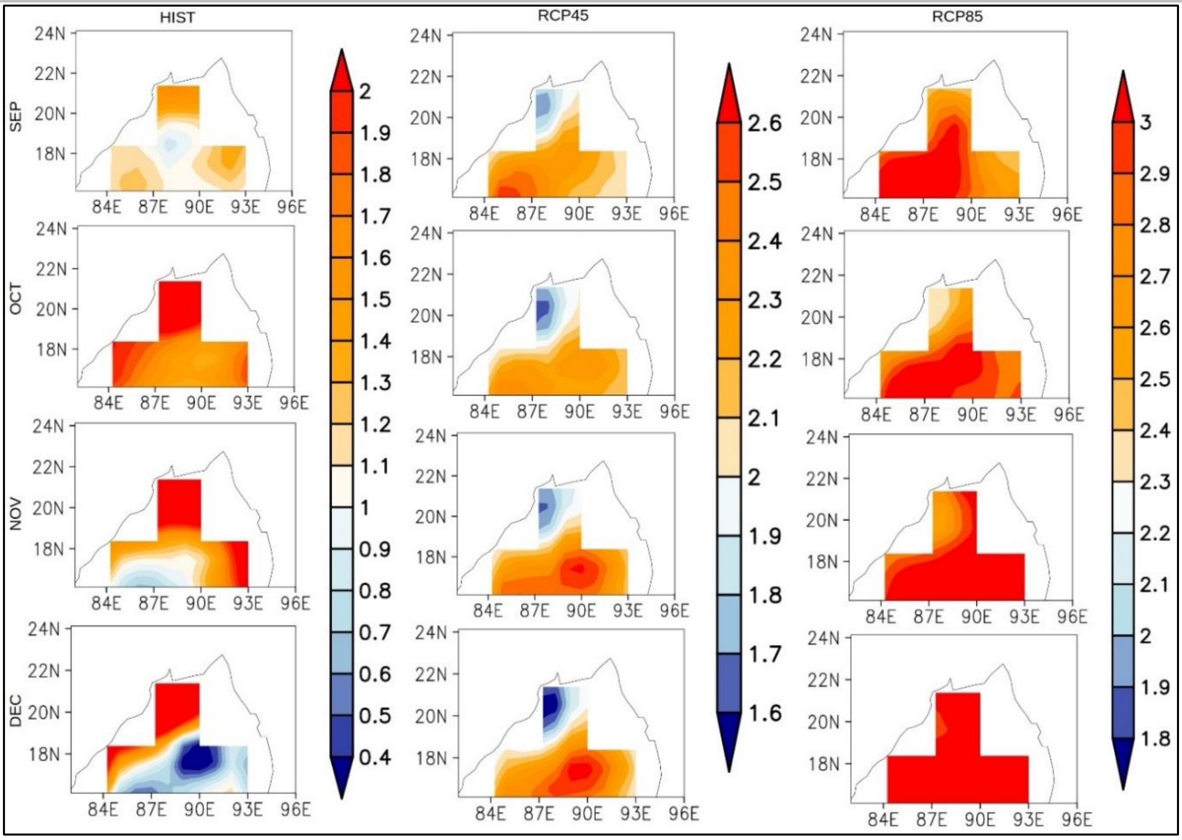


Figure 8.27: Spatial distribution trend of sea level rise (mm)

8.3.27 Bias correction of model data during the historical period

From the ***Figure 8.28***, it is seen that the model CMCC daily precipitation data for June, July, August and September month during the historical period (1985 to 2014) underestimates the precipitation value (negative value) when differentiated from the observed precipitation value (ERA5 reanalysis data). The model precipitation value also depicts value very close to zero indicating that the model is fit to be used for extreme events analysis.

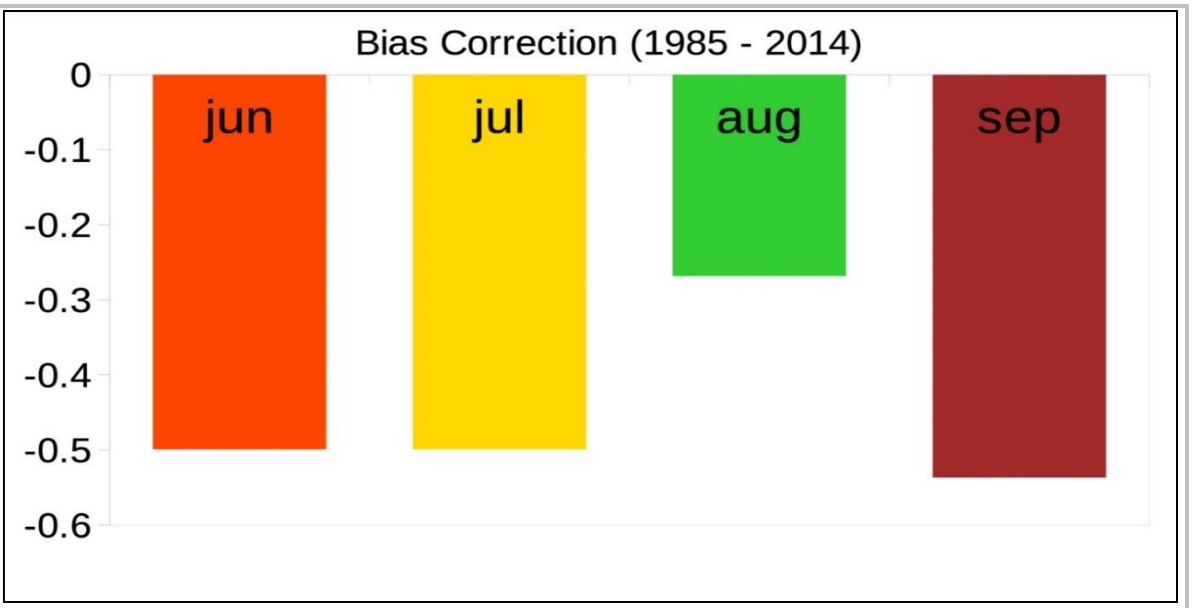


Figure 8.28: Bias correction of precipitation (mm/day) for June, July, August and September month

8.3.28 Extreme precipitation events at 95th percentile during historical period and future projections

In the (***Figure 8.29 a & b***), intensity of precipitation greater than 33.1 mm/day is considered as very heavy precipitation events based on 95th percentile. June month has total 50 number of events, July has total 37 number of events, August and September months both have each total 25 number of events of very heavy precipitation during the historical period (1985 to 2014). While during future projections (2015 to 2050), all the months depict an increase in the number of events with June having 91 total number of events followed by July (58 total number of events), August (51 total number of events) and September (36 total number of events). Hence, overall total number of very heavy precipitation events from June to September, which is more than 33.1 mm/day, is 137 times during historical period whereas during future projections, it occurs for 236 times indicating higher amount of precipitation in future.

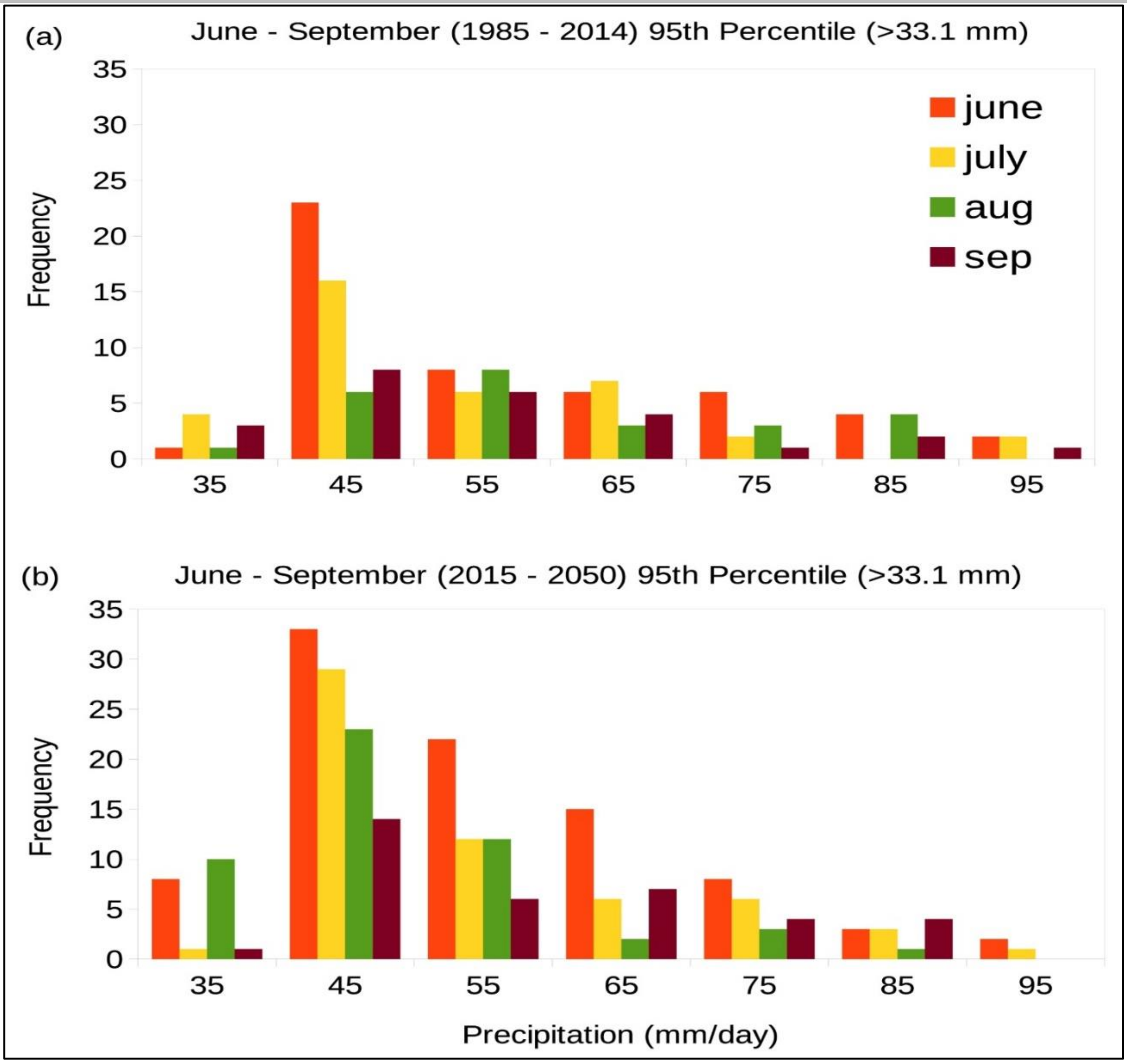


Figure 8.29: Total number of events at 95th percentile (>33.1 mm/day) as very heavy precipitation

8.3.29 Extreme precipitation events at 99th percentile during historical period and future projections

In (***Figure 8.30 a & b***), intensity of precipitation greater than 86.7 mm/day is considered as extremely heavy precipitation events based on 99th percentile. During historical period (1985 to 2014), June month has 15 total number of events, July has 7 total number of events, August has 5 total number of events and September has 6 total number of events. During future projections (2015 to 2050), June month depicts slightly lesser total number of events (13) than the historical period while July month depicts similar total number of events (7). As for August and September months, both depict higher total number of events with 12 and 9 events respectively. However, overall total number of extremely heavy precipitation events from June to September, which is more than 86.7

mm/day, is 33 times during historical period whereas 41 times during future projections indicating rise in extremely heavy precipitation in future.

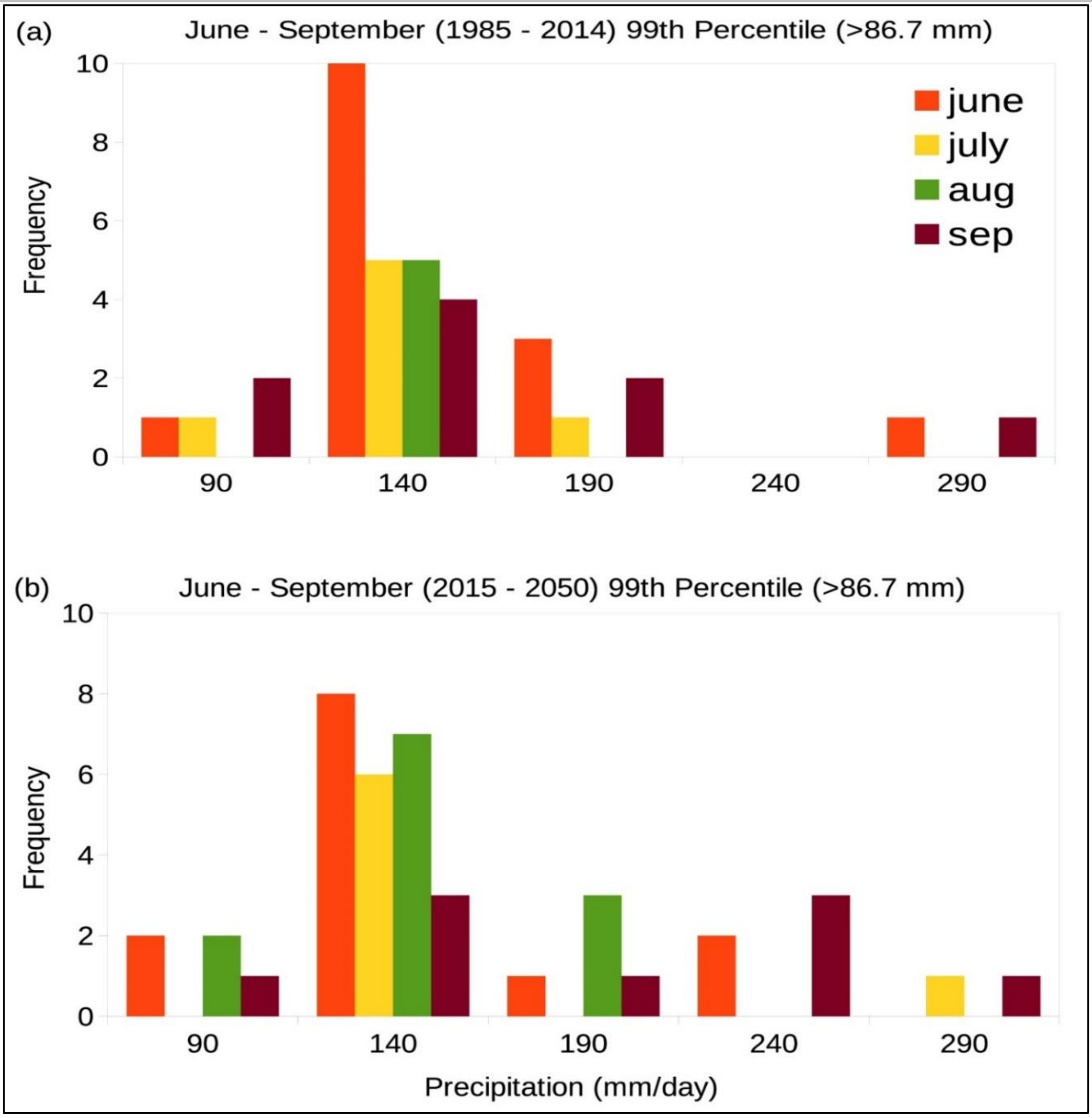


Figure 8.30: Total number of events at 99th percentile (>86.7 mm/day) as extremely heavy precipitation

***Note**: During (a) historical period (1985 to 2014) and (b) future projections (2015 to 2050) for June, July, August and September month over the Meghnaghat project location (23.125° N – 23.625° N through 90.25° E – 90.5° E). Y-axis indicates number of frequency and X-axis indicates intensity of precipitation (mm/day) of more than 86.7 mm/day but less than or equal to 90 mm/day, 140 mm/day, 190 mm/day, 240 mm/day and 290 mm/day for each month.*

8.4 Datasets and Methodology for hourly precipitation events

8.4.1 Dataset used

MRI AGCM (CMIP6) model generated by Meteorological Research Institute, Tsukuba, Ibaraki, Japan at 0.25° x 0.25° resolution hourly precipitation data have been used for present simulation (1985 to 2014) and future projections (2015 to 2050).

8.4.2 Results

Bias correction of model data during the historical period

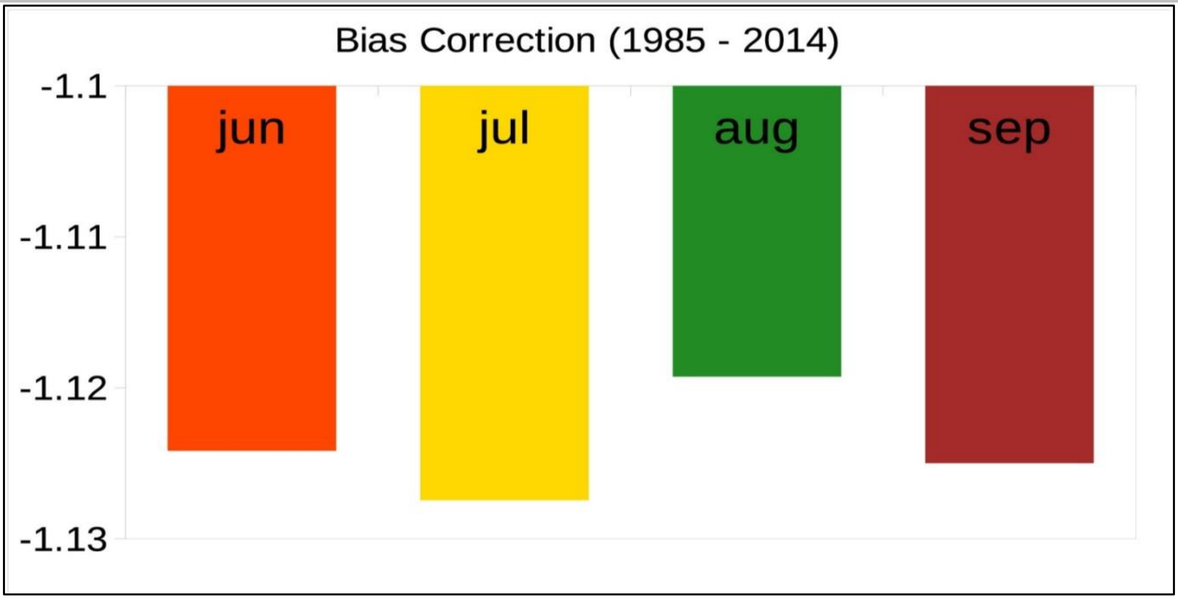


Figure 8.31: Bias correction of precipitation (mm/hour)

Note: *for June, July, August and September month during historical period (1985 to 2014) between ERA5 reanalysis precipitation data and model MRI precipitation data over the Meghnaghat project location (23.125° N – 23.625° N through 90.25° E – 90.5° E).*

From the ***Figure 8.28***, it is seen that the model MRI model hourly precipitation data for June, July, August and September month during the historical period (1985 to 2014) underestimates the precipitation value (negative value) when differentiated from the observed precipitation value (ERA5 reanalysis data). The model precipitation value also depicts value somewhat close to zero indicating that the model is fit to be used for extreme events analysis.

8.4.2.1 Extreme precipitation events at 95th percentile during historical period and future projections

Intensity of precipitation greater than 29.1 mm/hour is considered as very heavy precipitation events based on 95th percentile. June month has total 561 number of events, July has 178 number of events, August has 226 number of events and September month has total 251 number of events as very heavy precipitation during the historical period (1985 to 2014). While during future projections (2015 to 2050), all the months depict an increase in the number of events with June having 638 total number of events, July (216 total number of events), August (247 total number of events) and September (308 total number of events). Hence, overall total number of very heavy precipitation events from June to September, which is more than 29.1 mm/hour, is 1216 times during historical period whereas during future projections, it occurs for 1409 times indicating higher amount of hourly precipitation in future.

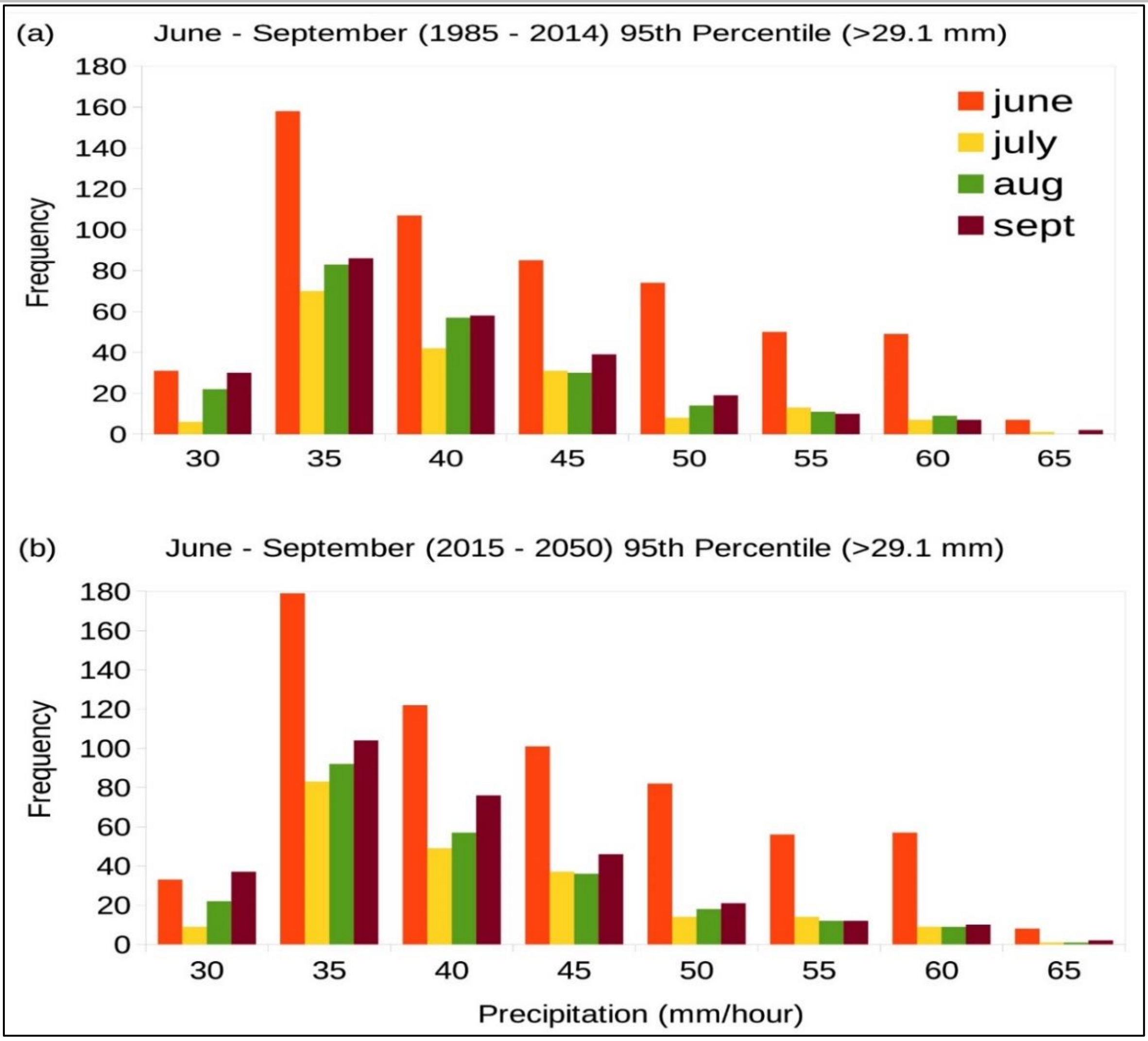


Figure 8.32: Total number of events at 95th percentile (>29.1 mm/hour)

Note: *very heavy precipitation during (a) historical period (1985 to 2014) and (b) future projections (2015 to 2050) for June, July, August and September month over the Meghnaghat project location (23.125° N – 23.625° N through 90.25° E – 90.5° E). Y-axis indicates number of frequency and X-axis indicates intensity of precipitation (mm/day) of more than 29.1 mm/day but less than or equal to 30 mm/hour, 35 mm/hour, 40 mm/hour, 45 mm/hour, 50 mm/hour, 55 mm/hour, 60 mm/hour and 65 mm/day for each month.*

8.4.2.2 Extreme precipitation events at 99th percentile during historical period and future projections

In ***Figure 8.33,*** intensity of precipitation greater than 60.9 mm/hour is considered as extremely heavy precipitation events based on 99th percentile. During historical period (1985 to 2014), June month simulates 217 total number of events, July has 18 total number of events, August has 14 total number of events and September has 15 total number of events. During future projections (2015 to 2050), June month projects 267 total number of events, July of 27 total number of events, August of 21 total number of events and September of 23 number of events. Likewise in very heavy precipitation, overall total number of extremely heavy precipitation events from June to September, which is more than 60.9 mm/hour, is 264 times during historical period whereas 338 times during future projections indicating rise in extremely heavy precipitation in future.

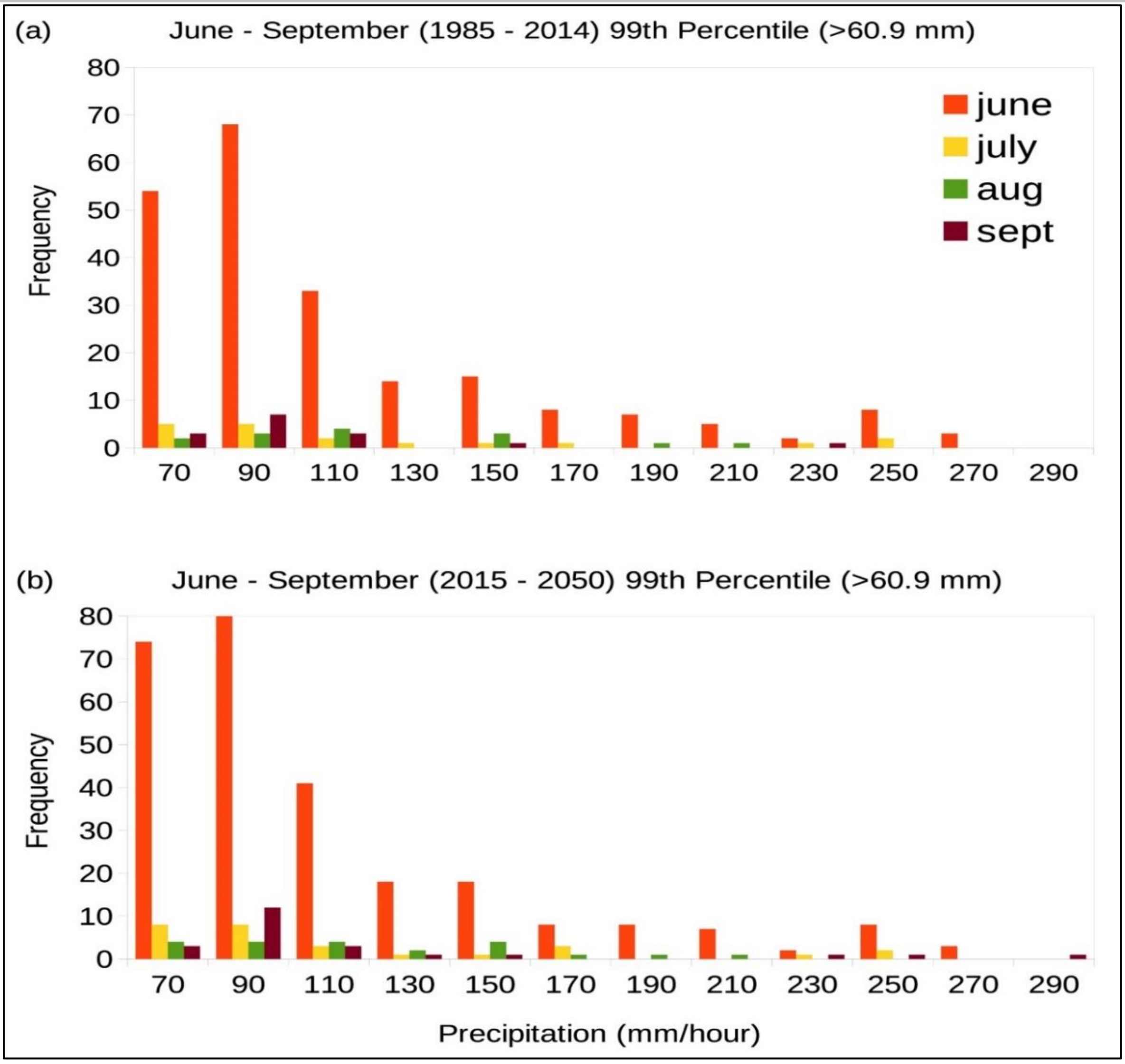


Figure 8.33: Total number of events at 99th percentile (>60.9 mm/hour)

***Note**: extremely heavy precipitation during (a) historical period (1985 to 2014) and (b) future projections (2015 to 2050) for June, July, August and September month over the Meghnaghat project location (23.125° N – 23.625° N through 90.25° E – 90.5° E). Y-axis indicates number of frequency and X-axis indicates intensity of precipitation (mm/day) of more than 86.7 mm/day but less than or equal to 70 mm/hour, 90 mm/hour, 110 mm/hour, 130 mm/hour, 150 mm/hour, 170 mm/hour, 190 mm/day, 210 mm/hour, 230 mm/hour, 250 mm/hour, 270 mm/hour and 290 mm/hour for each month.*

In this study, the precipitation, maximum temperature, minimum temperature and sea level rise are assessed for historical (1985 to 2014) and future projection (2015 to 2050) over the Meghnaghat project site. In order to assess the nature of these climatic parameters, observation data (BMD), reanalysis data (ECMWF ORAS5) and Atmospheric General Circulation Model (CMCC, Italy) and Atmospheric Ocean General Circulation coupled model (MIROC) have been used. We find a great variation in all the climatic parameters over the project site with decreasing trend of precipitation and increasing trend of maximum temperature, minimum temperature and sea level rise towards the future period. As the project site is located with the adjoining Meghna river, the site is vulnerable and exposed to climate change associated risk. As can be seen from the above climate change study, the site could be exposed to adverse impacts because of these altering precipitation, maximum & minimum temperatures and sea level rise.

9 Environmental and Social Management Plan

9.1 Introduction

Environmental Management Plan is concerned with the implementation of the measures necessary to minimize or mitigate adverse impacts and to enhance beneficial impacts. All mitigation and monitoring measures would be as per the World Bank EHS Guidelines, DEG and AIIB E&S Framework and Bangladesh national standards

The Environmental and Social Management Plan (ESMP) is prepared to minimize or mitigate adverse environmental impacts identified in the E&S Risk and Impact assessment report as specified in Chapter 5 during pre-construction, construction and operation stages. The ESMP outlines mitigation and monitoring requirements that would ensure compliance with the GoB environmental laws and regulations and comply with the Environmental and Social standards and guidelines of Multiple Funding Agencies viz. AIIB, DEG and IFC. Unless the mitigation and benefit enhancement measures that are identified in the ESIA are fully implemented, the prime function of ESMP cannot be achieved. The key indicator for measuring success of mitigation measures/action plans is compliance with Statutory Environmental Quality Standards (EQS) of Bangladesh.

The main objective of the Environmental Management Plan (ESMP) and Environmental Monitoring Plan is to ensure implementation of the mitigation measures planned to reduce the environmental impact by the implementation of the power plant project, and to verify and record the environmental impact. Thus, the objectives of ESMP is to formulate Mitigation measures and to minimize or eliminate negative impacts arising from the proposed activities.

The ESMP and Monitoring Plan are worked out based on the following:

- To reduce the environmental impact to the permissible level by the mitigation measures during the period of construction and operation, so that a hazardous impact would not occur.
- To configure a responsible organization for the implementation of the mitigation measures.
- To implement the ESMP and Monitoring Plan adequately during the period of construction and operation. The permissible level mentioned above is determined based on the national standard of Bangladesh listed below.

Environmental Management Plan (ESMP) includes the list of actions for curbing environmental and social adverse impacts, monitoring, and also formulating budgetary cost for implementation of the Environmental and Social Management Systems (ESMS). In case any non-compliance, change in scope, or unanticipated impact arises during project implementation, corrective action would be taken accordingly as per statutory requirements and funding agencies' environmental and social guidelines and standards.

9.2 Mitigation Measures

For effective and environment friendly operation of a project, a set for guiding tools and suggestions are necessary which need to be followed at various stages of plant installation, operation and maintenance. This plan generally has various components of management depending on the type of project or plant activity and types of discharge and their pollution potential. This Environmental and Social Management Plan (ESMP) once prepared, forms the basis of environmental management actions from the part of the project authority may need modification or up-gradation because of changes in the plant operation or accurate pollution load/environmental problems detected afterwards.

All beneficial and adverse impacts which may likely to occur at different phases of the project have been identified. Predictions, evaluation, aspect of mitigation and benefit enhancement measures have also been discussed concurrently with impact prediction and evaluation. In view of the earlier discussion summary of recommended mitigation and benefit enhancement measures are presented in ***Table 9.1*** below.

Table 9.1. Environmental and Social Management Plan (ESMP)

Project phase	Identified impacts	Mitigation measures	Monitoring	Responsibility	
				Implementation	Supervision
Pre-Construction	Emission of fugitive Dust	• Sprinkling of water on unpaved and paved surface throughout the work area to arrest dust emissions, covering of stockpile materials with canvas or plastic sheets, use of wind barriers and enclosures wherever possible and to be specifically used across locations of sensitive receptors; • The unloading of materials and other activities to be carried away from the sensitive receptors around the plant site; • Placing excavated materials in areas designated for dumping / disposal purposes and damping of excavated materials to prevent dust emissions; • Sheet covering of sourced landfill materials in the designated storage area on site; • Minimizing drop heights for material transfer activities such as unloading of materials; • Conducting periodic air quality monitoring and in case parameters shows exceedance stringent control measures to be implemented; • Installing wind barriers, particularly across locations of sensitive receptors to prevent dust propagation.	Workzone dust	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE.	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS
Construction	Impact on local drainage pattern	• It is recommended to construct stormwater Drain outside plant boundary to channelize the incoming rainwater water flow from the outer catchment area towards the river to restrict impoundment and flooding within the village land during the construction period.	Water logging around the site	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE.	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS.
	Higher noise level	• Normal working hours of the contractor would be between 06:00 and 18.00 hours from Saturday to Thursday. If work needs to be undertaken outside these hours, it would be limited to activities that do not exceed the noise criteria at nearby noise sensitive receptors; • Strict adherence to OSHA standards for noise exposure; • Restriction in night-time vehicle movement; • Use of low noise generating equipment or equipment known to emit noise strongly in one direction away from residential & sensitive areas wherever possible is recommended; • Regular maintenance of equipment and machinery. • Periodic noise monitoring as per the schedule • Carry out noise monitoring at receptors as per the proposed monitoring schedule and in case exceedance happens, temporary sound barriers would be used at the working equipment with high sound power level. • Restriction on night-time vehicle movement through the approach road and restriction on honking;	Noise level monitoring (24-hrs) Day-time and night time noise	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE.	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS.
	Impact on Livelihood due to land procurement (landowner, Land dependent and Fisherman)	• The procurement procedure and compensation calculation to be circulated; • Compensation to be provided prior to taking possession of land and additional compensation to be provided for Vulnerable Households, if any • Enhancement of sustainable livelihood by training locals for skill development; • Sourcing unskilled labours from local community; • Livelihood Restoration Plan should be formulated and implemented successfully; • The existing dilapidated ghat would be renovated for fisherman community and additional facilities to be provided to continue unhindered fishing activities; • To ensure no interruption is caused for the community to access the river, adequate stakeholder engagement would be conducted during construction and operations phases. • Prepare and implement a Grievance Redress Mechanism to handle all grievances related to the project. • Implement a Stakeholder Engagement Plan for proper and regular communication and stakeholder engagement activities of the project to its stakeholders	Economic Condition of PAP	Executing Agency with Deputy Manager Social & Community Development	UMPL Project Manger
Construction Phase	Generation of sewage, discharge of return water from sand slurry	• Provision of adequate sanitary facilities (modular toilets and showers) for the construction workforce; • Installation of sewage treatment facilities • Proper recycling/disposal of refuse generated through authorized Recycler/Waste Management Agency •	• Incidence of contagious diseases	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE.	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS and EPC EHS Team.
	Outbreak of diseases	• Installation of toilets and sewage treatment facilities in workers' camps. • Installation of medical facilities and implementation of periodic health check-ups • Training to sensitize the workers on health management. • Prohibiting/restricting non-local workers from making any kind of social contacts with the local population. • Prevention of epidemics among workers (HIV/AID, dengue fever, malaria, hepatitis A) • Elimination of potential breeding site for harmful insects, provision of preventive medicine as necessary			

Project phase	Identified impacts	Mitigation measures	Monitoring	Responsibility	
				Implementation	Supervision
	Impact of traffic: • Community disturbance and potential safety hazards, • Exhaust emission from vehicles, Increase of fugitive dust due to traffic movement. • Increase in probability of accidents involving human as well as domestic animals.	• Providing Bus arrangement for worker to commute. • Reduction of vehicle speed in village residential areas and close to schools/hospitals • Regulation of speed limit to 20 km/hr when passing through residential and school areas. • Comply traffic regulations, installation of traffic signs, and education on driving safety • Implementation of safety programs • Install traffic signals with vehicle stop mark lines at intersection points and designated crossovers (zebra crossing) •	Road Safety provisions and records of incidents including minor collision & accidents	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE.	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS and EPC EHS Team.
	Vulnerable groups, uneven distribution of benefit	• Implementation of Livelihood restoration plan; • Priority of employment for local residents, development of employment standard; • Employment for Lodging, Housing and Civic Services; • Utilization of local service (cleaning, catering, raw materials); • Implementation of the preliminary education and training programs with local authority;	Socio-economic conditions of local residents	Executing Agency with UMPL Deputy Manager Social & Community development	UMPL Project Manager
	Labour influx	• Labour camp with all amenities like drinking water, sanitation Facility, cooking facility should be provided • Labour should not enter the nearby villages without prior information • Access of the local community in labour camp should be restricted • Labour should not share any village resource • Periodic health check-up of labour would be carried out • Awareness training would be carried among migrant labour about local culture, tradition and value system • Labour Management Plan and Labour Accommodation Plan has been prepared and given in Appendix N and O respectively.	Incidents of Conflict with community due to labour influx	Executing Agency with UMPL Deputy Manager Social & Community development	UMPL Project Manager
	Impact Related to GBV and SEAH	• Formulation & implementation of Gender Policy in the workplace for all the workers working directly under UMPL or their sub-contractors. • Formulation of a sexual harassment committee headed by a woman member of UMPL management and formulation of SOP for daily working procedure of the committee and implementation • of code of conduct related to GBV and SEAH for all working personnel. • Regular training programme to be carried out during induction of new workers and employees. Yearly training to be conducted for UMPL & contractor staffs working in power plant. • Complaint Box to be installed in various place in the power plant and workers' accommodation	Complaints registered or reported related to GBV or SEAH	Sexual harassment Committee	UMPL Project Manager
	Impact on air: • Fugitive dust from operation of concrete batching plant, transport of raw material and manpower, Pre-fabrication and fabrication work including shot/sand blasting onsite • Emission generated due to operation of diesel driven drilling machine during laying of pipeline • Transportation of construction material by vessels/barges and other transport vehicles would also contribute to exhaust emissions.	• Sprinkling of water on unpaved and paved surfaces throughout the work area under land development process to arrest dust emissions; • To minimize the dust emission, excavation to be conducted carefully and placing the excavated materials in areas designated for dumping / disposal purposes. Damping of excavated materials and covering by tarpaulin and surrounding by protective boundary to prevent dust emissions; • Minimizing drop heights for material transfer activities such as unloading of materials; • Concrete batching plant to be located away from the sensitive receptors; • Additional net fencing/ solid barrier boundary wall facing the sensitive receptors to minimise transport of the dust; • Burning of waste generated should be strictly prohibited; • Avoiding on-site fabrication work and shot/sand blasting work; • Vehicles and heavy earth moving equipment, machineries to be regularly maintained to conform to the emissions standards stipulated under Environment Conservation Rules, 1997; • Sheet covering to be used during transportation of dusty materials to designated storage area on-site; • Implementing non-polluting transports (Cycle, car-pools, etc,) • Conducting periodic air quality monitoring and in case parameters shows exceedance stringent control measures to be implemented. • In case of complaints arising from the residents and pedestrians regarding dust emission, the construction technique should be reconsidered.	PM_{10}, $PM_{2.5}$, SO_x, NO_x, VOC, PAH	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS and EPC EHS Team.
	Increased noise level due to: • Heavy machineries and transportation of equipment. • Horizontal Directional Drilling (HDD), cutting of pipe and laying of gas	• Normal working hours of the contractor would be between 06:00 and 21:00 hours from Saturday to Thursday. If work needs to be undertaken outside these hours, it would be limited to activities that do not exceed the noise criteria at nearby noise sensitive receptors; • Strict adherence to OSHA standards for noise exposure; • Restriction in night-time vehicle movement;	Ambient Noise Quality Work zone Noise level	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS and EPC EHS Team.

Project phase	Identified impacts	Mitigation measures	Monitoring	Responsibility	
				Implementation	Supervision
	• Traffic congestion and vehicular movements in the Approach road used by construction workers to commute to and from the site, would generate temporary noise and vibration . •Pre-fabrication and fabrication work including shot/sand blasting onsite.	• Use of acoustic enclosures for DG sets; • Use of low noise generating equipment (silencer, muffler) or equipment known to emit noise strongly in one direction away from residential & sensitive areas wherever possible is recommended; • Regular maintenance of equipment and machinery; • On-site fabrication work and shot/sandblasting to be avoided; • Mandatory use of Personal Protective Equipment (PPE) (earplug, ear mufflers) by construction workers; • Distribution of free ear plug to villagers of adjoining areas. • Construction of temporary fence around Project site • Rotation of workers to prevent worker's prolonged • exposure to noise • Periodic noise monitoring. • Carry out noise monitoring at receptors as per the proposed monitoring schedule and in case exceedance happens, temporary sound barriers would be used at the working equipment with high sound power level.		Manager/Deputy Manager-HSE	
	Soil runoff, turbid water, waste water from equipment cleaning and runoff erosion	• The surface runoff from the construction site to be channelized through storm water drainage system • Provision of adequate size double chambered sedimentation tank; • Effluent generated during cleaning of equipment/miller wash would be stored and treated in temporary sedimentation tank before discharge; • Wastewater generated from the concrete batching would be discharged after treatment to comply with discharge standards; • Restriction of earth work activities during the monsoon season; • Construction of protection wall and fencing around the construction sites to arrest runoff erosion; • Periodic monitoring at the water outlet	Stormwater Effluent (BOD, COD, TSS, pH, temperature, O&G and Phosphate, Sulphate and turbidity)	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE.	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS and EPC EHS Team.
	Leakage of harmful Substances, fuel oil, hazardous chemicals	• Carrying out the work carefully to avoid leakage of harmful substances; • Periodic checking and maintenance of sources of potential leakages; • Containment of harmful substances tanks, storage area with provision of sheds, concrete floor and bund; • Use of drip tray during refuelling; • A leak and spill protection guidelines & procedures would be prepared for implementation of leak/spill protection onsite; • A site-specific Emergency Response Plan would be strictly adhered to; • Use of appropriate spill control kits and scraping off contaminated soil immediately after spillage for safe disposal; • Waste oil would be collected and stored for recycling or disposal; • Implementation of training programs related to contamination events for the workers.	Surface water, groundwater and soil monitoring for io & grease, hydrocarbons	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE.	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS and EPC EHS Team.
	Loss of floral and faunal habitats	• Avoid noisy construction activities closer to identified faunal habitat including avoidance/preventive measures during breeding seasons. • Create green buffer around the site with similar/native species; • Provision of landscapes with native species to supply habitat for terrestrial and riparian species and improve aesthetics; • Adequate bird's flight diverters, wishbone-type equipment's and insulators to be provided in the transmission lines to increase its visibility for birds; • Construction of fence around the site to prevent entry of domestic animals; • LPG/ Kerosene to be used for cooking to reduce impacts caused on vegetation due to smoke generated otherwise; • Use of trawlers/barges with valid requisite licenses and provision of emergency handling capacity or tie-ups; • Careful handling of barges/trawlers to avoid leakage into the Meghna River and any accidental oil spillage to be contained by adequate spill kits; • Compaction and stabilization of banks to be carried out to reduce the bank erosion caused by the movement of large barges and vessels; • Penalty clause under contractual agreements to be implemented on trapping / catching of fishes by the subcontractors; • Mid-afternoon us recommended as the ideal time to enter the Khal by vessels considering the reduction in faunal activity; • Promotion of local fish breeding sites by the project proponent in consultation with the Fishery Department as a step to conserve fish resource.	Flora and Fauna	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE.	UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS and EPC EHS Team.

Project phase	Identified impacts	Mitigation measures	Monitoring	Responsibility	
				Implementation	Supervision
	Income, livelihood, vulnerable group	• Increase employment/hiring of local people and project affected people to ensure sustainable livelihood for the project affected people through direct and indirect employment. • • Potential employment of the local communities in various skilled, unskilled and semi-skilled roles e.g., contractors, supervisors, workers, etc., during construction phase.	Socio-economic indicators	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Soil and Groundwater contamination	• Paving the work areas to avoid seepage; • Construction of embankment surrounding the proposed land constructed before commencement of land filling activity; • Provisions of silt traps in the designated channels; • Storage of chemicals in paved areas with secondary containment. • Prevent discharge of oil and chemical contaminated water into the soil without treatment; • Presence of adequate spill control kits • Site and activity specific Emergency Response Plan would be formulated and working personnel to be trained regarding the occurrences of contamination events; • Periodic monitoring of soil and ground water quality.	Soil Quality and Groundwater Quality Groundwater Quality (Heavy metals, COD, TSS, faecal coliform, pH, Mercury, oil and gas, Hardness, TDS, sulphate, phosphate, nitrate, and chloride, Fluoride)	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Generation of Construction Solid Wastes	• Construction solid wastes (concrete, rubble etc) would be stored onsite and used for backfilling of excavated land and landfilling in sterile areas on site. • All packaging wastes and used oil would be sent to waste recyclers. • Food wastes generated during construction phase would be disposed off appropriately following discussion with local authority; • Drill cuttings and drilling mud would be stored in designated separate place and disposed through authorised third-party agency; • To prevent indiscriminate handling of waste, the works would be trained regarding segregation and disposal; • The waste storage area would be minimum 50 m away from Meghna River / any other surface stream; • Waste oil would be used for maintenance of vehicles and construction equipment; while any hazardous oil and soil contaminated with hazardous materials would be disposed off suitably in line with Waste Management Practice in Bangladesh.	Solid Waste Inventory, Manifest/records for disposal.	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Generation of liquid effluent	• Sewage and sullage generated from washroom would be collected, treated and discharged in septic tank-soak pit. Periodic cleaning of solids in soak-pit would be carried out. • Wash water generated from vehicle washing/equipment cleaning on site would be stored in pits and treated before discharge. A water management procedure would be prepared for implementation of water management plan.	BOD, COD, pH, TSS, faecal coliform TSS, COD, pH, oil and gas, nitrate, phosphate	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Generation of Drilling mud with drill cutting	• Adequate management of drilling mud including testing of hazardous characteristics to be conducted; • The drilling mud & drill cuttings would be stored in a designated area with paving and secondary containment like dyke to obliterate chances of soil, surface & groundwater contamination due to seepage & surface run-off. • Disseminate information about quicksand properties of bentonite among working personnel and community; • Mud pit would be properly fenced with signage to prevent entry of workers and stray animals into the area.	Bentonite (TCLP)	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	River traffic	• Strict adherence to river traffic management plan during construction of jetties and filling materials procurement; • Enforcement and adherence to river traffic rules • The movement and operation of river transportation system of the project would be governed by the tidal activity; • Formulation and implementation of adequate off-site spill response procedure. • It is recommended that the movement of vessels carrying construction material and equipment to the site would be restricted between 10 pm to 4 am, without affecting other users significantly, especially the local fishermen.	Traffic count	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Increase in turbidity of water, likely impact on fishermen and impact on riverine ecology due to construction of water intake channel	• In order to specifically assess the impact of construction of water intake channel into the Meghna Branch channel, it is recommended to carry out Hydrodynamic modelling of the branch channel to understand the flow regime in the channel due to this construction activity. • In order to manage the impacts due to dredging, UMPL is recommended to prepare a specific Dredged management plan which comprise of quantity of dredged material, dredging location, dredging schedule and chain of activities following capital dredging operation during the construction activities. Dredging would be carried out and dredged material managed as per the Dredged Material Management Plan. Indiscriminate dumping of dredged material would be strictly prohibited. • It would be ensured that the dredged material undergo waste characterisation before disposal.	Surface water quality, social consultation	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development

Project phase	Identified impacts	Mitigation measures	Monitoring	Responsibility	
				Implementation	Supervision
		• UMPL would help the fishermen to identify alternative location nearby for docking their boats. • UMPL would undertake consultation with the affected fishermen to ensure that their livelihood is not adversely impacted during the construction of water intake channel.			
Operation	Emissions of gases	• Continuous Emission Monitoring System (CEMS) will be installed. • Monitoring of ambient air quality at periodic interval (e.g. monthly) • Periodic maintenance and monitoring of air pollution control equipment to be ensured • Preparation and implementation of Air Quality Management Procedure as part of EMP implementation. •	SPM, PM_{10}, $PM_{2.5}$, SOx, NOx, VOC, CO, PAH	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Noise generation	• Periodic monitoring of work-zone and ambient noise during the operation phase. • In case there is exceedance with the standard, adoption of practical mitigation measures to attenuate noise at source level or by way of adopting other feasible mitigation measures. Source-specific noise reduction would be the best mitigation measure. Padding with noise absorbent materials inside/outside in each industrial building of principal noise generating sources, wherever feasible would enhance attenuation and minimize the noise levels at the receptor at Plant boundary and beyond. Apart from this UMPL would adopt all initiatives to put any high noise generating equipment within robust acoustic enclosures. • In case it is not sufficient, UMPL would consider additional increase in height of the boundary wall by another 3 m with Noise Protection wall (NPW), with a total height of boundary wall as 6 m on all sides except the riverside boundary. • On the riverside, no NPW has been considered. • Based on the land availability, the development of a greenbelt (Plantation of Trees with broad leaves and dense foliage) along the entire periphery of the plant would be undertaken. This would help to further reduce the noise level at the receptor end. • Use of PPEs like ear mufflers, earplugs etc. by the workers working in high noise zone. • Periodic monitoring of work-zone and ambient noise.	Ambient Noise Quality (day and night) Work Zone Noise level	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Solid Waste generation	• All Solid wastes would be stored in colour coded waste bins adequately placed onsite. The waste would be collected from waste bins on site at periodic intervals and hauled to recyclers for recycling and disposal. • All packaging wastes and used oil would be sent to waste recyclers. • Food wastes generated during operation from canteen/kitchen would be sent for composting offsite. • Hazardous waste, fuel tanks would be places under sheds surrounded by bunds or other containment device to prevent spilled oil, fuel and chemicals from reaching the receiving waters; • Oily and chemical waste to be stored in secondary containment (~110% more than its capacity) and sold to GoB approved venders; • Solid and Hazardous waste plan would be based on national as well as WB/IFC EHS guidelines and adequately implemented; • Batteries containing liquid inside would be kept on impervious place; • A proper manifest record would be maintained of waste travelling/ removed from the site; • Waste oil would be used for maintenance of vehicles and construction equipment; while any hazardous oil and soil contaminated with hazardous materials would be disposed-off suitably in line with Waste Management Practice in Bangladesh. • A site and activity specific waste management procedure would be prepared for implementation of waste management plan.	Waste Inventory, Quantity and Manifest/records for disposal	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Liquid Waste Generation	• Effluent generated onsite would be treated in guard pond for reuse. Excess treated water meeting following compliance with discharge norms would be used for farming or discharged into waterbodies; • Sewage would be treated in a Sewage Treatment Plant and used for gardening / landscaping; • Reuse/recycling of treated water would also explore opportunities to reuse the water for flushing of toilets, water sprinkling on unpaved surface and landscaping; • Implementation of water management procedure as part of the EMP; • Treatment of wastewater generated from the various units would be in accordance to GoB Environment Conservation Rule (1997) Schedule 9 and 10 (Standards for Waste from Industrial Units or Project Waste) and the applicable World Bank Group environmental requirements and World Bank/IFC guidelines; • Periodic monitoring of treated sewage and effluent (once in a month).	BOD, COD, TSS, pH, faecal coliform, phosphate, sulphate, chloride, oil and gas, temperature.	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Stormwater Generation	• Stormwater from the site would be collected via gradient into the constructed stormwater drain for discharge into the river. Oil and gas trap would be installed at the outlet of stormwater drain to remove any oil and grease washed from the site along with stormwater; • Water from the storm water drainage would be treated in accordance to GoB Environment Conservation Rule (1997) Schedule 10 (Standards for Waste from Industrial Units or Project	BOD, COD, TSS, TDS, Phosphate, Sulphate.	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development

Project phase	Identified impacts	Mitigation measures	Monitoring	Responsibility	
				Implementation	Supervision
		Waste) and the applicable World Bank Group environmental requirements and World Bank/IFC guidelines; • The first flush water would be collected separately and treated in ETP onsite before discharge/reuse.		Manager/Deputy Manager-HSE	
	Intake of Drinking and process water	• The water intake points would be metered to ensure water withdrawal is within stipulated limit. • The site would have demineralization plant, Ion Exchange plant and RO Unit for treatment of water to make it suitable for process uses, cooling and drinking. • Periodic monitoring of drinking water quality (WHO Drinking water Standards) and process water quality. •	WHO Drinking Water Parameters	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Failure of turbine and leakage or rupture of gas pipeline	• Stack dispersion of gas would be ensured through bypass stack • Installation of emergency isolation valves. • Provision of remotely actuated shut-off system.	Leakage of Natural gas	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Spillage of oil and chemicals hazardous in nature	• Provision of spill kits in chemical/fuel handling and storage areas. • Fuel/chemical tank storage areas would be equipped with oil/chemical spill bank and countermeasure for underground oil seepage and designed as physical containment area. • Periodic training of staff working in chemical/fuel handling and storage areas. • Formation of Emergency Response Team (ERT) • Preparation and implementation Spill Management Procedure.	Monitoring of surface water, groundwater and soil monitoring	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Increase in turbidity of water, likely impact on fishermen and impact on riverine ecology due to maintenance of water intake channel	• It would be ensured that the dredged material undergo waste characterisation before disposal. • Maintenance activities of the water intake channel would be carried out during the driest period of the year (between November to March) when water level of Meghna Branch Channel recedes to the lowest which would reduce the probability & extent of re-suspension of sediment. • It would be ensured that the excavation would be carried out using bucket dredgers so that spillage of material is minimum during dredging activity. It would be ensured that dredged material is not disposed into the river. • Growth of algae and gastropod would be cleaned using high pressure water jet or manually through scrapping as per requirement.	Surface water quality	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Loss of habitat of flora and fauna	• Green belt development would be initiated with plantation of native and engage with local forest department and Upazila administration for plantation activities outside the project area; • Construction of boundary wall around the power plant area premises to prevent entry of domesticated animals; • Regulation of traffic speed, especially during the night to prevent accident of wild and domesticated animals; • Use of low-intensity artificial lighting (LED) to prevent insects from being attracted to the Substation area; • Use of barrier nets (seasonal or year-round), fish handling and return systems, fine mesh screens, and wedge-wire screens, and aquatic filter barrier systems would be explored in the water intake system; • Explore potential employment of local people through relevant skill enhancement, preliminary education and training programs; and • Utilization of local service (cleaning, catering) and materials.	Flora and Fauna	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Prevention of disease, accidents, other safety related issues including natural disasters	• Spill protection plan preparation and implementation. Also include implementation of gas leakage prevention procedures and available on-site all preventive equipment and materials as part of the process of developing emergency plan. • Preparation and implementation of Disaster Management Plan including natural calamities. Formation of ERT team. • Fire protection equipment and facilities would be made available at suitable locations in power plant including fixed fire protection system, fire hydrants, portable firefighting equipment, fire vents, alarm system, fire compartments and fire exit signs. Preparation of safety standard. • Public addressal system to inform any emergencies and tie up with hospitals and police station for any aid in the event of any emergency. • Emergency contact details would be displayed on site for worker's direct use in the event of any emergency, or incident.	Road Accident and Safety Measures	Implementation of Best management practices onsite would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE	UMPL Site Manager in collaboration with UMPL Deputy Manager – Community Development
	Community Health & Safety	• Periodic maintenance of the plant machinery would be carried out to reduce the noise and air pollution impact	Social Consultations and monitoring of incidents		

Project phase	Identified impacts	Mitigation measures	Monitoring	Responsibility: Implementation	Responsibility: Supervision
		• Periodic Air pollution, noise monitoring and treated wastewater sample analysis would be carried out to assess the impact level.			
	Occupational Health & Safety	• Occupational Health & Safety Plan would be prepared by UMPL/O & M Contractor engaged by UMPL that would cover aspects of health & safety hazards, their prevention & control procedure and identify training needs and frequency. • OHS Manual will be prepared and stringently followed during the operation of the plant • The Project would adopt a total safety control system, which aims to prevent the probable accidents such as fire accidents or chemical spills; • Firefighting systems, such as sprinklers, portable extinguishers (appropriate to the flammable hazard in the area) and automated fire extinguishers would be provided at strategic locations with clear labelling of the extinguisher type. • Plant equipment at hot temperatures that can pose risk to workers would be identified and protected to prevent accidental contact. Training on handling, hazard due to contact with hot surfaces would be provided; PPEs (gloves, insulated clothing would be used) • Constant monitoring of pressure, density and temperature of gas pipeline; installation of pressure safety valves to prevent any explosion; • Material Safety Data Sheets (MSDS) for each chemical used would be available and readily approachable at the facility • A safety manual for storage and handling of Hazardous chemicals would be prepared and implemented; • The staff would be trained for first-aid and firefighting procedures. The rescue team would support the first-aid and firefighting team; • A first-aid centre with the trained personnel; • Training and rehearsal of the emergency response procedures by the emergency team members and personnel on site would be completed periodically; • A safe assembly area would be identified, and evacuation of the premises would be practised regularly through mock drills; • Safe work practices would be developed to provide for the control of hazards during operation and maintenance; • In the material storage area, hazardous materials would be stored based on their compatibility characteristics; • A near miss and accident reporting system would be followed and corrective measures would be taken to avoid / minimize near miss incidents; • Safety measures in the form of Dos and Don'ts would be displayed at strategic locations; • Safety audits would be conducted periodically as per the regulatory requirements; • Firefighting system would be tested periodically; • All hydrants monitor and valves would be visually inspected every month. • Fire safety certificate from the competent Govt. Fire Authority has to be obtained on periodic basis. • Monitoring of occupational hazards in the working environment designed and implemented by accredited professionals as part of an Occupational health and safety monitoring program. • Maintaining the record of occupational accidents and diseases.	Incident reporting and maintenance of incident register		
	Impact Related to GBV and SEAH	• Formulation & implementation of Gender Policy in the workplace for all the workers working directly under UMPL or their sub-contractors. • Integration of GBVH into UMPL HR policy and investigation system • security-guard training on codes of conduct GBVH provisions, the Voluntary Principles on Security and Human Rights, cultural norms and expectations • Formulation of a sexual harassment committee headed by a woman member of UMPL management and formulation of SOP for daily working procedure of the committee and implementation of code of conduct related to GBV and SEAH for all working personnel. • Regular training programme to be carried out during induction of new workers and employees. Yearly training to be conducted for UMPL & contractor staffs working in power plant. • Worker grievance mechanism with specific gender-based violence and harassment provisions. • Complaint Box to be installed in various place in the power plant and workers' accommodation • Developing a system of analysing any reported incidents and implementing remedial measures to prevent any recurrence	Complaints registered or reported related to GBV or SEAH	Sexual harassment Committee	UMPL Project Manager

9.3 Environmental and Social Monitoring

The environmental monitoring programme has been devised with the following objectives:

- To evaluate the effectiveness of the proposed mitigation measures and the protection of the ambient environment as per prescribed/ applicable standards for the Project;
- To identify the need for improvements in the management plans;
- To verify compliance with statutory and community obligations; and
- To allow comparison against baseline conditions and assess the changes in environmental quality in the Project.

9.3.1 Indicator and Monitoring Schedule

Environmental and Social Monitoring would form an integral part of the Environmental Management Plan implementation procedure. During construction phase, the Contractor (and their sub-contractor) would be entrusted with carrying out the environmental monitoring; while in operation phase UMPL or its Contracting Operating agency would hire third party agencies for environmental monitoring at periodic interval. The monitoring also aims to ascertain whether activities are in progress as per the schedule and the timelines are being met and evaluate whether project affected entities (households and local community) have been compensated and that PAPs have at least the standard of living are no worse off than it was before the project.

UMPL Management would allocate dedicated budget for environmental and social management plan implementation, training, environmental monitoring, analysis and reporting, verification monitoring and capacity building. However, in-built engineering control measures, viz. air pollution control measure, acoustic enclosures for noise control, water treatment plant and wastewater treatment plant etc are excluded from the aforesaid budget and are included in the Project Capital Expenditure (CAPEX) cost estimate and/or operating cost estimates. The Environmental Monitoring budget estimates for construction and operation phase of the UMPL Power Plant, Gas Pipeline and Jetty area has been provided in ***Table 9.2*** below.

Table 9.2. Environmental and Social Monitoring Plan

Parameters	Locations	Method	Frequency	Annual Budget (in BDT)	Responsible Agency	
					Implemented by	Supervised by
Environmental and Social Monitoring During Pre-Construction Phase						
Air quality: PM_{10}, $PM_{2.5}$, SOx, NOx,	2 locations (1 location inside the site; and 1 location outside plant boundary in nearby settlement)	Sample collection and laboratory analysis	Monthly (24-hrly)	5,00,000 EPC contractor's budgets	Contractor through third-party laboratory	UMPL EHS team
Noise Level	3 locations (1 location inside the site; and 2 location outside plant boundary in nearby settlement and sensitive receptor, i.e Masjid)	Noise level collection and analysis	Once in a week (day and night)	1,50,000 EPC contractor's budgets	Contractor through third-party laboratory	UMPL EHS team
Environmental Monitoring During Construction Phase						
Air quality: PM_{10}, $PM_{2.5}$, SOx, NOx,	6 locations (3 locations inside plant – 1 location near material storage area 1 location near batching plant 1 location in laydown area 3 locations outside plant boundary – 1 location near main gate, 1 location in the nearest Mosque 1 location in Dudhghata primary school	Sample collection and laboratory analysis	Monthly (24-hrly)	30,00,000 EPC contractor's budgets	Contractor	UMPL EHS team

Parameters	Locations	Method	Frequency	Annual Budget (in BDT)	Responsible Agency Implemented by	Responsible Agency Supervised by
Noise Level	7 locations (3 locations inside plant- 1 location in laydown area, 1 location in near Pipeline area 1 location near batching plant 4 location outside plant boundary 1 location near main gate, 2 location in the nearest Mosques, 1 location near school 1 location in outside the laydown area in the nearest mosque)	Noise level collection and analysis	Daily within the plant Once in a week outside the plant (day and night)	15,00,000 EPC contractor's budgets	Contractor	UMPL EHS team
Water quality DO, COD, PH, TSS oil and grease both for surface and ground water and total coliform index.	2 locations for surface water – 1 location in the jetty 1 downstream 3 locations for groundwater- 1 location within the plant near raw material storage area 1 location outside the plant in its south 1 location in the laydown area Wastewater monitoring- STP outlet	Sample collection and laboratory analysis	Monthly	10,00,000 EPC contractor's budgets	Contractor	UMPL EHS team
Drinking water quality (WHO Drinking Water Guidelines and parameters)	Borewells	Sample collection and laboratory analysis	Monthly	100,000 EPC contractor's budgets	Contractor	UMPL EHS team
Livelihood Restoration Plan	Project location	Budget allocations, disbursement of compensation and entitlement as stipulated in the LRP, grievances etc	Once during planning stage	As stipulated in LRP	Regular monitoring by UMPL	UMPL EHS team
LRP Implementation	Project Location	Intermittent assessment of the implementation of LRP to ensure project deliverables are met and suggest any changes/adjustment	Assessment of the livelihood restoration during implementation and third-party post implementation of the LRP	As stipulated in the LRP	Regular monitoring by UMPL during implementation and Third Party audit to be engaged by UMPL post LRP implementation	UMPL EHS team
Environmental Monitoring During Operation Phase						
Air quality: SPM PM_{10}, $PM_{2.5}$, SOx, NOx, and Lead, VOC.	6 locations (1 location inside plant- 1 location in the plant main gate 4 locations outside the plant, 2 in North East & North-west of the plant, and 2 around the plant near sensitive receptors using stationary air quality station (To be based on GLC and location of sensitive receptors)	Sample collection and laboratory analysis	Quarterly	30,00,000 O&M contractor's budgets	O&M Contractor through third party	UMPL EHS team

Parameters	Locations	Method	Frequency	Annual Budget (in BDT)	Responsible Agency	
					Implemented by	Supervised by
Stack monitoring NOx, CO, PM2.5 and O2	Main stack and bypass stack	Continuous Emission Monitoring System	Continuous	Installation included in EPC Cost Monitoring and maintenance in O&M cost	O & M Contractor	UMPL EHS team
Noise Level	6 locations 6 locations (1 location in the plant main gate 5 locations outside the plant near sensitive receptors through continuous monitoring system and information board.)	Noise level collection and analysis Quarterly(24-hours)	Quarterly (24-hours)	5,00,000 O&M contractor's budgets	O&M Contractor	UMPL EHS team
Water quality DO, COD, PH, TSS oil and grease both for surface and ground water and total coliform index.	6 locations (3 locations for surface water 50 m and 100 m from the point of discharge of effluent on upstream and downstream locations for groundwater 1 near Common monitoring basin I near hazardous waste storage area 1 outside the plant in its south-east)	Sample collection and laboratory analysis	Quarterly	10,00,000 O&M contractor's budgets	O&M Contractor	UMPL EHS team
Drinking water quality (WHO Drinking Water Guidelines and parameters)	Existing borewell (if used)	Sample collection and laboratory analysis	Quarterly	10,00,000 O&M contractor's budgets	O&M Contractor	UMPL EHS team
Raw and treated sewage and effluent (BOD, COD, TSS, pH, Temperature, faecal coliform, sulphate, phosphate)	3 locations (1 sample at outlet of STP, 1 sample at outlet of ETP, 1 sample at outlet of CMB)	Sample collection and laboratory analysis	Monthly in addition with regular monitoring system of ETP	30,00,000 O&M contractor's budgets	O&M Contractor	UMPL EHS team
Indoor Air Quality Monitoring	2 locations (Admin building and Dormitory and Canteen)	Sample collection and laboratory analysis	Six-monthly	10,00,000 O&M contractor's budgets	O&M Contractor	UMPL EHS team
Work zone Noise	2 locations (1 m from the noise generating equipment)	Sample collection and laboratory analysis	Six-monthly	10,00,000 O&M contractor's budgets	UMPL EHS team through third party agency	UMPL EHS team
Health & safety Monitoring						
Health and Hygiene of Workers	Plant & Surrounding	Observation and consultation	Quarterly	-	UMPL EHS Team	UMPL Corporate
General Occupational health and safety for reporting any accident, near miss and other occupational related accident and diseases	Plant and laydown	Observation and consultation	Daily	-	EHS Contractor O&M Contractor	UMPL EHS Team

Parameters	Locations	Method	Frequency	Annual Budget (in BDT)	Responsible Agency Implemented by	Responsible Agency Supervised by
Visual inspection of use of PPE	Plant	Physical verification for integrity and safety to use. In case of respirators and SCBA arrange third party fit test	Monthly Six Monthly	2,00,000 EPC Budget during construction 1,00,000 O&M Budget during Operation	EHS Contractor O&M Contractor	UMPL EHS Team
Regular Medical Check-up of Workers	Plant	Physical Examination, Audiometry, Spirometry, Total Lung Capacity, Eye Check-up, Vertigo Communicable/infectious Diseases	Annually	2,00,000 EPC Budget during construction 1,00,000 O&M Budget during Operation	EHS Contractor O&M Contractor	UMPL EHS Team
Social Monitor During Both Phase						
Employment Opportunity	In Plant	To honour the local communities demand hence giving first preference to locals	Annually	-	UMPL Social Team	UMPL Corporate
Stakeholder Engagement	All Stakeholders	Build trust and amiability amongst the stakeholders involved by conducting regular meetings with stakeholders	Every month	50,000 UMPL Budget	UMPL Social team	UMPL Corporate
Grievance Mechanism	Community and Worker Grievance	Grievance raised, action taken, number of grievance committee meetings	Every Month	-	UMPL Social team	UMPL Corporate
Proposed Activities of Social Management Plan, LRP and CSR	Dudhghata Mouza and Surrounding	Direct Implementation of Proposed Activities	As per Plan	Budget mention for LRP, ESMP, CSR	UMPL Social team	UMPL Corporate
Community Health and Safety due to road traffic, accidents and pollution such as dust generation etc	Fence line community residing along the project footprint, Access Road and Water channel	Grievance raised verbally and through written complaints (including anonymous complaints)	Based on complaints raised/Continuous process	Part of the management cost	UMPL Social team	UMPL Corporate

9.3.2 Roles and Responsibilities

UMPL is the Project Proponent and has the following responsibilities:

- Implement and ensure environmental performance in 600 MW CCPP is in complete adherence to the Statutory and Financial Institutions' environmental and social performance standards, policies and guidelines during construction and operation phase.
- Overall responsibility for ESMP implementation during the construction and operation phase
- Supervise and ensure implementation of ESMP by in-house EHS&S professionals or consultant

- Review reports of the Independent (third-party) Environmental Monitoring Agency to ensure complete compliance with monitoring requirements
- Approve and enforce changes in the ESMP, as necessary, as part of an adaptive approach to environmental and social management of the 600 MW CCPP
- Responsible for interacting with stakeholders to record their grievances and document the same for redressal.
- Develop a health, safety & environmental unit, headed by the Deputy Manager - EHS to implement ESMP responsibilities and ensure management, implementation, monitoring and compliance of the ESMP, ESIA, and any approval conditions, including construction supervision and performance of all 600 MW CCPP staff, contractors and subcontractors
- Review of ESMP performance and implementation of correction actions, or stop work procedures, in the event of breaches of ESMP conditions, that may lead to serious impacts on local communities, or affect the reputation of the project
- Ensure effective communication and dissemination of the content and requirements of the ESMP to contractors and subcontractors
- Assisting the contractor with implementation of Environmental and Social Management Procedures
- Report on environmental performance to DOE, the Funding Agencies, and other regulators as per the compliance requirements.

Supervision Consultant (Owner's Engineer)

The Supervision Consultant would be responsible for monitoring compliance to all specifications related to Environment & social obligations in the Contract for the project, that would include the following:

- Adopt necessary design alterations in the project as per the recommendation of the ESIA study findings
- Supervision of proper implementation of all the ESMP recommendations by EPC Contractor/sub-contractors
- Carrying out quality auditing, monitoring and supervision of sub-contractors (Including laboratories) under their control.
- Ensure and certify periodic sampling and certify related testing of environmental parameters namely ambient air quality, noise level, water quality, performed by external third-Party agencies
- Establish and maintain a system of records of the monitoring conducted and their outcomes
- Ensure implementation of all observations of periodic audit issued by Lenders' Consultant during the construction stage till trial & commissioning of the plant.

Deputy Manager – EHS

The Deputy Manager – EHS would have the following responsibilities:

- Preparation and implementation of the Environmental Supervision Plan during construction and obtain approval of the same from UMPL Management.
- Preparation and implementation of the Environmental Monitoring (periodic) Plan during construction and operation phase.
- Communication and liaison with all the Statutory bodies (e.g. DoE) regarding any queries/disputes and ensure timely submission of the compliance reports.
- Preparation and maintenance of Environmental Records (e.g. daily water consumption, wastewater generation and treated wastewater volume, waste inventory, waste generation record, waste recycling/disposal records etc).
- Supervision of contractor performance on implementation of the Construction and Work Camp Management Plan. Reporting any incidents or non-compliance with the ESMP to the UMPL Management Group.
- Ensuring adequate training and sensitization and education of all staff involved in environmental supervision
- Periodically assess budget allocated for EHS provisions and obtain approval for new/additional allocations with justification, when required.

EPC EHS Team

The EPC EHS team would have the following responsibilities:

- Preparation of Environmental and Social Management Plan (ESMP) and ensure reporting of implementation of the same to UMPL EHS division.
- Ensure availability of resources and appropriate institutional arrangements for implementation of ESMP
- Ensure compliance to statutory EHS compliance requirements during both construction and operation, and all the requirements of Funding Agencies.
- Supervision of contractor EHS team's performance on implementation approved ESMP and ESAP during construction phase and operation phase.
- Carry out compliance/enabling audits at periodic intervals, and inspections of all the project activities; suggest corrective actions against any non-conformance.
- Organize training programs and awareness activities on environment, health and safety for site staff and community.
- Impart periodic training to Contractor's EHS staff on Environmental Plans and Procedures and Implementation Strategy.
- Ensure implementation and maintenance of Environmental Records (e.g. daily water consumption, wastewater generation and treated wastewater volume, waste inventory, waste generation record, waste recycling/disposal records etc) by Contractor's EHS staff. Also include preparation of other necessary EHS documents and record keeping system.
- Ensure periodic environmental monitoring activities are carried out as per plans and programs established during both construction and operation stages.

Contractor's EHS Team:

The Contractor's EHS team would be responsible for implementation of Environmental and Social Management Plans and Procedures of UMPL in totality under the supervision of UMPL EHS Supervisor. All the basic environmental management services and environmental amenities installation and commissioning would be included contractually in Contractor's scope in case of lumpsum turnkey contract.

Deputy Manager – Social & Community Development

The Deputy Manager – social & community development would have the following responsibilities:

- Implementation of social Management Plan Recommendation
- Implementation of Resettlement Action Plan Recommendation
- Implementation of Livelihood Restoration Plan Recommendation
- Need Assessment Survey for CSR Plan Preparation
- Preparation of CSR Plan and Implementation
- Stakeholder Engagement and dissemination of information as per Stakeholder Engagement Plan during construction & operation phase
- Community Grievance Redressal

Labour Welfare Officer

The Labour Welfare Officer would have the following responsibilities:

- Establish contacts and hold consultations with a view to maintaining harmonious relations between the management and workers
- Bring to the notice of factory management, the grievances of workers, individual as well as collective, and to act as a Liaison Officer between the management and labour
- Advise on fulfilment by the management and the concerned departments of the factory of their obligations, statutory, concerning regulation of working hours, maternity benefit, compensation for injuries and sickness and other welfare and social benefit measures.

- Looks after the enforcement of laws governing occupational health, safety, welfare, work-environment, Leave with Wages and Working Hours etc.
- Responsible for fulfilment of the statutory provisions in the factories, as assigned from time to time.
- Supervise functioning of amenities such as canteens, shelters for rest, creches, adequate latrine facilities, water, sickness and benevolent scheme payments, pension and superannuation funds, gratuity, payments, granting of loans and legal advice to workers
- Advise on provision of welfare facilities such as accommodation, food-stuffs, social and recreational facilities and sanitation and on individual personal problems and on the education of children;
- Advise the factory management on questions relating to training of new starters, apprentices, workers on transfer and promotion, instructors and supervisors; supervision and control of notice board and information bulletins

9.3.3 Reporting Mechanism for Environmental and Social Monitoring Program

A robust reporting system would provide the Project with the necessary feedback mechanisms to ensure quality and timely implementation of the works. The reporting system would ensure regular flow of information from the Project site to the Project headquarters and, as necessary, to regulatory authorities and funding agencies. The reporting system would provide a mechanism to ensure that the measures proposed in the Project's ESMP are implemented.

Before the civil works start, the HSE Division of the Project Sponsor, in association with UMPL, would finalise the format for reporting on the status and progress of environmental monitoring. The format would be designed to meet all the compliance conditions associated with the environmental clearance from the Department of Environment and the Government of Bangladesh. The contractor would be required to submit the duly filled up reporting form on a monthly basis to the Project Developer. A further report, detailing the results of pollution monitoring for air, noise, soil, and water would be submitted quarterly as envisaged in the monitoring plan. A semi-internal E&S monitoring would be carried for the project. A health and safety incident/accident report would be prepared and submitted in the event of an incident or accident. Independent verification of the effectiveness of the mitigation measures by the EPC (Engineering, Procurement, and Construction) contractor during the construction phase can be done by UMPL HSE team with a periodic third-party audit.

During the operation phase of the Project, the Operations Manager and HSE Personnel would carry out an annual internal E&S monitoring to ensure effectiveness of ESMP implementation and other E&S requirements. The Deputy Manager (Social & Community Development) would have additional responsibility of monitoring the implementation of social components of the ESMP, both during the construction & operation phase. He/ she would be also responsible for implementation of livelihood restoration and corporate social responsibility (CSR) activities to be conducted by UMPL. Both Operations Manager and HR Manager would further report to the Plant Manager, who would be overall in-charge of the Plant operations and management.

UMPL would develop and implement a programme of reporting through all stages of the project cycle. Reporting would be done in form of environmental check list, incident record register, environmental and social performance reports (weekly, monthly, quarterly, half yearly, yearly etc.).

The quarterly progress reports of the management measures would form an integral part of the Quarterly Progress Reports that can be submitted to the lenders. Additional compliance reports to the Regional Office and Head Office of the DOE required as a part of environmental clearance process would also be prepared and submitted based on the necessary monitoring and reporting formats. Audit and reporting by independent Third-party Environment & Social consultant would be carried out semi-annually during both construction and operation phase of the project

Outline of the Environment, Safety, Health & Social Audit report would broadly include i) Approach & Methodology; ii) Reference framework; iii) Project description including Permits & licenses; iv) Compliance to Environment and Social System and Procedure followed by Corrective Action Plan.

The EHS team would be responsible for communication with regulatory agencies and stakeholders as per the requirement. All complaints and enquiries would be properly dealt with and records would be maintained in Inspection and audits reports comprising the finding and corrective action plans would be carried out.

9.3.4 Institutional Setting and Implementation Arrangement

The ESMP (mitigation plan) would be included in the construction contract and the contractor would be responsible for implementation of the measures associated with design and construction. UMPL's staff, specifically the EHS Manager and Site In charge, would monitor the implementation of these mitigation measures by the contractors at the site. These two officers would be responsible for the field level monitoring of the Project. The additional Management Plans identified in the ESMP would be prepared through third-party independent E & S consultant.

The roles and responsibilities of the Project Developer (UMPL) and Contractor for implementation and monitoring have been outlined in ***Table 9.3*** below.

Table 9.3. Roles and Responsibility

UMPL	EPC/O&M Contractor
Obtaining statutory clearances required during pre-construction stage of the Project	Interaction with Project Developer and appointed supervision consultant, if any
Overall project co-ordination and management through EPC and supported by the third-party environmental consultant/s	ESMP Implementation and Reporting
Interaction and reporting to the respective department of GoB	Obtaining permits required during the construction stage
Interaction and reporting to lenders	Environmental monitoring through laboratory
Effective implementation of ESMP and monitoring of ESMP implementation Monitoring of ESMP implementation would be through third party E&S monitoring consultant	Filling of reporting formats as per the reporting schedule and submission to Project Developer
Keeping records of all permits obtained by EPC Contractor	Filling of reporting formats as per the reporting schedule and submission to Project Developer
Approval of plans prepared by EPC Contractor	
Addressing grievances of local community and information dissemination	

9.3.5 Organizational Structure

The overall management and coordination of the project would be managed through Managing Director and Chairman, UPML; who would be supported by the Executive Director and Head of various departments like Finance, Technical, Human Resources and Accounts. Executive Director would be the Head of Projects. The Head –Projects would supervise, monitor and control the activities of Site Manager and the Deputy Manager - EHS at the site. The contractors would be controlled by the site manager during construction and operation phase. The project does not attract any significant adverse social impacts or risks as indicated in the previous sections. The project footprint area is confined to the site and its immediate vicinity and a specific target stakeholder.

During construction phase, the Deputy Manager – EHS would coordinate and supervise with contractor's EHS team to ensure implementation of environmental management plan on site. It is proposed that UMPL recruits a team of EHS professionals reporting to Deputy Manager – EHS, headed by an EHS supervisor for implementing and supervising the environment, health and safety issues; and ESMP on site during the operation phase. Similarly, it is proposed that Social & Community Development personnel is recruited during construction and operation phase at site for managing the social (including workers and neighbouring community) issues and redressing their grievances. An organization structure proposed for implementation of the EMP during various phase of the project at Meghnaghat 600 MW CCPP is as presented in ***Figure 9.1.***

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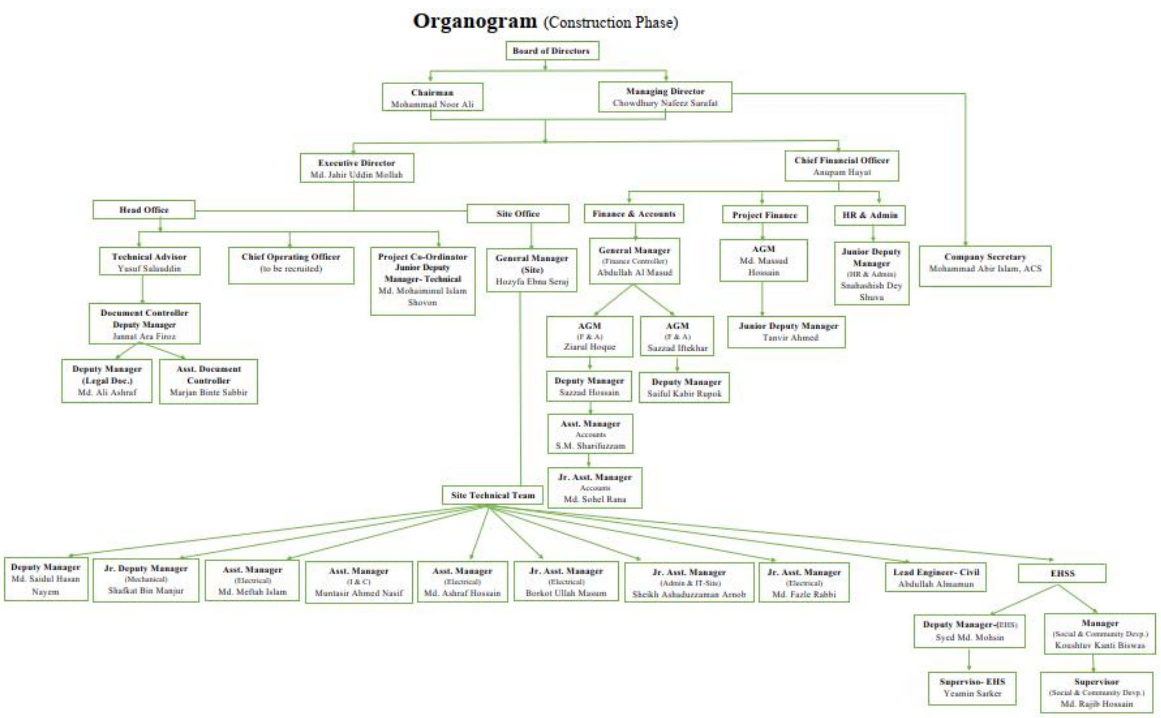


Figure 9.1: Organogram UMPL

9.4 Training

9.4.1 Construction Phase

Construction Phase Prior to commencement of major civil works at site, a suitably qualified in-house/ external expert would be appointed by the EPC (Engineering, Procurement, and Construction) contractor in consultation with UMPL to develop and deliver a training program on implementation of the ESMP, environmental monitoring and reporting in line with the applicable reference framework for the Project. The training would include the following topics:

- Environment, Health and Safety Policy of the contractor,
- Environment and fundamentals of environmental pollution in relation to the Project,
- HSE management plans prepared by the Contractor,
- Do's and Don'ts for the construction workers,
- Safety procedures and guidelines,
- Internal reporting and response system,
- Hazardous chemicals and waste handling,
- Community Health & Safety (Including GBV/SEAH)
- Code of Conduct

In addition, specific training would be provided to the team involved in environmental monitoring and reporting, which would include:

- Applicable environmental guidelines and standards,
- Sampling site selection guidelines in line with environmental monitoring plan,
- Sample collection, storage, transportation and analysis procedures,

- Solid and hazardous waste management,
- Quality assurance and quality control,
- Environmental monitoring report preparation

The training would help in capacity building and implementation of the ESMP during the construction phase of the Project. It would also help in ensuring internal and external monitoring and verification of the environmental performance of the Project. The reporting and verification during the construction phase would be semi-annual and the reports would be submitted to the Department of Environment and the Lenders.

9.4.2 Operation Phase

Prior to the commencement of the Plant operation, a suitably qualified in-house/ external environmental expert would be engaged by UMPL to develop and deliver a training program on operation phase environmental monitoring and reporting. The topics would be mostly same as that during the construction phase. However, it would also include following modules, which are specific to the operation phase:

- Continuous emission monitoring,
- Wastewater and thermal discharge monitoring,
- Aquatic ecology monitoring,
- Hazardous chemicals and waste management,
- Occupational health and safety programs,

The training would help in capacity building and implementation of the ESMP during the operation phase of the Project. It would also help in ensuring internal and external monitoring and verification of the environmental performance of the Project. The reporting and verification during the operation phase would be annual and the reports would be submitted to the Department of Environment and the Lenders.

9.5 EHS Plans for Construction and Operation Phase

9.5.1 Construction Phase

Prior to the commencement of works, the EPC contractor in cooperation with Project Developer would develop the following plans:

Health and Safety Plan

The EPC Contractor has prepared an EHS Plan prior to commencing work to reduce the below mentioned hazards:

- Falling from height,
- Falling into water,
- Entanglement with machinery,
- Tripping over permanent obstacles or temporary obstructions,
- Slip Trip & Fall,
- Falling from Hight,
- Burning
- Suffocation,
- Explosion,
- Contact with dangerous substances,
- Electric shock,
- Variable weather conditions,
- Lifting excessive weights; and

- Traffic accident.

The EPC Contractor has also prepared and would implement a Construction EHS Plan prior to commencing work to manage the construction related environmental aspects as Pollution Prevention, Ecology Management, waste management, labour management plan, sanitation aspects, water conservation, Risk Assessment, Monsoon Contingency, Traffic management plan, Hazardous Material Handling and Storage Management, Emergency response, etc.

9.5.2 Operation Phase

During operation Phase UMPL or O & M Contractor would prepare below mention management plan for smooth operation of the plant.

- Waste Management Plan - Waste management plan would encompass measures for effective segregation, handling, storage and disposal of solid (including hazardous wastes) wastes generated from the Plant operations
- HSE Management Plan – HSE management plan would be prepared for the plant operation for the plant premises
- Emergency Response and Disaster Management Plan - Based on the detailed QRA of the Project after finalisation of project design, firm emergency response and disaster management plan will be developed to delineate procedures in the event of emergencies or disasters to prevent loss of life and reduce impact on properties and environment. The plan would address on-site and off-site emergency situations and would include awareness programs for the Plant personnel, local community and local administration.
- Community Management Plan
- CSR Plan
- Greenbelt Development Plan
- Spill Management Plan
- Stormwater management Plan
- Offsite Vehicle & Riverine Traffic Management Plant

Apart from that UMPL would develop Environmental and Social Management System as per guideline of the multilateral funding agency and implement the same for the entire plant premises

9.6 Green Belt Development Plan

Unique Meghnaghat Power Limited (UMPL) would develop green belt within the proposed 600MW RLNG-based Combined Cycle Power Plant premise as part of Sustainable Development and Management of Natural Resources, to provide noise barrier and for banks of Meghna river, to increase their protection from storms and cyclones. Green belts are also capable of absorbing air pollutants thereby reducing the concentration of air pollutants in the ambient air, as well as providing aesthetic improvement; and result in biodiversity enhancements through creation of habitats for fauna and avifaunal species. From pollution prevention perspective, the green belt would be developed using source-oriented approach since the proposed project site does not have any industrial establishment in the immediate vicinity (say 1km radius) and the pollutants emitted by the plant need to be contained.

The green belt would be developed within the plant boundary and along the banks of Meghna River Channel immediately outside the plant boundary. The total land area of the 600MW RLNG-based Power Plant is 21.07 acres out of which, approximately 6.22 Acres of land would be available for green belt development.

This green-belt development plan only considers green belt only within the plant boundary.

In order to comply with the provision for developing greenbelt, UMPL would consider developing offsite Avenue Plantation along the Approach Road to their Plant. UMPL would also consider off-setting the green belt by engaging in various Community plantation & Social Forestry programmes as a part of their Community Development Plan for development of the overall foliage cover of the area.

9.6.1 Green Belt inside Plant Boundary:

Green belt would be developed inside the proposed plant boundary by planting shrubs & trees and developing turf. Priorities would be given to the native plant species with low water requirements.

Trees: Trees would include medicinal plants, ornamental trees, fruit bearing trees and hard wood trees which provide good ground protection against erosion & storms and also purify the air. Some of the key plant species identified are:

- Supari (Areca catechu),
- Narikel (Cocos nucifera)
- Debdaru (Polyalthia penduriformis),
- Neem (Azadiracta indica)
- Aam (Mangifera indica),
- Peyara (Psidium guajava),
- Dalim (Punica granatum),
- Ata (Annona reticulate)
- Orjun (Terminalia arjuna)
- Krishnochura (Delonix regia), etc

Trees would be planted mainly in the periphery of the site along the site boundary, and along the open stretches. For internal roadside plantation, the first row of plants along both sides of the internal road would be shrubs, following which trees with low girth-size would be planted.

Shrubs: Shrubs would be planted in the first row along both the sides of the internal roads, along road medians, open areas in and around main plant units, auxiliary units and the area surroundings the administrative building in project area. For plantation of woody shrubs, a minimum distance 2 m would be maintained between two plants. Additionally, plantation of small ornamental herb species like Gada (Tagetes patula), Jiu (Jasminum auriculatum), Dopati (Impatiens balsamina), Alovera (Aloe vera), Golap (Rosa chinensis) and different types of Pata Bahar is recommended on the roof top and in the open areas in front of administrative building, dormitory, guard & guest house of the project area. Some of the commonly grown shrubs identified are as follows:

- Togor (Tabernaemontana divaricata),
- Bagan Bilash (Bougainvillea glabra),
- Pata Bahar (Codiaeum variegatum),
- Jaba (Hibiscus rosa-sinensis),
- Rangan (Ixora chinensis),
- Lebu (Citrus aurantifolia).

Plantation of Durba grass/ Barmuda grass (Cynodon dactylon) would be carried out in the understory of tree and shrubs over the surface soil. The ***Figure 9.2*** below shows plan for green belt development within the site and along the Approach road.

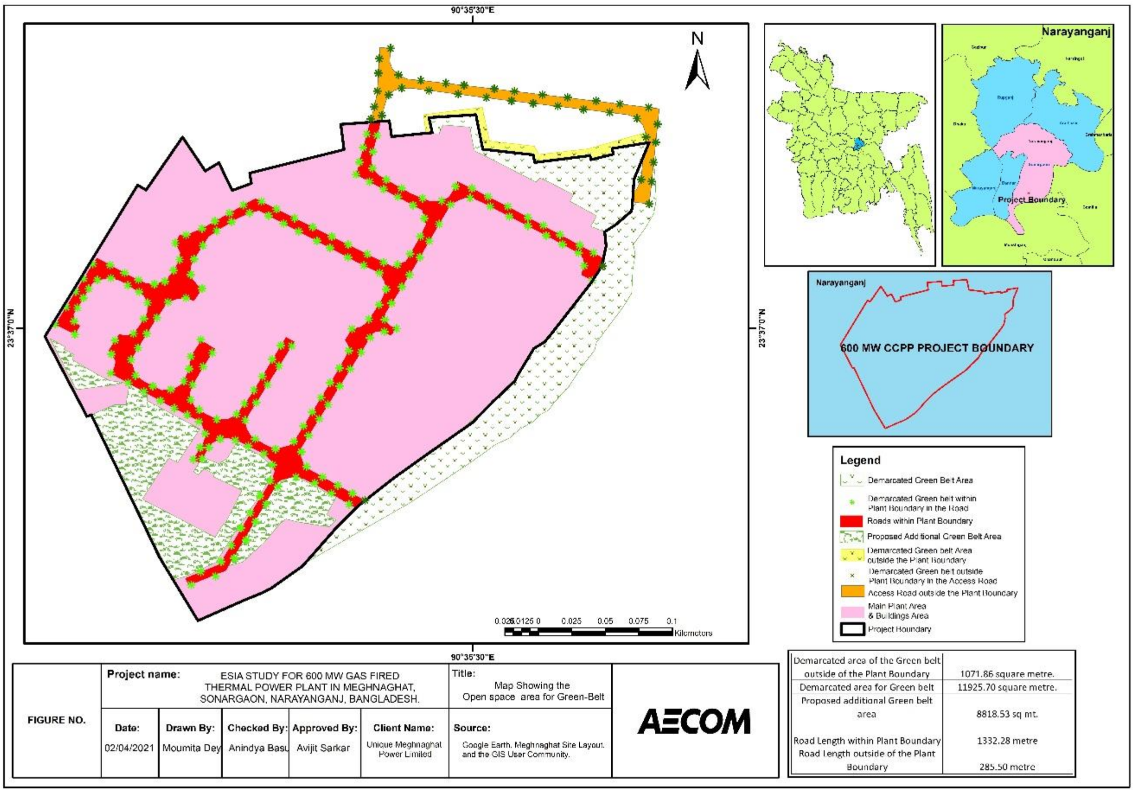


Figure 9.2: Green belt development with tentative plantation plan

The plantation activities would be carried out in phases depending on finalization of the construction plan and availability of land parcels for green belt development.

Nursery:

A nursery would be developed, as per the feasibility of the site. The main agenda of establish a nursery would be, to nurture the saplings of trees and shrubs, which would be transferred to the green belt, at a mature stage. The nursey would operate in such a manner, it would act as a continuous supply chain of the green belt programme.

Other than this, preparation of organic fertiliser like vermicomposting would be an inherent part of the nursery work plan.

Detailed Calculation:

From the site layout of the gas-based power plant it has been derived that total 6.22 acres of land would be available for the green belt development, which is almost 29 percent of the total site area.

Within the total 6.29 acres of green belt area 2.94 acre of land is designated as demarcated green belt area, which is situated at the northern and north east site of the area. Another parcel of land estimated around an area of about 2.17 acre is situated near the transmission tower area, alongside the southern boundary wall of the site. The total road length inside and around the site is approximately 1132 m, it has been considered that plantation would be done both side of the road, hence the total area available at the both side of the road would be approximately 4528 sq. m or 1.11 acre. (considering the plantation width of 2 m).

Also, an area of 0.26 acre of land has been demarcated as green belt area, outside the plant boundary at the north side, but it has not been considered within the green belt plan of the power plant. The breakup of total green belt area is tabulated in ***Table 9.4:***

Table 9.4: Break up of available area for greenbelt development

Land details	Area of land parcel	Type of plantation proposed
Demarcated green belt area	2.94 acre	Trees

Land details	Area of land parcel	Type of plantation proposed
Open space near transmission tower area	2.17 acre	Trees would be planted along peripheral boundary wall only, and shrubs would be planted in the rest of the area.
Land at the both side of the internal roads	1.11 acre	Shrubs
Demarcated land area outside the plant	0.26 acre	Trees
Land at both side of the outer road of the plant	0.28 acre	Shrubs

Source: Layout

UMPL would also explore opportunities and options for developing avenue plantation along the Approach Road to the Plant; and implement the best possible onsite and/or off-site green belt development opportunities.

The detailed estimation of greenbelt is provided below:

Demarcated Green belt area

The total land area demarcated for this specific area is approximately 2.94 acre or 11926 sq. m. For this area mainly trees would be planted. Considering each tree would occupy an area of around 25 sq. m (including girth area), and spacing area between two trees would be another 15 sq. m. Therefore, estimated number of trees within this specific area would be (11926/40) = 298 trees. Approximately 275-300 trees of categories as mentioned above would be planted within the site.

Open space near Transmission tower area

The site is demarcated at the southern part of the site, near the southern boundary wall. For this site plantation of trees would be considered alongside the boundary wall, and the rest area would be plantation of shrubs.

Considering the length of boundary wall is 228.68 metre, and the breath of each tree would be approx. 5 m, so the total area would be used for tree plantation is (228.68 x 5)= 1143 sq. m. or 0.28 acre, and the rest of the area (2.17 – 0.28) = 1.89 acre would be used for shrub plantation.

Total number of trees needed alongside the boundary wall would be (228.68/10) = 22 trees approximately. considering the girth-size of the tree is 5 m, including the canopy, and the spacing between two trees would be another 5 m.

Total number of shrubs needed for the rest 1.89 acre or 7648 sq. m would be (7648/8) = 956 approximately. This is calculated considering that each shrub would occupy an area of 4 sq. m and the spacing between two shrubs would be another 4 sq. m.

Roadside plantation

Roadside plantation would also be done around and within the roads of the site. It has been estimated that total road length is 1130 metre, and mainly shrubs would be planted on the both side of the road. Considering the length of each shrub would be 2 m, and spacing between two shrubs would be another 2 m. Therefore, total number of shrubs on the both side of the road would be (1132/4) x 2 = approximately 566 shrubs.

Expenditures for the Green belt Development

Based on the requirement of the green belt development an annual expenditure would be formulated for the development and maintenance of the green belt. The expenditure included the cost of saplings, equipment and the labour charges. The total expenditure for the development of the green belt is tabulated below Table 9.5.

Table 9.5: Expenditure for development of greenbelt

Expenditure details	Unit rate (BT)	Total number	Additional cost (BDT)	Total cost (BDT)
Cost of shrubs	100	1522	Cost of grasses/turfing and climbers in the remaining available open space and along the boundary walls is estimated at approx. 1,00,000 BDT.	152200
Cost of trees	150	320		148000

Expenditure details	Unit rate (BT)	Total number	Additional cost (BDT)	Total cost (BDT)
Labour charges for two horticulturist and 3 unskilled labour for 6 months	10,000/month	5		3,00,000
Manure for 6 months	2000/month			12,000
Water consumption	Water required for the green belt development and maintenance would be obtained from the water stored in Rainwater Harvesting Structure constructed onsite, hence no cost for water is envisaged.			
Total Cost (BDT)				**6,12,200**

Total estimated Capital Expenditure: **BDT** 6,12,200, say 6,13,000 (Six lakh thirteen thousand Bangladeshi Taka approx.)

Total estimated Operational Expenditure per year: **BDT 3,50,000**[57] (Three lakhs and fifty thousand Bangladeshi Taka approx.).

The Expenditure furnished for greenbelt development is tentative and would be finalised after discussion with the Horticulturists once the construction schedule is completed. A detailed schematic for phase-wise green belt development would be prepared by the Contractor before the construction activities commence and once zone-wise construction schedule is finalized for the project. Also, the extent of noise attenuation due to green belt development has been assessed in details and the outcome(s) have been discussed in noise modelling section of the report.

9.7 Spill Management Plan

The proposed project involves handling of hazardous chemicals and oil during pre-construction & construction phase as well as operation phase. Due to continuous operation of heavy earth moving equipment, vessels/barges carrying construction material, DG sets and other equipment, chances of accidental spillage & leakage of HSD/fuel oil would be more during the construction phase. UMPL would ensure that a proper Spill Management/Response Plan is in place and the same would also be adhered to and followed by the Contractors during the construction Phase. It would also be ensured that the Spill Management Plan of the Contractor is in line with UMPL's Spill Management Plan.

The types of spills/leakages that are generally probable at site includes, but not limited to the following:

- Spillage of HSD from refuelling, leaks, overfilling or connection/disconnection incidents
- Accidental spillage of fuel oil or any other hazardous chemical from vessels to the River water
- Accidental release due to breach in storage of HSD, Fuel oil and other hazardous chemical
- Improper handling of hazardous chemical, HSD/fuel oil
- Improper disposal of waste oil/used oil, leading to accidental release to the ground or river

Spill / Release Response Strategies

Spill / release response strategies for combating spill / release incidents include:

- Prevent or reduce further spillage.
- Mechanical containment and recovery.
- Clean-up, and
- Any combination of the above strategies.

A brief explanation of these various response strategies is provided in the following sections.

Prevent or reduce a spill / release incident

[57] *This excludes the cost of BCPA registered pesticides/herbicides, which would be applied on a need basis only and is not likely to be a general horticultural practice. Therefore, the quantity & cost of these pesticides/herbicides cannot be determined at this stage.*

One of the first response actions, if safe to do so, is the isolation or prevention of the source of the spill / release in an attempt to limit any further discharge. Such first response actions can involve an emergency shutdown of the particular equipment, isolation of a valve or line causing the spill or providing some immediate containment to prevent the further spread of a spill / release. Such measures are only a first immediate response prior to a more coordinate effort being planned and undertaken.

Mechanical Containment and Recovery

Mechanical containment and recovery refer to the restriction of a spill / release movement through the use of booms or some other form of physical barriers and its subsequent removal using skimmers and other mechanical means. These operations may be required for large spills or spills / release which may impact environmentally sensitive areas. This response option would be used if the spill / release:

- Threatens environmental sensitive areas, or
- The spill is unlikely to be removed by natural processes.

The feasibility of a containment and recovery response is dependent upon having surface pollution that is capable of being contained and recovered and having suitable conditions for equipment deployment. In case there is any incident of spillage into River water, this method may be employed to contain the spill & recover spilled material to avoid further deterioration of River water, which is a sensitive receptor.

Clean-up

Oil or chemical spills may be allowed to collect or strand on a specific location in order to assist with clean-up operations. Once a spill is controlled in terms of isolating the source, a response to a spill normally changes from an emergency to a project and needs to be managed as such. This involve clean-up of the spilled materials using soak mats/ pads to absorb the spill and scrapping of contaminated soil. Such operations usually involve the collection of significantly greater volumes of material than was originally spilt. UMPL would ensure provision of adequate number of spill kits in their working area for spill clean-up.

Waste Management

Spill response operations have the potential to generate liquid and solid wastes, if there are clean-up operations. The types and quantities of waste material largely depend on the amount of liquid material spilt and the specific clean-up methods employed. Disposal options for oily wastewater for large spill include high temperature incineration, bioremediation or disposal at secured landfill sites. UMPL would carry out management of clean-up spill material in adherence to National regulations and in line with guidelines of the multilateral funding.

9.8 Dredged Material Management Plan

Dredging activities would be undertaken for the proposed 600 MW combined cycle gas power plant (hereinafter referred to as “plant”) during both construction and operation phases of the project. Capital dredging during construction phase will be undertaken during construction of River Intake Channel and during demolition of the temporary jetties prior to the commencement of operation phase. The periodic maintenance dredging will be undertaken as integral part of operation and maintenance (O&M) of the river intake channel throughout the operation phase.

The dredged material which would be generated from the above activities, needs to be stored and handled properly and any indiscriminate storage & disposal of the dredged material could lead to the potential contamination of soil, groundwater and nearby surface water body. Therefore, a proper management plan is required to efficiently handle, store and manage the dredged material. A dredged material management plan would be a two-stage process:
The initial stage of the dredging management plan would chiefly constitute of scoping activities as delineated below:

- Assessment of environmental, engineering, and economic risks and uncertainties linked with the dredging activity.
- Preliminary studies and surveys, which would help to quantify the dredged material, along with identification of transportation route, storage area etc.
- Identification of applicable local and national level permits, if any, for storage and handling of dredged material.

Final phase of a dredge material management plan consists of key activities, like:

- Identification of suitable technology for dredging and handling of the dredged material.

- Compliance with the applicable local and national regulations of Bangladesh for dredging and management of dredged material.
- Physical, Chemical and biological characterization
- Allocation of responsibilities for dredged material management plan.
- Budgetary allocation; and
- Implementation of the management plan.

The following diagram represents the overall procedure for the dredged material management:

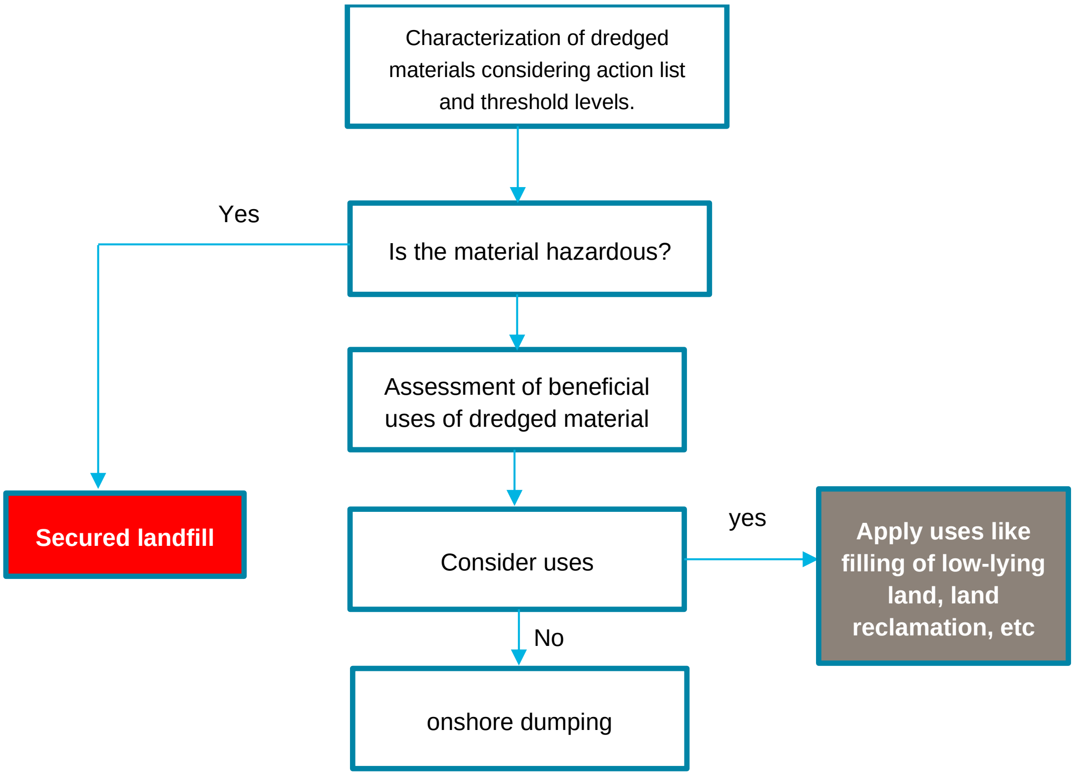


Figure 9.3: Schematic diagram of Dredged Material Management

The framework for management of dredged material is presented below:

- The dredged material excavated from the River Meghna Channel during capital or maintenance dredging would be stored in a designated pit, identified within the plant. The storage pit for the dredged material would be constructed using impermeable liner (clay and LDPE liner) or reinforced cement concrete (RCC) to prevent any leaching from stored dredged material to the soil and ground water table. There would be secondary containment around the designated pit in the form of PCC/RCC bund wall of approx. 0.2m to prevent entry of run-off from the site into the pit. The pit will also have polythene top cover to prevent entry of rainwater into the pit. The dimension of the pit would be determined based on the estimation of the capital dredge materials generated during dismantling of jetties and construction of water intake channel with the assumption that periodic dredging material quantity (annually) would be lesser than capital dredging.
- It is recommended to carry out TCLP (Toxicity Characteristics Leaching procedure) for the dredged material to identify any trace of hazardous elements in the dredged material. In case hazardous material is detected in the dredged material, the same would be arranged to be disposed to the nearest hazardous waste facility for further treatment. In the absence of hazardous waste facility within 10km radius of plant, disposal in authorised landfill would be adopted as per the methods acceptable by World Bank. Disposal in riverine body would strictly be opted out. In the absence of a specific standards for disposal of dredged material in Bangladesh, it is recommended to follow Criteria followed in Japan and accepted by World Bank as follows:

Table 9.6: Criteria for Harmful Bottom Sediments, Japan (unit: mg/l)

Contaminated Materials	Dumping in Landfills (mg/l)
Alkyl mercuric compounds	Not detectable
Mercury and its compounds	0.005
Cadmium and its compounds	0.1
Lead and its compounds	1
Organophosphorus compounds	1
Chromium (VI) compounds	0.5
Arsenic and its compounds	0.5
Cyanogen compounds	1
PCB	0.003
Copper and its compounds	-
Zinc and its compounds	-
Fluoride	-

Reference: Criteria are based on the examination of dissolution of contaminated materials Source: Assessment of the Environmental Impact of Port Development, United Nations, New York, 1992

In the absence of hazardous waste facility, the toxic or harmful dredged materials can be disposed in landfill subject to testing of material samples and compliance with the above guidelines/standards every time such disposal mode is contemplated.

- In case the dredged material is found to be non-hazardous in nature, it would remain stored in the pit and used for land-filling activities within the site or nearby sites, as required.
- The plant would measure the quantity of dredged materials generated each time dredging is undertaken, keep a record of the quantity generated and quality of the sediment, and disposal methods adopted as part of implementation of Environmental Management System.
- It is recommended to engage a EHS personnel with requisite qualification for overall supervision of the dredged material management implementation process so that the procedures are strictly adhered to.
- The indicative budgetary estimate for implementation of Dredge Material Management Plan (CAPEX and OPEX) including manpower, equipment and other associated resources is presented below:

Table 9.7. Estimated Budgetary Allocation for Dredging Management Plan

Item	CAPEX ($ USD)	OPEX /per year ($ USD)
Construction of Storage pit for dredged material and periodic maintenance cum Clean-up (O & M)	30,000	10,000
TCLP/Contamination analysis (third party)	-	5,000
Disposal/Reuse of dredged material (third party agency)	-	8,000

(Note: Testing and disposal of dredged material arising from both Capital dredging & maintenance dredging have been considered in the indicative costing)

9.9 Stormwater Management Plan

Stormwater management Plan has been prepared in an effort to reduce runoff of rainwater into the site and surrounding areas causing inundation of these areas.

The goals of stormwater management include:

- Reduction of potential of flood damage, including damage to life and property,
- Minimize, to the extent practical, any increase in stormwater runoff from the project site to the surrounding area causing inundation and stress on public stormwater drainage systems,

- reduce soil erosion from the project site and protect public safety through the proper design and operation of stormwater basins
- minimize pollutants in stormwater runoff from the site to restore, enhance, and maintain the chemical, physical, and biological integrity of the river waters, to protect public health, to safeguard fish and aquatic life and scenic and ecological values, and to restore the domestic, municipal, recreational, industrial, and other uses of water.

9.9.1 Stormwater drainage within the site

The Storm water drainage network is designed to collect rainwater from the building / roof, roads, storage tank areas and cooling tower water basin, paved and unpaved areas, drainage for pipe trenches, cable trenches etc., overflow water for clean water tank/basin, other drainages for which water quality meet the standards. The rainfall intensity considered for design of stormwater drain is considered as 120 mm/hr.
Storm water drainage network would be designed to collect following discharge:

- Rainwater from building / roof
- Rainwater from roads
- Rainwater from storage tank areas and cooling tower water basin
- Rainwater from paved area and unpaved areas
- Drainage for pipe trenches, cable trenches etc.
- Overflow water for clean water tank/basin.
- other drainages which water quality meet the standards.

Storm ditch or box culverts are the drainage structures to be used for main roads within the proposed plant. Heavy box culverts would be in use where truck movement is envisaged inside the plant. The types of storm drain conduits to be used consists of concrete pipes, concrete boxes, spiral rip metal pipe, corrugated metal pipe, pipe arches, corrugated polyethylene and polyvinyl chloride (PVC). For unfinished areas, where installations are not foreseen, it is assumed that drainage is obtained by natural ground absorption and thus, separate drainage arrangement is not planned for the same. Yard area would be sloped a minimum of 1% to drain away from building and structures towards drainage channels.

The design for storm ditches is based on the self-weight of the storm ditch structure, the compaction load of 20 kN/m^2 (as per the Contract), loads due to soil load and ground water load (ground level and ground water level are considered to be same). The storm ditches in the proposed power plant drainage network, varies in width and depth. Depending on their depth, they are categorized into two groups - Group 1 consists of structures with their vertical height between the base slabs and ground level to be within 1 m and those exceeding are grouped under Group 2. Similarly, the box culverts are categorized based on their net depth, first category comprises of net depth within 0.85 m, where the section would be 800 m × 850 m and the remaining under the second category with a of section of 1000 m × 1000 m. The storm ditches would be constructed with M30 grade concrete and Fe 420 steel for both Grades and the construction of the box culverts would be with M40 grade concrete and Fe 420 steel. The freeboard of 0.3 m would be provided throughout as a safety factor against overflowing and steel grating covers to be provided for the concrete channels. The figures below show the cross-section for each storm ditch group.

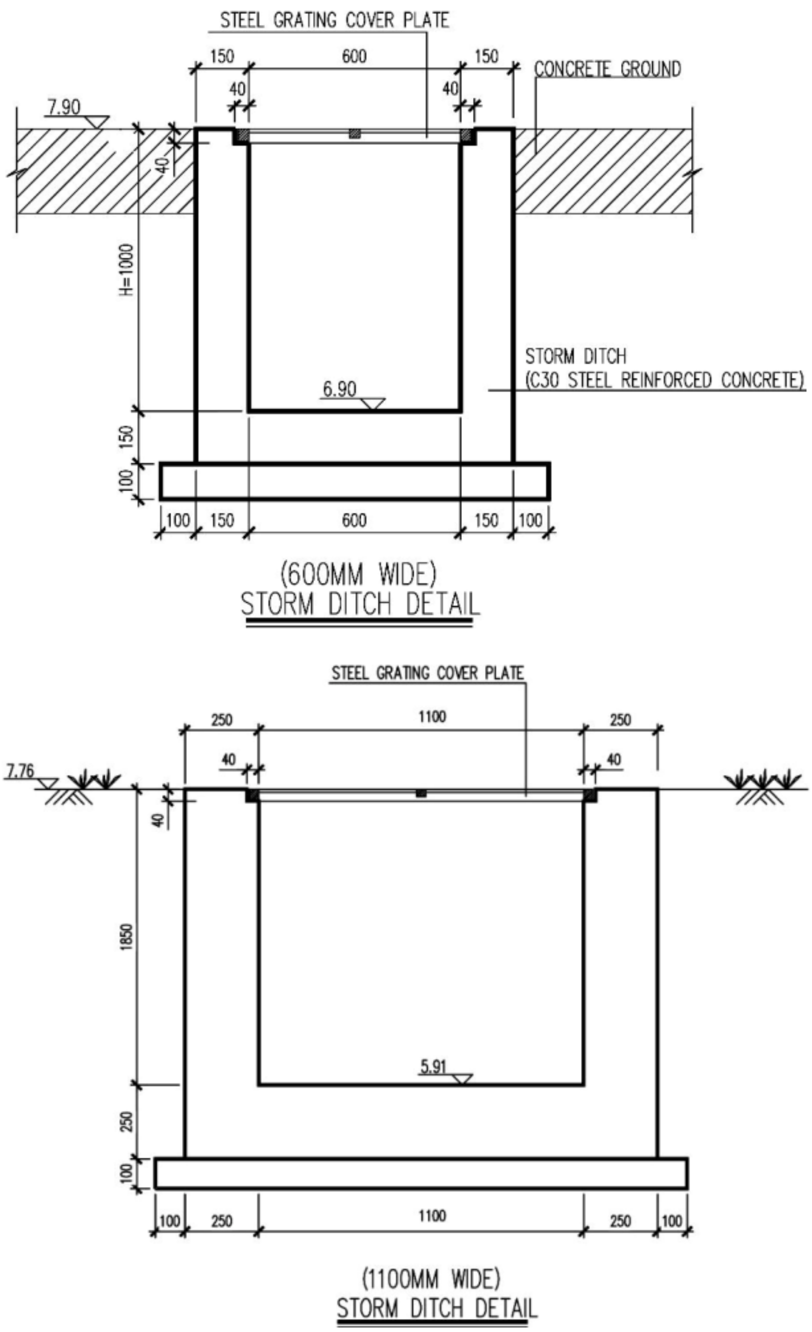


Figure 9.4: Cross section of storm ditches

The yard area of the proposed project would be provided with a 2% slope and the steeper shoulder slope of 2.5 %, to drain away water through the drainage channels. A minimum of 1% slope would be provided for the flow of storm-water under the effect of gravity towards the storm water basins. The slope of the road section has been presented in the figure below.

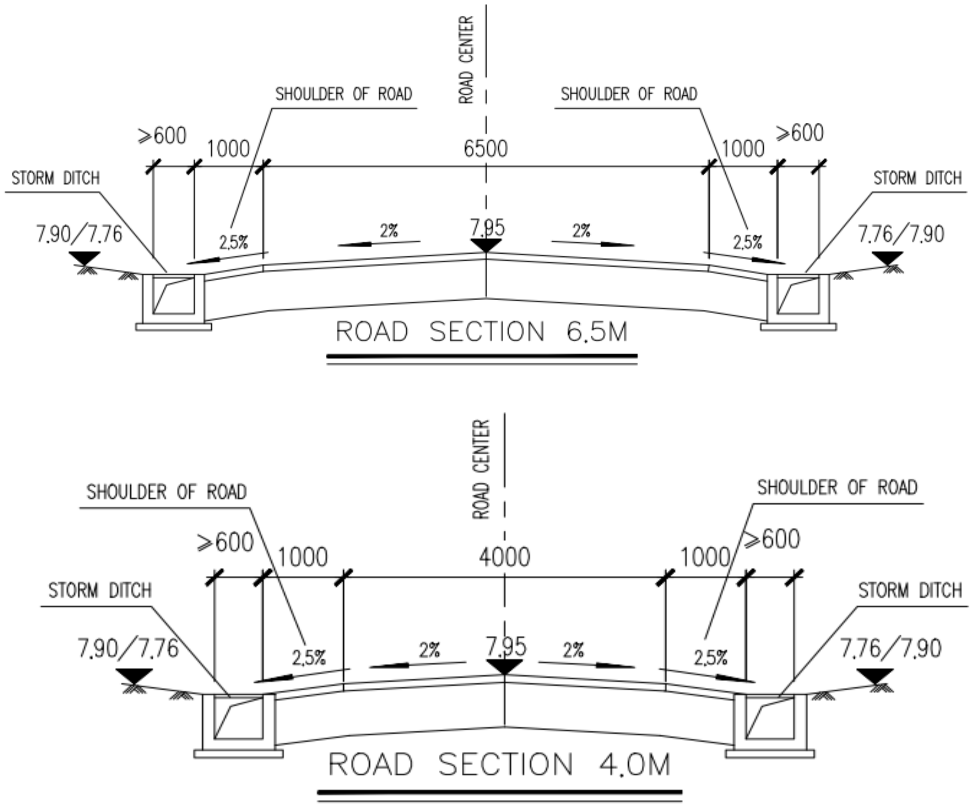
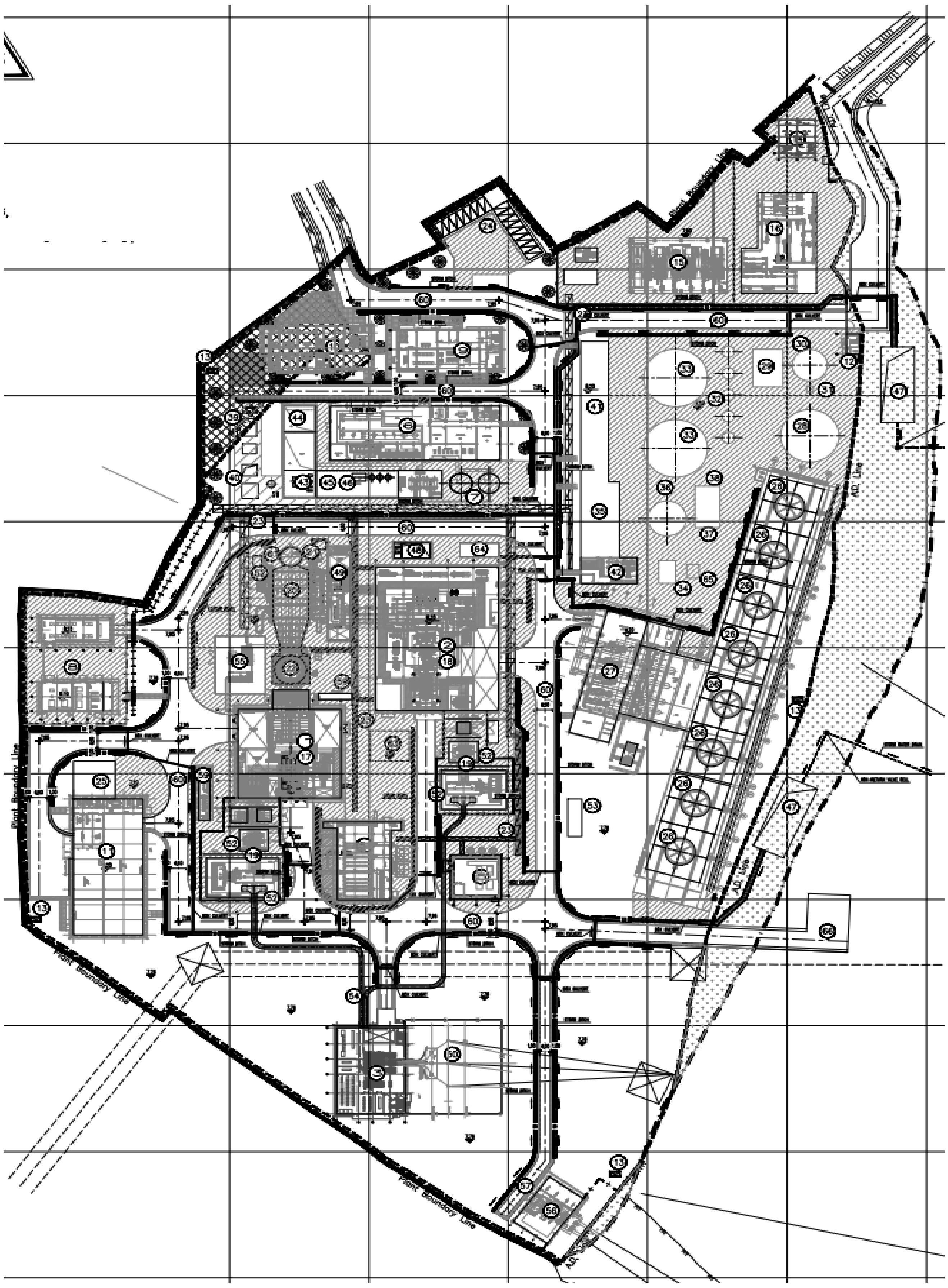


Figure 9.5: Slope of road section

In the project site, two drainage channels would be set up within the plant area as the main drainage. The length of the drainage channel is about 600 m, and the width is 450 mm. Two storm water basins would be arranged at the river side for the storm water drainage of the whole plant, at the south and north of the plant. The catchment area within the boundary wall is about 8.65ha and based on the integrated runoff coefficient of 0.76, the maximum one hour rainfall of the whole plant is about 6580 m3/h and the total storage capacity of the two storm water basins would be about 1650 m3. The total capacity of the two storm water basins would be considered for 15 min storage. The outlets of the two drainage channels are set on the east side of the plant area, which would eventually be discharged by overflow channel to the Meghna River. Non-return valve would be provided, before the storm-water eaves the plant boundary, to ensure one-directional flow and no reversed flow takes place after being discharged into the river channel. The storm water network of the plant is shown in the Figure below.



LEGEND

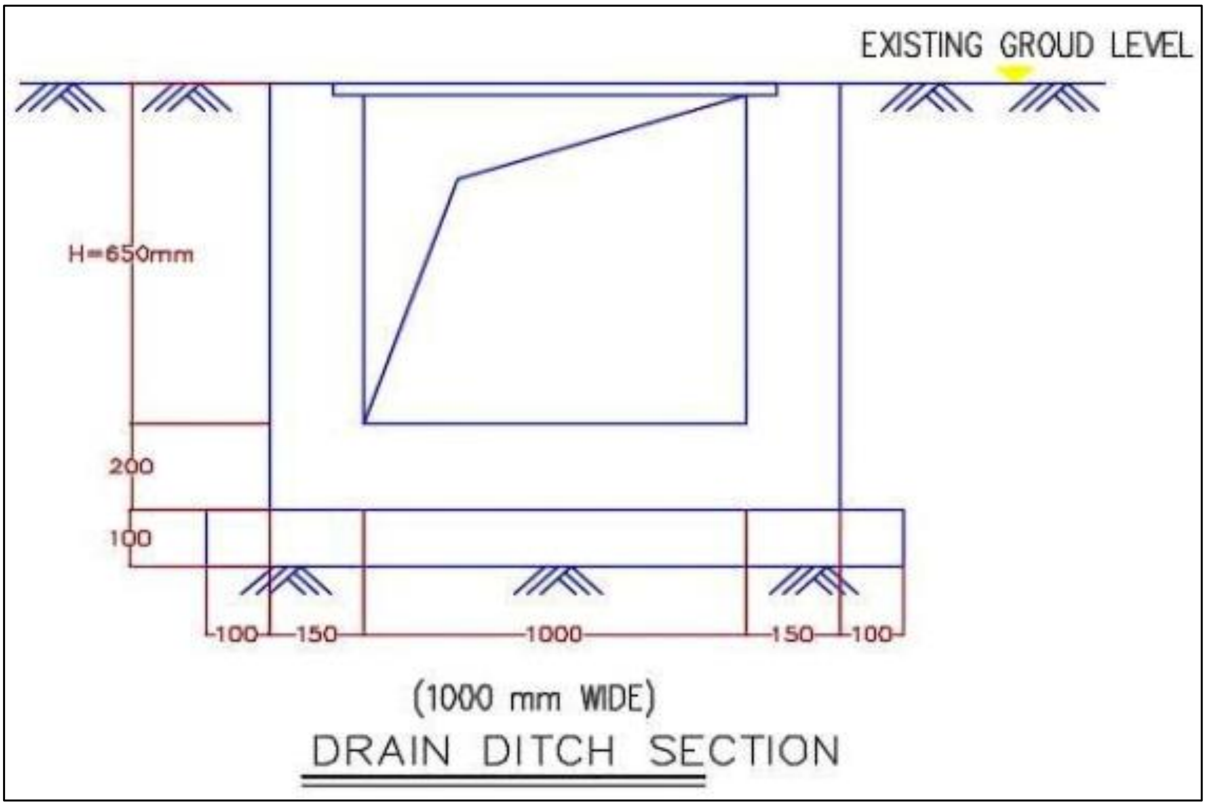
LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
	BUILDING		FENCE
	SINK		PIPE RACK
	ROAD	7.76	OUTDOOR ELEVATION
	HARDENED GROUND	8.20	INDOOR ELEVATION
	BOUNDARY WALL		SIDEWALK
	GREENERY		TRANSMISSION TOWER
	CABLE TRENCH		RETAINING WALL
	PLANT BOUNDARY LINE A.D. LINE	SD	STORM DITCH
	BOX CULVERT		

Figure 9.6: Plant's internal storm water system (Source: Drawing No. UNQ/00/W/UGZ—CEP2P/CE-001provided by UMPL)

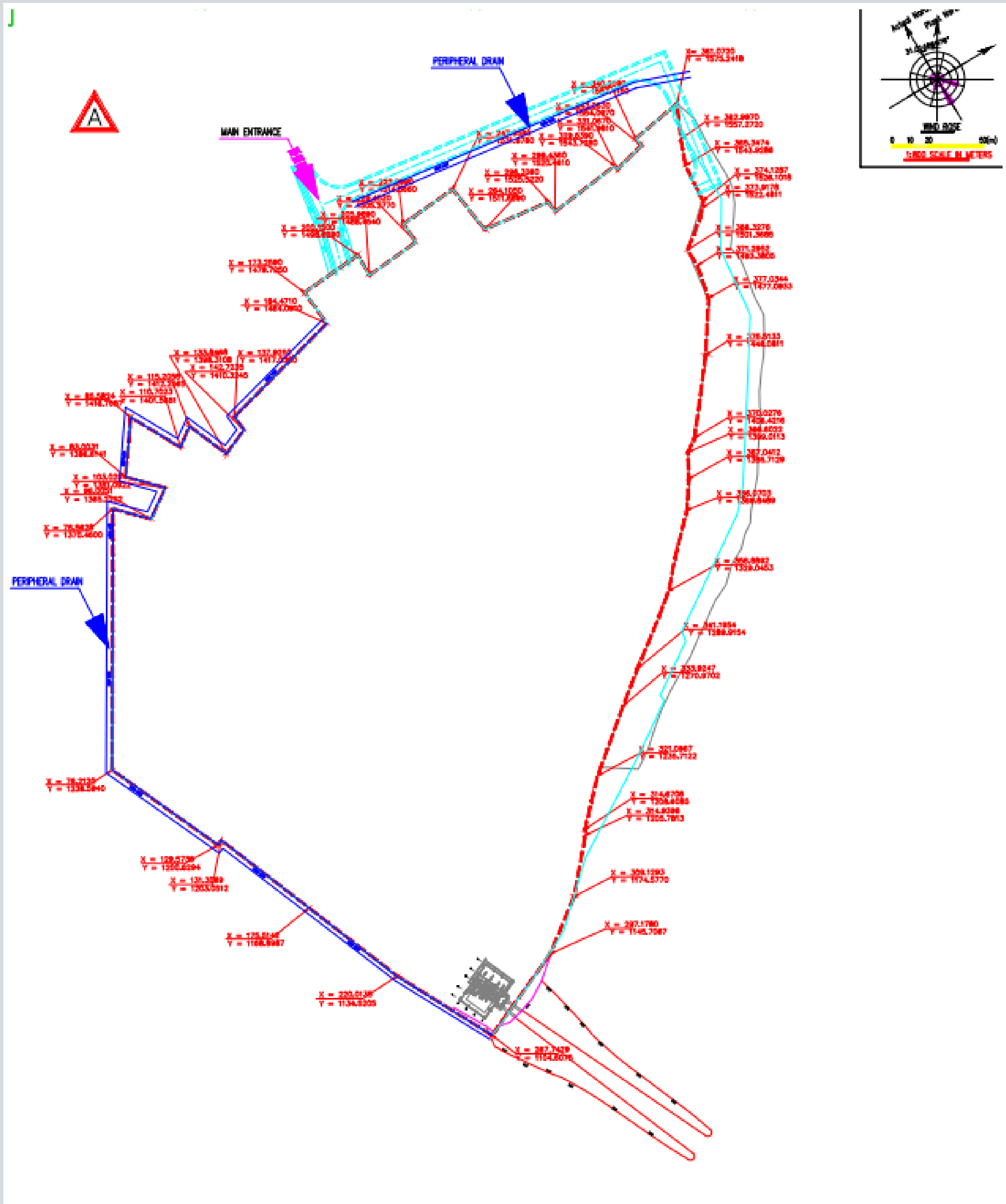
As the site has been raised substantially (HFL + 1 m = 7.76 m), the raised site would impede the natural drainage in the lower catchment of the river, including the surrounding village and the approach road. This may lead to water impoundment in the area surrounding the plant (including Approach Road) as the natural slope of the area has changed due to raising of the site.

9.9.2 Stormwater drainage outside the site

UMPL would take up the construction of peripheral stormwater Drain outside plant boundary to channelize the incoming rainwater water flow from the lower catchment area towards the river to restrict impoundment and flooding within the village land. The stormwater drain would be aligned in a manner to ensure stormwater flow by gradient from the villages into the river through stormwater drain constructed around the Proposed Plant at its outer periphery. This would help avoiding the potential chances of inundation as the collected water would be adequately drained. A continuous 200 ft (60 m) wide strip outside the plant boundary at the village side is considered as the catchment area to design the stormwater drainage size outside the plant. The area is calculated as 39647 sq. m. Considering a free board of 150 mm, drain width of 1000mm and Drain height of 650 mm has been determined, as shown below



The outer peripheral drainage network is given below.


A
PERIPHERAL DRAIN
MAIN ENTRANCE
PERIPHERAL DRAIN
WIND ROSE

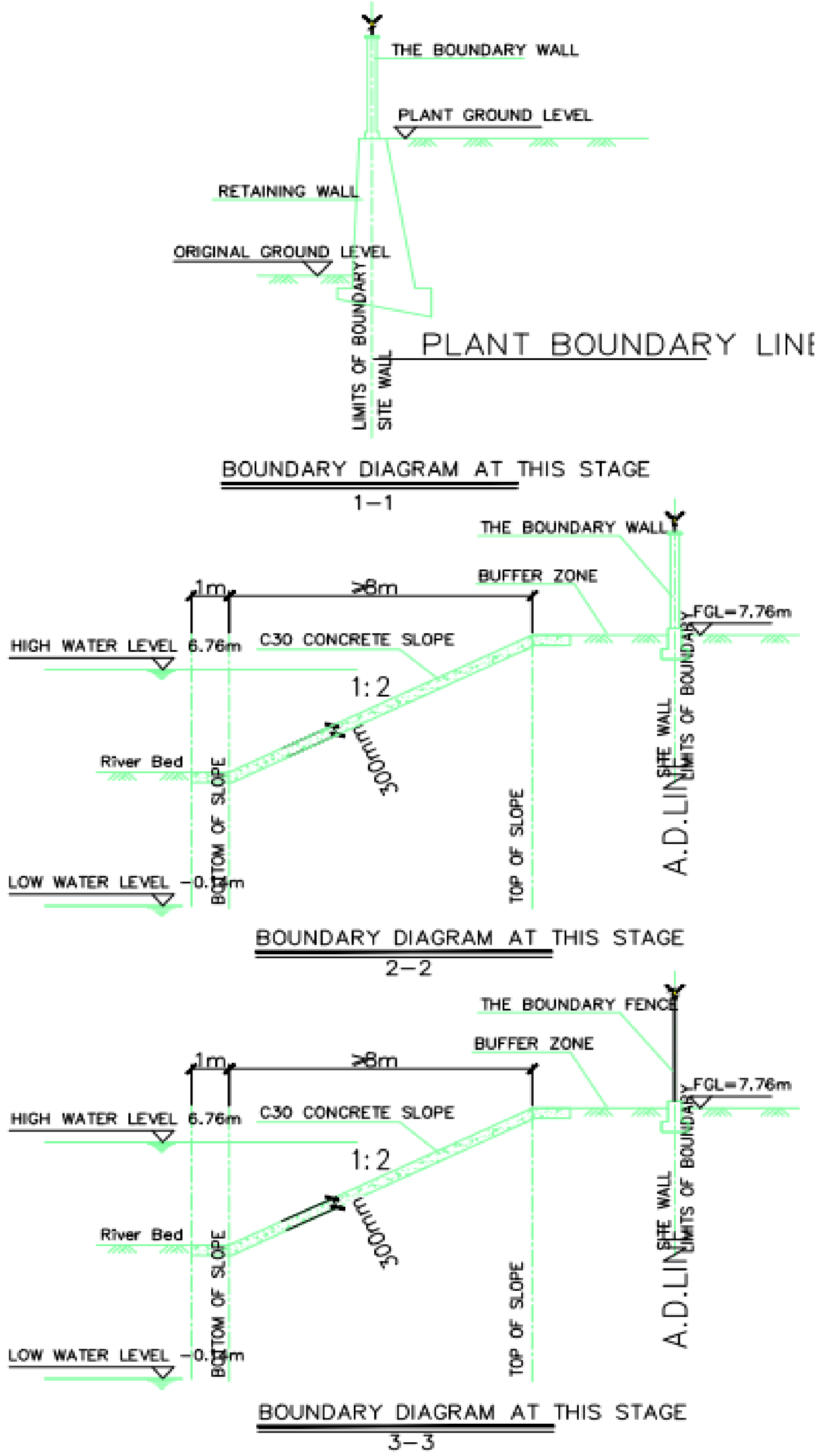


Figure 9.7: Plant's outer peripheral drainage system (Source: UMPL)

In order to ensure that the stormwater management plan including the stormwater drains are properly functioning, the following are recommended:

- Periodic inspection of both internal and external drains to ensure that free flow of water is maintained and there is no clogging in the drain due to natural or anthropogenic reasons. It is to be particularly ensured that inspection and cleaning of drain is carried out during monsoons and storms to remove leaves, debris and accumulated water & sludge, if any.
- As a part of Community interactions and development program, UMPL is recommended to undertake regular consultations with the neighbouring communities about functioning of the stormwater drains and its adequacy to prevent inundations of the surroundings.
- It is recommended that both internal and external drain to be provided with silt traps before discharge of the stormwater to Meghna River.

9.10 Offsite Vehicle & Riverine Traffic Management Plan

The objectives of Offsite Vehicle & Riverine traffic management are as follows:

- The traffic management goals are unambiguously understood by all individuals involved (personnel, suppliers, contractors, visitors, statutory regulatory bodies, etc),
- The potential for traffic related hazards is minimized offsite,
- The traffic flows are smooth and safe without congestion
- To create pedestrian –friendly traffic movement

Additional offsite vehicular traffic and riverine traffic dur to construction and operation of the proposed project may cause adverse impacts on the nearby communities and environment. In order to mitigate those adverse impacts, Traffic Management plan needs to be formulated during construction as well as operation phases of the plant.

9.10.1 Offsite Vehicle & Riverine Traffic Management during Construction Phase

The project site is located in the area adjoining Meghna river, thus the bulk of the heavy machinery and equipment, construction material which would be required for the development of the proposed project is/ would be transported via the waterways. Two Jetties having area of 735 sq. m and 810 sq. m would be used to receive construction material as well as heavy equipment & machinery.

However, the road traffic movements in the Project Area are likely to increase during the construction phase of the proposed project. Road transportation will be availed for personnel commuting to and from work along with river traffic, there would be additional on the existing traffic due to plying of pick-up vans and sedans of UMPL. There is traffic management plan in place which encompasses the following aspects:

- All vehicles would undergo routine repair and maintenance to keep the vehicle in good operating condition
- Drivers and operators would be checked for fitness and any driver/operator impaired due to any reason, including but not confined to the influence of drugs and / or alcohol would not be allowed to drive.
- Defensive driving techniques would be adopted to ensure driving well within the safe limits of the vehicle and equipment operating limits and leaving enough time and room to react in the event of an unexpected condition or movement of another person, vehicle or equipment to avoid a collision or out of control situation.
- Speed limit of 20 km/hr within the site would be followed and use of mobile phone while driving would be prohibited
- Implementation of a safety program (signage, speed restrictions, lights on trucks, truck load restrictions etc.) within the construction area.
- To ensure safety of villages along the Approach Road, all drivers would be adequately trained to understand the road condition during the site EHS Induction, be sensitive and cautious when driving through the villages to avoid any conflict with local villagers. There would be a driver behavioural guide in place.
- All drivers would follow the speed limit, direction of signalman, particular humps or bridges, sensitive locations, horn usage restriction, high beam lights, etc.

- As a part of River traffic management, it would be ensured that there is proper Safety warning signage for river jetty area, prevent Spills or discharges of oil, chemicals, cargo, sewage, grey water and ballast water, All boat/ship/Barge slow down to speed of 8 knots around the jetty area) to turn around, maintain safe distance from others Boats (Local Boat) around jetty area and ensure all the required safety equipment on vessel.

In addition to the above aspects which has been stated to be covered in the Traffic Management plan, the following are recommended in addition to the existing Traffic management plan:

- Collaboration will be undertaken with local communities and responsible authorities to improve signage (e.g., pedestrian crossings, speed limits etc.), visibility and awareness for pedestrian safety,
- The transportation of raw materials would be carried out in covered condition (sheeting). Restrict night-time movement of vehicles carrying raw materials, fuel, chemical and transporting workers. Ensure quick deployment of spill response procedure to allow quick response to clean up any offsite spills of oil/lubricants from the ships or machinery. Ensure quick deployment of spill response procedure to allow quick response to clean up any offsite spills of oil/lubricants from the ships or machinery.
- Depending upon the tidal activity the movement of boat & barges associated with proposed project related transportation, would be operated.
- It is recommended that the movement of vessels carrying construction material and equipment to the site would be restricted between 10 pm to 4 am, without affecting other users significantly, especially the local fishermen.
- Install traffic signals with vehicle stop mark lines at intersection points and designated crossovers (zebra crossing)
- Adoption of Stakeholder measures for avoidance of traffic incidents like display of educational materials and signboards to ensure elderly and children are aware of the increased traffic risk and safety measures

9.10.2 Offsite Vehicle & Riverine Traffic Management during Operation Phase

Movement of traffic during operation would be very minimum, restricted to movement of staffs and Contractual workers only. Traffic due to the project would be mainly due to plying of UMPL and O&M contractor personnel and would include around 3 Nos. of Sedan Car, 7 Nos of Micro Bus and 2 Nos. of Pick up Vans, which would ply to & fro the project site in the Approach Road. The net contribution due to the operation of UMPL on daily average traffic load is not significant, considering this road will be used mainly for conveyance of personnel working at site. However, in order to avoid congestion of the Approach road, the following are recommended as a prat of Traffic Management plan for offsite vehicular traffic:

- Ensure all vehicles with valid pollution fitness certificates are used.
- Enforce local road and river traffic rules;
- Formulation and implementation of a safety program (signage, speed restrictions, lights on trucks, truck load restrictions etc.) and sensitize all the vehicle drivers;
- Provide drivers training on safe driving;
- Installation of vehicle tracking system (VTS) in cars to monitor adherence to speed limit.
- Regulate speed limit of vehicles to 20 km/hr in the village road.
- Restrict night time movement of vehicles
- Restrict use of horns when passing through village roads, and especially at night.
- Adoption of Stakeholder measures for avoidance of traffic incidents like display of educational materials and signboards to ensure elderly and children are aware of the increased traffic risk and safety measures

9.10.3 Implementation and Monitoring of the Management Plan

In order to ensure that the traffic management plan is implemented and adhered to during construction and operation phases of the Project. UMPL would ensure that adequate monitoring to ensure compliance by all site personnel, including management, supervisory staff, and contractors. All site personnel would be responsible for the identification, reporting of incidents in case of non-compliance to the plan.

Implementation of the management plan would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE. Supervision would be carried out by UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS. Monitoring will be achieved through monthly reporting including Corrective Action Plan, if required for ensuring Compliance.

9.11 Drill Cutting & Drilling Mud Management Plan

The section below provides a framework guidance on management of drill cuttings and drilling mud generated during Horizontal Direction Drilling (HDD) for laying of Natural gas pipeline under the riverbed of Meghna. The plan would enable UMPL to carry out environmentally sound handling, storage & disposal of drill cuttings & drill mud, ascertain UMPL's commitment to environmental compliance and ensure the health, safety and well-being of all personnel involved in the project.

Drilling using HDD method uses sustainable construction criteria like lesser construction waste including provision of using materials like bentonite, less noise, lesser impact to the environment. However, it would be required to dispose the drilling mud & drill cuttings in an environment friendly manner as per the prevalent regulations, to avoid issues like contamination to soil & water resource, etc.

The following are recommended as a part of Management measures for the drill cuttings and drilling mud generated during HDD process:

- Adequate management of drilling mud (e.g. bentonite and drill cuttings) would commence with testing for its hazardous characteristics; safe storage and disposal. Toxic Characteristics Leachate Procedure (TCLP) test is recommended to be carried out for the drilling wastes to identify the toxicity quotient and leaching potential before its disposal is planned.
- The drilling mud & drill cuttings would be stored in a designated area with paving/impervious liner and secondary containment like dyke to obliterate chances of soil, surface & groundwater contamination due to seepage & surface run-off.
- The drill cuttings and drilling mud would be disposed though authorised third-party agency. If the drilling mud is assessed to be hazardous, it will be disposed to a hazardous waste facility; while if found non-hazardous, the same will be disposed to authorized landfill through the third party contractor after appropriate mud dewatering through evaporation method.
- In order to alert the working personnel and community from the quicksand properties of bentonite, the storage area of drilling mud & drill cuttings would have proper signages, barricades and boundary. Entrance to the drilling mud storage area would be strictly restricted except those deputed to work in the area and adequately barricaded under proper security monitor to prevent accidents and loss of lives.

9.11.1 Gender Action Plan

The Gender Action Plan (GAP) was prepared with the objective to ensure gender mainstreaming and gender inclusive participation across all levels of the project lifecycle and decision-making processes. The GAP has analysed the potential Gender-based impacts (adverse and beneficial) from the proposed project and understand how the project will impact on the rights of women and recommend actions to incorporate and engage women across the project cycle. The status of women in the area was ascertained from interaction with them during consultation and secondary data.

It has been recommended in the plan to implement measures by involving project-affected women in applicable employment opportunities, consciously involve them in the decision-making process and develop an understanding in the community regarding multiple roles of women. The activities to be taken up for ensuring participation of women during the life cycle of the project are recommended in the plan. The detailed plan is provided in Appendix L of the ESIA report.

9.11.2 Implementation and Monitoring of the Management Plan

In order to ensure that the drill waste management plan is implemented during construction phase of the Project. UMPL would ensure that adequate monitoring to ensure compliance by the contractors and supervisory staff. All site personnel would be responsible for the identification, reporting of incidents in case of non-compliance to the plan.

Implementation of the management plan would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE. Supervision would be carried out by UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS.

9.12 Hydrotest Water Management Plan

The section below provides a framework guidance on management of hydrotest water used for testing of pipeline integrity. Hydrostatic (Hydro) Testing of the gas pipeline would be done assessment of strength and leaks. Hydrotest water is contaminated with materials used during pipe manufacture and also particulates from construction. Chemicals like oxygen scavengers and biocides may be added to hydrotest water to prevent corrosion damage and build-up of micro-organism in the pipeline. Disposal of this water to unpaved land or river would have potential to contaminate soil, ground and surface water. However, this is a short-term activity and large amount of water would not be discharged. The following are recommended as a part of Management measures for the hydrotest water to mitigate the impacts from improper storage and disposal of hydrotesting water.

- It is recommended that for each test the pipeline would be filled with water and as per feasibility, the hydrotest water would be temporarily stored in a sump and reused. UMPL, through its technology provider and contractor/sub-contractor, explore possibilities of to reuse the water for multiple tests, as per requirement
- Monitoring of the hydrotesting water would be undertaken to ensure compliance to Standard for disposal to Inland Surface Water as per ECR 1997 or IFC's guidelines on effluent discharge, whichever is stringent, before discharge to Meghna River. Important parameters would be pH and metal content.
- It is recommended that possibilities would be explored to reduce use of chemical additives, and biocides; and judicious selection of additives is conducted in terms of dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential

9.12.1 Implementation and Monitoring of the Management Plan

In order to ensure that the hydrotest water management is carried out judiciously, adequate monitoring of implementation of the monitoring plan would be required periodically during the activity. UMPL would ensure periodic monitoring to ensure compliance by the contractors and supervisory staff. All site personnel would be responsible for the identification, reporting of incidents in case of non-compliance to the plan.

Implementation of the management plan would be the responsibility of UMPL appointed contractor(s) or contractor nominated sub-contractor(s) under supervision of the UMPL nominated Site Manager/Deputy Manager-HSE. Supervision would be carried out by UMPL Site Manager in collaboration with UMPL Deputy Manager – EHS.

9.13 Green Technology for Sustainable use of Energy and Water

Green Technology has been considered and is likely to be implemented in every possible opportunity, by UMPL in its 600MW Combined Cycle Power Plant project. The ESIA Study identifies and assesses the following Green Technologies for sustainable use of water and energy onsite, which the project would consider for implementation throughout its operational lifecycle toward attaining Sustainable Business Goals:

- Installation and use of Solar Photo-voltaic (PV) Panels for generation of renewable energy for proposed project's internal streetlights.
- Water conservation at site through construction of Rain Water Harvesting Structures and network of conduits for collection and transferring of rainwater from the proposed plant for reuse onsite.

9.13.1 Solar Street Light

A battery based solar streetlight is a stand-alone system, which would store electricity generated by solar panel in solar battery. Solar LED streetlight is powered by photo-voltaic panel, generally mounted on the light structures or integrated in the pole itself. There is also another type of streetlight called integrated solar streetlight. In both type of streetlights, the photo-voltaic panel charge solar battery during daytime, which powers LED lamp during night. Streetlight comes with dusk to dawn sensors, which automatically switch-on the light in evening and off in the morning. UMPL would install Solar LED street lighting poles integrated with solar PV panels in the proposed 600MW Combined Cycle Power Plant, along its internal roads and in the periphery along the site boundary. This section discusses in detail the benefits of installing Solar LED streetlights both with respect to environment and economy, along with a detailed installation plan.

9.13.1.1 Benefits of Installing Solar LED Street Lighting poles

This section carries out a comparative analysis of the benefits of installing Solar LED street lighting poles over Conventional Energy-fed Lighting Poles, to draw highlight the various advantages and disadvantages in context of expenditure and sustainability of installing and operating the streetlights through green technology

Green Technology

In this regard, solar photo voltaic cells have been considered as the green technology.

A battery based solar streetlight is a stand-alone system, which would store electricity generated by solar panels in the solar battery. Solar LED streetlight would be powered by photo-voltaic panel, generally straddling on the light structure or integrated in the pole itself.

The suitable option is, to use a 24-Watt solar streetlight, which is suitable for factories and in places where illumination is required more than the normal situation.

Expenditure of a 24-Watt solar LED streetlight pole with integrated solar panel and battery

In this section, the capital and operational cost for installation of a solar LED streetlight pole has been estimated based on veritable data obtained through desktop searches. The details of particulars for the installation is given in table below.

Table 9.8 : Equipment for solar installation in plant

Particulars	Capacity/Period
Solar light	24 Watt
Solar panel	100 Watt
Solar battery	75 AH
GI Pole	7-8 metre
Charge controller	12 Volt
Sensor	Dusk to dawn
Accessories	Panel structure, wire, connectors nut bolts etc.
Back up time	24 hours
Longevity	10 years
Panel guaranteed life	25 years

The cost of installing the above Solar LED light with ancillary equipment is estimated to be approximately 35,000 Bangladeshi Taka and minimal operational cost afterwards. The Panel life guarantee is usually for 25 years, which is likely to cover the operational lifecycle of the project.

Conventional Electrical Streetlight

Conventional electrical streetlight uses the grid current to power up, and typically uses 80-watt lamp.

Expenditure of a Conventional electrical streetlight

Assuming that, the streetlight would be in use only in night-time, this would be leading to a total usage time of 12 hours. An 80-Watt lamp consumes energy of 0.08 kilo Watt per hour. According to Bangladesh Power Development Board's electricity tariff rate, the price of 1 kWh electricity for the commercial sector is 8.56 Bangladeshi Taka. Considering this, the cost to light an 80-Watt streetlight for one hour would be:

The cost per hour: 0.08 x 8.56 = 0.69 Bangladeshi Taka/hour

For 12 hours the total cost would be: 0.69 x 12 = 8.21 Bangladeshi Taka.

So, the monthly expenditure would be: 250 Bangladeshi Taka.

Therefore, the annual operating expenditure per annum is estimated as: Approx. (250 x 12) = 3,000 Bangladeshi taka.

The annual operating expenditure for only electricity would be approx. 3000 Bangladeshi Taka, and installation of full set up of one conventional lighting pole is estimated at 10,000 – 12,000 Bangladeshi Taka.

Total project life cycle would be 25 years, so the total cost for one conventional electrical streetlight pole would be:

10,000 (minimum installation charge) + (3000 x 25) = 85,000.

From the above cost benefit analysis, the following inferences could be drawn regarding the advantage of using solar PV lighting poles over the conventional electrical poles from both environmental and monetary perspectives:

- In case of solar light, only the installation charges are required, after which it would be able to run for a long time with the renewable resource (solar power), thus incurring no recurring operational expenditure. On the other hand, the installation charge of electrical streetlamp although cheaper than solar PV cells, the operational expenditure arising from recurring cost of electricity bill would be much higher when considered for project lifecycle. By installing Solar PV cells, the potential savings to the project for one Solar PV Lighting pole throughout the project life would be (85,000 – 21,000) = 64,000 Bangladeshi taka or 758 US dollar.
- From sustainability point of view, if solar streetlight comes into use, the project could get a benefit in terms of taxation, for using the green technology, whereas conventional electrical streetlight would not provide such opportunity to the project.
- By using renewable resources, the project would adopt clean and environmentally friendly technology, whereas, in case of electrical streetlight using convention power, emissions of green-house gases into the atmosphere in terms of tonnes of CO_2 equivalent would occur. Hence the project would be able to show case its sustainable business approach at the same time saves considerably on the cost.
- The use of renewable energy would help the project to set an example of sustainable development, which would earn a good reputation for the project and make it a model for other existing and future industries to follow in the future.

Therefore, considering the above, it would be preferable, to consider the use of solar technology for the streetlights in the facility.

9.13.1.2 Installation Plan of the Streetlight

The streetlight would be installed along both sides of the internal roads of the proposed site, place diagonally opposite to each other on two sides of the roads at a distance of approx. 50. This indicates that the distance between 2 lighting poles on the same side of the road would be 100 m; while distance between two lighting poles located on the other side of the road and diagonally opposite to each other would be 50 m. This installation pattern of the lighting poles is depicted in the below ***Figure 9.8 :***

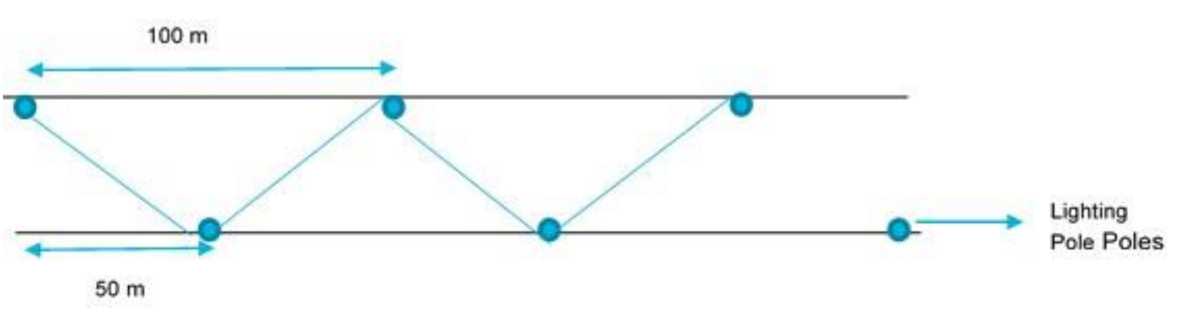


Figure 9.8: Installation pattern of the solar street lights

This figure shows the installation pattern of the streetlight alongside the road at the project boundary and as well as in the internal road network, in the facility. The blue dot represents the streetlight, in the picture. In case of single facility like pump house, ETP and other open facilities, where a focused illumination is necessary, one or two poles of light would be separately installed in the close proximity of the unit.

The below ***Figure 9.9*** shows Internal Road Network within the proposed site:

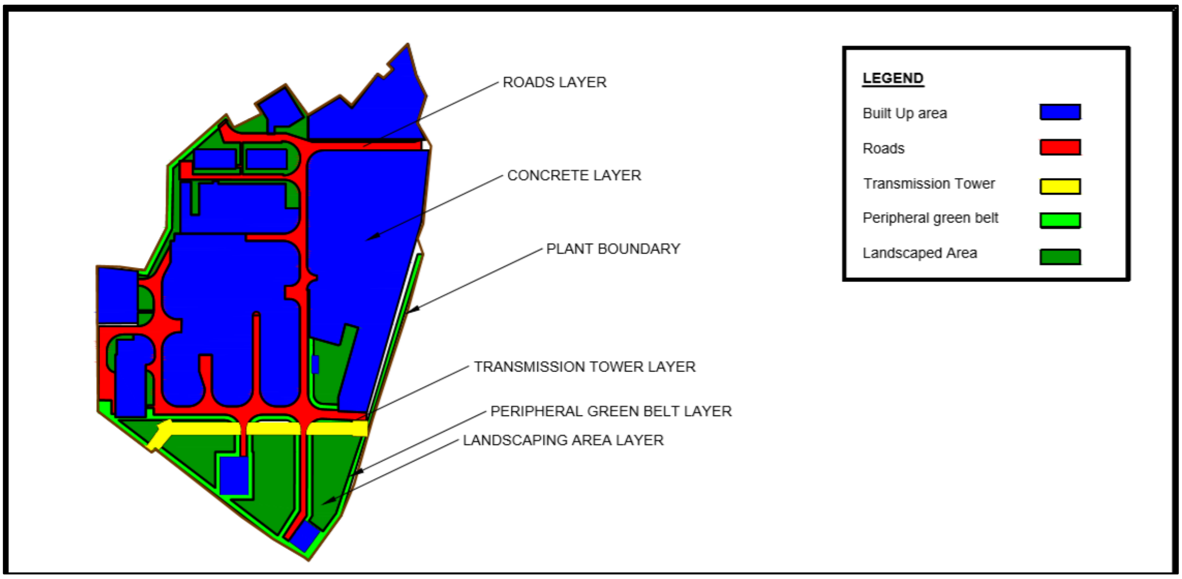


Figure 9.9: Internal Road Network

The total area of internal roads is approx. 11,221 sq. m with length of the road being approx. 1675 m. The width of the road varies along the entire stretch as shown in Figure 2. From Figure 2, it is understood that there are 9 intersections on the internal road network, where the width of the road is more. Therefore, it is assumed that at 9 intersections and peripheral boundary, total 30 streetlights would be installed

The road length is approx. 1675 m, considering distance between 2 diagonally opposite post is 50 m, total post along road length would be = (1675/50) = approx. 34 light poles.

Assuming total 16 light poles in all the open areas in the facilities, the total number of lighting poles using Solar PV panels in the proposed site is approximately 80 lighting posts would be installed.

Now saving for installation of one Solar PV Lighting post against 1 conventional lighting post is = Approx. 64000 Bangladeshi taka throughout project life cycle.

Total estimated saving for 80 solar PV lighting post = Approx. 5120000 Bangladeshi Taka.

Additionally, the installation of roof top photovoltaic cell would provide an advantage of using renewable energy, over conventional energy for the other illumination source in office buildings and facility. This would also provide the advantages discussed in above section. However, installation of roof top PV cells draws a need of another detailed study, which would not be possible in the present stage of the project, it may be carried out at the later stage of the project.

9.13.2 Rainwater Harvesting Structure

UMPL plans to develop a Rainwater Harvesting Structure on site to collect and conserve rainwater from the Site. The rainwater would be collected from:

- Roof Top
- Roads and other paved open areas
- Open and Green Space

9.13.2.1 Roof Top Rainwater Collection:

The rooftop rainwater would be collected from the roof of all the buildings and main plant. In this regard, it is assumed that rooftop rainwater can only be collected from 60% of the main plant area. The total available rooftop areas are obtained from the Site layout ***Figure 9.10*** below.

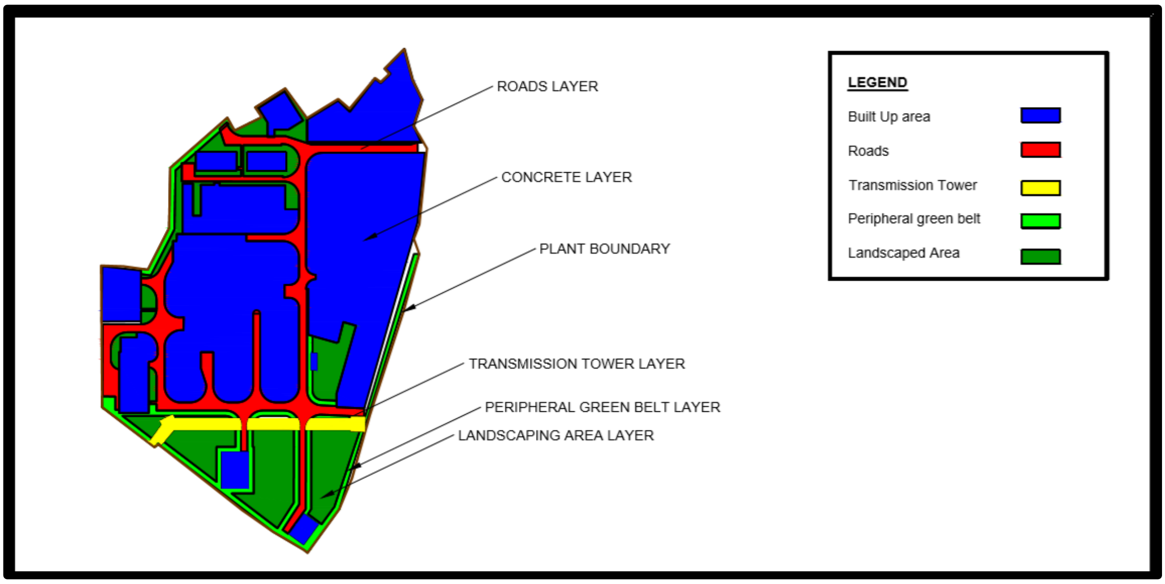


Figure 9.10: Site Layout Demarcating Plant, Utilities and Open Green Space

The rooftop rainwater harvesting potential is calculated by the following equation:

RWH Potential = Rainfall in m/yr. x Run-off coefficient in % x catchment area of roof in sq. m.

The run-off coefficient for rooftop is considered as 80% or 0.8 considering 20% water loss due to evaporation and pipeline losses.

The total average annual rainfall in the study area is approx. 2037.2 mm i.e. 2.0372 m. The Table 9.9 below shows total rainwater harvesting potential from Rooftop.

Table 9.9. Rooftop Rainwater Harvesting Potential

Name	Area in Sq. Metre	Run-off Coefficient	Annual Rainfall in m/yr.	R.W Harvesting Potential in cum/yr.
Hydrogen Station	989.954006	0.8	2.0372	1613.387441
Administrative	406	0.8	2.0372	661.68256
Dormitory	532	0.8	2.0372	867.03232
Fire Station	432	0.8	2.0372	704.05632
Workshop Warehouse	611.593828	0.8	2.0372	996.7511571
NG Pressure Regulation Station	1000	0.8	2.0372	1629.76
Dormitory/Control Building for RMS	225	0.8	2.0372	366.696
Chemical House	1836	0.8	2.0372	2992.23936
Fuel Gas Supply and Booster Building	1125	0.8	2.0372	1833.48
Pump House	1167.685141	0.8	2.0372	1903.046535
Cooling Towers	3528			0
Space for GIS connection	1292	0.8	2.0372	2105.64992
Main Plant Area	14401.36456	0.8	2.0372	14082.46074
Total RWH Potential (roof-top only)				**29756**

The rainwater collected from all rooftops would be collected into a covered RCC stormwater collection drain through PVC conduits conveying water from rooftop to drain. Rainwater from stormwater drains would flow by gradient into an underground rainwater harvesting tank located towards the periphery of site near the river-side boundary.

Road Rainwater Collection:

The rainwater from the paved internal roads would be collected in the roadside stormwater drains and then flow into the rainwater harvesting structure mentioned above. For estimating rainwater harvesting potential from roads, a run-off co-efficient of 0.5 is considered. The equation shown for rooftop rainwater also applies here. The rainwater harvesting potential from internal roads are as follows.

Road Areas	Run-off Coefficient	Rainfall m/yr.	RWH Potential cum/yr.
11222	0.5	2.0372	11431

9.13.2.2 Open Space Rainwater Collection:

For open unpaved and green space, it is assumed that about 90% of water is lost through evaporation, transpiration, and percolation into the soil i.e. the runoff generated is only 10%. Hence the runoff coefficient is considered as 0.1. The run-off from green area would flow by gravity into the peripheral stormwater drains from where it would flow into Rainwater Harvesting Structure. The equation shown for rooftop rainwater also applies here. The rainwater harvesting potential from open space is as follows.

Road Areas	Run-off Coefficient	Rainfall m/ yr.	RWH Potential cum/ yr.
29916	0.1	2.0372	6095

The total RWH potential for the proposed site including rooftop, roads and open space is estimated to be approx. = Approx. 47281 m^3/yr.

Assuming 70% of the total rainwater potential would become actual rainwater collected from the stormwater into the rainwater harvesting structure, the total rainwater stored in the structure is estimated to be approximately 33097 m^3/yr. (remaining 30% losses in stormwater drains due to leakages in conduits and drains.

Now the rainwater harvesting structure would be an underground RCC tank with outer clay liner to prevent leakage of water into groundwater table. The rainwater harvested in the underground storage tank would not recharge groundwater table at any point of time; but would only be used for reuse for potable and non-potable purposes on site.

The storage tank would be constructed assuming rainfall in peak month and for storage capacity for 10 days because the general assumption is stored rainwater from storage tank would be pumped daily for reuse on site. This would significantly reduce freshwater withdrawal volume from the intake point in Meghna River channel to meet the daily water requirement of 676.22 m^3/hr at site.

Considering peak rainfall of 753 mm or 0.753 m in the month of July, the total maximum rainwater volume during the peak monsoon month is estimated to be 17500 m^3.

Therefore, the total volume of the rainwater storage tank = (17500 x 10)/30 = 5800 cum.

Assuming depth of the RCC tank being 4m below ground level, the dimension of the tank would be approx. 38m x 38m. The final dimensions of the underground Rainwater Harvesting storage tank would be 38m x 38m x 4m.

Alternatively, a rainwater harvesting pond with double lined (HDPE liner below and LDPE liner on top with clay liner below) base and side wall membrane would be constructed of the similar dimensions. The advantage of underground storage tank over pond is that the chances for contamination of harvested rainwater is much lesser in underground tank as the tank is not exposed to atmosphere and not allowing any pollutants to enter.

In this regard, it needs to be mentioned, that irrespective of whether a pond or an underground storage tank (UST) is constructed, the rainwater from the pipeline needs to enter into an RCC basin before entering into pond/UST and this basin would be installed with sand and gravel filter bed to remove all the impurities e.g. suspended solids from the rainwater before it enters the tank/pond.

Also, the drains carrying stormwater/rainwater from all parts of the site would join into a single main drain entering into a basin. This drain would have 2 bypass system controlled by valves/sluice gate. The first bypass system would take the first flush and any contaminated stormwater (in the event of oil/chemical spills enter stormwater channels) into the ETP for treatment. The second bypass would carry excess rainwater outside the plant boundary for discharge into the Meghna River. The second bypass system would become operational when there is sudden increase of rainwater volume as compared to the site storage capacity or in the event of plant shut down. The bypass systems would be activated and deactivated through a manually operated sluice gates in such a manner that when any one bypass gate gets open, the other 2 gates (for RWH structure/pond line and other bypass line) would remain closed.

The details of the cost associated with construction of Rainwater Harvesting network would be finalized in discussion of UMPL Management at a later stage of the ESIA study. This network would significantly reduce raw water consumption from the intake point and promote sustainable business amongst other industrial units in the area.

9.14 Inspection, Monitoring and Audit

In order to implement the EMP, the on-site EHS team would adhere to a time-bound and action-oriented Environmental Action Plan to implement the mitigation measures provided to address each of the identified environmental and socio-economic impacts. This approved EMP would be monitored on a regular basis, quarterly or half-yearly and all outcomes would need to be audited in accordance with existing EHS commitments. The monitoring process would cover all stakeholders including contractors, labourers, suppliers and the local community impacted by the project activities and associated facility thereby increasing the effectiveness of suggested mitigations measures. UMPL would ensure that all the contractors comply with the requirements of conditions for all applicable permits, suggested action plans and scheduled monitoring. The inspections and audits would be carried out by an internal trained team and external agencies/experts (third party). In addition to the EHS team, an on-site internal labour expert would be responsible for closely monitoring the scope of services of the contractors and subcontractors and checking compliance with applicable National labour laws & core labour standards. Internal labour expert would also review of payroll ensuring that contracts, HR policies and grievance mechanisms for workers are in place and minimum wage, overtime pay, and benefits of all workers are provided on time. It is proposed that results of monitoring by the internal labour expert would be reviewed by the external consultant during semi-annual visits. The entire process of inspections and audits would be documented and key findings of which would be implemented by the proponent and contractors in their respective areas.

9.15 External Monitoring

Semi-annual and annual E&S monitoring would be undertaken by External consultant who would be assigned the role of independent external monitoring Consultant. During their visits, experts of External consultant would carry out independent audit on compliance to National & International policies, standards and regulations and review the implementation status of environmental & social management plans. External monitoring experts would also review the reports of internal monitoring. Audit reports would be prepared and submitted to Lenders after carrying out the site visitExternal Audit is proposed semi-annually and annually during the construction phase and up to a period of 1 year from the commencement of operation.

9.16 Reporting and Documentation

UMPL would develop and implement a programme of reporting through all stages of the project cycle. Delegated personnel would require to fully complying with the reporting programme in terms of both timely submissions of reports as per acceptable level of detail. Reporting would be done in form of environmental check list, incident record register, environmental and social performance reports (weekly, monthly, quarterly, half yearly, yearly etc.)

9.17 External Reporting and Communication

The EHS head is responsible for ensuring that communication with regulatory agencies and stakeholders are maintained as per the requirement. All complaints and enquiries are to be appropriately dealt with and records would be maintained in a Complaint/Enquiry Register by the delegated staff of EHS. Progress reports would be prepared and submitted to Lenders during the construction phase and up to a period of 3-5 years after technical completion.

9.18 Internal Reporting and Communication

Inspection and audits finding along with their improvement program are to be regularly reported to the senior management for their consideration. The same are also to be communicated with the staff working on the project. To maintain an open communication between the staff and management on EHS and social issues the followings are being used:

- Team Briefings,

- On-site work group meetings,
- Work Specific Instructions; and
- Meeting with stakeholders.

9.19 Documentation

Documentation and record keeping system has to be established to ensure updating and recording of requirements specified in EMP. Responsibilities have to be assigned to relevant personnel for ensuring that the EMP documentation system is maintained and that document control is ensured. The following records would be maintained at site:

- Documented Environmental Management System
- Legal Registers
- Standard Operating Procedures (SOP)
- Work Instructions
- Incident Reports
- Training records
- Monitoring reports
- Emergency preparedness and response procedures
- Audit report and complaints/Grievance Addressal register with issues of complaints attended and resolved
- Daily, weekly, monthly records of environmental management system including daily waste generation and disposal, daily water consumption, monthly monitoring reports etc.

9.20 ESMP review and Amendments

The ESMP acts as an environment and social management tool which needs to be reviewed periodically to address changes in the organisation, process or regulatory requirements. Following a review, the EHS head of UMPL would be responsible for making the amendments in the ESMP. The amended ESMP would be communicated to all the staff.

9.21 Stakeholder Engagement and Grievance Redressal

Stakeholder Engagement Plan (Refer Appendix P) and Grievance Redressal Mechanism (Refer Chapter 12) has been formulated and would be implemented and monitored both for construction and operation. It would help in project implementation and operation and settle as many disputes as possible through consultations, negotiation and mutual settlement.

9.22 Corporate Social Responsibility

Unique group as responsible business entity already involved various CSR activity like contribution to Prime Minister Fund for building nation, donating critical care unit to Hospital, distribution of relief materials in the wake of any National emergency including pandemic outbreak etc.

Figure 9.11: Photograph of Relief Material Distribution During Pandemic Outbreak

Apart from that as per preliminary assessment UMPL as separate entity would also contribute in below community development activity as CSR

- Road and Drainage facilities development
- Health Support
- Contribution in improvement of religious structure.
- Education and School Development
- Develop Ghat Facility

9.23 Proposed CSR Budget

Budget for ESMP implantation for construction phase would be allocated by EPC contractor and UMPL separately. Apart from that, cost for mitigation measures would be included in the EPC contract. Community consultation was carried out by UMPL for assessing the needs of the local community. Based on the outcome of the consultations, certain activities have been identified for implementation in next two years. The details of these identified CSR activities and the estimated allocation of expenditure is presented in ***Table 9.10.***

Table 9.10: CSR Budget with Timeline

Sl.	Planned Activity	Amount (BDT)	Timeline
A.	**Road and Drainage facilities development**		
1	Development of Dudhghata Madhyapara Jame Mosque approach road	685,152.00	2021
2	Develop drainage facilities for Purbopara Jame Mosque approach road (Adjoining area of the plant)	1,478,078.00	2022
3	Purbopara Jame Mosque approach road	3,099,295.00	2022
4	Develop drainage facilities (from Dudhghata government primary school to Purbopara Jame mosque approach road)	954,850.00	2021
5	Streetlights (Battala-Plant)	100,000.00	2022

Sl.	Planned Activity	Amount (BDT)	Timeline
B.	**Health Support**		
1	Organize health camp for the villagers of Dudhghata and other nearby villagers as well.	3,000,000.00	July 2021-Dec, 2023
2	Distribute free medicines to community through community clinic.	120,000.00	July 2021-Dec, 2023
C.	**Contribution in improvement of religious structure;**		
1	Contribution in improvement of religious structure (ozukhana, fan, namaj mat and others) (Madhyapara mosque, Purbopara mosque, Mollabari mosque, Sardarbari mosque, Paschim Para mosque)	3,000,000.00	2020-2023
D.	**Education and School Development**		
1	Almira/book self and book for school library of Dudhghata Government primary school	250,000.00	2022
2	**"Shohid Minar"** for Korbanpur Government Primary School	300,000.00	2021
3	Distribute study materials (reference book, school bag, drawing book, pencil box etc) (Primary School Dudhghata & Korbanpur)	500,000.00	2022-23
4	Equipped school with backboard, sports kits, water purifier, chair, table etc (as per requirement) (Primary School Dudhghata & Korbanpur)	500,000.00	2022-23
5	Contribute to organize school annual sports program (Primary School Dudhghata & Korbanpur)	500,000.00	2022-2023
E.	**Develop a Ghat Facilities**		
1	Develop River Ghat facilities with approach road for local river users	8,307,055.00	2022
F	Support towards local fishermen		
1	Provision of funds to Sonargaon Upazilla Fishery Department to support sustenance of indigenous fish species		2022-2023
	Total	**22,794,430.00**	

UMPL is recommended to undertake need assessment of the local community, based on which a detailed CSR plan would be prepared.

Budget for LRP is presented separately in Livelihood Restoration Plan document.

9.24 Budgetary cost for ESMP implementation

The estimated cost for implementation of mitigation measures proposed in the ESMP is indicated in ***Table 9.11.***

Table 9.11: ESMP Budget

Sl.	Proposed EHS & Social Mitigation Measures	CAPEX, BDT	OPEX (per year), BDT
1	Green Belt Development	6,13,000	3,50,000
2	Rainwater Harvesting Structures	25,00,000	3,00,000
3	Solar LED streetlights	28,00,000	5,00,000
4	E&S monitoring by third party independent consultant (quarterly x 4 audits) per year		20,00,000
5	Annual social audit by third-party to assess status of implementation of implementation of SEP, GAP, HRIA, GRM and CSR	-	10,00,000
6	Construction of Noise Protection wall (NPW) of 3 m height along the periphery of 990m length (except the side towards the riverfront)	3,00,00,000	30,00,000
7	Total cost of E&S monitoring (refer Table 7.2)		1,74,00,000
8	Waste Management Facility (Hazardous and non-hazardous)	15,00,000	5,00,000
9	Dredge material management Testing of dredge material (considering 1 no sample of dredged material per every dredging)	-	1,50,000
	Disposal through authorised vendor		20,000 per cum of dredged material
10	Spill kits for spill prevention	5,00,000	-

Sl.	Proposed EHS & Social Mitigation Measures	CAPEX, BDT	OPEX (per year), BDT
11	Annual survey of invasive alien species by independent Biodiversity Expert	-	3,00,000
12	Additional HSE equipment (e.g. fire extinguishers, safety harness, helmets, reflective jackets, goggles, safety shoes, gloves, fire retardant forms, etc)	50,00,000	5,00,000
	Total	4,29,13,000	2,30,00,000 (excluding the cost of testing of dredged material @ 20,000 BDT per cum of dredged material)

The CAPEX for implementation of the mitigation measures is estimated to be approximately 4,29,13,000 BDT and the OPEX is about 2,30,00,000 (excluding the cost of testing of dredged material @ 20,000 BDT per cum of dredged material) BDT.

10 Risk Assessment

The Quantitative Risk Assessment (QRA) study was carried out based on International QRA Guidelines developed by the United Kingdom (UK) Health and Safety Executive (HSE), the Centre for Process Safety (CCPS) of the American Institute of Chemical Engineers (AIChE) and other guidelines reflecting the current industry QRA best practice. Internationally accepted Failure Frequency Databases such as the International Association of Oil & Gas Producers (OGP), database was utilized for deriving failure frequencies.

The primary objective of the QRA study is to identify and assess the risks associated with the Hydrogen generation facility, Hydrogen Storage, Natural Gas Pipeline installation and HSD Atmospheric tank and subsequent quantify the relevant risk events, demarcate vulnerable zones and evaluate the nature of risks posed to persons working within the facility and in the vicinity. The QRA Study covers a wide range of incidents right from small leaks to worst case scenario catastrophic ruptures. The Scope of Work for the study is described below:

- Identify potential risk scenarios that may arise due to the facility.
- Hazard Analysis, Inventory Calculation and Model and appraise the risks associated with all flammable hazards resulting from potential loss of containment accident scenarios (consequence Analysis).
- Identify risk posed by the facility and its associated operations
- Failure Frequency Assessment and Risk Calculation/Assessment
- QRA to confirm that risk can be reduced consistent with the ALARP principle according to the UK HSE risk acceptance criteria.
- Recommend risk prevention/ reduction and mitigation measures to ensure that all risks within the “ALARP” Region as per Practical/ Best Practices.

10.1 Methodology

The QRA was carried out as per the following broad steps.

10.1.1 . Pre-Project Data Collection involving:

- Collection of data related to the Chemical/Fuel Composition, site Layouts, P&IDs, project details including process, manning pattern, overview of the facility in terms of piping, outside population/habitation in the vicinity etc.
- Data sorting, compilation and analysis followed by identification of hazards during various stages.
- Quantitative Risk Assessment using the Consequence Analysis results and Failure Frequencies/ Probabilities
- Development of recommendations for risk prevention/ mitigation.
- Report preparation

There are typically five stages of a QRA study. The details of the specific steps in documenting the QRA study are described below:

- The first stage of the study after data collection is the system definition stage, where the potential hazards associated with the facility operations are organized and the overall QRA working strategy is evolved- the final objectives need to be borne in mind during this step. This step is important in framing the QRA study.
- The second stage of the QRA deals with identification of Hazards, marking of Isolatable Sections and Isolation Time. The hazard identification consists of a qualitative review of possible incidents that may occur, based on previous experience or judgment where necessary.
- The third stage of the QRA deals with Consequence Analysis which is carried out in order to evaluate the resulting consequential effects of the incidents, with specific emphasis on the impact on personnel, both “Onsite” (covering UMPL/ Contractor personnel) and “Offsite”.
- The fourth stage of the QRA deals with “Failure Frequency (FF)” analysis or, essentially, estimation of the “Probability” of the incident, or related incident outcome case. Failure rate data is essentially derived from internationally well known (generic database. The generic failure rates data, upon which the study is based,

are taken from published databank source (OGP Database Report No: 434September 2019). The generic database reflects the worldwide experience of the oil & gas sector. The generic failure data base selected for calculating the failure frequencies and the values in the database are fine tuned to reflect the mechanical and process design of the system.

- Numerous calculation models are developed to estimate the physical effects of an accident and to predict the damage (lethality/injury) of the effects. Consequence due to various types of exposure are then considered, e.g., consequences caused by exposure to heat radiation.
- Failure frequencies so derived would be combined with the consequence models' predictions to derive composite risk values/results in the fourth stage of QRA.
- The next stage is to introduce criteria, which are yardsticks to indicate whether the risks are acceptable, ALARP principle adopted from UK-HSE were used for the purpose. Circles of damage and risk are assessed and plotted on the developed layout. Risk in the form of Individual Risk and Societal Risk calculated.

Individual Risk considers the geographical distribution of risk to an Individual and is presented in the form of risk contours or lines of equivalent risk.

'Societal Risk/Group Risk' would consider both the likelihood of major events occurring and the number of the fatalities which may result. These results would be used to identify the major risk contributors and recommending the risk reduction methods to be implemented. Societal Risk would be represented in the form of F-N curve, where the frequency "F" at which "N" is number of fatalities predicted to occur.

The fifth and final step involves comparing the risk values derived during the fourth stage with Risk acceptance criteria, essentially to understand whether the risks posed by the project are "Acceptable", "As Low as Reasonably Practical (ALARP) or "Unacceptable". In case Risks are above the acceptance values, then it is necessary to propose risk reduction measures to bring them within the acceptable range. Heat radiation contours for individual scenarios when mapped on the plot map provide input for deriving risk reduction measures. The fifth and final step involves comparing the risk values derived during the fourth stage with Risk acceptance criteria, essentially to understand whether the risks posed by the project are "Acceptable", "As Low as Reasonably Practical (ALARP) or "Unacceptable". In case Risks are above the acceptance values, then it is necessary to propose risk reduction measures to bring them within the acceptable range. Heat radiation contours for individual scenarios when mapped on the plot map provide input for deriving risk reduction measures.

10.1.2 Documents used for the Study

Several Documents such as P&IDs, Layouts, Key Plan, Feasibility Report, MSDS of Hydrogen, Diesel, Natural Gas and other associated documents were referred before proceeding for the study. A detailed assumption criterion has been developed for failure frequency analysis, where different leak size, has been considered for NG pipeline, diesel tank, hydrogen storage etc., under different weather conditions. Based on the assumption several type of hazards like jet fire, pool fire, explosion curve has been modelled, and superimpose on the plant layout.

10.1.3 Hazard Identification

Hazard refers to any event/activity that has the potential that could cause harm or ill health or injury to people or damage to assets or impacts environment. Hazard identification is the fundamental step in risk assessment. The procedure has to identify the hazards systematically arising from normal and abnormal operation of the plant. The unidentified hazard may strike any time which results in accidents and loss of containment. So, it is very important that the hazard identification to be carried out in comprehensive manner. Unidentified hazard negates the risk assessment process; risk cannot be assessed for those hazards and control measures cannot be developed and implemented.

This stage of any QRA study is to identify the potential accidents that could result in the release of the hazardous material. This is achieved by a systematic review of the facilities together within effective screening process. Chemical Hazards are generally considered to be of three types: -This stage of any QRA study is to identify the potential accidents that could result in the release of the hazardous material. This is achieved by a systematic review of the facilities together within effective screening process. Chemical Hazards are generally considered to be of three types: -

- Flammable
- Reactive
- Toxic

There is a possibility of failure associated with each mechanical component (e.g., vessels, pipes, flanges, instrument tapping etc.). These are generic failures and can be caused by such mechanisms as corrosion, vibration or external impact (mechanical or over-pressure).

The range of possible releases for a given component covers a wide spectrum, from a pinhole leak up to a catastrophic rupture (of a pipeline) or full-bore rupture (of a pipe). It is both time consuming and unnecessary to consider every part of the range; instead, representative failure cases are generated. For a given component these should represent fully both the range of possible releases and their total frequency. In line with the standard approach and guidelines, various failures cases are considered for the different isolatable sections are provided in ***Table 10.1.***

Hazard Identification (HAZID) assists in detecting process and non-process hazards affecting the project execution and operational stage. The main objective of the HAZID is to identify potential major accident events- it is important to ensure scenarios identified in the HAZID are factored into the QRA. Hazard Identification (HAZID) assists in detecting process and non-process hazards affecting the project execution and operational stage. The main objective of the HAZID is to identify potential major accident events- it is important to ensure scenarios identified in the HAZID are factored into the QRA.

10.2 Identification of Major Hazardous Substances

The following major hazardous substances at specific locations are identified in the facility in below ***Table 10.1***: -

Table 10.1: Impact Prediction Criteria

Material	Physical State	Hazard
Natural Gas	Gas	Jet Fire, Flash Fire, Fireball and VCE/UVCE
HSD	Liquid	Jet Fire, Pool Fire, Flash Fire and VCE
Hydrogen	Gas	Jet Fire, Flash Fire, Fireball and VCE/UVCE
Sulphuric acid		
Ammonia		
Chlorine		

Natural gas is flammable when mixed in air at concentrations from 5 to 15% (volume basis). Its fire-related properties are comparable to other light hydrocarbon fuels. Natural gas is buoyant at ambient conditions because of the difference in density between methane and air. Pipeline leaks or rupture may possibly result in various fire hazards depending upon whether the ignition is immediate or delayed. In addition, Natural gas is a non-toxic (non-poisonous), but can cause death by suffocation if the gas displaces the air in a confined space. The following effects will be experienced as gas concentration increases:

- At 25 to 30% gas in air, the oxygen deficiency can cause ringing ears, euphoria, and unexplained behavioural changes.
- At 50% gas-air mixture, a person taking in a few breaths will be incapacitated and unable to self-rescue.
- At 75% gas, a person is immediately incapacitated, and death will occur in a matter of minutes.

Incomplete combustion can occur when the gas mixture is richer than 10% and incomplete, incomplete combustion will lead to formation of less stable carbon monoxide. Carbon monoxide is toxic (poisonous) and can cause physical illness and death when inhaled under certain conditions. It is lighter than air and mixes very thoroughly.

If not contained, natural gas combustion can be hazardous. Uncontrolled combustion causes a very sharp pressure shock wave through a gas / air mixture. If this type of combustion is in an unconfined space (such as in the open atmosphere), the result is a flash fire. If in a confined space, an explosion may occur.

In case of leaks from buried pipelines, the transient flow will be channelized through the voids from the overlaying soil. If the leak is sufficiently large, then soil may be ejected above the pipeline. The jet will entrain air as it moves upward and will get disperse depending on the prevailing wind direction and other meteorological conditions. The concentration of gas till its Lower Flammability Limit (LFL) is hazardous, as it can catch fire on availability of ignition source. The total duration of release and its impact/consequence will depend on how quickly the release is identified and the sectionalizing valve isolates the pipeline section. If the material encounters an ignition source while it is in the flammable concentration range, a jet fire may occur. The momentum of released material from a buried pipeline generally results in vertically oriented fires. Such fires have smaller hazard ranges than horizontally orientated fires.

Following a rupture, or large puncture, there will be rapid depressurization in the vicinity of the failure. For the proposed project, the overlying soil may be ejected with the formation of a crater of a size and shape, which influences the behaviour of the released gas. At the start of the release, a highly turbulent mushroom shaped cap is formed which increases in height above the release point due to the source momentum and buoyancy and is fed by the gas jet and entrained air from the plume which follows. In addition to entrained air the release can also result in entrainment of ejected soil into the cap and plume. Eventually, the cap will disperse due to progressive entrainment and a quasi-steady plume will remain.

If the large scale quasi-instantaneous flammable gas release is under pressure is ignited almost immediately a fireball will result. In order for a fireball to occur, the cloud must be ignited before it has time to disperse hence there must be an ignition source close to the release point at the time of release. The energy released by the rupture of the pipeline typically results in the formation of a crater around the rupture point. Gas enters the crater from each end of the ruptured pipeline. Once the fireball has dissipated, this gas continues to burn as a crater (or trench) fire. Crater fire generally occurs when the ignition of the gas released by rupture is delayed.

Hydrogen is a colourless, odourless, tasteless, flammable nontoxic gas which is flammable over a wide range of concentrations. Some of the unique hydrogen properties that contribute to potential hazards (flammability and explosivity) are:

- Hydrogen is combustible over a wide range of concentrations. At atmospheric pressure, hydrogen is combustible at concentrations from 4% to 74.2% by volume.
- Hydrogen has very low ignition energy.
- Hydrogen burns with a nonluminous flame which can be invisible under bright light.
- Due to its small molecular size, Hydrogen can easily pass-through porous materials and has the ability to be absorbed by some containment materials. This can eventually result in loss of ductility or embrittlement (this reduces performance of some containment and piping materials such as carbon steel). Loss of ductility/embrittlement is accelerated at elevated temperatures.
- The auto-ignition temperature of a substance is the lowest temperature at which it will spontaneously ignite without the presence of a flame or spark. The auto-ignition temperatures of hydrogen and natural gas are very similar. Both have auto-ignition temperatures over 1,000°F, much higher than the auto-ignition temperature of gasoline vapor.
- Hydrogen burns with a pale blue flame that is nearly invisible in daylight, so it is almost impossible to detect by the human senses. Impurities such as sodium from ocean air or other burning materials will introduce colour to the hydrogen flame. Detection sensors are almost always installed with hydrogen systems to quickly identify any leak and minimize the potential for undetected flames.
- In addition, hydrogen flames radiate little infrared (IR) heat, but substantial ultraviolet (UV) radiation. This means that when someone is very close to a hydrogen flame, there is little sensation of heat, making inadvertent contact with the flame a significant concern. UV overexposure is also a concern, since it can result in sunburn-like effects.
- If a large hydrogen cloud comes into contact with an ignition source, ignition will result in the flame flashing back to the source of the hydrogen. In open spaces with no confinement, flames will propagate through a flammable hydrogen-air cloud at several meters per second, and even more rapidly if the cloud is above ambient temperature. The result is a rapid release of heat, but little overpressure, and the combustion product is steam. It should be noted that hydrogen combustion is more rapid than combustion of other fuels. A hydrogen cloud will burn within seconds, and all of the energy of the cloud will be released.
- However, if hydrogen gas mixtures enter confined regions, ignition is very likely and can result in flame acceleration and generation of high pressures capable of exploding buildings and throwing shrapnel. Flammable mixtures of hydrogen in confinements such as pipes or ducts, if ignited, will readily result in accelerated flames and conditions that can lead to transition to detonation. Detonation does not occur in unconfined hydrogen-air mixtures without strong shockwaves (i.e., explosives).
- A leak in a pressurized (>200 psia) hydrogen storage system will result in a jet that may extend for some meters. If ignited, the jet flame can cause serious damage to anything it encounters.
- Liquid hydrogen has different characteristics and different potential hazards than gaseous hydrogen, so different control measures are used to ensure safety. As a liquid, hydrogen is stored at -423°F, a temperature that can cause cryogenic burns or lung damage. Detection sensors and personal protective equipment are critical when dealing with a potential liquid hydrogen leak or spill.

- The volume ratio of liquid to gas is approximately 1:850. So, if you picture a gallon of liquid hydrogen, that same amount of hydrogen, existing as a gas, would, theoretically, occupy about 850-gallon containers (without compression). Hydrogen undergoes a rapid phase change from liquid to gas, so ventilation and pressure relief devices are built into hydrogen systems to ensure safety.
- Liquid hydrogen is also colourless. It is extremely cold and only persists if maintained in a cryogenic storage vessel. Storage is usually under pressures up to 150 psi. If spilled on ambient-temperature surfaces, liquid hydrogen will rapidly boil and its vapours will expand rapidly, increasing 848 times in volume as it warms to room temperatures. If the liquid hydrogen is confined (such as between valves closing off a length of pipe) and left to warm without pressure relief, pressures approaching 25,000 psia are possible. With the exception of specially designed enclosures, there is a high potential for exposed confinements to rupture under such pressures, producing high-pressure jets of gas and high-speed shrapnel. Ignition is extremely likely under such circumstances. If large quantities of hydrogen displace the oxygen in the air, hydrogen will act as an asphyxiant

The following elements should be considered to ensure safe operations:

- A workspace can be configured to mitigate hazards by understanding and taking advantage of the characteristics of hydrogen.
- Materials of construction must be carefully selected to account for their mechanical behaviour in hydrogen service at the intended operating conditions.
- In designing a hydrogen system, it may be possible to reduce risk by "designing out" the hazard.
- Hydrogen piping systems must be carefully designed and installed to minimize the potential for leaks and allow for their easy detection.
- Safety of the workspace may be improved by using interlock systems working in unison with hydrogen and fire detectors.

Proper ventilation can reduce the likelihood of a flammable mixture of hydrogen forming in an enclosure, following a release or leak.

- Hydrogen is unlike other fuels such as gasoline vapours or propane, which are heavier than air and tend to accumulate at ground level. Hydrogen is lighter (less dense) than air and will accumulate near the ceiling, roof area, or in pockets at these locations.
- When the buoyancy of hydrogen is not properly taken into account in the design of facilities, hydrogen leaks can become more dangerous than leaks or spills of conventional fuels. The building codes of many countries require to have ventilation openings near the ground to remove gasoline vapor, but ventilation high in the workspace is not always addressed. As a result, even slow releases of hydrogen in such buildings could lead to the formation of a flammable concentration at the ceiling.
- Passive ventilation features such as roof or eave vents can prevent the build-up of hydrogen in the event of a leak or discharge. In designing passive ventilation, ceiling and roof configurations should be thoroughly evaluated to ensure that a hydrogen leak will be able to dissipate safely. Inlet openings should be located at floor level in exterior walls. Outlet openings should be located at the high point of the room in exterior walls or roof. Inlet and outlet openings should have a minimum total area of 0.003 m2 per 1 m3 of room volume, or 1 ft2 per 1,000 ft3 of room volume, per 29CFR 1910.106

Active (mechanical, forced) ventilation can be used to prevent the accumulation of flammable mixtures, if passive ventilation is insufficient. Active ventilation can be used to ensure sufficient vent flow is maintained to keep the concentration of hydrogen below that which will burn in air (suggest setting vent flow to ensure concentration is less than 25% LFL = 1% H2 by volume). For example, NFPA 52 (para. 9.3.3.5.5) requires a minimum of 1 ft3 per minute per ft2 of room area and at least 1 ft3 per minute per 12 ft3 of room volume for proper hydrogen ventilation. Note that no practical ventilation rate can effectively disperse hydrogen from a massive release from a pressurized vessel, pipe rupture, or blowdown.

- Active ventilation may be required if the configuration of the room may cause hydrogen to accumulate in the ceiling or roof area. Hydrogen accumulation may be a problem, for example, in rooms with a peaked roof or in rooms with dropped or false ceilings.
- Equipment used in forced ventilation systems (fan motors, actuators for vents and valves, etc.) should have the applicable electrical classification (class, division, group, and operating temperature) and should be approved for hydrogen use. Systems that recirculate air should be avoided.

- If active ventilation systems are relied upon to mitigate gas accumulation hazards, procedures and operational practices should ensure that the system is operational at all times when hydrogen is present or could be accidentally released.
- Hydrogen equipment and systems should be shut down if there is an outage or loss of the ventilation system

Hydrogen cylinders and storage tanks should be stored outside at a safe distance from structures, ventilation intakes, and vehicle routes. This applies even while in use. Best practices call for compressed hydrogen bottles supplying a manifold to be located outside, with welded lines to connect to indoor equipment. If a hydrogen cylinder is used inside, additional safety considerations must be addressed, including (but not limited to):

- limiting total hydrogen volume based on workspace size
- maintaining minimum spacing between cylinders of hydrogen and oxidants
- securing of cylinders properly

Additional recommendations for cylinder storage inside a shed or other enclosure include:

- Buildings (e.g., sheds) used for storing hydrogen cylinders should be constructed of non-combustible materials.
- Detached storage facilities should have normal and emergency ventilation system with inlets low to the ground and exhausts at the highest point of the room in the exterior wall or roof. The inlets and exhausts should be oriented in the same direction (for wind tolerance).
- Hydrogen sensors should be installed at the exhaust within the enclosure to detect any leaks.
- The storage facility should have an automatic shutoff that activates if a leak is detected or a problem occurs in the facility that is being supplied with hydrogen.
- Ignition sources (e.g., open flames, electrical equipment, or heating equipment) should not be allowed within the storage facility.
- The gaseous hydrogen system should be electrically bonded and grounded.
- An automatic shut-off valve should be located in liquid hydrogen withdrawal piping as close to the vessel as practical

Hydrogen storage facilities should be equipped with venting systems for both normal operating requirements and emergency situations. Vent lines for hydrogen (including pressure relief lines and boil-off from cryogenic systems) should be vented to a safe outside location. The vent should be designed to prevent moisture or ice from accumulating in the line. Unused hydrogen should be disposed of by venting or possibly flaring. The vent system should:

- be leak tight
- avoid air intrusion or be designed to handle the possibility of an explosion inside the piping
- be unobstructed and protected from the weather
- safely release the unused hydrogen above the facility roof or at a remote location
- be designed to carry the excess flow of the venting gas or liquid

According to NASA guidelines, for hydrogen vent rates greater than 0.5 lb/sec, flaring may be considered. Large quantities of unused hydrogen that can't be handled by the vent system should be flared at a remote location. It should be assumed that hydrogen in vent systems will ignite, so the systems should be designed to maintain their integrity and not present hazards to their surroundings. This is not an issue for smaller commercial systems. Flare systems must have:

- pilot ignition
- flameout warning systems
- a means to purge the vent line

Hydrogen piping systems must be carefully designed and installed to minimize the potential for leaks and allow for their easy detection. Piping systems should be designed in accordance with the applicable codes and standards and to:

- Minimize leaks through the use of welded joints where possible.

- Ensure that personnel will be able to easily reach joints and fittings (to check for leaks).
- Prevent or reduce the chance of personal injury (i.e., contact with cold surfaces, head impact, tripping hazards, etc.).
- Minimize stresses (structural and thermal) in piping components and connected equipment.
- Strive for leak-tight joints.
- Determine proper sizes and settings of pressure relief devices.
- Include properly labelled shutoff valves at safe locations.

Flow restrictors, such as orifice meters, in the supply line are an effective means of limiting the supply flow rate and controlling leakage rate.

Piping should be labelled to indicate content, flow direction, and design and test pressures.

For Cylinder Storage Area the following would be ensured

- Cylinders should be handled only by trained personnel.
- Cylinders should be stored at a safe location outside the lab.
- Cylinders should be secured from tipping over by holders or restraints designed for such service. Double cylinder restraints (high and low) should be installed in a seismically active area.
- Cylinders should be equipped with a pressure regulator designed for hydrogen and marked for its maximum cylinder pressure.
- Regulators should be equipped with two gauges, installed to show both the cylinder pressure and the outlet pressure.
- Hydrogen supply lines should have a manual shutoff valve to allow isolation of equipment. A quick connect should never be used in place of a shutoff valve.
- Excess flow valves or flow restrictors should be used to control maximum hydrogen flow, particularly when using ganged cylinders.

A compressed gas cylinder should be considered to be "in use" if it is in compliance with one of the following:

- Hydrogen cylinders located outdoors should not be installed within 10 feet of windows, doors, or other building openings, or within 50 feet of ventilation intakes.
- Storage areas should have a minimum of 25% of the perimeter open to the atmosphere. This open space can incorporate chain-link fence, lattice construction, open block, or similar materials for its full height and width.
- Storage areas should be kept clear of dry vegetation and combustible materials for at least 15 feet.
- Cylinders stored outside should not be placed on the ground or on surfaces where water can accumulate.
- Storage areas should be provided with physical protection from vehicle damage.
- Storage areas can be covered with canopies of non-combustible construction.
- Check for compliance with local fire and building codes and storm water regulations for property line setback, threshold storage amounts, and berm requirements.
- Revise hazardous materials storage documents filed with local response authorities for any significant change in hydrogen or other hazardous materials storage.
- Post "NO SMOKING WITHIN 25 FEET" signs in gas cylinder storage areas.

Pipelines offer one of the safest modes of transporting hazardous materials compared to other means of transportation such as road, rail and marine transportation. This is witnessed by the very few recorded incidents of fatality or injury despite the millions of kilometres of pipelines in use worldwide. It is also pertinent to note that pipeline failures have reduced drastically over the last decade, mainly on account of better data communication, construction, pipeline engineering, quality testing, welding techniques, metallurgy technology and a host of other causes. Leakages from pipelines have occurred historically due to a variety of reasons. Some of the predominant causes for pipeline failures are discussed below. The Table 10.2 given next presents a detailed generic listing of potential incidents for a pipeline system.

Table 10.2: Generic Incidents for a pipeline system

Human Errors	Equipment Failures	System or Procedural failures	External Events
1) Hot tapping	1) Thermal Expansion	1) Inspection	1) Accidental Excavation
2) Repair / replacement	2) Internal corrosion	2) Operation	2) Earthquake
3) Start-up	3) External corrosion	3) Start-up / shutdown	3) Subsidence
4) Changing Operations	4) Bad welds	4) Communication	4) Avalanche
5) Shutdown	5) Fatigue	5) Maintenance	5) Flood/scouring
6) Preparation for maintenance	6) Cathodic protection fails	6) Leak detection	6) Lightning
7) Valve Operation	7) Cyclic stress	7) Emergency repair	7) Fire
	8) Internal erosion	8) Material specs	8) Vandalism/sabotage
	9) Control system failure	9) Modifications	9) Rail/road crossing
	10) Brittle fracture		
	11) Construction defects		

Source: American Institute of Chemical Engineers, Centre for Chemical Process Safety (CCPS)-Transportation Risk Analysis publication.

10.2.1 Causes of Failure for piping

When considering the data basis together, one broad conclusion comes out of the statistics, despite some variation caused by dissimilarity in the type of data collected - failures occur in roughly equal proportions in three broad categories:

- Failures caused by external mechanical interference.
- Failures caused by corrosion defects.
- Failures caused by external events such as natural hazards or operator error.

Some of these failures are time independent occurrences (e.g., external mechanical interference, earthquakes or overpressure), while others are time dependent (e.g., corrosion and fatigue failures).

10.2.2 Failure from Corrosion defects

Pipeline failures by corrosion can be due to internal corrosion or external corrosion. Internal corrosion is mainly on account of corrosive or aggressive material being transported- causes have included improper attention at upstream (at source) or erosion due to high velocities or two-phase flow. In the case of this project, the gas is highly processed upstream at different locations and the possibility of quality slips is minimal.

External corrosion failures are mainly due to moisture in the ground and aggressive soils and take two forms - small pinhole failures caused by pitting and more generalized corrosion leading to a reduction in pipe wall thickness. External pitting corrosion leads to small leaks that are often difficult to detect but that gradually grow in size over a period of time.

10.2.3 Failures caused by external events such as natural hazards or operator error.

External events can initiate and contribute to potential incidents considered in a Risk Analysis. Although the frequency of such events is generally low, they may result in a major incident. They also have the potential to initiate common cause failures that can lead to escalation of the incident. External events can be subdivided into two main categories:

- Natural hazards: Earthquakes, floods, tornadoes, extreme temperature, lightening etc.
- Man, induced events: Industrial activity, sabotage etc.

10.2.4 Probability of External Events

Normal design codes have sufficient safety factors to allow the facilities to withstand major external events to a particular level. Quantitative design rules usually used for seismic events, flooding, tornadoes and extreme wind hazards as follows:

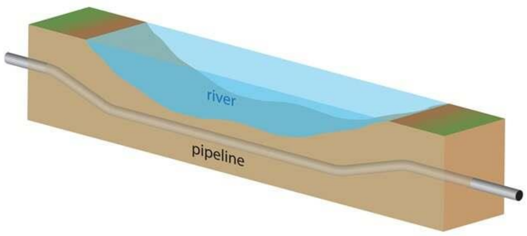
- Seismic: The design should withstand critical ground motion with an annual probability of 10^{-4} or less.
- Flooding: The design should withstand the efforts of worst flooding occurrence in 100-year period.

- Winds: The design should withstand the most critical combination of wind velocity and duration having a probability of 0.005 or less in a 50-year period (annual probability of 10^{-4} or less).

10.2.5 Failure Due to Hydraulic Forces

The pipelines under rivers might be subjected to loads caused by bank recession, streambed scour and fill, buoyancy, drag, movements of debris and sand, and temperature changes. It recommended that designers consider the effects of river traffic and future improvements likely to be made affecting navigation and flood control and, so far as possible, to eliminate such exposures. Among others the designer should:

- Obtain a complete historical survey detailing movements of banks and "thalweg, determine recorded depths of scour, and review the hydrograph of the stream (the information obtained should cover a considerable distance on each side of the proposed crossing location);
- Perform soil borings along the proposed crossing location; and,
- Provide flexibility for the crossing pipe sufficient to allow it to resist subsequent forces.
- Cathodic Protection robustness must be ensured through regular PSP monitoring and any defects taken up on priority. Proper records would be maintained as necessary.
- Any TCP (Temporary Cathodic Protection) would be monitored during the construction phase and replaced with PCP (Permanent Cathodic Protection) once the pipeline is operational. TCP would not be used beyond its design life; even in case pipeline construction delays take place.
- Vulnerable points such as water body/ river crossings etc. must be closely monitored for exposure, scouring activity of sediments etc.- PSP across both sides, casing condition etc. must be closely monitored and trends identified.



Pipelines that traverse a river are often buried beneath the riverbed and channel banks (see Figure). If the pipeline becomes exposed, it can be damaged by flowing water, debris transported in the water, or a phenomenon called vortex-induced vibration (VIV).

River scour is defined as the erosion of a riverbed (vertical scour) or riverbanks (lateral scour) by flowing water. Scour can occur gradually or episodically during floods. Factors that control scour are the river flow, the characteristics of the riverbed and riverbank sediments, and the capacity of the river to transport sediments. Construction or other changes upstream and downstream of a pipeline crossing can influence river flow and channel morphology.

Riverbed scour occurs when the shear stress induced on the riverbed by flowing water exceeds the resistance of channel bed material (i.e., the critical shear stress for erosion). The eroded sediments are transported as bed load (i.e., movement of the bed material by rolling, sliding, or saltation along the bed) or suspended load or both, depending on the composition of the bed material. Riverbed scour may occur due to high flows, a decrease in the sediment supply (such as might result from construction of a dam upstream), or an increase in longitudinal slope of the channel resulting from reduction in channel sinuosity or loss of river floodplain with distance downstream.

Riverbank erosion typically occurs when higher flows within an incised channel cause increased forces along the channel banks that exceed the resistance to scour of the channel bank material. Erosion of one or both banks lead to widening of the river. The process of aggradation (sediment deposition) in the river may result in the formation of sand and gravel bars in the channel. The sand and gravel bars concentrate flows against one or both banks causing erosion of the riverbank and widening the river, potentially exposing a buried pipeline at its approach to a crossing. Once the pipeline is exposed, debris in the flowing water, specifically during high-flow events, can directly impact the pipeline resulting in failure of the pipeline crossing. In addition, an exposed pipeline may experience vibration due to the flowing water.

Buried pipeline river crossings can be exposed by multiple scour mechanisms. Once exposed, a pipeline may be subject to failure due to hydrodynamic forces of the flowing water, debris carried by flowing water, and/or fatigue failure due to VIV. To prevent breakage and subsequent accidental product releases, all stream crossings should have burial depths and/or erosion countermeasures designed and constructed according to site-specific conditions and acceptable flow return frequencies.

10.2.6 HDD Hazards

Potential risks that are a part of all HDD include a failure to complete the bore, safety of the public and workers, environmental issues, damage to surface structures, and striking other underground structures. Risk reduction is the attempt to identify potential risks during the planning and design phase so that they may be eliminated or reduced.

Failure to complete the bore is often the main concern, as the project would not be attempted if the product pipe could not be installed. The following are some of the frequent problems that can result in a failed bore attempt:

1. Obstructions can cause a failed bore if the drill bit, reamer, or product pipe cannot be advanced past the object. If identified during planning, the best approach is to avoid the obstacle. If the bore cannot be changed, an appropriate response can be developed before installation begins. Typical obstructions faced during HDD construction are cobbles and boulders, gravel beds, wood, bedrock, and construction debris or foundations.
2. Hydro lock is a condition that may occur when the circulation from the bore hole is lost and the subsurface formation is resistant to fracturing, resulting in a hydraulic cylinder in the bore hole. This problem is common in fine-grained rock, frozen ground, and any formation that is resistant to hydraulic fracturing.
3. Line and grade problems occur due to faulty tracking and steering or subsurface conditions that prevent or hamper the proper steering. The improper matching of the downhole tools to the subsurface conditions can also cause line and grade problems.
4. Bore hole collapse severely impacts the chances of success on any HDD project. Soft or loose soils present a high risk of collapse during HDD operations. When a bore hole collapses, there is an immediate increase in rotary torque and pressure and a decrease or loss of circulation.
5. A failure or damage to the product pipe during HDD installation can occur due to an improper ream bore hole, poor workmanship, and improper HDD design. The best approach to avoid product-pipe failures is to establish conservative design criteria and follow the pipe manufacturer's guidelines. It is also important to make sure that the products specified in the design are actually the products delivered to the work site. Another key factor in maintaining suitable product pipe is to ensure that all weld or fusion connections are properly performed and tested.
6. Surface heave or humping is a condition that is usually a result of excess pumping of drilling fluids after a loss of circulation. This condition can quickly pressurize the formation and cause a heave at the surface. Heaving can also arise from reaming with a barrel reamer without enough depth, which can result in a displacement of soil towards the surface. Pulling the reamer or product pipe through the bore hole too rapidly can also result in a surface heave.
7. Fortunately, large surface collapses are rare. Heaving or humping the surface is a far more common occurrence. Surface collapse is typically a result of a significant over excavation above the bore hole, which can be caused by large volumes of thin drilling fluid used at high velocities, incomplete filling of the annulus with drilling fluids for a large-diameter bore near the surface, or leaks in high- pressure pipes after installation, which erode the soil above the bore hole.

Possible hazards and identify factors and specific project characteristics that may aggravate the safety risk resulting from the identified hazards from HDD is presented below ***Figure 10.1:***

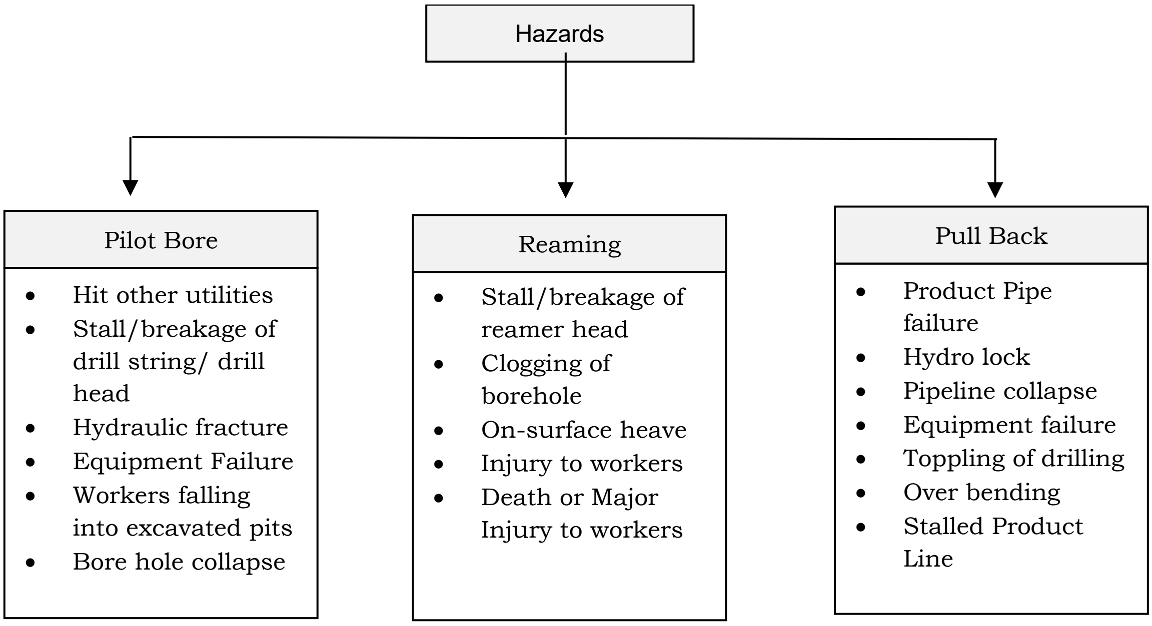


Figure 10.1: Hazards from HDD

The following risks are identified from HDD:

- A high pulling force caused by wrong ballasting with respect to the weight of the drilling fluid.
- A high pulling force caused by a small design bending radius. Higher normal forces on the bore hole wall and higher radial displacements of the pipeline during the pullback operation are also caused by a small design bending radius. High radial displacements may lead to breakage of drill pipes.
- Damage of the coating of the pipeline caused by unawareness of obstacles of natural origin due to misinterpretation of the results of the soil investigation.
- Damage of the coating of the pipeline caused by occurrence of obstacles of man-made origin.
- Damage of the coating of the pipeline caused by wrong choice of the coating of the pipeline in relation to the forces in between the pipeline and the obstacles.
- A high pulling force caused by an irregular shaped bore hole with small 3D-bending radii.
- A high pulling force caused by bore hole instability due to soil and groundwater conditions.
- A high pulling force caused by bore hole instability due to erroneous chosen drilling fluid.

Based on the defined risks a series of measures to reduce the magnitude of the risks could be established. The following measures can be taken before starting future HDD's and during the performance of the future HDD's:

- Measurement of the weight of the drilling fluid during the drilling stages and application of additional reaming operations.
- Usage of new formulas for the calculation of the design bending radii.
- Detailed soil investigations with attention for the occurrence of obstacles.
- Historical research on the occurrence of man-made obstacles.
- Usage of a strong coating to prevent damage due to contact with obstacles.
- Measurement of the shape of the bore hole before starting the pullback operation.
- Detailed soil investigations with attention for the occurrence of bore hole instability.
- Measurement of the chloride concentration of the groundwater in the soil layers through which the horizontal directional drilling is carried out.

Diesel key points: Diesel is a complex mixture of chemicals mainly obtained from the distillation of crude oil. Diesel is produced by blending straight-run middle distillates (minimum 40%) with varying proportions of straight-run gas oil, light vacuum distillates, light thermally cracked distillates and light catalytically-cracked distillates. Diesel key points are described below:

Fire

- Flammable
- Vapour / air mixtures may be explosive
- Use foam and liquid-tight protective clothing with breathing apparatus
- Health
- Irritating to eyes, respiratory system and skin
- Severe lung injury may occur following aspiration of liquid
- Possible carcinogen Environment

Irritating to eyes, respiratory system and skin • Chemical pneumonitis may arise following aspiration of vomitus (secondary to ingestion) or inhalation of aerosol (or aspiration of liquid) during manual siphoning • Prolonged skin exposure may cause skin irritation • Possible carcinogen • Diesel is considered not to be a human reproductive or developmental toxicant

Environment

- Dangerous for the environment
- Inform Environment Agency of substantial incidents

Like most chemicals, the amount of diesel you are exposed to must be above a certain level to cause adverse health effects. A short, one-off exposure to diesel will not normally cause any long-term health effects. Occasional skin exposure may lead to dermatitis (eczema). Breathing large quantities of diesel vapour or drinking diesel-based fluids may cause nonspecific signs and symptoms of poisoning such as dizziness, headache and vomiting. A severe form of lung damage called pneumonitis may occur if liquid diesel is inhaled directly onto the lungs, for example, whilst manually siphoning a tank or from inhaling vomit after swallowing diesel. This is why it is important not to make someone sick if they have swallowed diesel. There is limited evidence from animal studies that prolonged exposure may increase the risk of developing skin cancer. There is not thought to be any risk of cancer from short-term, occasional exposure.

CHP (Combined Heat and Power) and CCGT (Combined Cycle Gas Turbine) plants have become larger and more popular in recent years for local power and heat generation, and for mainstream power generation. Many are based on gas turbines within acoustic enclosures. Complex fuel supply pipework to the turbines at high pressure gives rise to an explosion hazard within such enclosures in the event of foreseeable small leaks if adequate ventilation is not provided.

The fuel supply to a gas turbine is required at high pressure. Whilst typically a 6MW unit requires gas at from 8 to 20 barg, a 40 MW unit uses 10 tons per hour at up to 30 barg. The pipework supplying the fuel to the turbine combustion chambers is convoluted. Its complexity increases with the size of the machine. The complexity is due to the supply from annular distribution pipes to the individual combustion chambers. Each chamber may require up to 4 main fuel supplies, and alternative fuel supplies. For a 40MW machine the pipework may include 30 flanges or flexible pipes; for a 250MW machine it may include over 200 flanges, 90 flexible hoses, 18 valves, and 8 bellows, all operating at 20 barg. Liquid fuel supplies may operate at up to 60barg. A particular problem associated with gas turbines arises from the absence of isolating valves on the fuel supply systems. The pipework is invariably connected to the combustion chambers without an isolating valve so that, whilst a blank can be inserted at this point for pressure testing of all upstream pipework, this final connection cannot be tested. In practise, whilst pipework is pre-assembled and tested by suppliers, it is often not tested at all when assembled on site, or following maintenance, because of the difficulty of access.

A fuel leak from the fuel supply pipework is foreseeable. It may arise following assembly, either when new or following maintenance. The fuel pipework is routinely dismantled for turbine maintenance at intervals of one to three years. It is predictable that a joint failure following incorrect assembly will arise. Gas turbines should operate without excessive vibration, and vibration detectors are often, but not always, fitted to larger units to detect bearing failure etc. Such vibration could also cause fuel pipe joint failure. Catastrophic, e.g., sudden guillotine pipe failure is very improbable, but a fuel leak from a flange, control valve, or welded pipe joint is a hazard against which appropriate precautions should be taken. Gas turbines are fundamentally a significant noise source and environmental pressures often dictate their installation within acoustic enclosures. The release of fuel within the enclosure is potentially hazardous if the release results in a volume of flammable fuel/air mixture within a significant fraction of the chamber volume. The release may be of gas, such as natural gas, flashing liquid such as propane, or liquid such as naphtha or fuel oil, or lubricating oil. Even the release of liquids at temperatures below their flash points can create an explosion hazard since releases from high pressures can generate fine mist which behaves as if it were a flammable gas. The ignition of such a gas or liquid mist fuel release would result, depending upon the construction of the chamber and its location, in explosion blast, fire ball, and missile effects which could seriously injure or kill persons nearby. The commercial implications of such an event are also likely to be very significant. The ignition of a fuel release would require the presence of a source of ignition. Electrical equipment within the enclosures is normally installed to appropriate zoning standards by the application of relevant codes of practice against ventilation data. This concept may provide inadequate protection however if ventilation is not properly designed. Furthermore, it is also impractical to exclude other sources of ignition entirely. Ignition may result from static discharges, from mechanical means such as moving parts in the event of a major pipe failure (pipewhip) or blade enclosure failure, from mechanical disruption of electrical equipment, from backflowing combustion gases in the event of a fuel pipe failure close to a combustion chamber, or from hot surfaces. The fuel is being burnt in turbine combustion chambers and the exhausts of some smaller units based on aircraft engines glow. The exhaust diffusers of larger units do not reach such high temperatures but are nominally at 450°C to 500°C. Thermal imaging techniques have been used to measure such surface temperatures and have identified hot spots of over 520°C. Auto ignition is the most probable source of ignition of a fuel release. Auto ignition temperature is not an absolute property of a fuel, and is a function of surface roughness, orientation, contamination and size, and of fuel purity, stoichiometry, velocity and turbulence. The literature values quoted for relatively common materials vary widely even for results obtained under standard conditions. Such values are unreliable for use with small margins in this application. Whilst it is clearly appropriate to take relevant precautions to minimise the presence of sources of ignition, it is not possible to eliminate them in these circumstances, and in the event of a fuel release within an acoustic enclosure the probability of ignition should be assumed to be very high, and in effect unity for practical purposes and risk assessment. Apart from the hazard of an explosion within the acoustic chambers, there are other explosion hazards, characteristic of any gas fired plant. In particular there is the possibility of the accumulation of a flammable gas/air mixture within the turbine and associated inlet and exhaust systems, and its ignition by the combustion process itself, e.g. at start up This hazard is relatively easier to mitigate, with adequate purging and reliable gas safety shutoff arrangements. Turbine could also lead to hazards also due to inadvertent closure of dampeners, trip of ID fans etc.

Since installing your boiler and associated plant, there may have been a number of changes in the process or system, resulting in a change in the amount of steam you require. This will in turn affect the way in which the boiler is operated, which could end up being very different from what was envisaged when it was installed. If a boiler is not operated within its design limits, it increases the risks of fatigue, stress and corrosion, which could eventually lead to leaks, ruptures and, in extreme cases, explosions. Similarly, with feed water, incorrect water treatment can lead to scaling, which will again damage the boiler and could lead to premature or catastrophic failure.

There is a wide range of safety and monitoring equipment that can be fitted to boilers, designed to help protect the boiler from operating outside the set parameters and shut it down to prevent a dangerous situation. This may include equipment such as alarms, water-level controls, burner controls and pressure-relief valves.
A faulty steam boiler brings with it the risk of a steam explosion. With significant stored energy, failure of steam (or pressurised hot water boiler plant) can produce a similar level of destruction and/or devastation as a bomb, potentially causing catastrophic damage, serious injury and possibly multiple fatalities. A boiler hazard arises:-

1. explosion can occur due to over pressure and temperature and improper combustion of fuel.
2. Burn injury due to hot water and hot steam pipeline leakage
3. Exposure to the hot surface of pipeline or machineries.
4. Water tube burst due to Failure in boiler water level control
5. Catches on the moving part of the machinery like F.D. fans or motors
6. Burst of the equipment body due to over pressure and over temperature

Water treatment

As with all systems where water is heated there will be a potential for scaling. This can lead to a loss of efficiency or, in extreme cases, premature failure of the boiler due to either scale build-up on the internal surfaces or debris from corrosion collecting in the bottom of the boiler. Water quality within the boiler must be maintained to reduce the risk of overheating, corrosion, water carryover causing destructive water hammer and build-up of solids. Water-treatment methods include water-treatment plant, such as base exchange, demineralisation and reverse osmosis; hotwells or de-aerators; and adding chemicals.

For chemical e.g. Caustic (Sodium Hydroxide), Hydrochloric Acid, Sulfuric Acid, Ammonia, Chlorine, Sodium hypochlorite, Sodium Phosphate handling - Vendor/manufacturer SOP should be followed for safe handling/Storage etc.

For Caustic (Sodium Hydroxide), Hydrochloric Acid, Sulfuric Acid, and Sodium hypochlorite etc. only localized impact could be seen. However, for Ammonia and Excessive Chlorine Reaction case the impact may be seen offsite. It is suggested that This damage distance in practice may be minimized through means of rapidly cutting off the source of leak, and, depressurizing and shutting down the

system connected. In addition, in case of a localized cloud, a fine spray of water or better still a spray of caustic (chlorine is more soluble in caustic) in a safe manner may help. In addition, as nearby areas could be affected, it is important for GC to inform neighbouring plants about their activities and measures to be taken by other plant personnel in the event of a chlorine gas scenario.

It may be noted that These chemicals are corrosive/toxic in nature for detailed toxic impact MSDS must be referred and Manufacturer best practice must be ensured.

Major accidents which may occur in power plants are summarized below ***Table 10.3:***

Table 10.3.: General Incident details and mitigation measures

General Incident in Power Plant	Mitigation Measures
Transport accidents	Speed limit to be maintained in plant area
Fall from the height during work on conveyer belt, conveyer control room etc	Safety belt, safety net
Struck by falling object	Safety helmet, safety net
D. M Plant	
Fire hazard	Fire extinguisher, eliminate the possible ignition source
Chemical burn by Spillage of sulphuric acid and caustic soda lye during unloading, overflow, Damage on storage tank or pipe line	Wash rinse exposed area, training, maintenance, proper supervision
High noise level	Ear plug, earmuff
Boiler Hazard	
Explosion in boiler due to over pressure and temperature	Continuous monitoring, maintenance and Emergency shutdown through BMS
Explosion in boiler due to improper combustion of fuel.	Post and Pre-purge cycle
Burn injury due to hot water and hot steam pipeline leakage	First aid and safety shower
Exposure to the hot surface of pipeline or machineries.	First aid and safety shower
Water tube burst due to Failure in boiler water level Control	Preventive Maintenance and inspection
Fire in diesel supply line	Fire detectors
Burn injury by hot fly ash	Safety Showers, First aid
Catches on the moving part of the machinery like F.D. fans or motors	Proper fencing on the moving parts of turbine
Burst of the equipment body due to over pressure and over temperature	Preventive Maintenance and inspection
Slip, trip and fall from the height during routine work, maintenance or inspection	Training, proper supervision, PPE's
Generator and Turbine Hazard	
Explosion in turbine due to cooling system failure	Other source to be ensured, Preventive Maintenance and inspection
Explosion in turbine due to lack of lubrication in coupling shaft	Preventive Maintenance and inspection
Fire on cooling oil	Preventive Maintenance and inspection
Explosion on hydrogen tank	Proper storage, isolation from the ignition sources
High noise level	Ear plug, ear muff should be provided
Switch Yard Hazard	
Fire on transformer	Firefighting apparatus
Electric shock and electric burn routine work, maintenance or inspection of electrical panels in switch yard	PPEs

Preventing Fires & Explosions

- Fires & explosions in boiler can also result from the ignition of volatile materials and fuels. The most hazardous procedures are during the firing-up and shutting-down procedures. The fuel supply to boiler should be fitted with an automatic shut-off mechanism.
- Operators should be trained in safe systems of work. The building should be designed to be non-combustible, with automatic fire suppression engineered or designed into the process where appropriate.
- Regular safety audits should be undertaken to ensure that hazards are clearly identified, and risk-control measures maintained at an optimum level.

10.3 Short listing of Release Scenarios

The range of incidents possible in the facility is established through identification of "Isolatable sections", from which the different categories of leakages/ releases may occur. The Isolatable Sections comprise those where Emergency isolation is possible. The QRA Guideline was utilized for deriving failure scenarios, release rates, inventories etc. are identified as follows:

- The initial step is the identification of sources and their physical location
- Calculation of the hold-up volumes within isolatable sections with respect to fluid within equipment and associated piping.

The isolatable sections of the layout are presented in the layout in ***Figure 10.2***

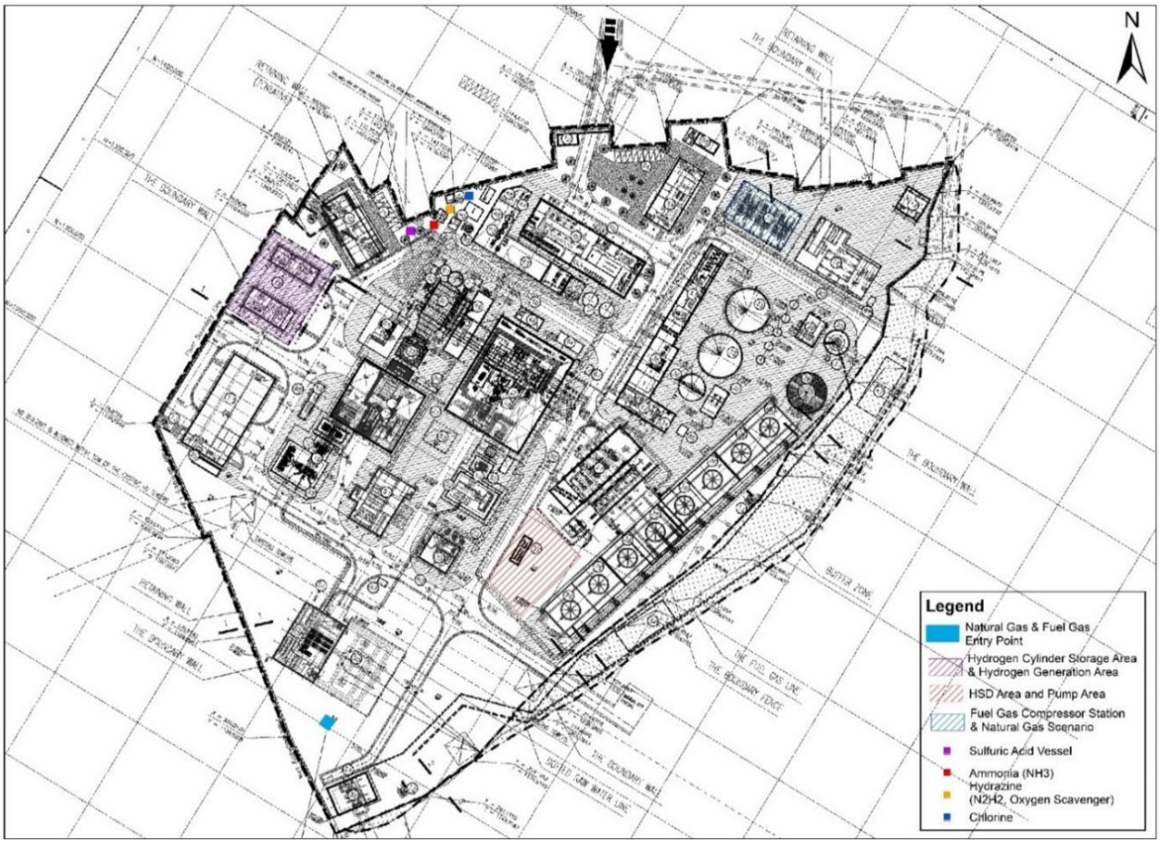


Figure 10.2: Isolatable sections in the layout

Table 10.4: Inventory Calculation/Input Table for the Risk analysis

S. No	Unit Name	Pipeline Día (in mm)	Temperature	Pressure	Vessel Capacity	Flow Rate	Density in Kg/m3	Isolation Time / Response Time	Considered Leak Sizes	Leak Type	Total Inventory (Kg)	Total Failure Frequency (Avg/Year)
1	Natural Gas	508	32°C	12 Kg/cm2	-	19.968 Kg/Sec	0.66	5 min	25mm	Small	71887.52	2.59E-03
									100mm	Minor	43133.60	8.39E-04
									250 mm	Major	28756.64	1.34E-03
									500 mm	Catastrophic Rupture	14379.68	1.34E-03
2	Diesel	25	Ambient	1 bar	20 m3	-	845	5 min	5mm	Small	-	1.47E-03
									15mm	Medium	-	7.11E-04
									CR	Catastrophic Rupture	-	7.11E-04
3	Hydrogen Cylinder Failure	-	Ambient	15 Mpa	50 L	-	0.089	-	CR	Catastrophic Rupture	-	4.60E-05
4	Hydrogen generation from hydrogen generation package to vessel	25	Ambient	3.2 Mpa	-	5 m3/hr	0.089	5 min	5mm	Small	0.31	1.10E-03
									CR	Catastrophic Rupture	0.54	5.02E-04
5	From Hydrogen generation after Vessel and compressor to Gas manifold	25	Ambient	15 Mpa		5 m3/hr	0.089	5 min	5mm	Small	1.44	2.00E-03
									CR	Catastrophic Rupture	2.55	9.07E-04
6	Hydrogen Vessel		Ambient	Atm	1 m3	-	0.089		CR	Catastrophic Rupture	-	4.60E-05
7	Hydrogen Chloride Vessel		Ambient	Atm	20 m3	-	-	-	CR	Catastrophic Rupture	-	5E-06
8	Sulfuric Acid Vessel		Ambient	Atm	5 m3	-	-	-	CR	Catastrophic Rupture	-	5E-06
9	Ammonia (NH3)		Ambient	10 bar	1 m3	-	-	-	CR	Catastrophic Rupture	-	5E-06
10	Hydrazine (N2H2, Oxygen Scavenger)		Ambient	Atm	1 m3	-	-	-	CR	Catastrophic Rupture	-	5E-06
11	Chlorine		Ambient	Atm	-	-	-	-	CR	Catastrophic Rupture	1500	5E-06

Isolation of intervention time is considered based on the specific scenario, location, leak size, intervention mode (automatic/manual), manpower presence and other local factors.

For each units, various failure scenarios were generated and for each identified failure case, the appropriate data required to define that case is calculated in the software. Estimated failure frequencies are assigned to the failure cases based on the published databases. When the appropriate inputs are defined, the software calculates the source terms of each release, such as the release rate, release velocity & release phase. These source term parameters then become inputs to the consequence modelling.

10.3.1 Consequence Analysis

Since risk is a combination of frequency and consequence, consequence (or impact) analysis is a necessary step in the risk management process. All models, including consequence models, have uncertainties. These uncertainties/impacts on consequence arise due to (1) an incomplete understanding of the geometry of the release, that is, hole size, (2) unknown or poorly characterized physical properties, (3) a poor understanding of the chemical or release process, and (4) unknown or poorly understood mixture behaviour etc. (5) Pasquil stability class (6) wind direction, (7) Mixing Height (7) Surface Roughness (8) MOC (9) Chemical Composition etc.

The Software PHAST/SAFETI, version 8.22 was used for the study for assessing the Risk and Consequence calculations.

Using the failure case data developed, the consequence program of the software package, undertakes consequence calculations for each identified failure scenario.

For the flammable materials, the software proceeds to determine the effect zones for the various possible outcomes of such a release. A release can ignite as the result of the event, which causes it, or can ignite close to the source before the flammable cloud has travelled away from the release source. If a release does not ignite in this way, and it is still flammable, it can be ignited at a number of points downwind if its path is such that it goes across (for example) a road, an area where people are present or other ignition sources. The risk analysis must account for all these possible outcomes.

The particular outcome(s) modelled depends on the behaviour of the release and the dilution regimes, which exist. This can be quite complex. The program undertakes these calculations for the selected representative meteorological conditions, which are derived from the annual meteorological conditions in the study area. The meteorological considered used for this project is given below: -

10.3.2 Weather Conditions

The weather stability class is normally Class D on sunny days and Class F for Night time. The average wind speed most of the time is 5 m/s for day time and 1.5 m/s. combining this with stability class D and F, consequence modelling is done for both the weather cases 5D and 1.5F.

The six representative weather classes on which the analysis is based are detailed in ***Table 10.5: -***

Table 10.5: Pasquil Stability Class

Surface Wind Speed (m/s)	Daytime Conditions **Strength of Sunlight**			Night Sky	
	Strong	**Moderate**	**Slight**	**Thin Overcast ≥ 4/8 Cloudiness****	**≤3/8 Cloudiness**
< 2	A	A-B	B	E	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
> 6	C	D	D	D	D

**Applicable to heavy overcast conditions day or night*

***Degree of Cloudiness = Fraction of sky above horizon covered by clouds.*

A- Extremely Unstable Conditions

B- Moderately Unstable Conditions

C- Slightly Unstable Conditions

D- Neutral Conditions*

E- Slightly Stable Conditions

F- Moderately Stable Conditions

In its original form, the Pasquil system contains seven categories (A to F) but joint categories are also common. Categories A (Very Unstable), D (Neutral) and F (Very Stable) are discussed next.

Category A (very unstable) occurs typically on a warm sunny day with light winds and almost cloudless skies when there is a strong solar heating of the ground and the air immediately above the surface. Bubbles of warm air rise from the ground in thermals. The rate of change (decline) of temperature with height (lapse rate) is very high.

Category D (neutral) occurs in cloudy conditions or whenever there is a strong surface wind to cause vigorous mechanical mixing of the lower atmosphere.

Category F (very stable) occurs typically on a clear, calm night when there is a strong cooling of the ground and the lowest layers of the atmosphere by long wave radiation. There is a strong inversion of temperature (i.e., warm air over cold air).

Table 10.6: Representative weather class

Weather Class	Wind Speed(m/s)	Pasquil Stability
I	3	B
II	1.5	D
III	5	D
IV	9	D
V	5	E
VI	1.5	F

Source: Handbook of Chemical Hazard Analysis Procedures by FEMA, USEPA and USDOT

Bangladesh has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures and humidity. There are three distinct seasons in Bangladesh: a hot, humid summer from March to June; a cool, rainy monsoon season from June to October; and a cool, dry winter from October to March.

Natural phenomena such as flood, cyclone, tornado and bore, hit Bangladesh almost every year, which causes not only transient damages but also secondary damages to the country such as deforestation, land erosion, and so on. Cyclones coming in from the Bay of Bengal are experienced in Bangladesh during the periods April to May and October to November. On occasions these can cause great damage and loss of life. The project site is located in the Bay of Bengal so is likely to experience the full effects of such cyclones.

The normal maximum summer temperature at project site range between 30 ^{0}C and 32 ^{0}C and maximum temperature is about 15 ^{0}C. May is the warmest month and January is the coolest month.

Winds are mostly from the north and northwest in the winter, blowing gently at 1 to 3 km/h in northern and central areas and 3 to 6 km/h near the coast. From March to May, violent thunderstorms produce winds of up to 60 km/h. During the intense storms of the early summer and late monsoon season, southerly (SSE, E, SE, ESE) winds of more than 160 km/h cause waves to crest as high as 6 meters in the Bay of Bengal, which brings disastrous flooding to coastal areas.

10.3.3 Damage Criteria

Jet Fire:

The consequence caused by exposure to heat radiation is a function of:

- The radiation energy onto the human body [kW/m2];
- The exposure duration [sec];
- The protection of the skin tissue (clothed or naked body).

It can be assumed that people would be able to find a cover or a shield against thermal radiation in 20 second time. Furthermore, 100% lethality may be assumed for all people suffering from direct contact with flames, such as the pool fire, a flash fire or a jet flame. The effects due to relatively lesser incident radiation intensity are given below.

In the study, the following criteria were used for estimation of heat radiation due to fire fatalities:

Heat Radiation Selection Criteria:

- 4.73 kW/m2: Maximum radiant heat intensity in areas where emergency actions lasting 2 min to 3 min can be required by personnel without shielding but with appropriate clothing. Corresponds to of painful burns and blistering after 20 second exposure (0% lethality)
- 6.31 kW/m2: Indicative of second degree burns after 20 second exposure (1% fatality)
- 12.5 kW/m2: Indicative of piloted ignition for susceptible structures (50% fatality)
- 37.5 kW/m2: Indicative of total asset loss (100% fatality)
- *(Source: QP-PHL-S-100, OGP Database 434, API-521)*

Flash Fire Selection Criteria:

The consequence distances should be identified for the following Lower Explosive Limit:

- 50 % Lower Explosive Limit
- 100 % Lower Explosive Limit

Explosion Criteria:

Blast peak overpressure from explosion for buildings should not exceed the following levels provided in Table 10.7. Internationally recognized and globally accepted TNO Multi energy model would be used for the modelling.

Table 10.7:Representative weather class

Level of Concern	TYPE OF DAMAGE
0.006895 bar	Breakage of small windows under strain
0.02068 bar	"Safe distance" (probability 0.95 of no serious damage1 below this value); projectile limit; some damage to house ceilings; 10% window glass broken.
0.070 bar	General buildings, offices
0.2068 bar	Industrial buildings, site roads, utilities etc.
1 bar	Range for 1-99% fatalities among exposed population due to direct blast effects

Source: Report Number: 434 International Association of Oil & Gas Producers (OGP)- March 2010- Table 2.8and PHL-S-100

10.3.4 Consequence Analysis Results

Events originating from within the installation may, depending upon the nature and quantity of hazardous chemical and the location of accident have the potential of affecting personnel within the installation or at times the general population in the surrounding area. The results of consequence analysis carried out for the identified/selected accident scenarios for this project are provided in below tables.

Table 10.8: Jet fire consequences result

Sr. No.	Isolatable sections	Leak Size Scenario	Weather Class	Distance downwind to intensity level (4.7 kW/m2) [m]	Distance downwind to intensity level (6.3 kW/m2) [m]	Distance downwind to intensity level (12.5 kW/m2) [m]	Distance downwind to intensity level (37.5 kW/m2) [m]
1	Natural Gas	25 mm	Category 1.5/F	15	14	13	11
			Category 5/D	14	14	12	11
		100 mm	Category 1.5/F	63	59	51	41
			Category 5/D	63	59	52	44
		250 mm	Category 1.5/F	151	140	119	91
			Category 5/D	151	141	122	98
		CR	Category 1.5/F	279	256	212	163
			Category 5/D	279	258	217	167
2	HSD - Atmospheric Tank	5 mm	Category 1.5/F	-	-	-	-
			Category 5/D	-	-	-	-
		15 mm	Category 1.5/F	-	-	-	-

Sr. No.	Isolatable sections	Leak Size Scenario	Weather Class	Distance downwind to intensity level (4.7 kW/m2) [m]	Distance downwind to intensity level (6.3 kW/m2) [m]	Distance downwind to intensity level (12.5 kW/m2) [m]	Distance downwind to intensity level (37.5 kW/m2) [m]
			Category 5/D	-	-	-	-
		CR	Category 1.5/F	2	2	-	-
			Category 5/D	2	2	-	-
3	Hydrogen generation from hydrogen generation package to vessel	5mm Leak	Category 1.5/F	-	-	-	-
			Category 5/D	-	-	-	-
		CR	Category 1.5/F	18	17	16	13
			Category 5/D	18	17	16	13
4	From Hydrogen generation after Vessel and compressor to Gas manifold	5mm Leak	Category 1.5/F	7	-	6	-
			Category 5/D	7	6	4	-
		25mm Leak	Category 1.5/F	38	36	33	28
			Category 5/D	37	36	32	28

Table 10.9. Fireball consequences Results

S.No	Isolatable Section	Leak Size Scenario	Weather Class	Distance downwind to intensity level (4.7 kW/m2) [m]	Distance downwind to intensity level (6.3 kW/m2) [m]	Distance downwind to intensity level (12.5 kW/m2) [m]	Distance downwind to intensity level (37.5 kW/m2) [m]
1	Hydrogen Cylinder	CR	Category 1.5/F	50	44	31	18
			Category 5/D	50	44	31	18
2	Hydrogen generation from hydrogen generation package to vessel	5mm	Category 1.5/F	20	17	12	7
			Category 5/D	20	17	12	7
		CR	Category 1.5/F	20	17	12	7
			Category 5/D	20	17	12	7
3	From Hydrogen generation after Vessel and compressor to Gas manifold	5mm	Category 1.5/F	32	25	20	11
			Category 5/D	32	25	20	11
		CR	Category 1.5/F	32	25	20	11
			Category 5/D	32	25	20	11
4	Hydrogen Vessel	CR	Category 1.5/F	9	8	6	3
			Category 5/D	9	8	6	3
Ammonia Storage	CR	Category 1.5/F	75	60	49	30	
		Category 5/D	75	60	49	30	

Table 10.10: Flash Fire consequences Results

S.No	Isolatable Section	Leak Size Scenario	Weather Class	Distance downwind to LFL [m] 100%	Distance downwind to LFL Fraction [m] 50%
1	Natural Gas	Leak 25 mm	Category 1.5/F	-	18
			Category 5/D	-	15
		Leak 100 mm	Category 1.5/F	46	108
			Category 5/D	42	109
		Leak 250 mm	Category 1.5/F	139	308
			Category 5/D	127	319
		Leak CR	Category 1.5/F	293	623

S.No	Isolatable Section	Leak Size Scenario	Weather Class	Distance downwind to LFL [m] 100%	Distance downwind to LFL Fraction [m] 50%
			Category 5/D	276	684
2	Atmospheric Tank	Leak 5 mm	Category 1.5/F	-	-
			Category 5/D	-	-
		Leak 15 mm	Category 1.5/F	-	-
			Category 5/D	-	2
		Leak CR	Category 1.5/F	3	8
			Category 5/D	3	-
3	Hydrogen Cylinder	CR	Category 1.5/F	7	10
			Category 5/D	10	22
4	Hydrogen generation from hydrogen generation package to vessel	5mm	Category 1.5/F	-	-
			Category 5/D	-	-
		CR	Category 1.5/F	2	3
			Category 5/D	3	7
5	From Hydrogen generation after Vessel and compressor to Gas manifold	5mm	Category 1.5/F	-	17
			Category 5/D	-	15
		CR	Category 1.5/F	29	39
			Category 5/D	41	56
6	Hydrogen Vessel	CR	Category 1.5/F	2	1
			Category 5/D	2	6
7	Ammonia Storage	CR	Category 1.5/F	7	9
			Category 5/D	13	25
8	Hydrazine Storage	CR	Category 1.5/F	-	2
			Category 5/D	-	2

Table 10.11: Pool Fire consequences Results

S.No	Isolatable Section	Leak Size Scenario	Weather Class	Distance downwind to intensity level (4.7 kW/m2) [m]	Distance downwind to intensity level (6.3 kW/m2) [m]	Distance downwind to intensity level (12.5 kW/m2) [m]	Distance downwind to intensity level (37.5 kW/m2) [m]
1	HSD - Atmospheric Tank	Leak 5 mm	Category 1.5/F	27	24	17	9
			Category 5/D	30	27	21	10
		Leak 15 mm	Category 1.5/F	43	38	28	21
			Category 5/D	44	38	28	21
		Leak CR	Category 1.5/F	60	53	41	31
			Category 5/D	60	52	40	32
2	Diesel Tank, pump to Downstream System Valve	Leak 5 mm	Category 1.5/F	46	41	30	21
			Category 5/D	44	38	29	21
		Leak 15 mm	Category 1.5/F	83	73	56	42
			Category 5/D	82	72	56	42
		Leak CR	Category 1.5/F	84	74	57	43
			Category 5/D	86	75	58	44
3	Ammonia Storage	CR	Category 1.5/F	10	8	5	-
			Category 5/D	11	10	6	-
4	Hydrazine Storage	CR	Category 1.5/F	19	18	10	-
			Category 5/D	20	19	11	-

Table 10.12: Explosion consequences Results

S.No	Isolatable Section	Leak Size Scenario	Weather Class	Overpressure Maximum distance [m]				
				0.02068 [bar]	0.1379 [bar]	0.2068 [bar]	0.7 [bar]	1 [bar]
1	Natural Gas	25 mm	Category 1.5/F	24	14	13	11	11
			Category 5/D	23	13	13	11	11
		100 mm	Category 1.5/F	125	69	65	57	56
			Category 5/D	115	67	63	56	55
		250 mm	Category 1.5/F	195	88	79	64	62
			Category 5/D	190	86	78	64	61
		CR	Category 1.5/F	266	106	93	71	67
			Category 5/D	269	107	94	71	67
2	Hydrogen generation from hydrogen generation package to vessel	5mm	Category 1.5/F	21	12	12	11	11
			Category 5/D	-	-	-	-	-
		CR	Category 1.5/F	62	28	26	23	23
			Category 5/D	59	34	33	31	31
3	From Hydrogen generation after Vessel and compressor to Gas manifold	5mm	Category 1.5/F	43	25	23	22	21
			Category 5/D	39	24	23	21	21
		CR	Category 1.5/F	109	53	50	45	44
			Category 5/D	112	62	59	54	54

Table 10.13: Toxic Results

S.No	Isolatable Section	Leak Size Scenario	Weather Class	Max Distance (m)
1	HCl Storage Tank	CR	Category 1.5/F	16
			Category 5/D	10
2	Sulfuric Acid Storage Vessel	CR	Category 1.5/F	4
			Category 5/D	2.5
3	Ammonia Storage Vessel	CR	Category 1.5/F	160
			Category 5/D	130
4	Hydrazine Storage Vessel	CR	Category 1.5/F	120
			Category 5/D	34
5	Chlorine reaction	CR	Category 1.5/F	1200
			Category 5/D	700

The resultant model representation of the above analysis is presented as a graphical manner to understand the effect of the hazard on the lay out.

Consequence Graphs on Layout

Weather Class 5/D

IS-01 – Natural Gas Entry point

Leak Size – 25 mm

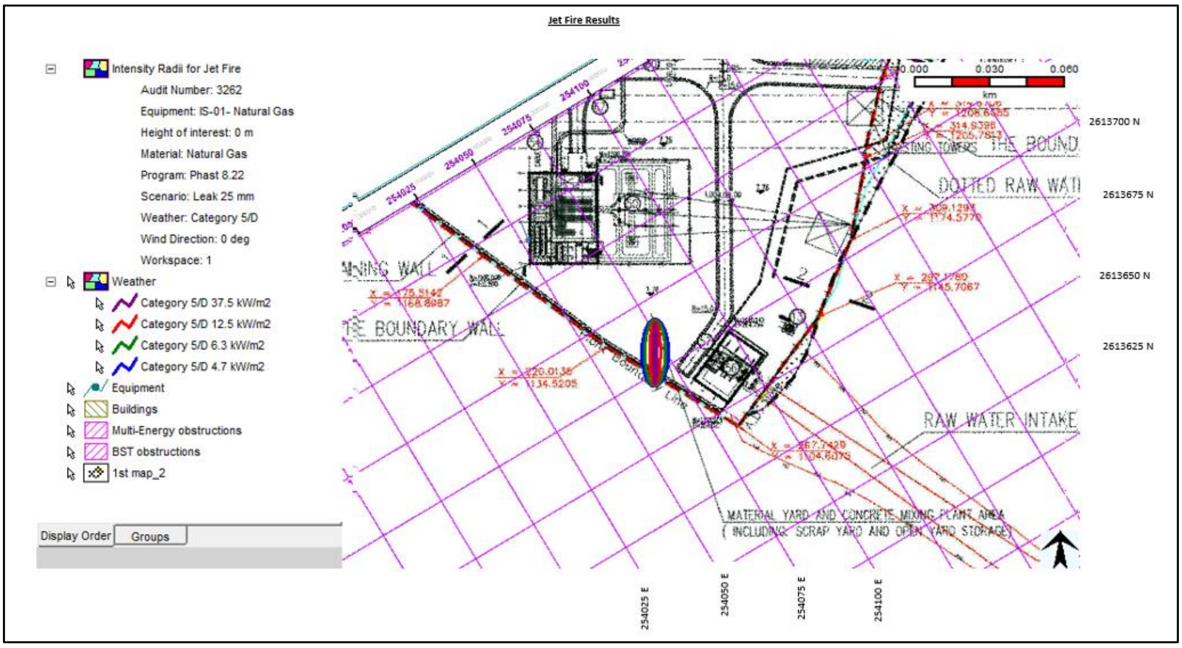


Figure 10.3: Jet Fire Scenario

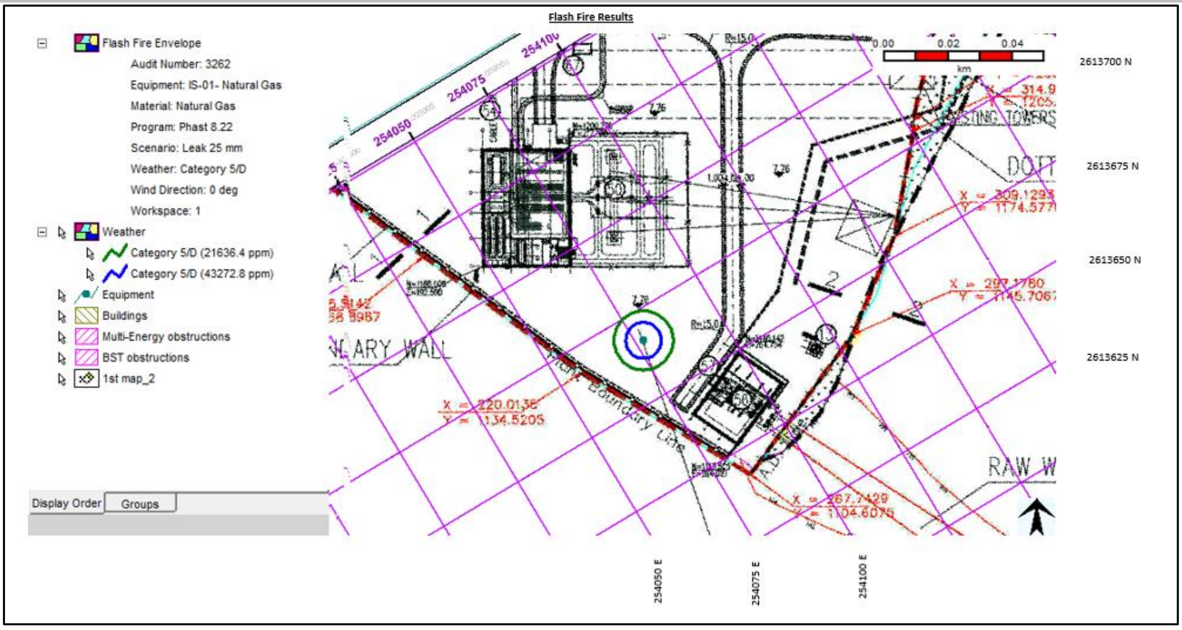


Figure 10.4: Flash fire scenario

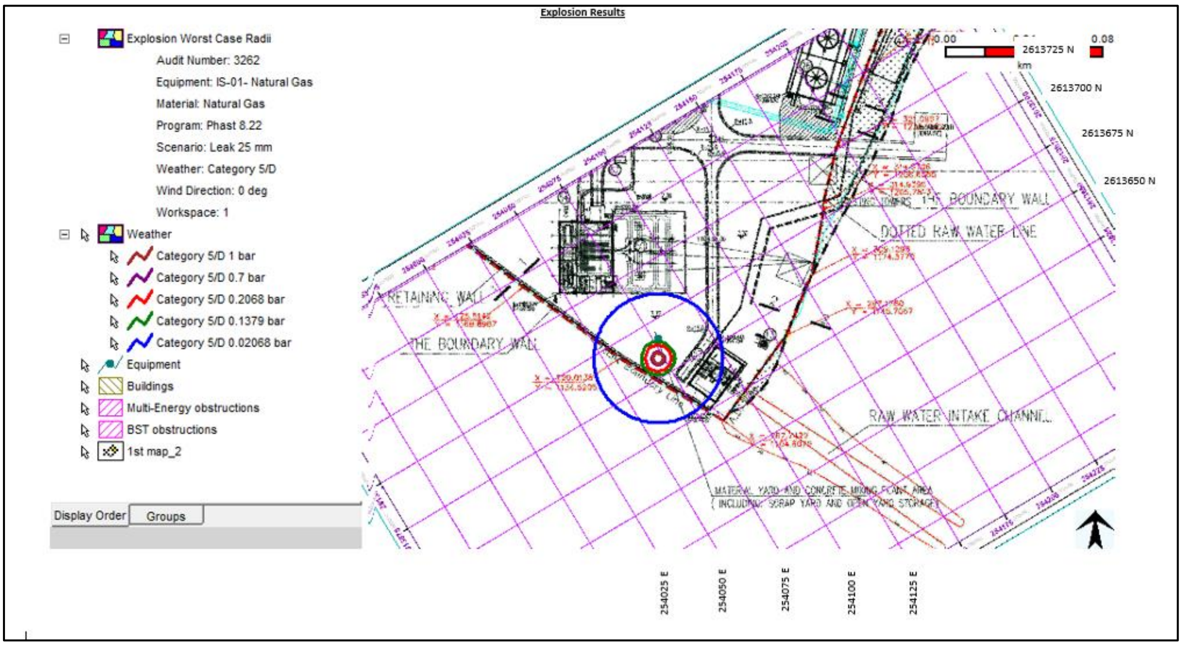


Figure 10.5: Explosion scenario

Weather Class 1.5/F

Leak Size – 25 mm

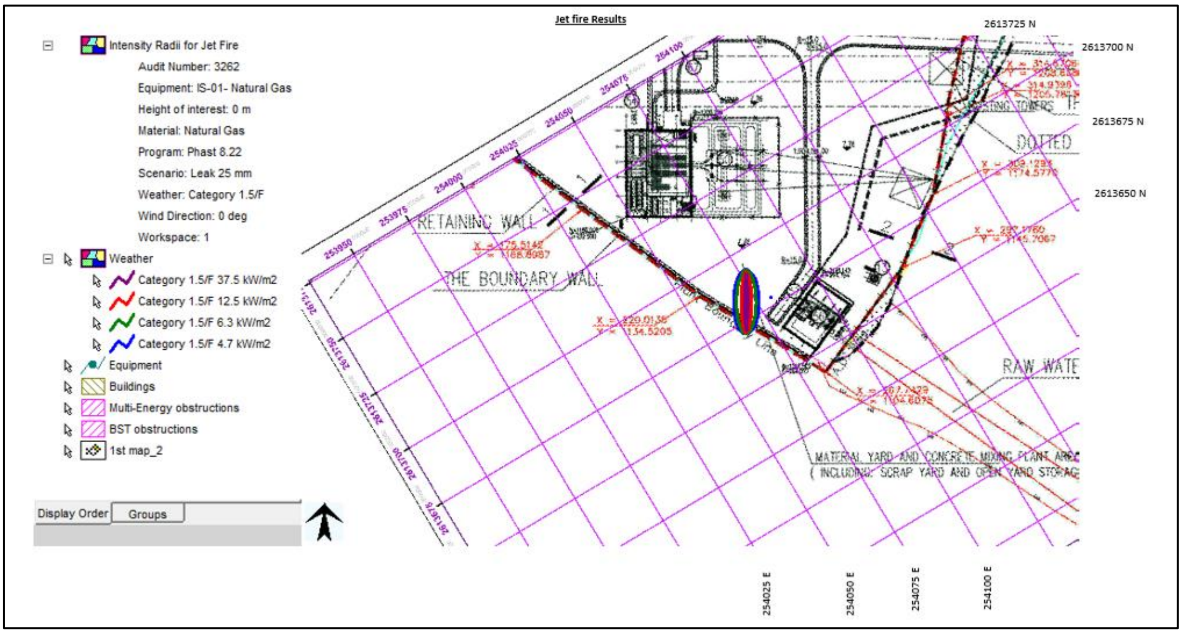


Figure 10.6: Jet fire scenario

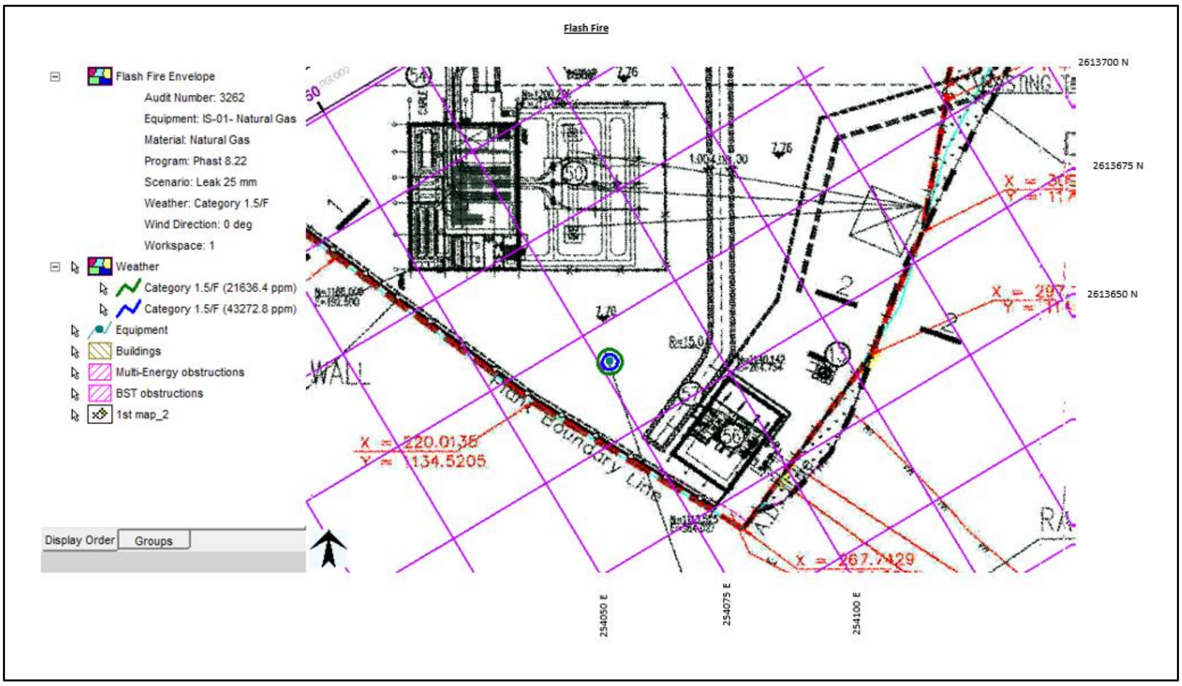


Figure 10.7: Flash fire scenario

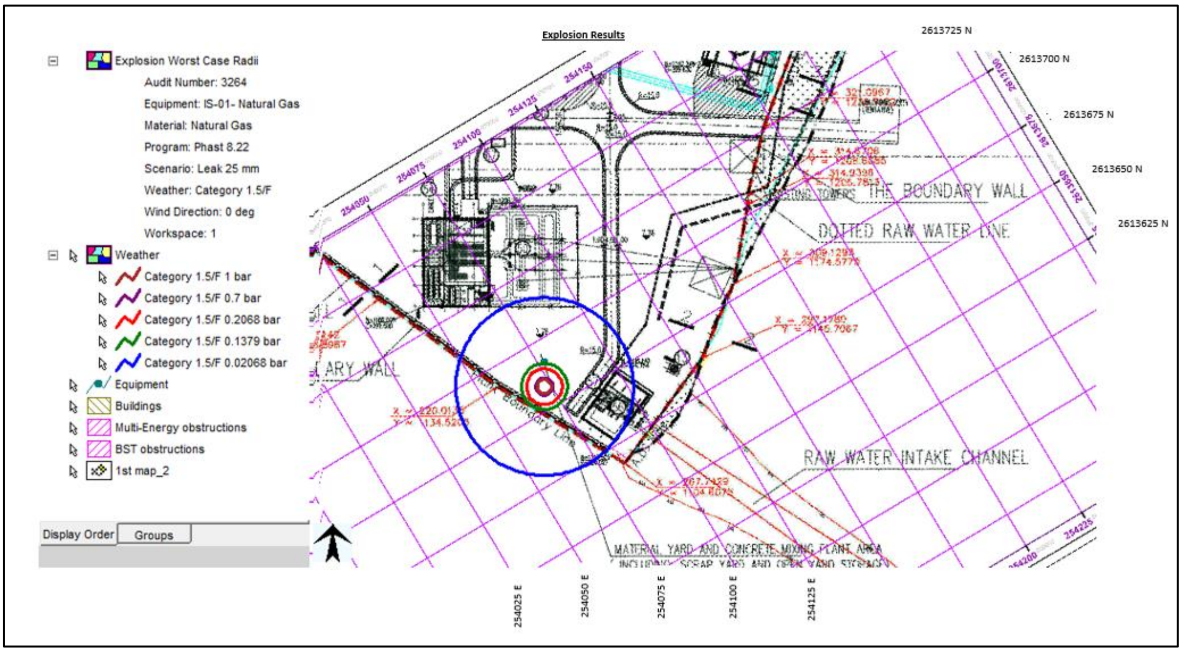


Figure 10.8: Explosion worst case scenario

Weather Class 5/D

Leak Size – 100 mm

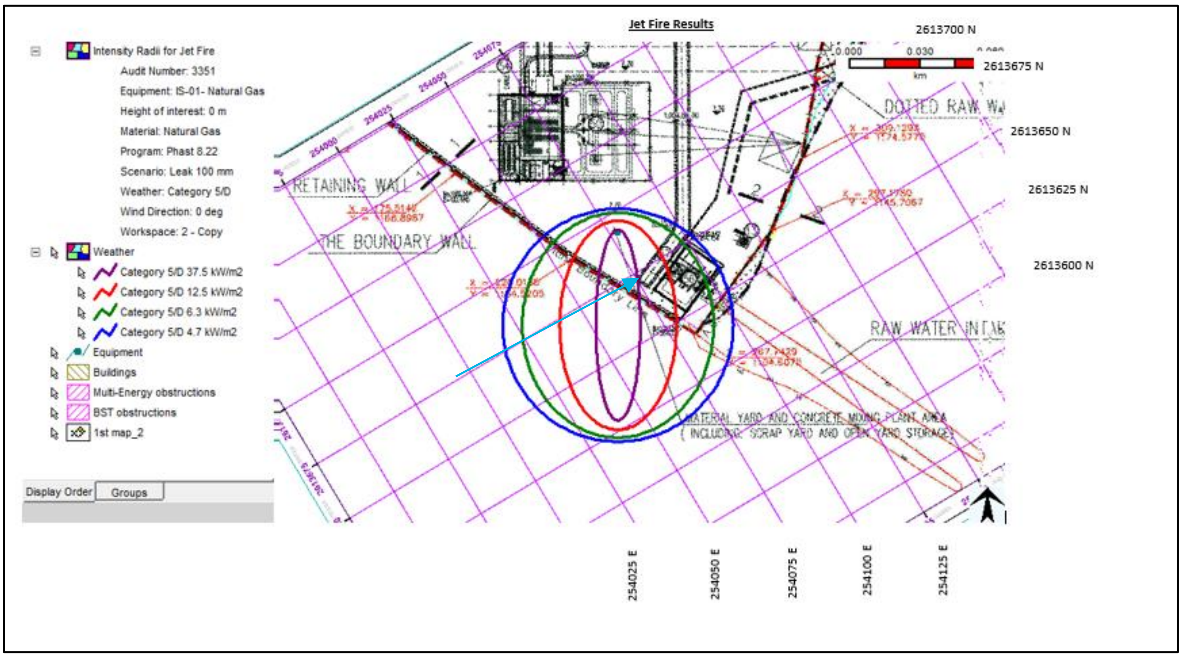


Figure 10.9: Jet Fire scenario

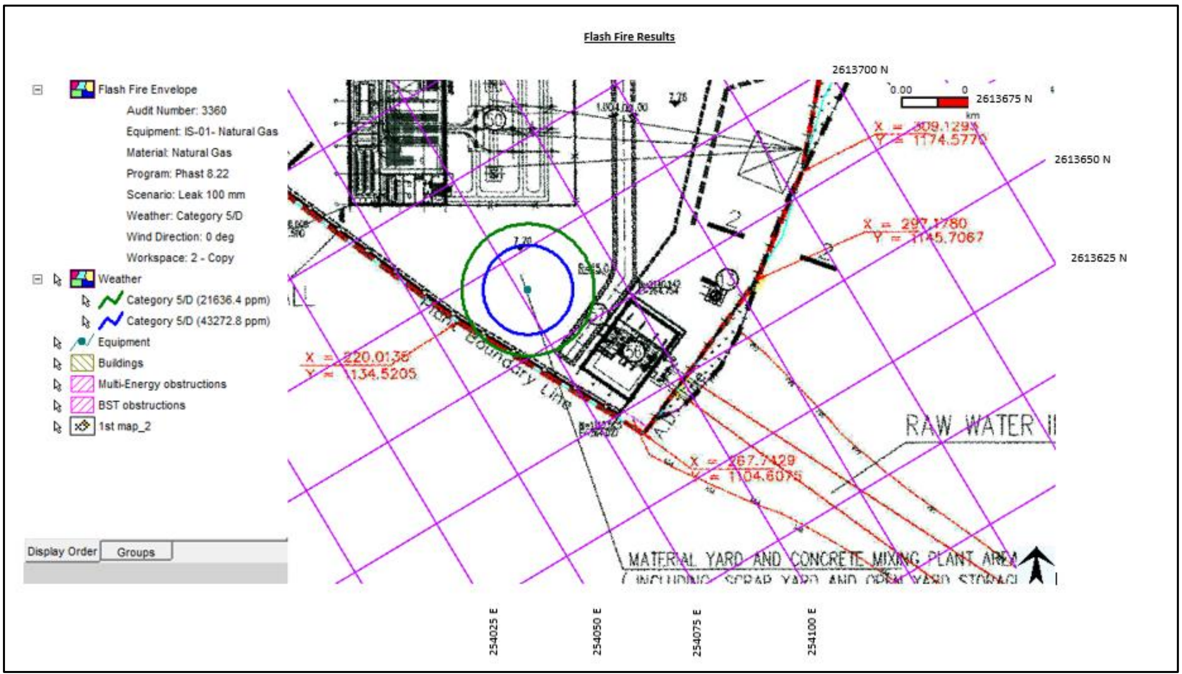


Figure 10.10 : Flash fire Scenario

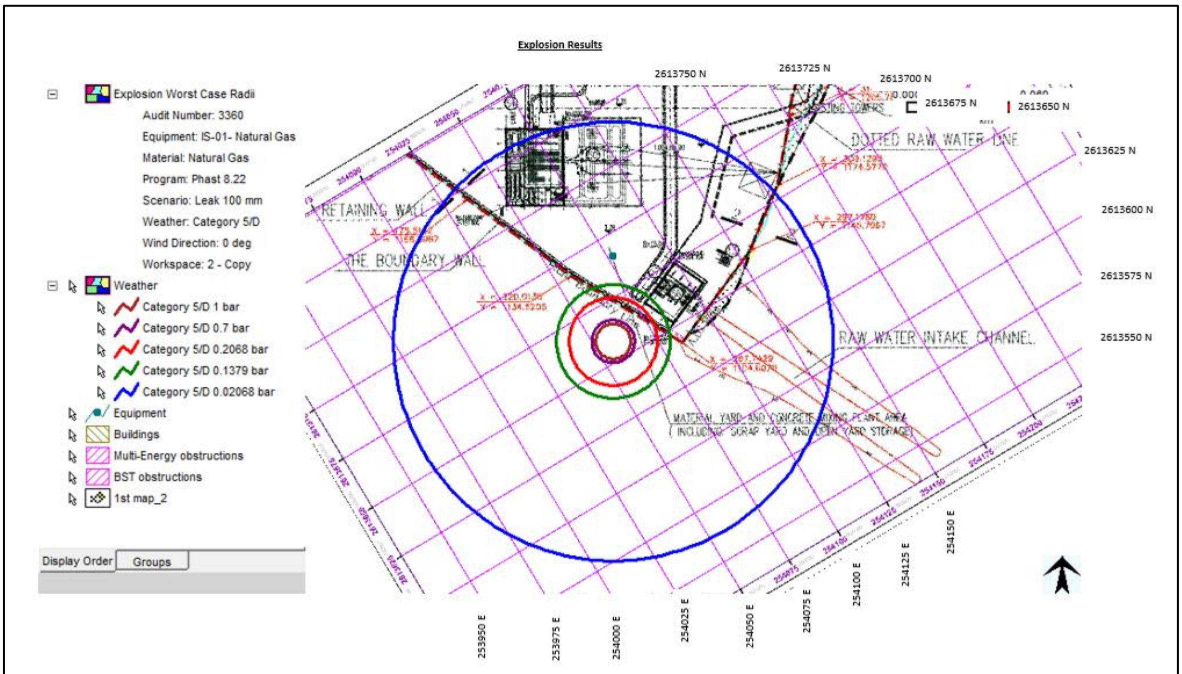


Figure 10.11 : Explosion wort case scenario

Weather Class 1.5/F

Leak Size – 100 mm

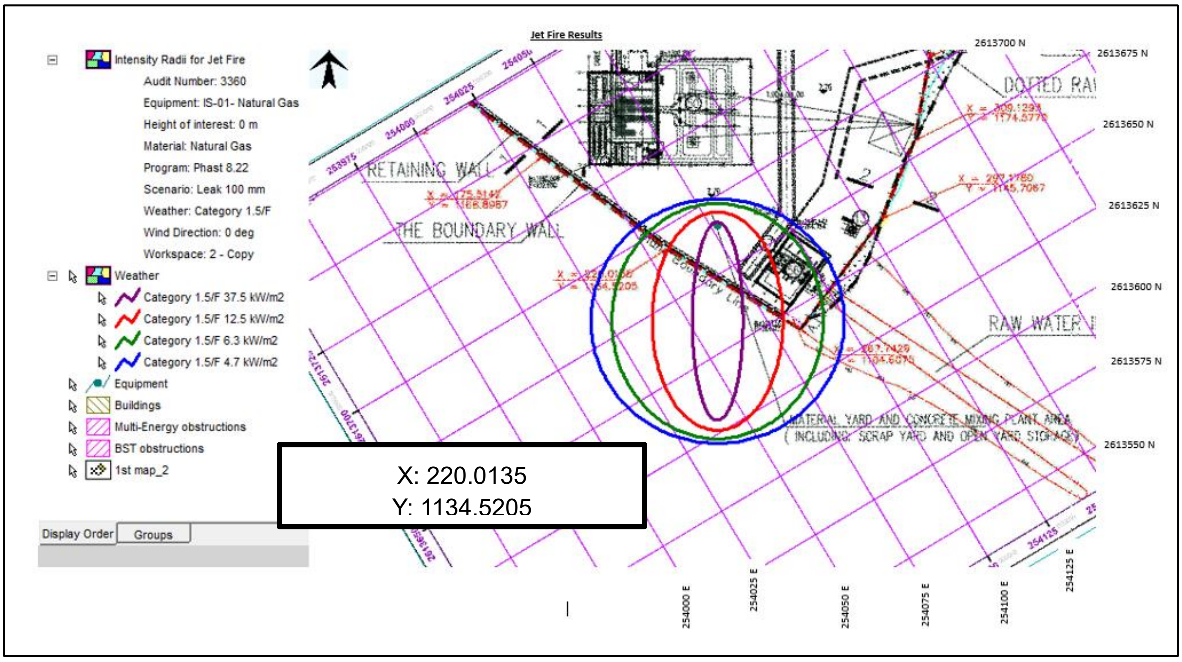


Figure 10.12 : Jet fire scenario

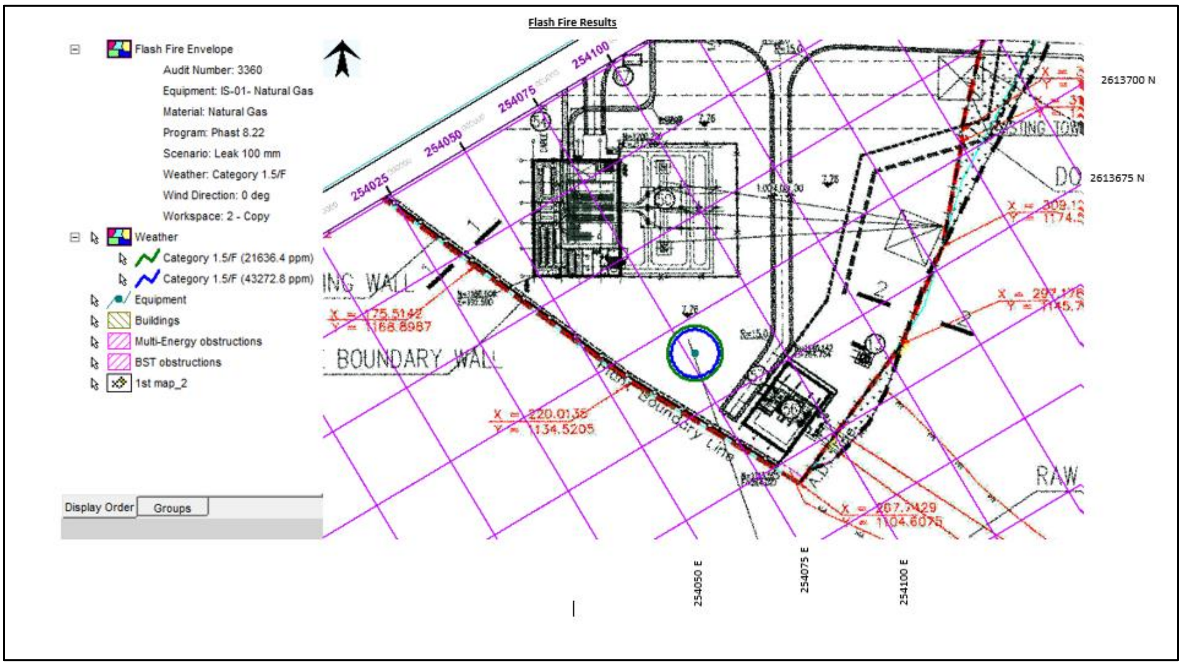


Figure 10.13: Flash fire scenario

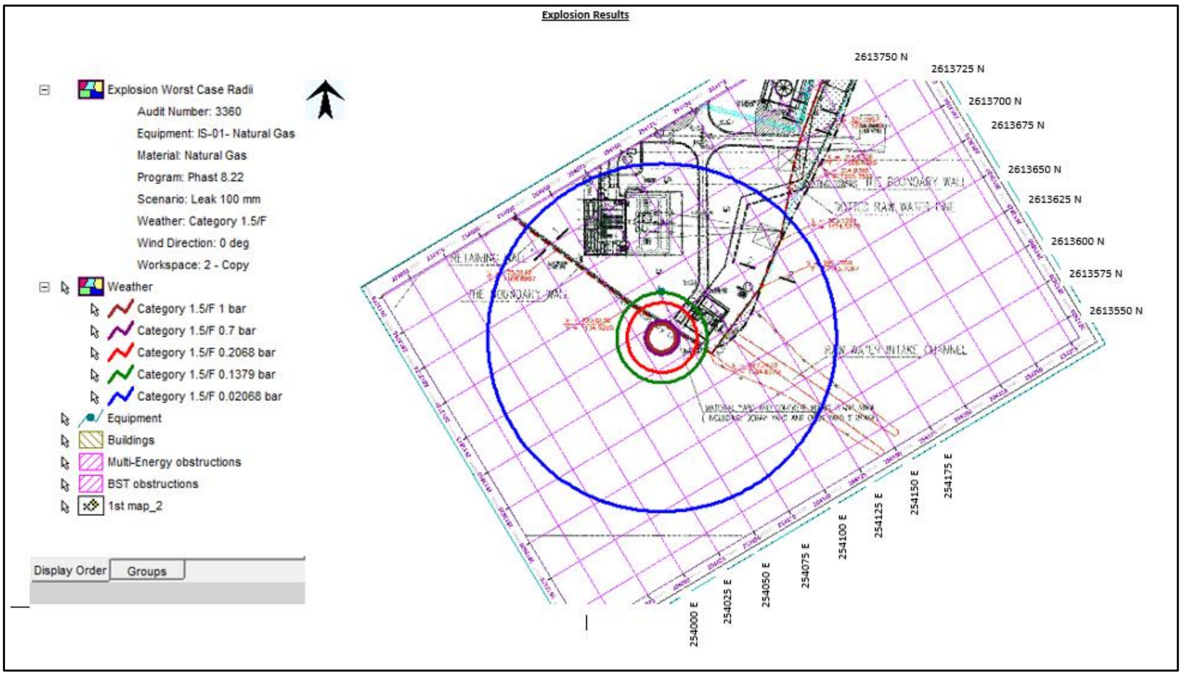


Figure 10.14: Explosion worst case scenario

Weather Class 5/D

Leak Size – 250 mm

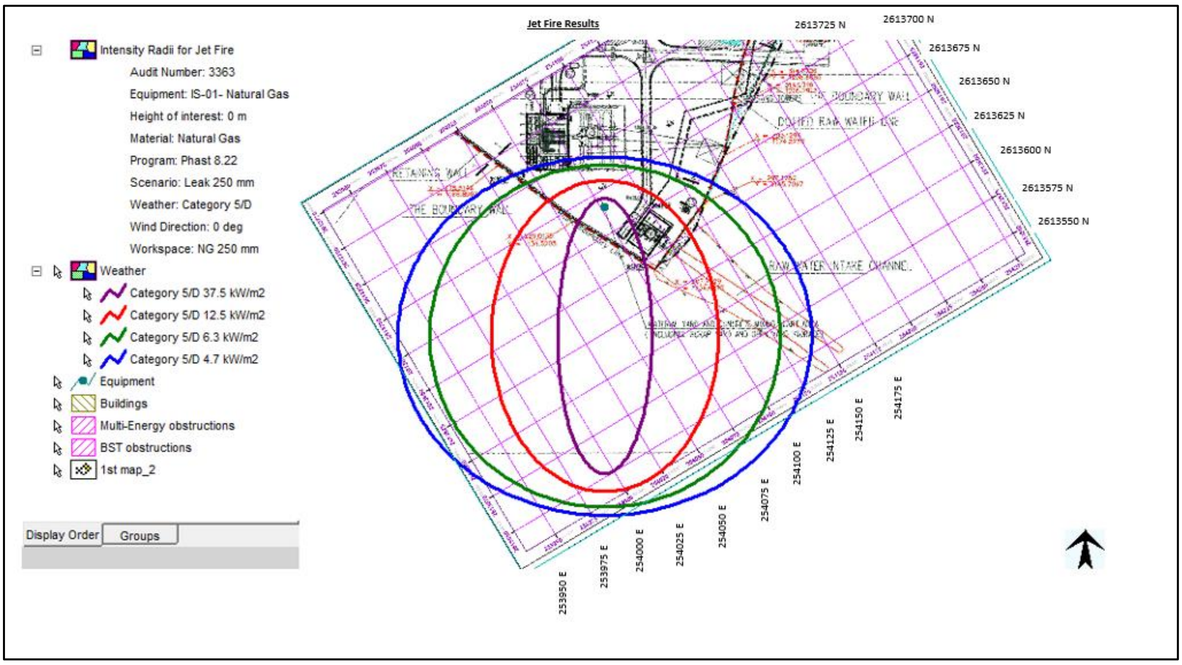


Figure 10.15: Jet fire scenario

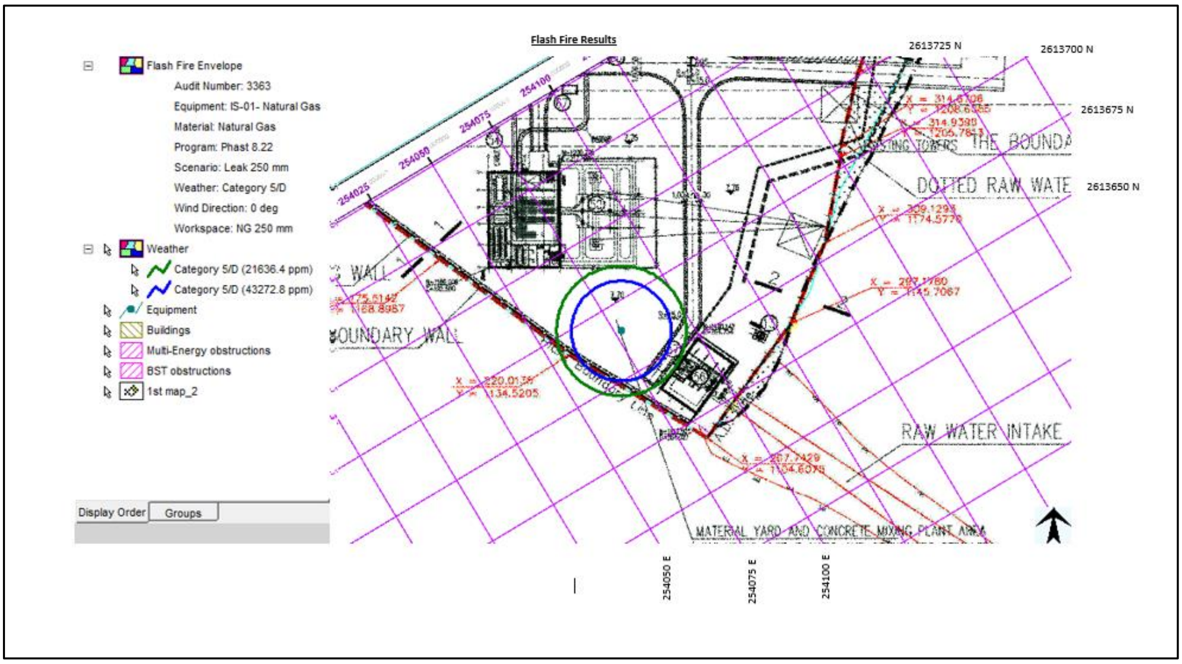


Figure 10.16: Flash fire scenario

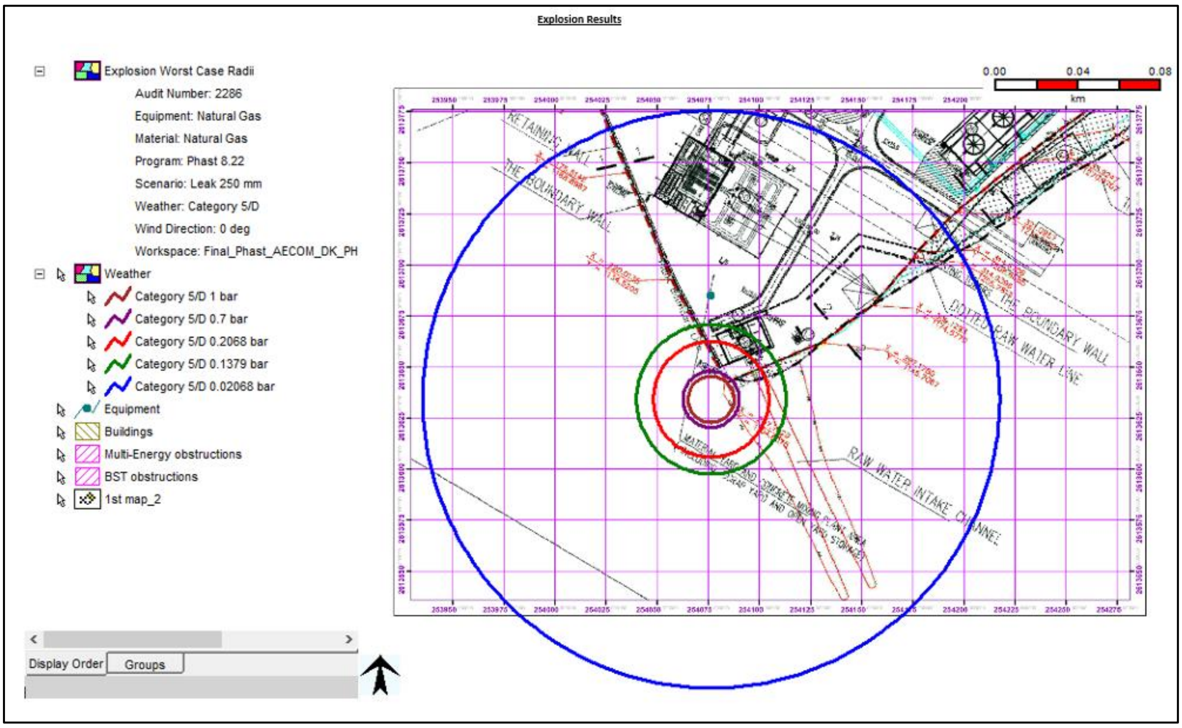


Figure 10.17: Explosion worst case scenario

Weather Class 1.5/F

Leak Size – 250 mm

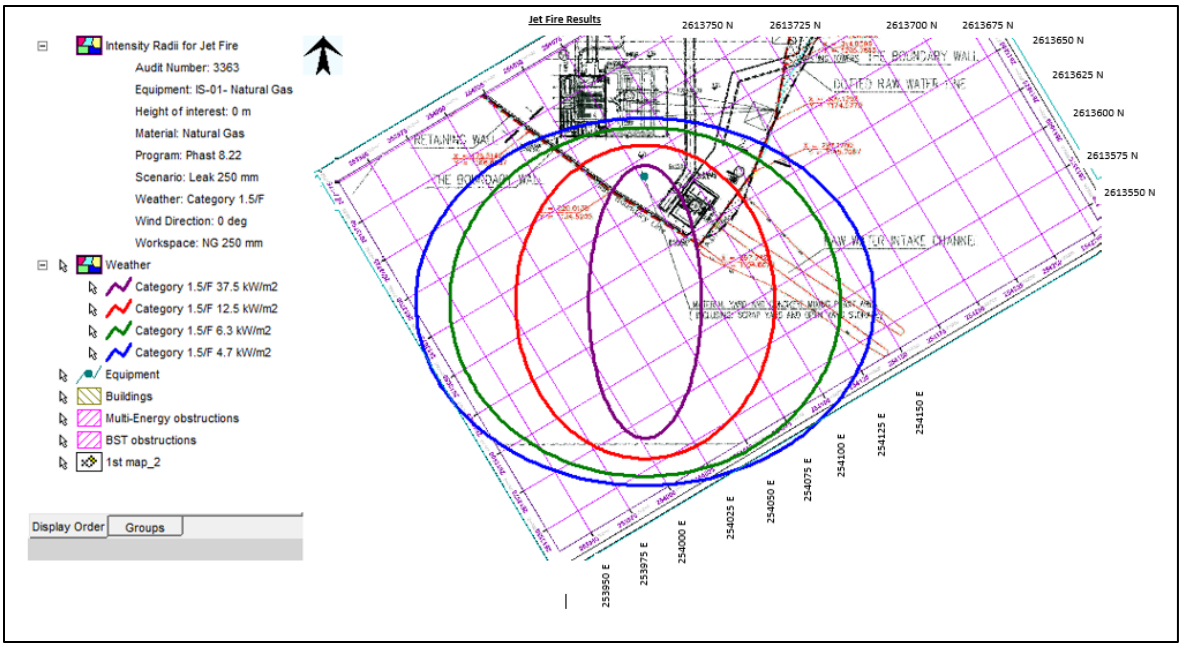


Figure 10.18: Jet fire scenario

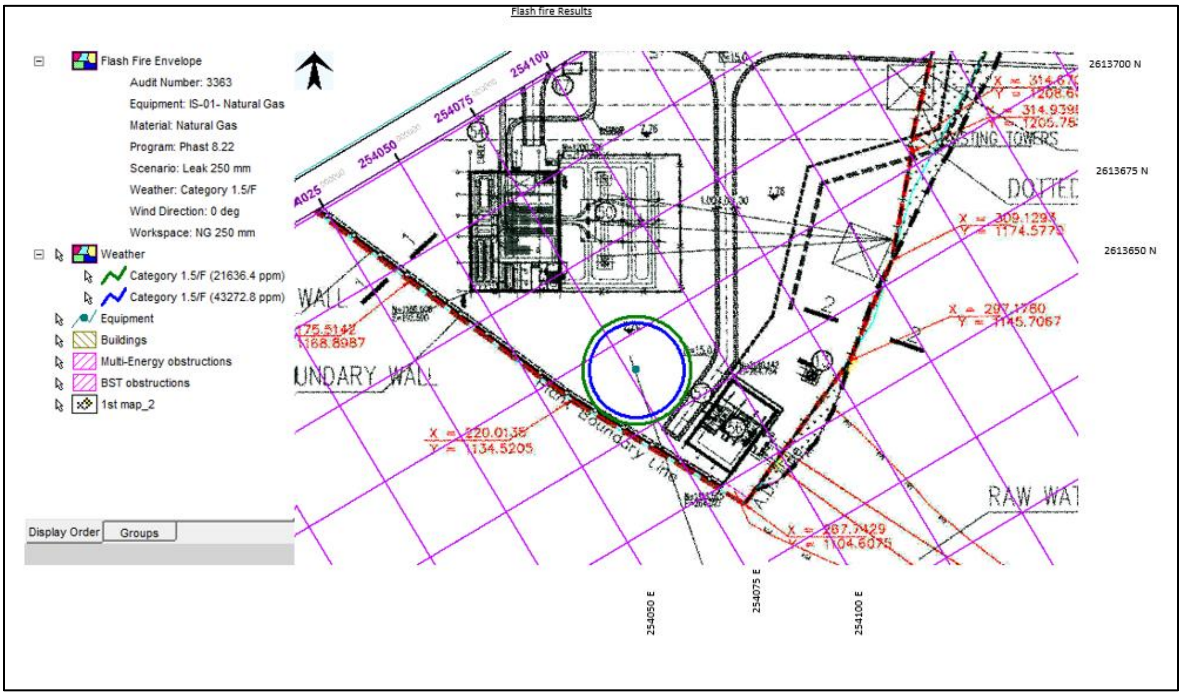


Figure 10.19: Flash fire scenario

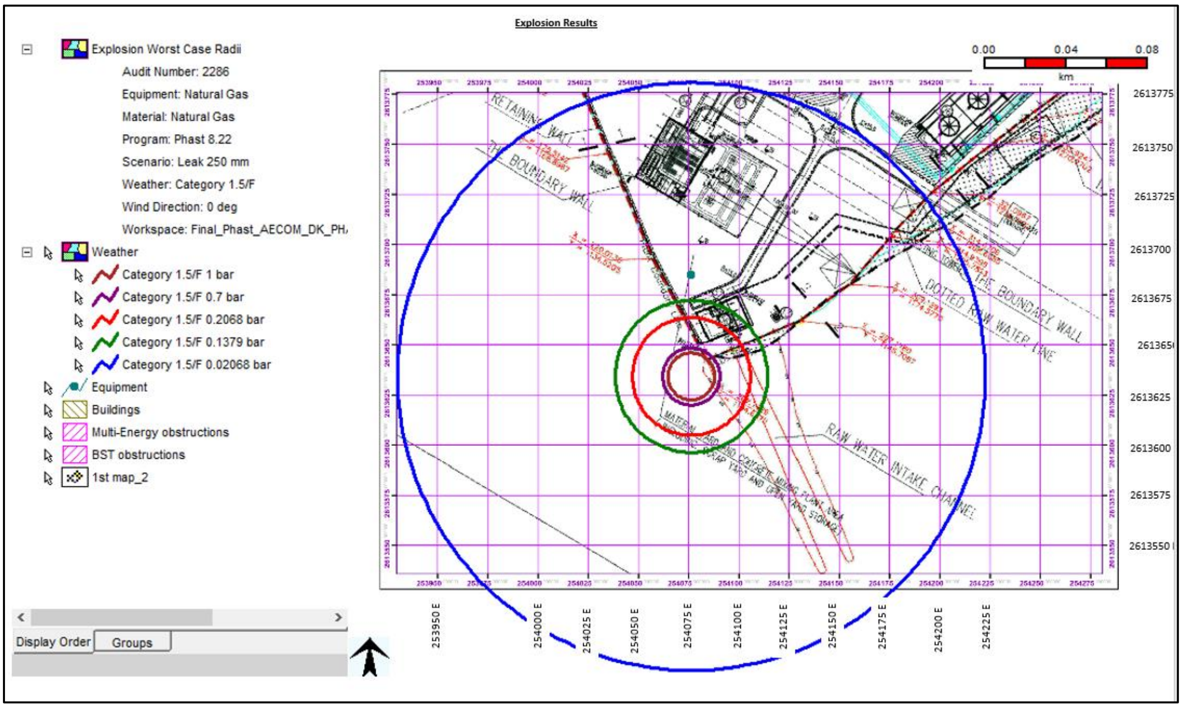


Figure 10.20: Explosion worst case scenario

Weather Class 5/D

Leak Size – CR

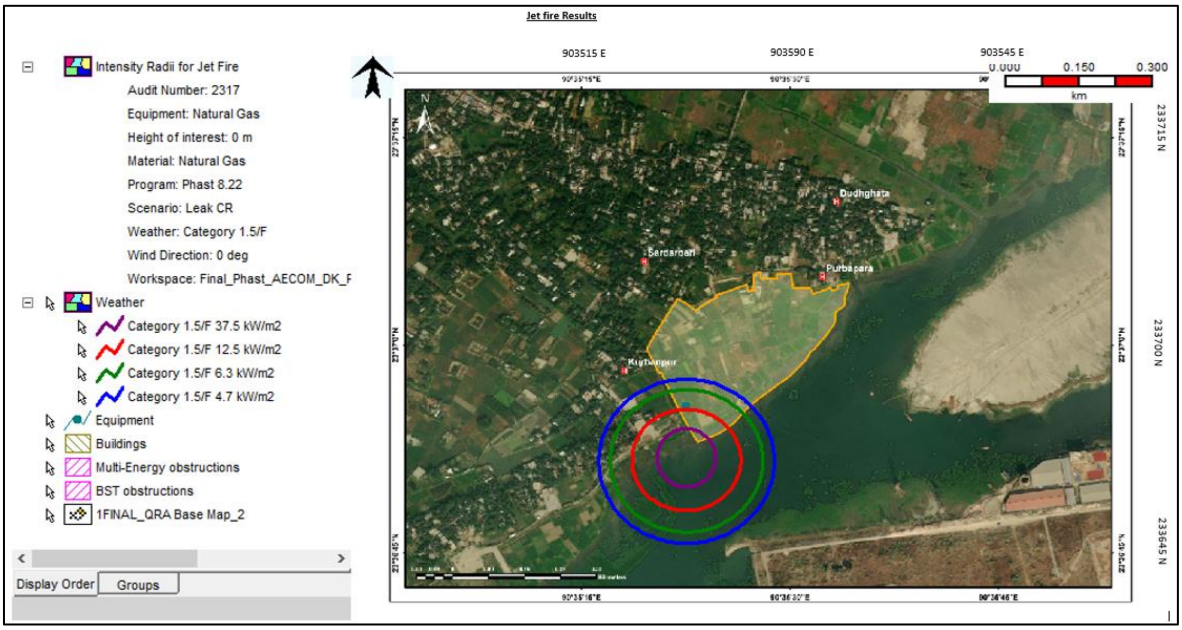


Figure 10.21: Jet fire scenario

Figure 10.22: Flash fire scenario

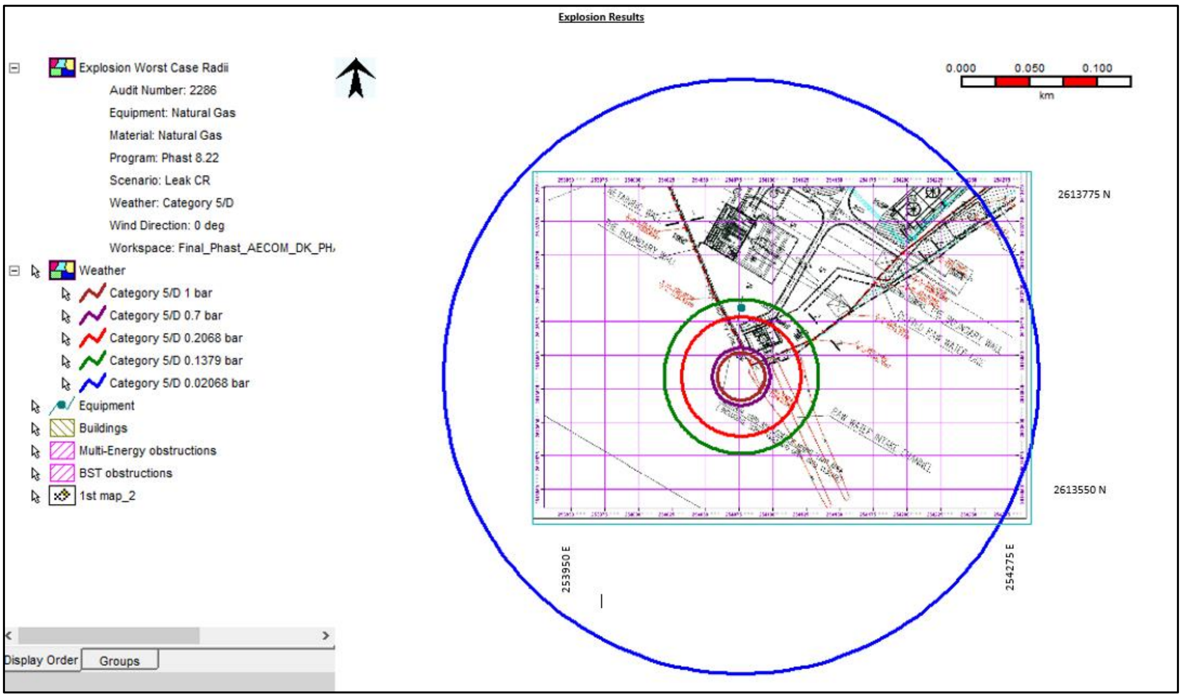


Figure 10.23: Explosion worst case scenario

Weather Class 1.5/F

Leak Size – CR

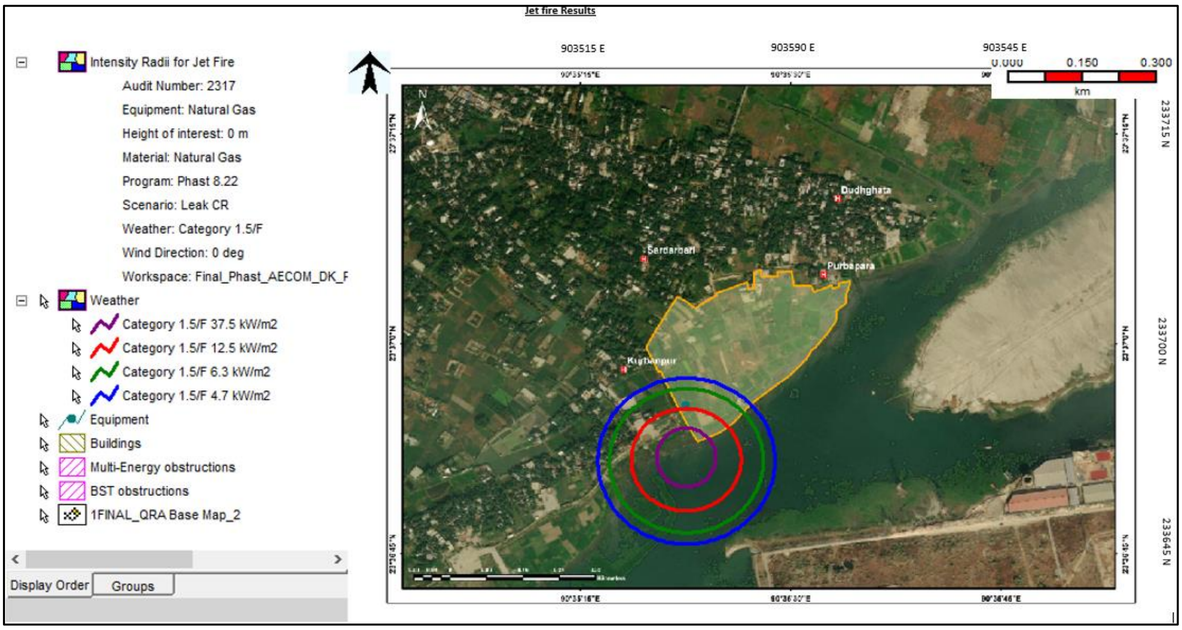


Figure 10.24: Jet fire scenario

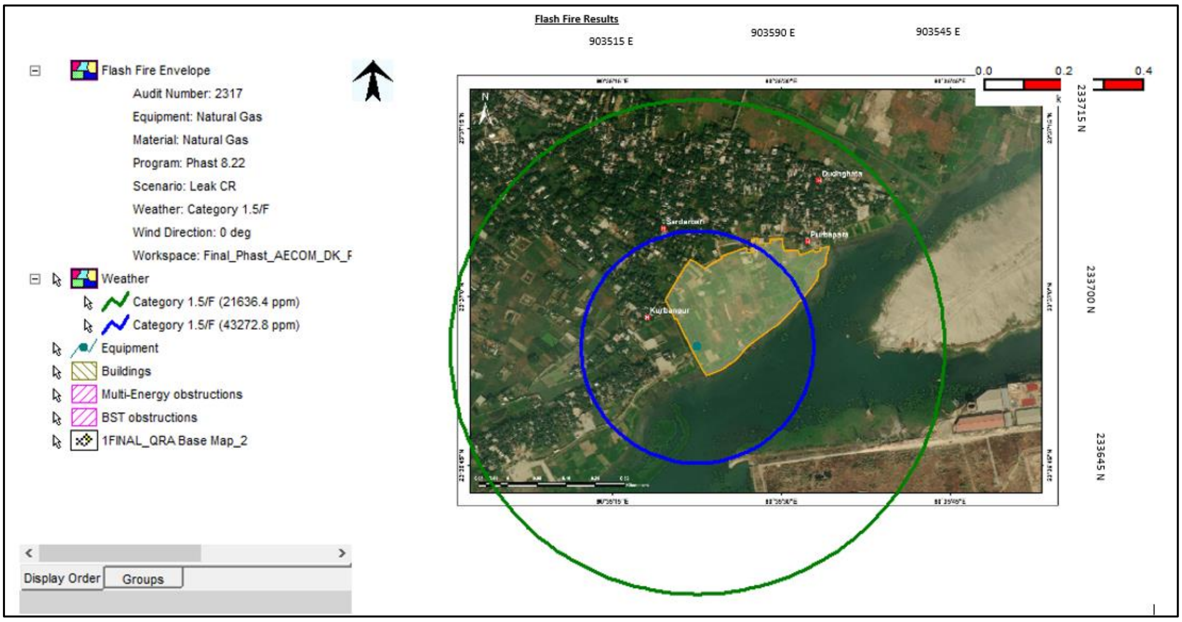


Figure 10.25: Flash fire scenario

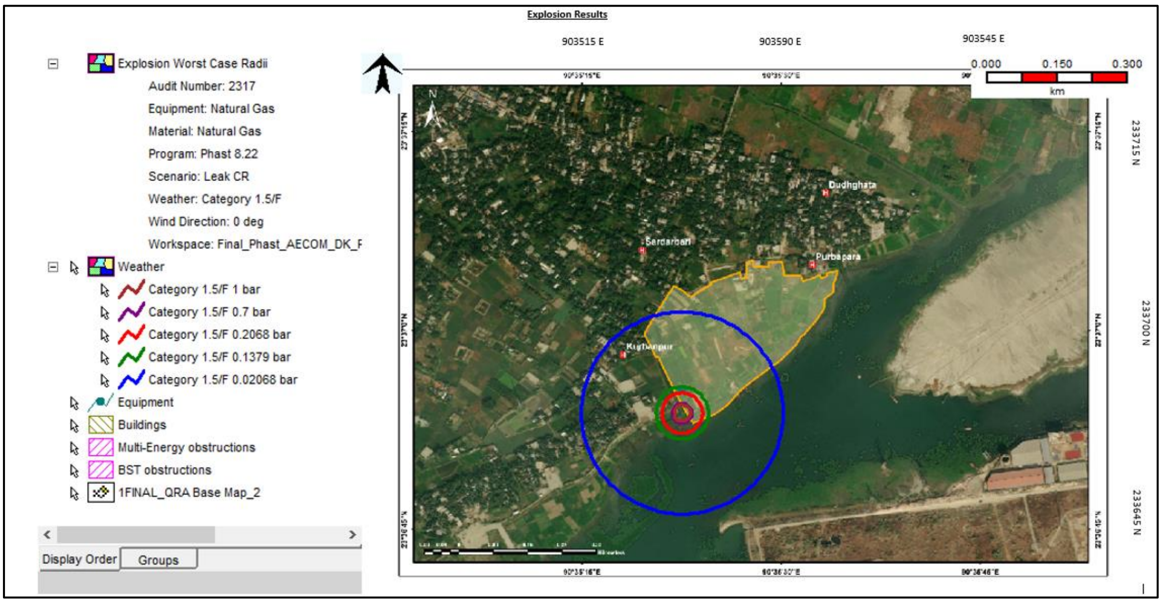


Figure 10.26: Explosion worst case scenario

IS-02- HSD Scenario (Including Tank)

Weather Class: 5/D

Leak Size: 5mm

Figure 10.27: Pool fire scenario

Weather Class: 1.5/F

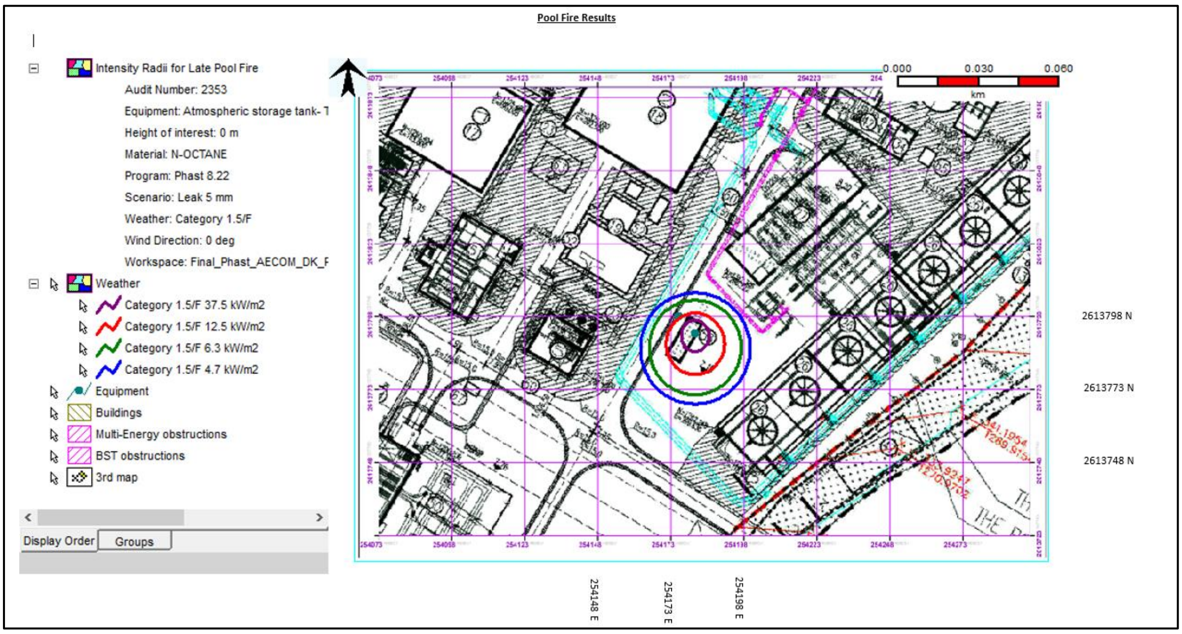


Figure 10.26 : Pool fire scenario

Weather Class : 5/D

Leak Size : 15mm

Pool Fire Results

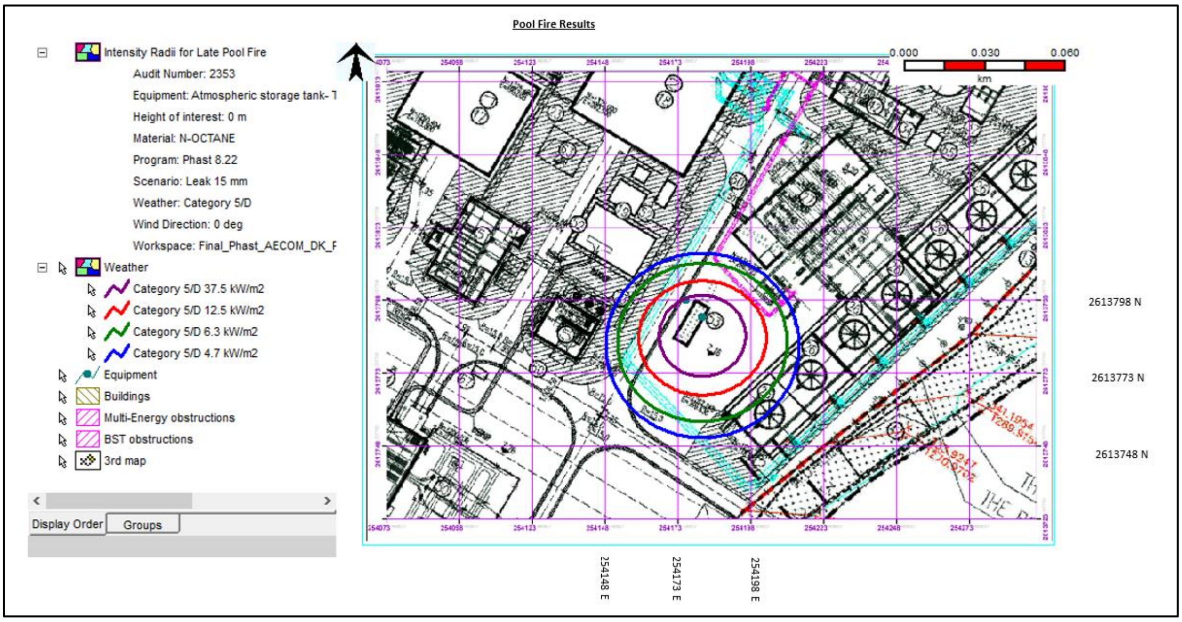


Figure 10.27: Pool fire scenario

Weather Class: 1.5/F

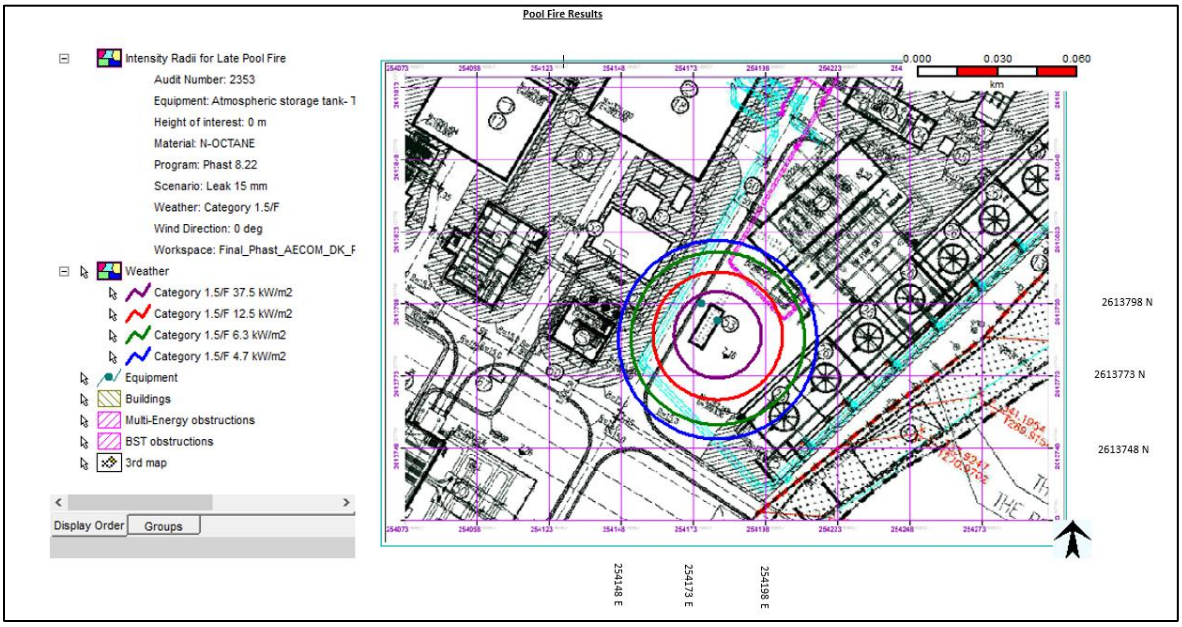


Figure 10.28: Pool fire scenario

Weather Class : 5/D

Leak Size : CR

Figure 10.29: Jet fire scenario

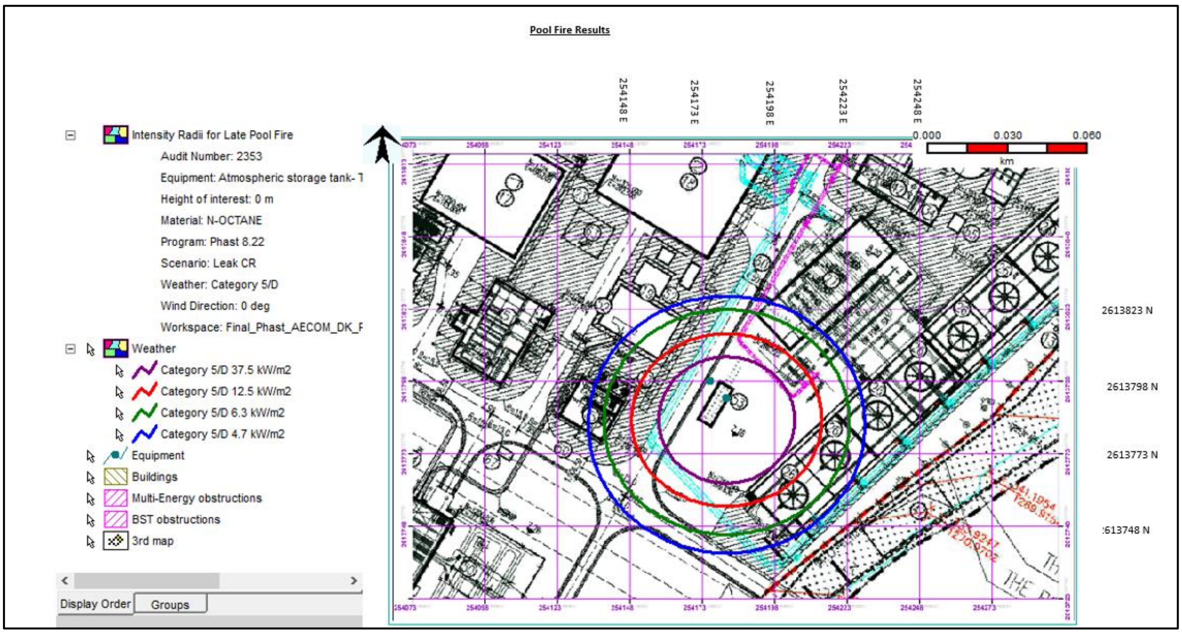


Figure 10.30: Pool fire scenario

Weather Class : 1.5/F

Leak Size : CR

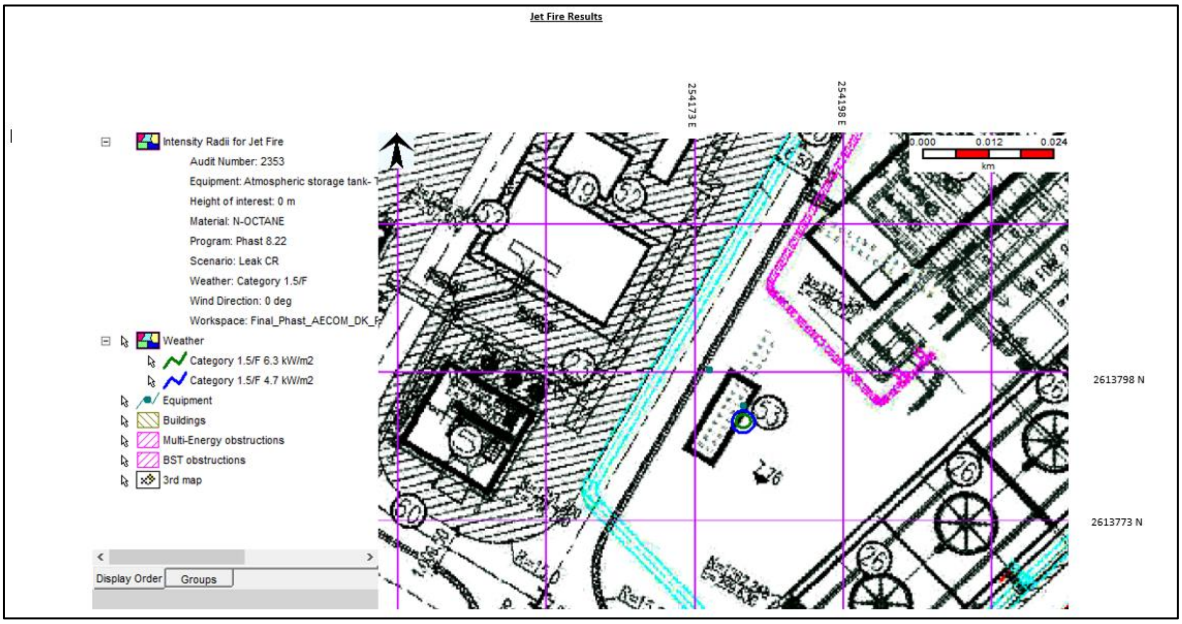


Figure 10.31: Jet fire scenario

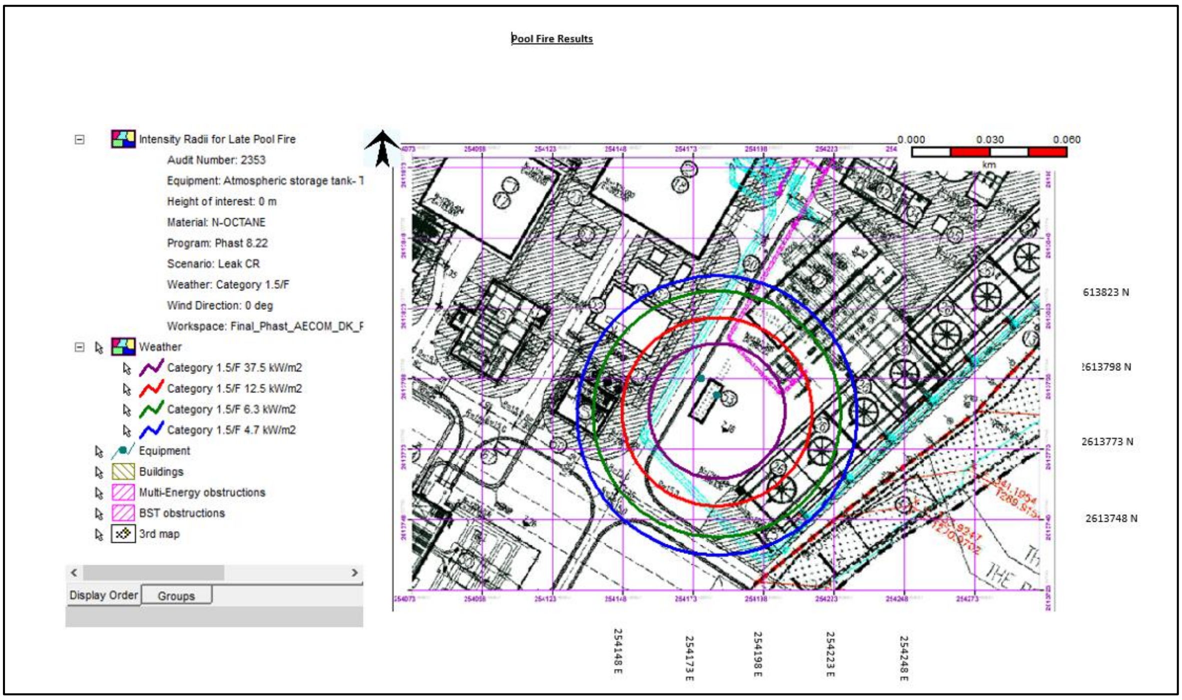


Figure 10.32: Pool fire scenario

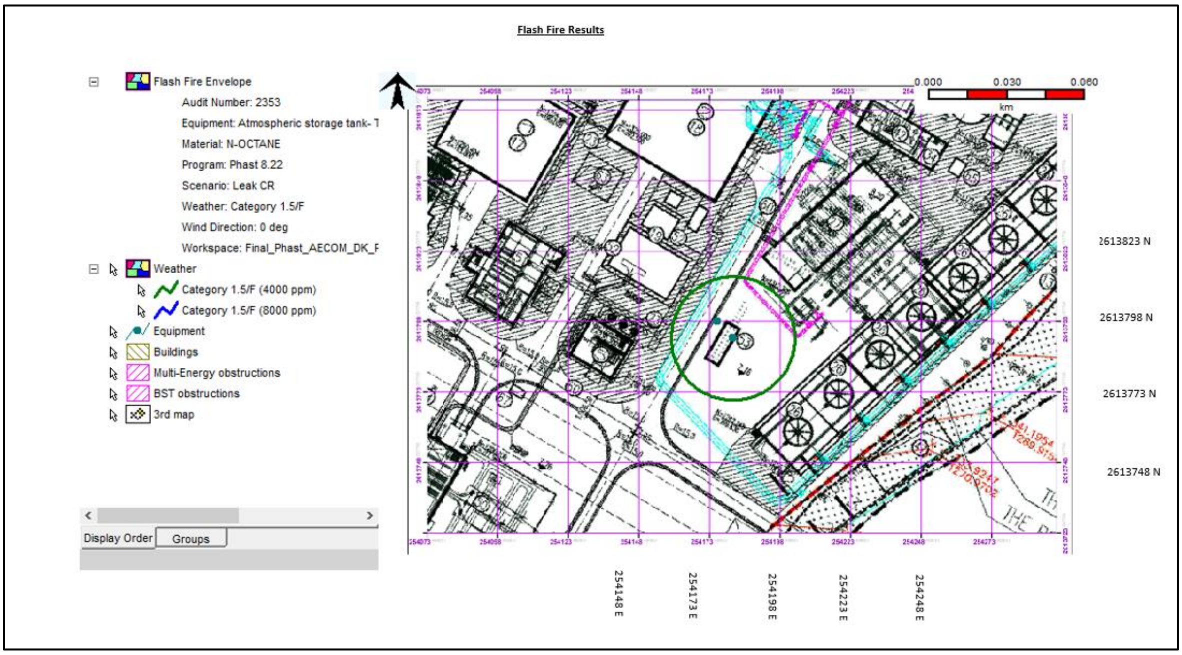


Figure 10.33: Flash fire scenario

IS-03- Hydrogen Cylinder

Weather Class : 5/D

Leak Size : CR

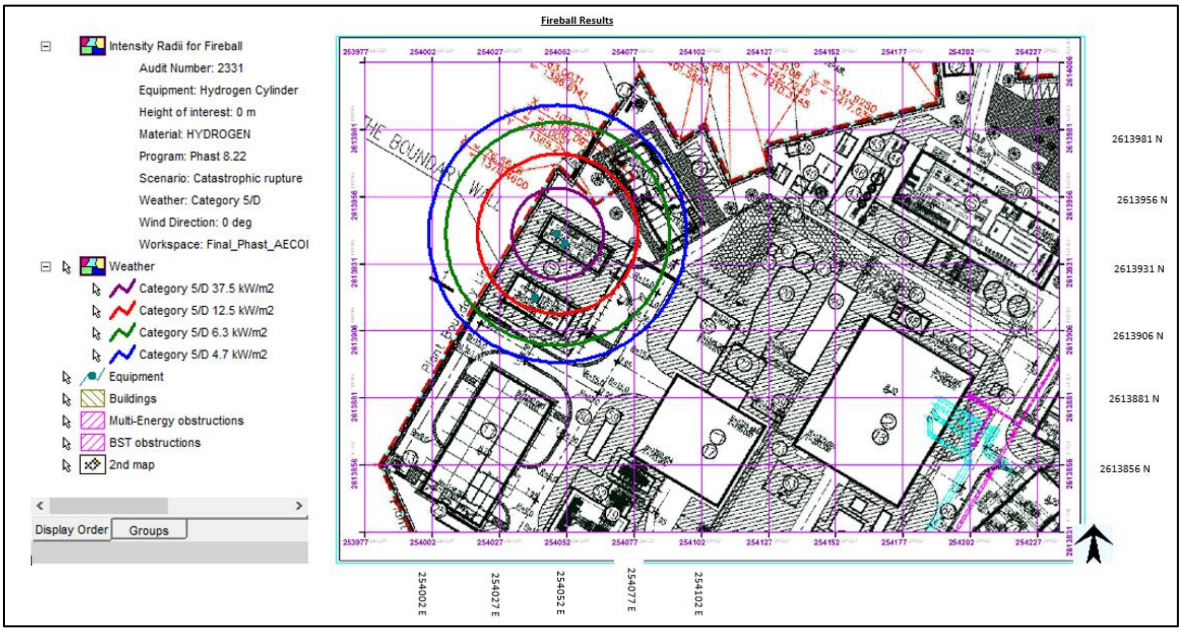


Figure 10.34: Fireball scenario

Figure 10.35: Flash fire scenario

Weather Class: 1.5/F

Leak Size: CR

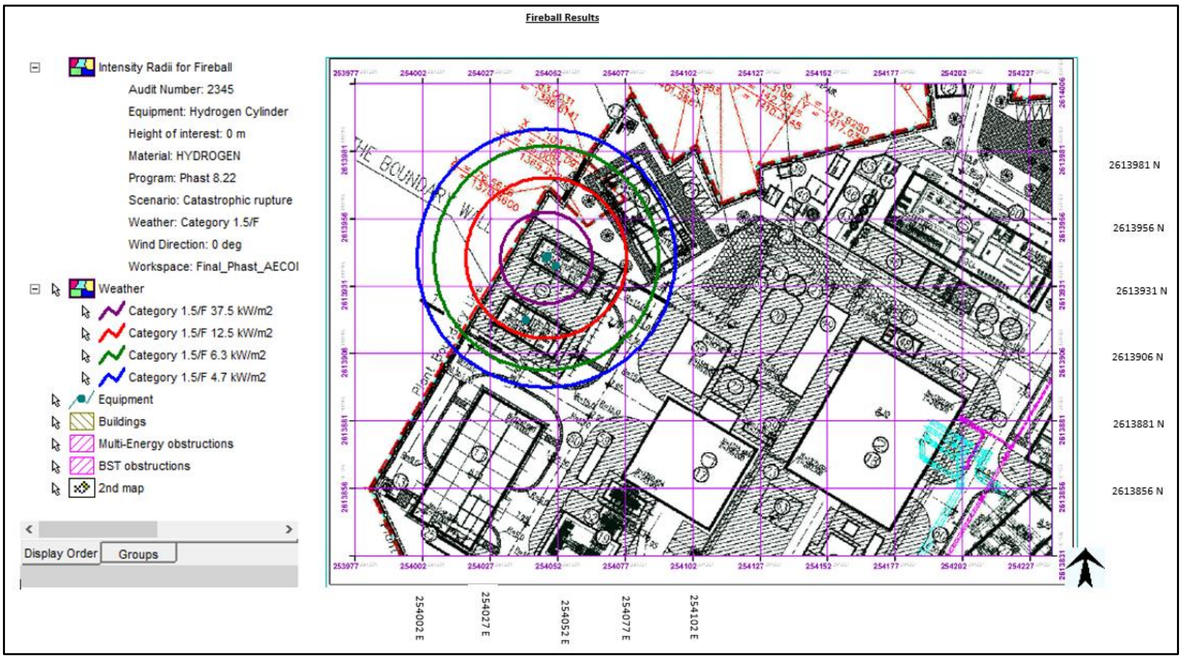


Figure 10.36: Fireball scenario

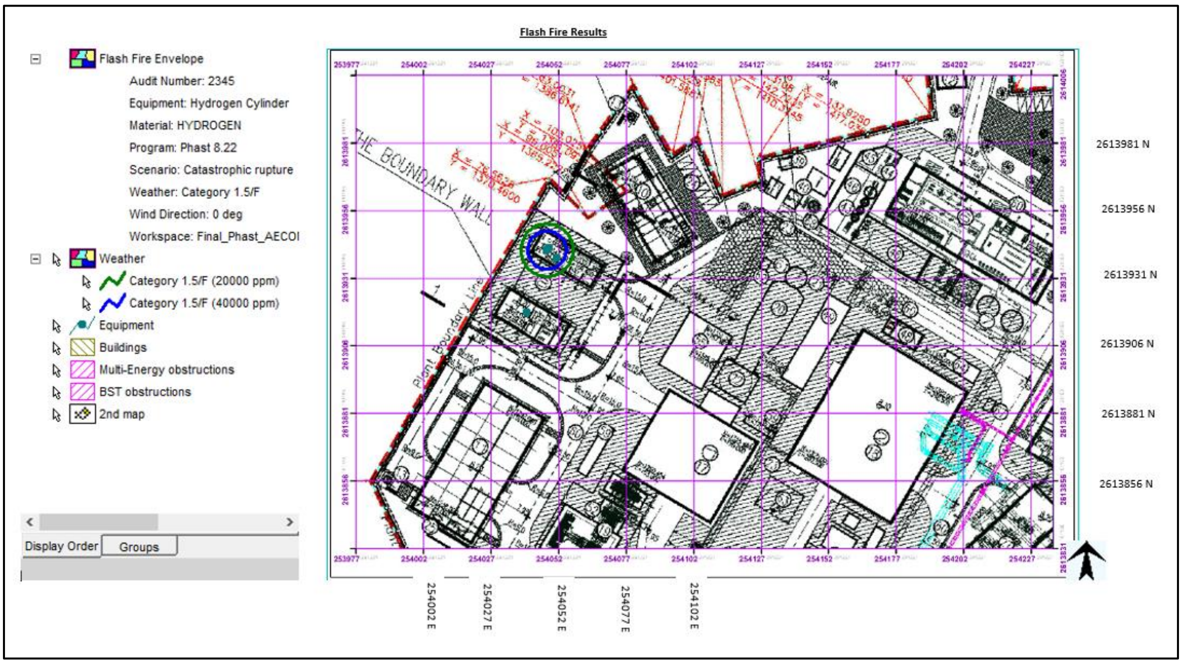


Figure 10.37: Flash fire scenario

IS-04- Hydrogen generation from hydrogen generation package to vessel

Weather Class: 5/D

Leak Size: 5mm

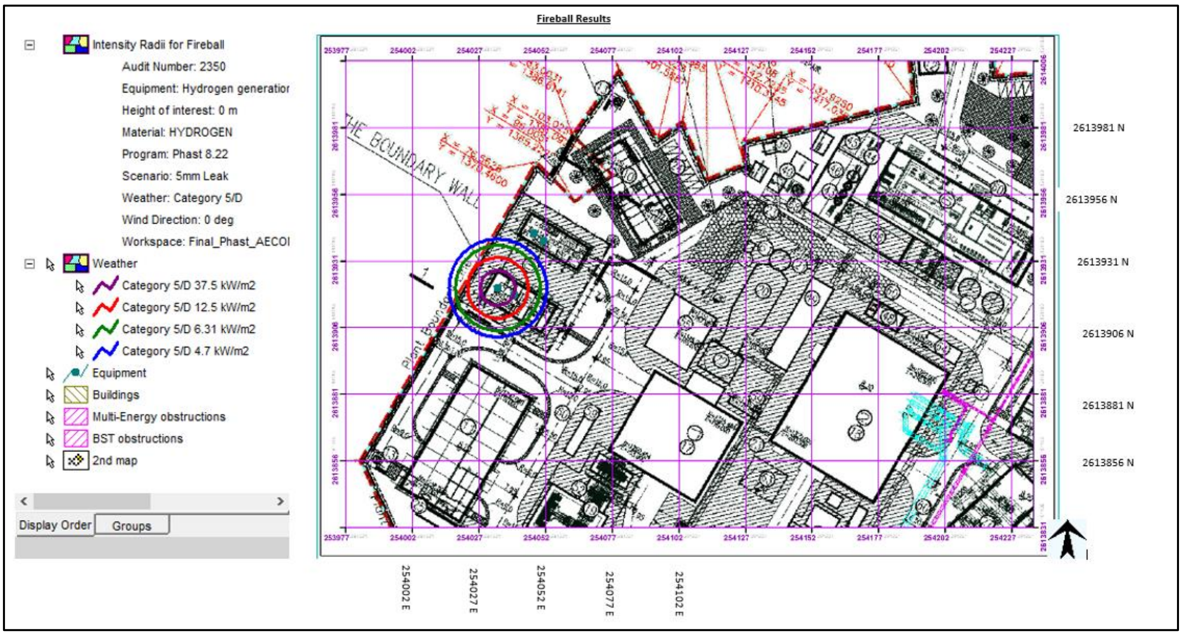


Figure 10.38: Fireball scenario

Weather Class: 1.5/F

Leak Size: 5mm

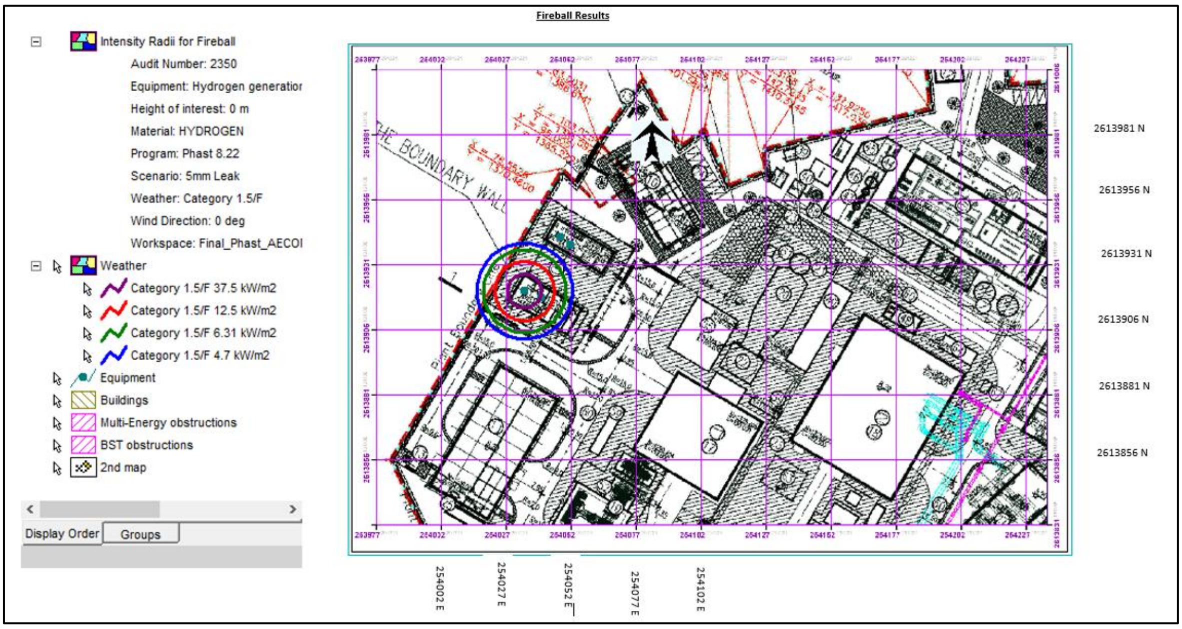


Figure 10.39: Fireball scenario

Leak Size: CR

Weather 5D

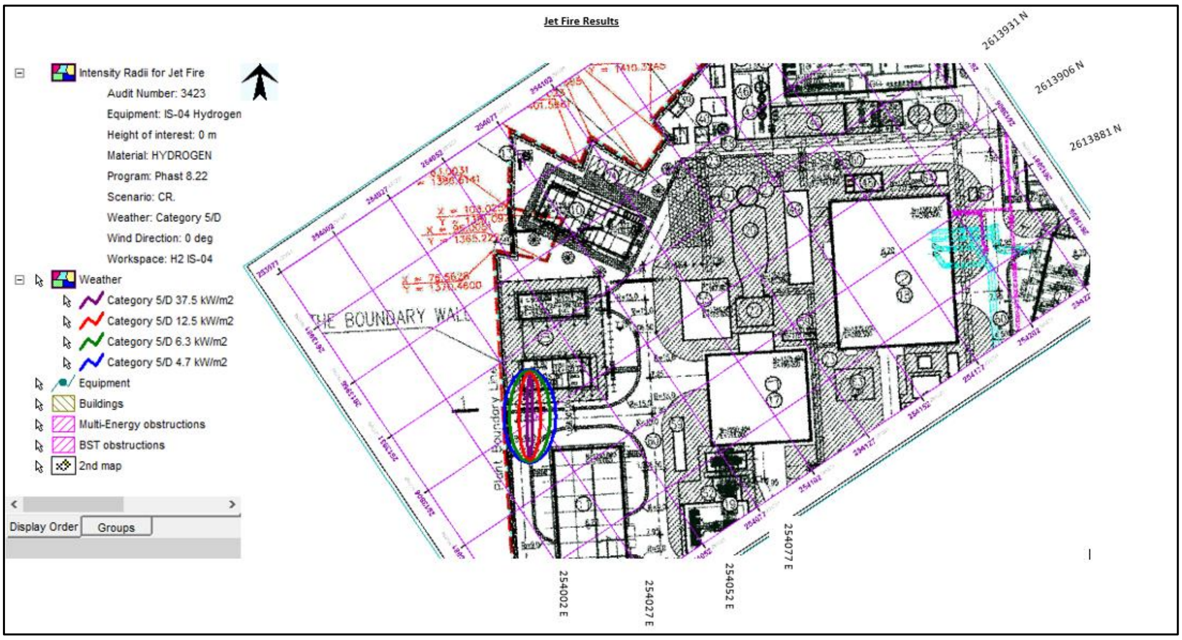


Figure 10.40: Jet fire scenario

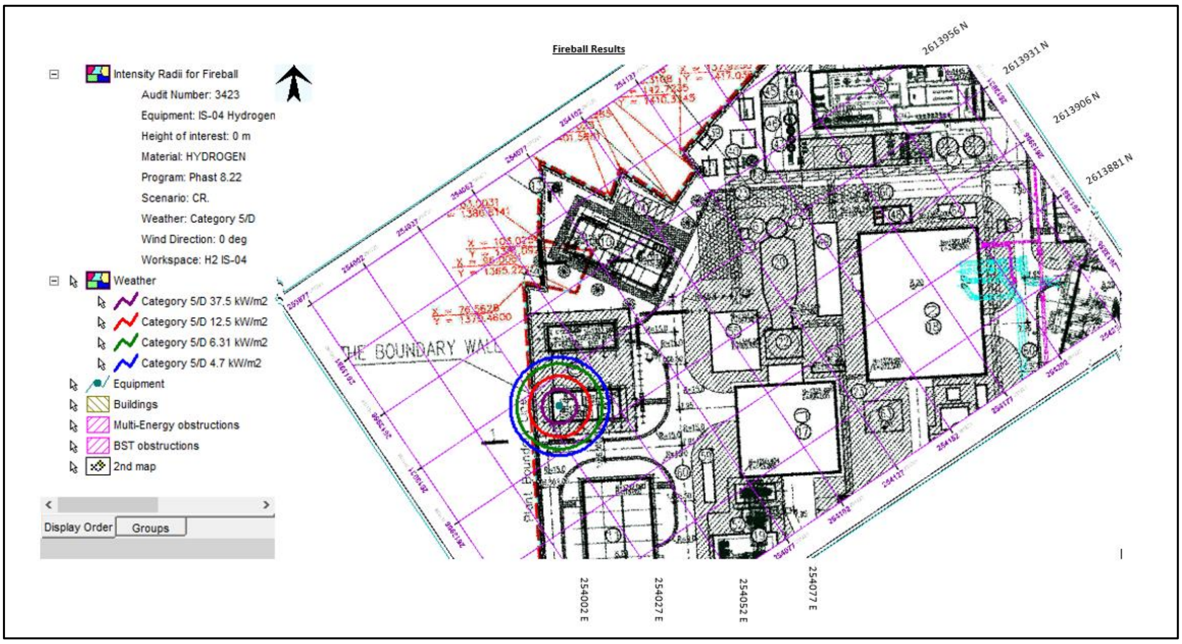


Figure 10.41: Fireball scenario

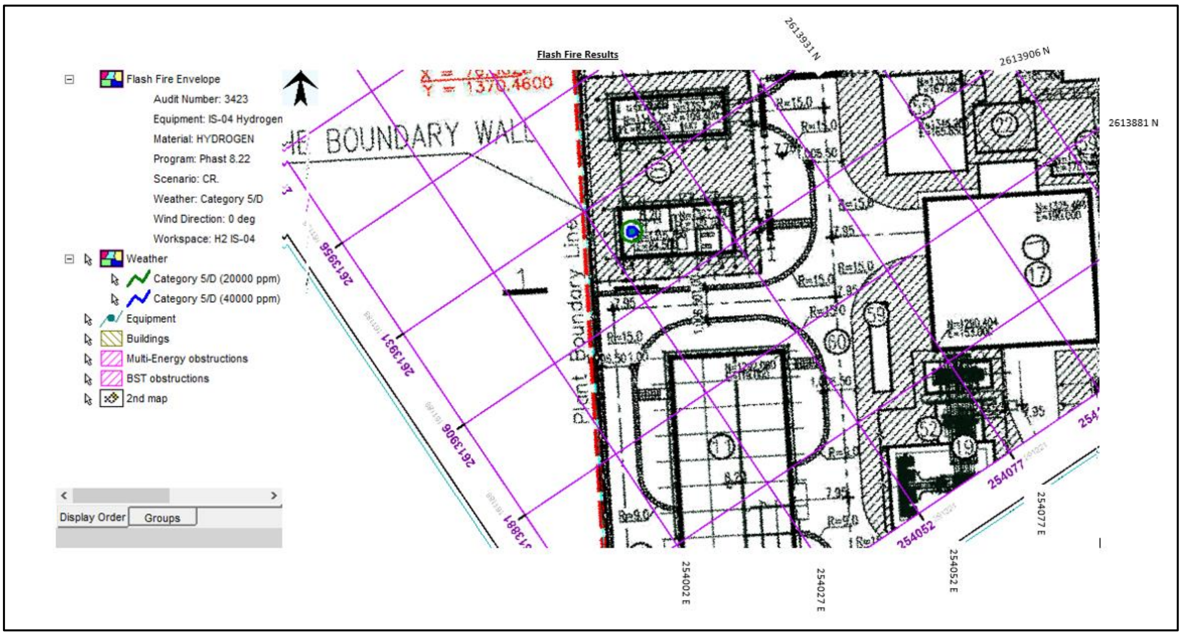


Figure 10.42: Flash fire scenario

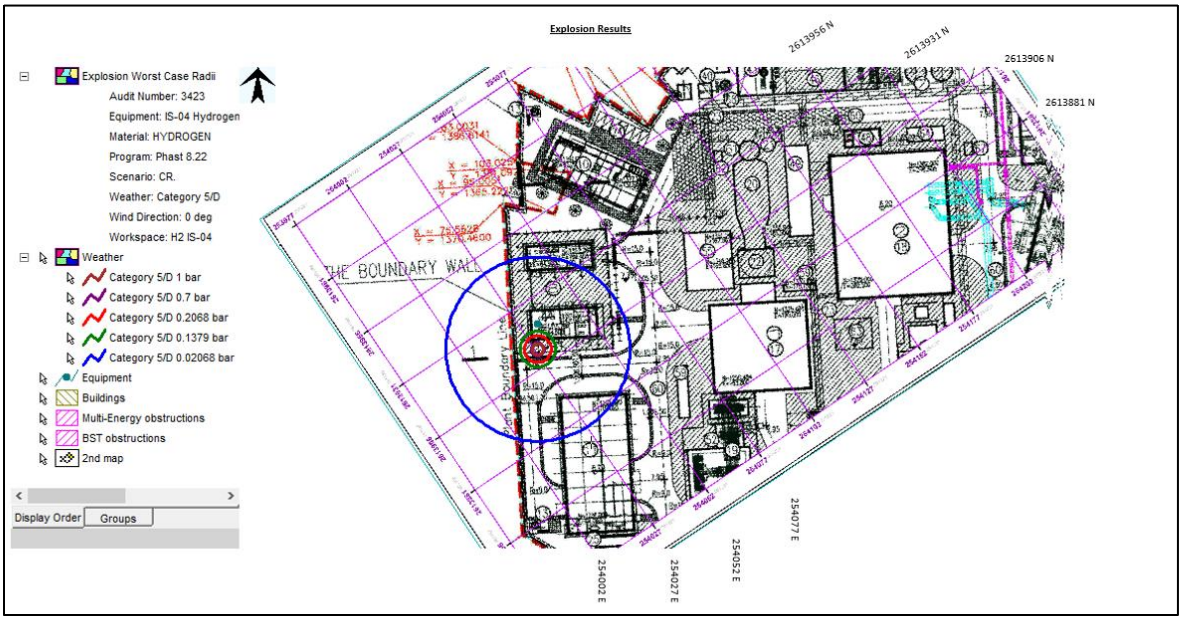


Figure 10.43: Explosion worst case scenario

Weather 1.5 F

Leak Size: CR

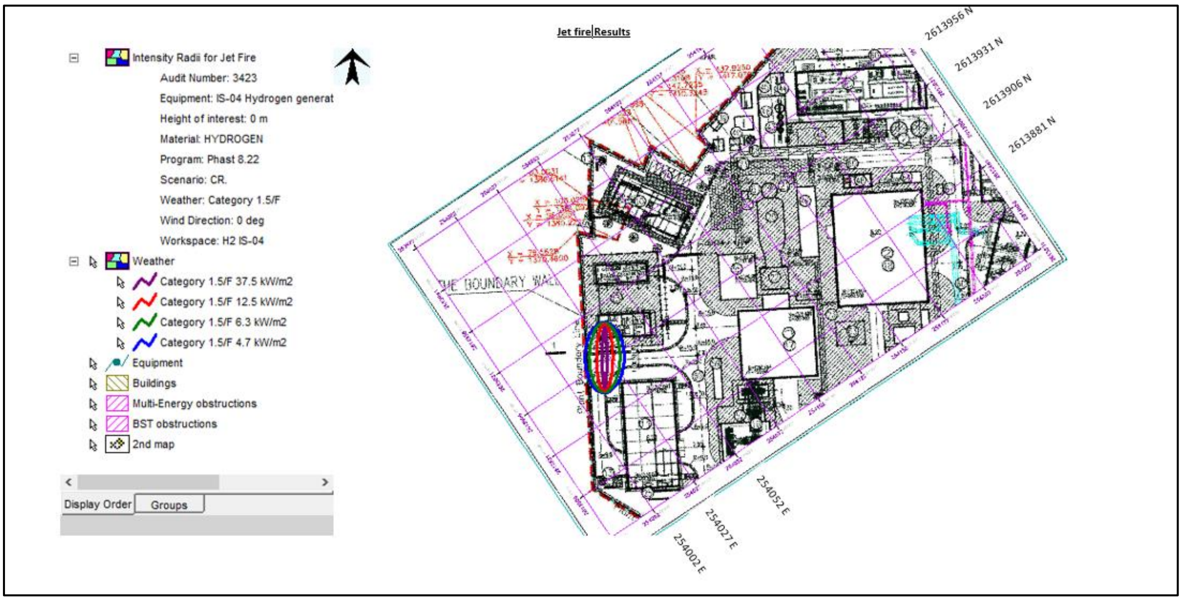


Figure 10.44: Jet fire scenario

Figure 10.45: Fire Ball scenario

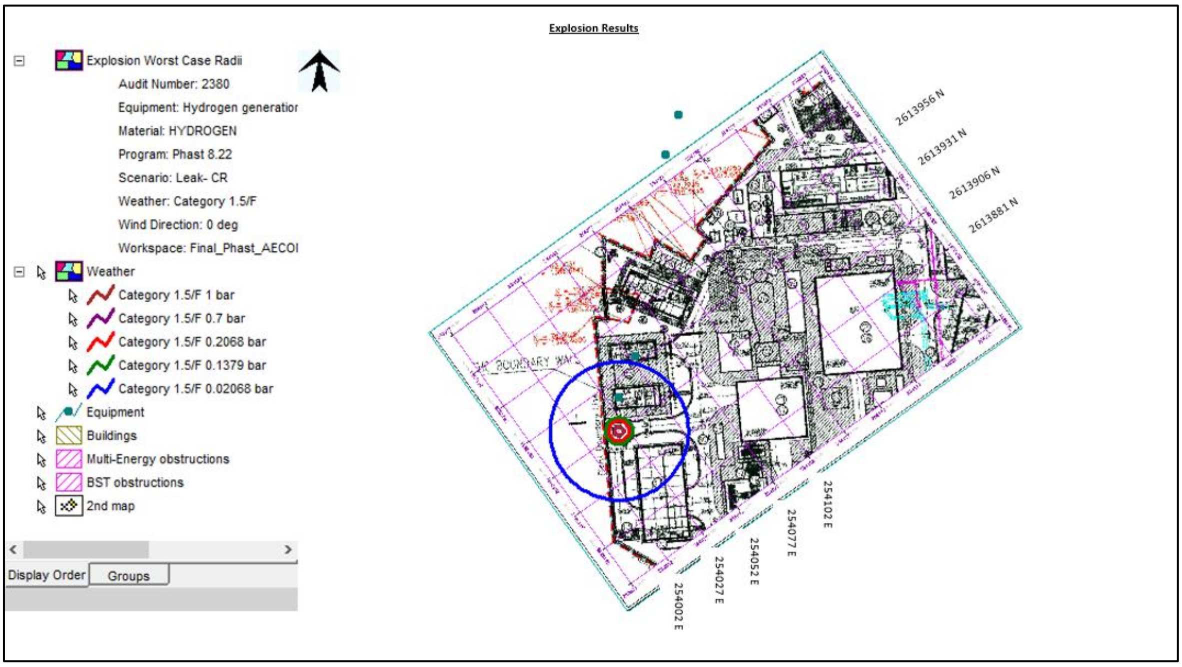


Figure 10.46: Explosion scenario

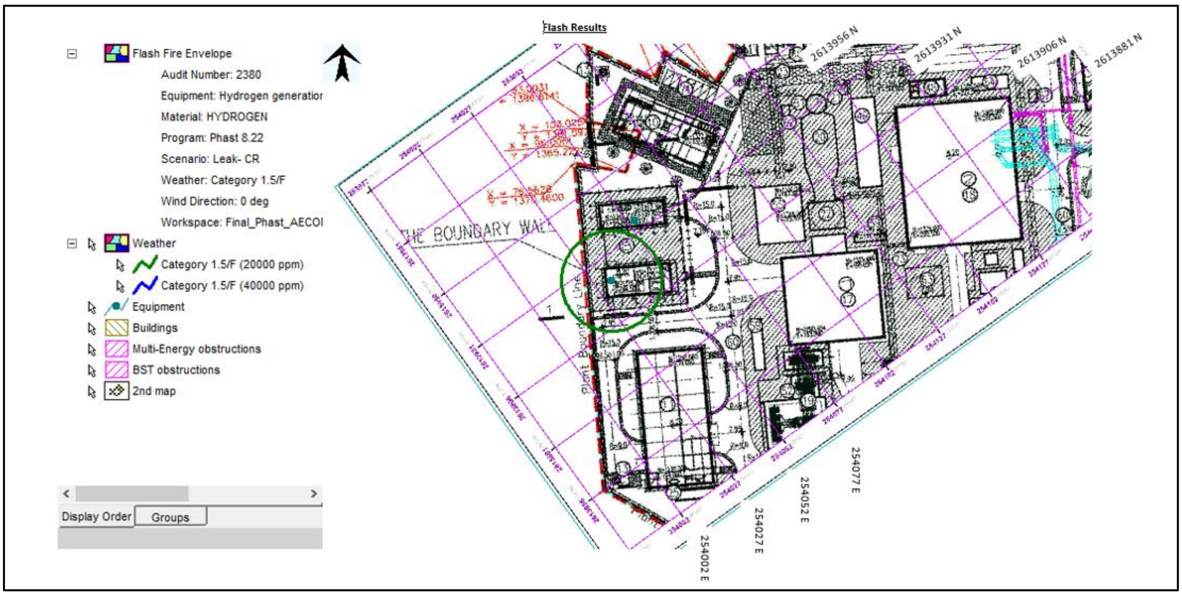


Figure 10.47: Flash fire scenario

IS-05- From Hydrogen generation after Vessel and compressor to Gas manifold

Weather Class: 5/D

Leak Size: 5mm

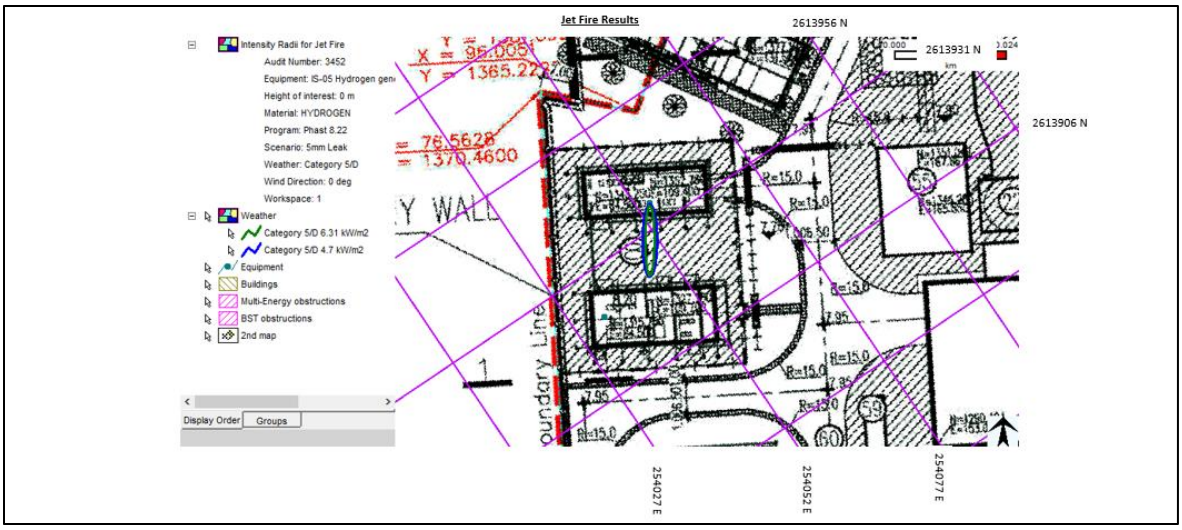


Figure 10.48: Jet fire scenario

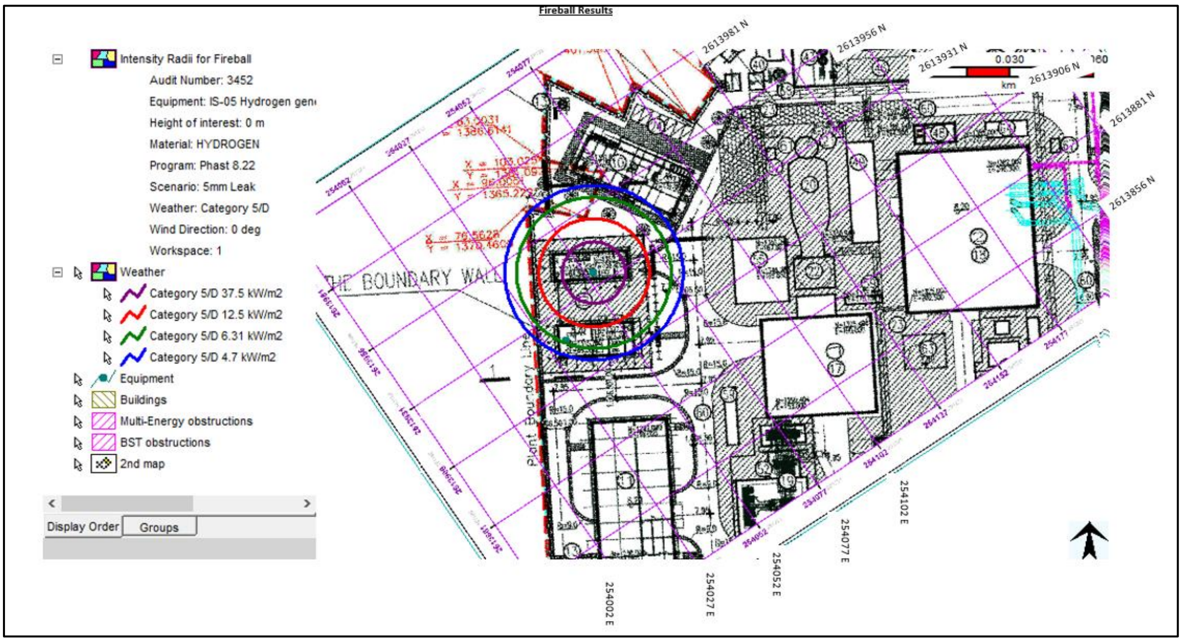


Figure 10.49: Fireball scenario

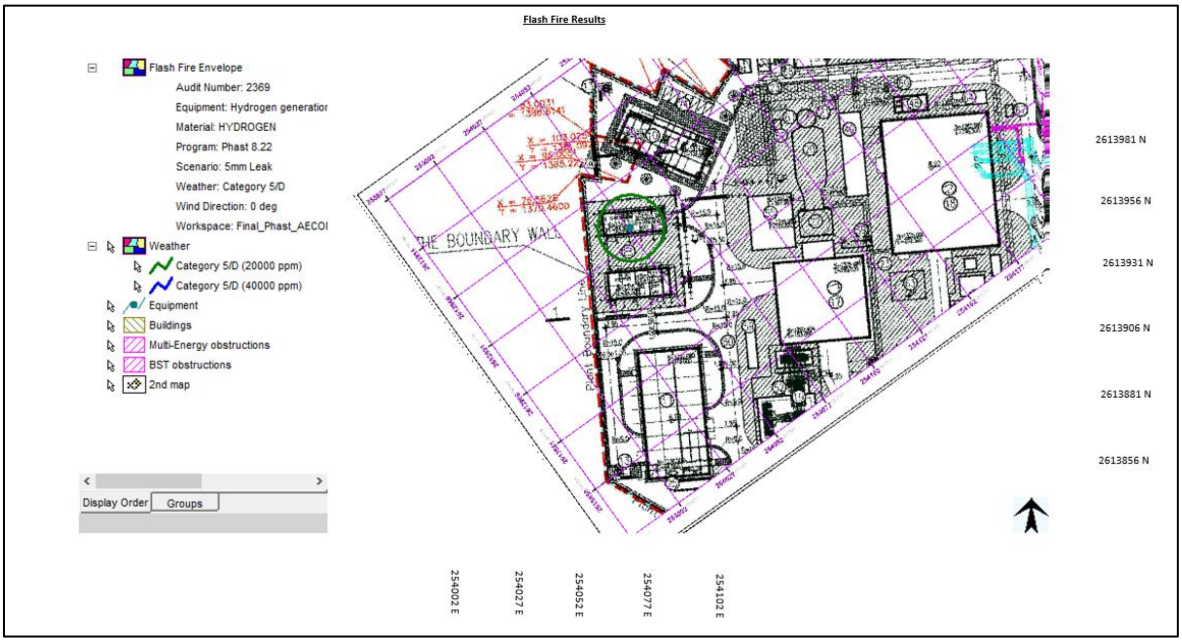


Figure 10.50: Flash fire scenario

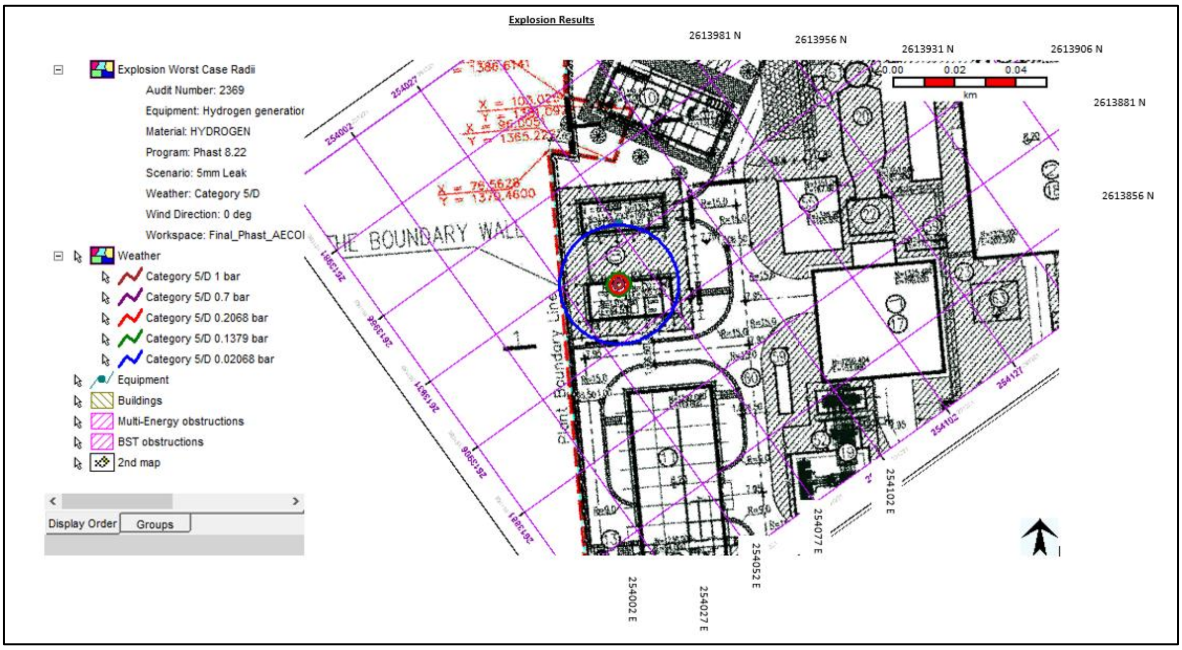


Figure 10.51: Explosion worst case scenario

Weather Class: 1.5/F

Leak Size: 5mm

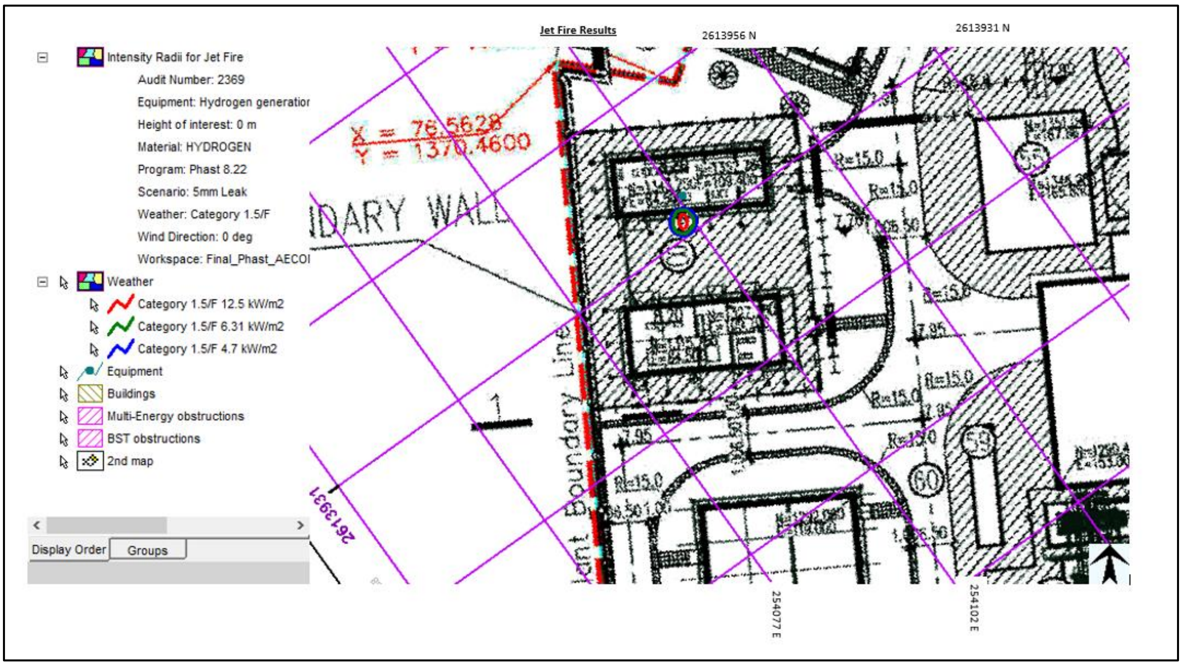


Figure 10.52: Jet fire scenario

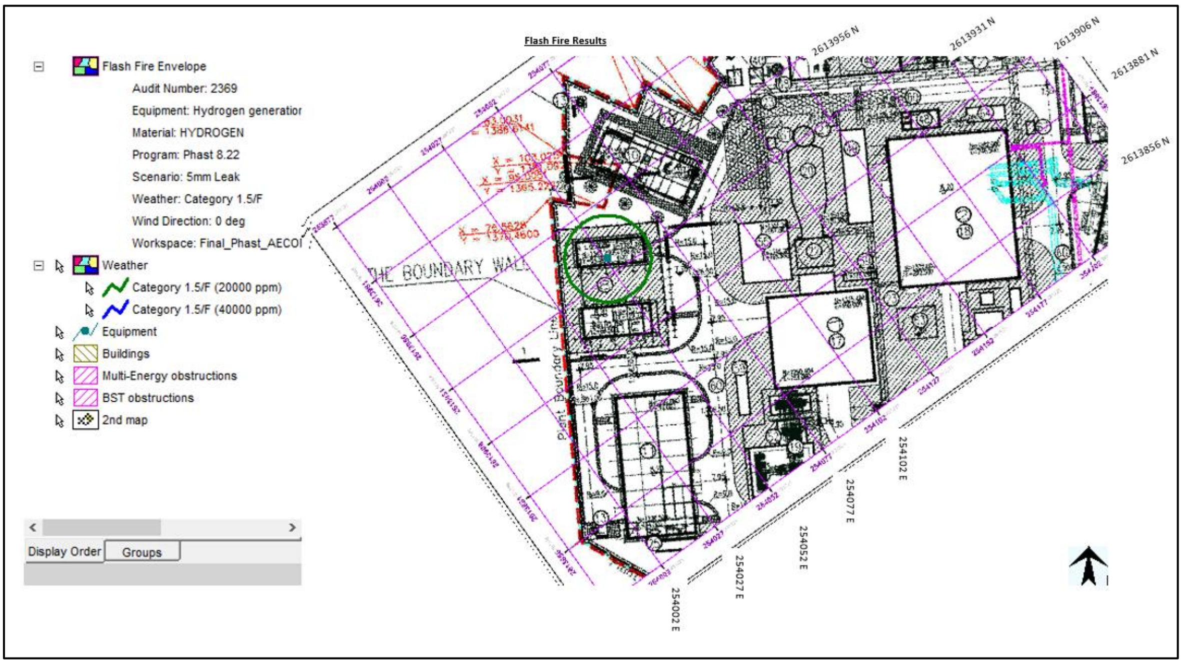


Figure 10.53: Flash fire scenario

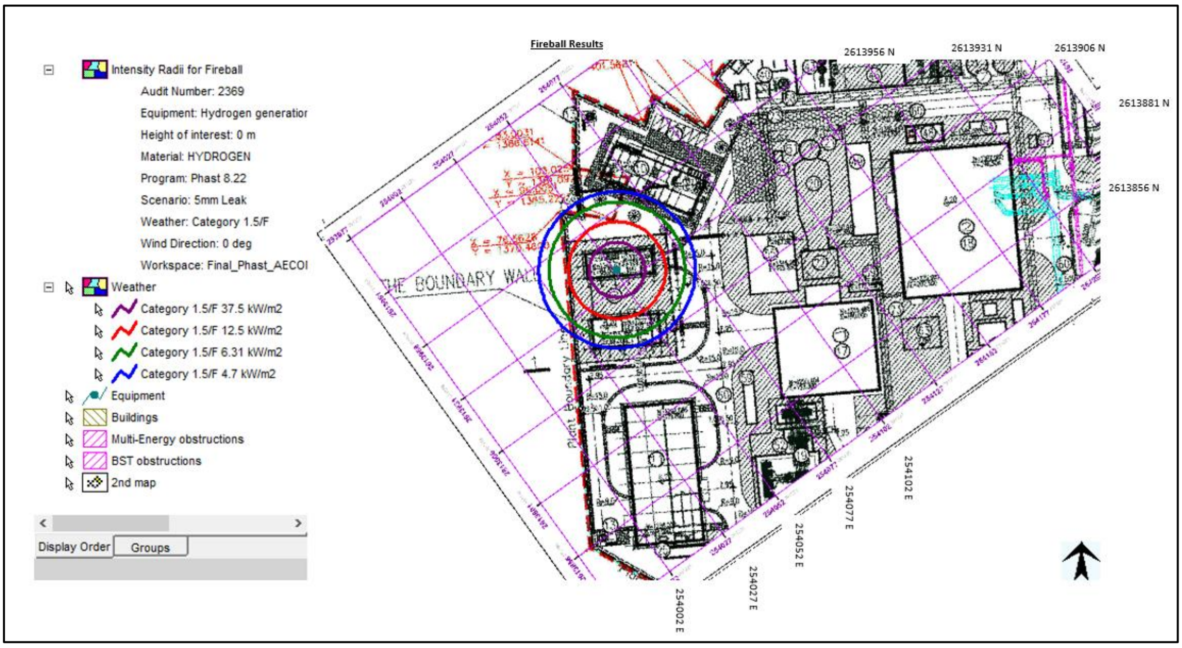


Figure 10.54: Fireball scenario

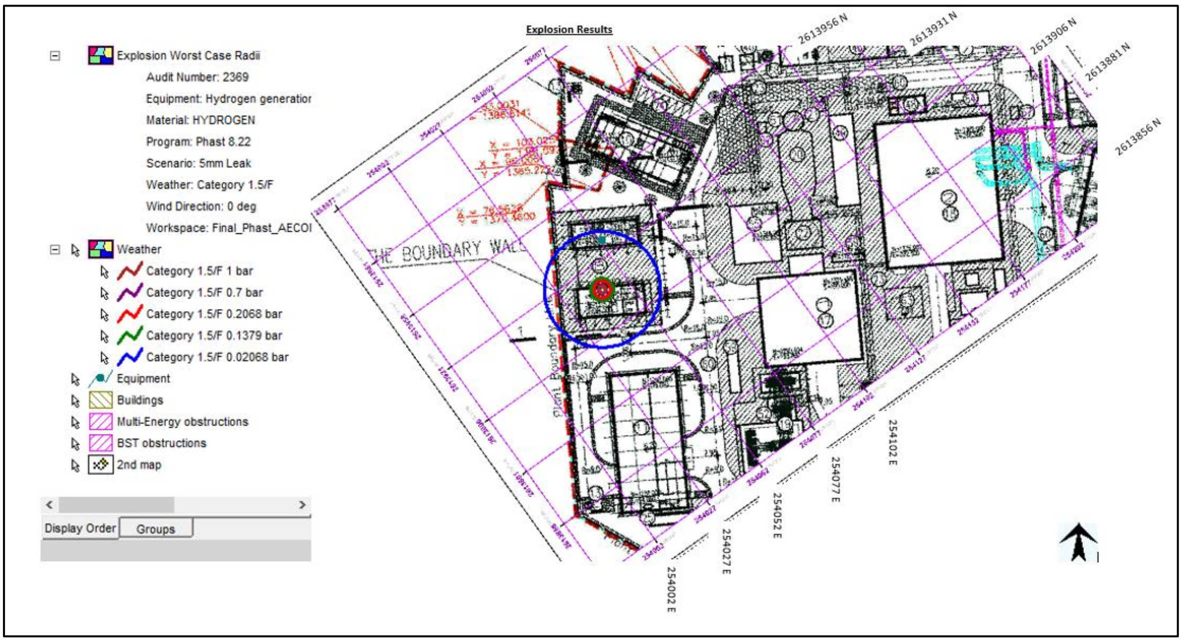


Figure 10.57: Explosion worst case scenario

Weather Class: 5/D

Leak Size: CR

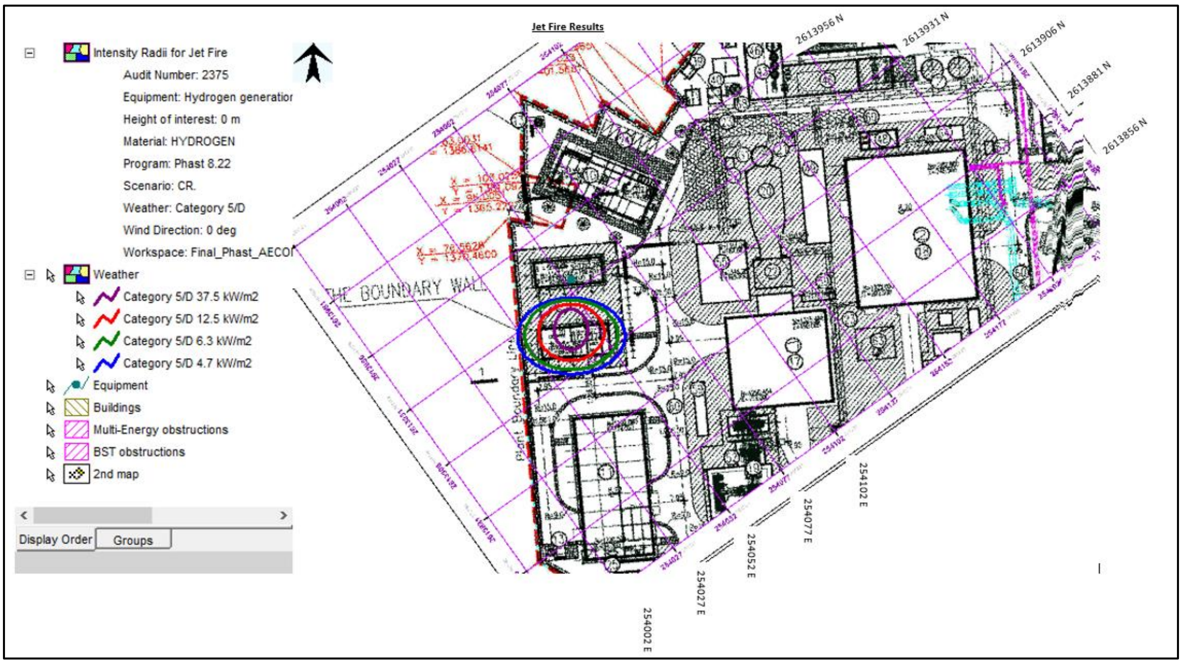


Figure 10.55: Jet fire scenario

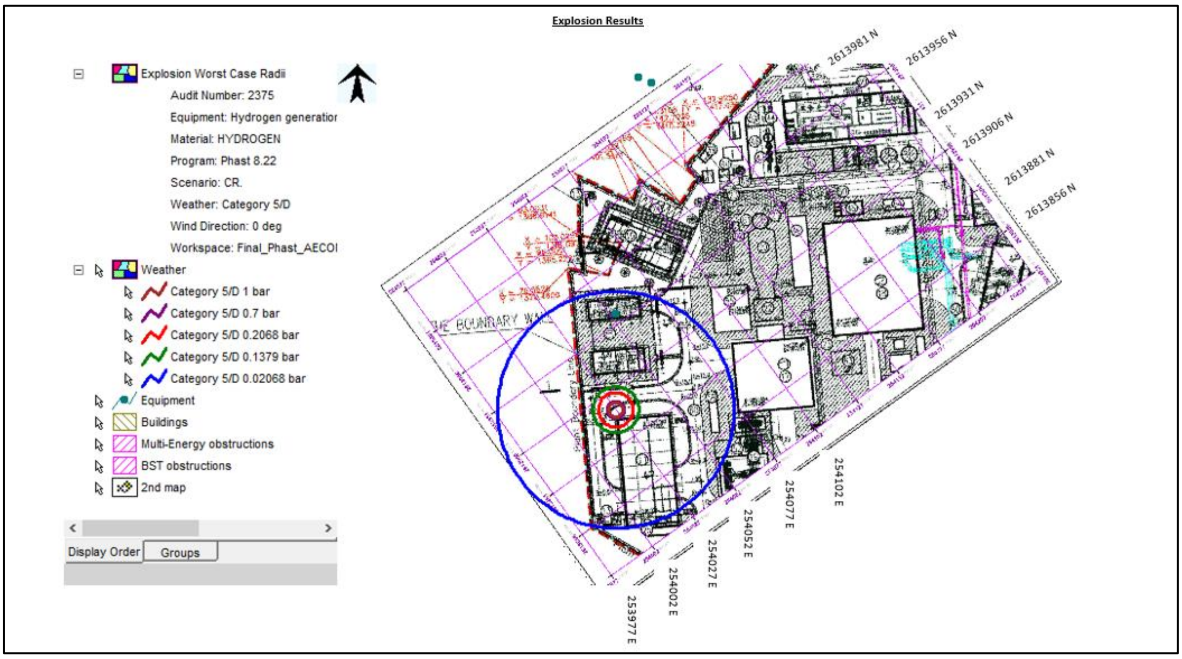


Figure 10.56: Explosion worst case scenario

Figure 10.57: Fireball scenario

Weather Class: 1.5/F

Leak Size: CR

Figure 10.58: Jet fire scenario

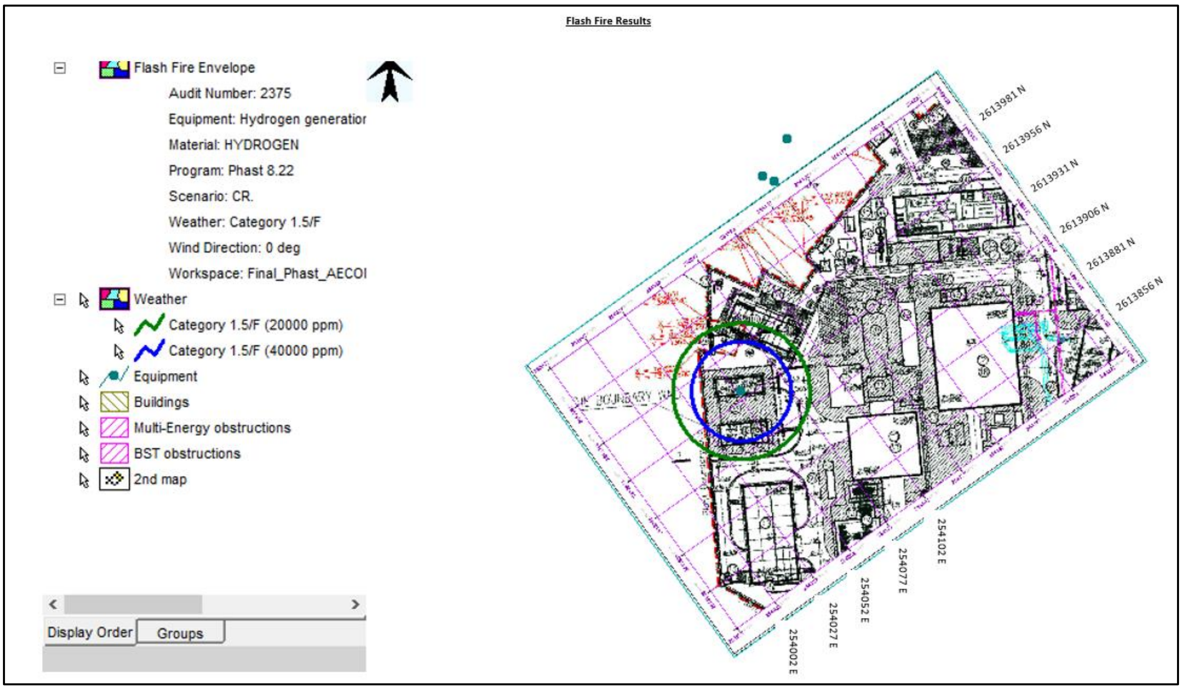


Figure 10.59: Flash fire scenario

Figure 10.60: Fireball scenario

Figure 10.61: Explosion worst case scenario

IS-06- Hydrogen Vessel

Weather Class: 5/D

Leak Size: Catastrophic rupture

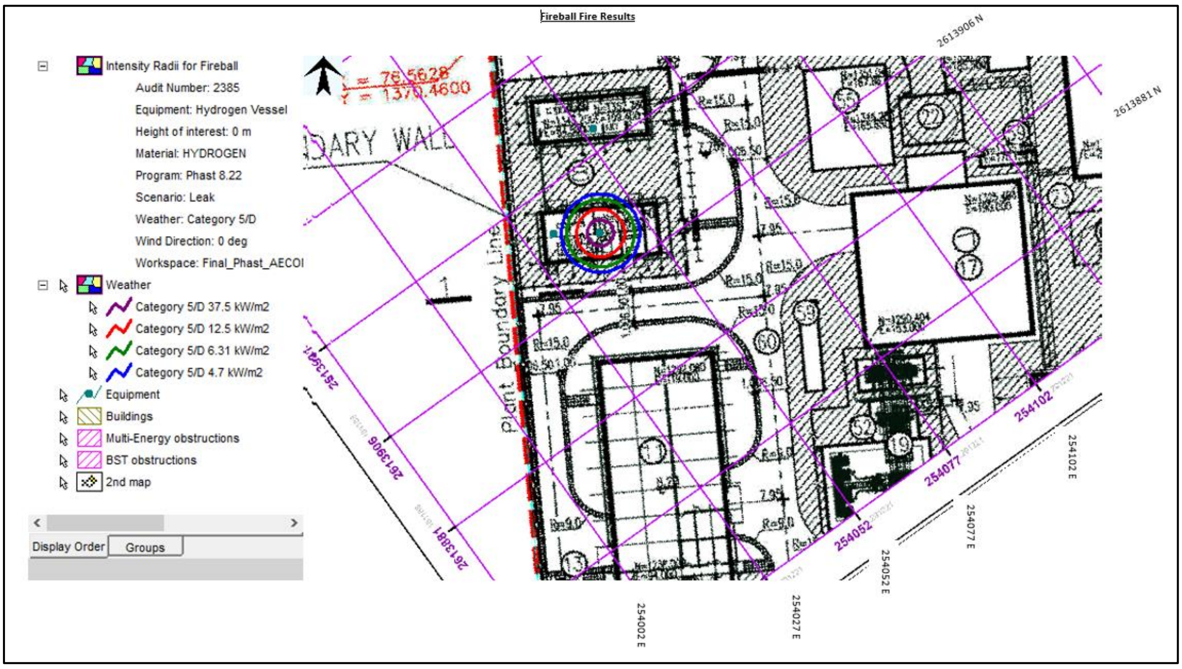


Figure 10.62: Fireball scenario

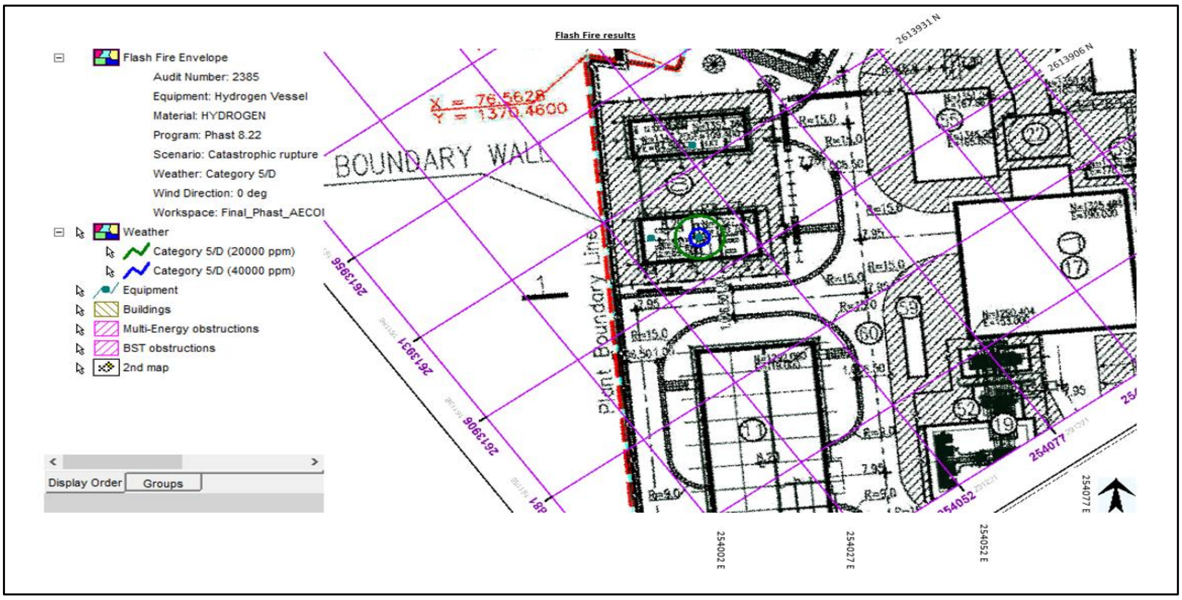


Figure 10.63: Flash fire scenario

Weather Class : 1.5/F

Leak size : CR

Figure 10.64: Fireball scenario

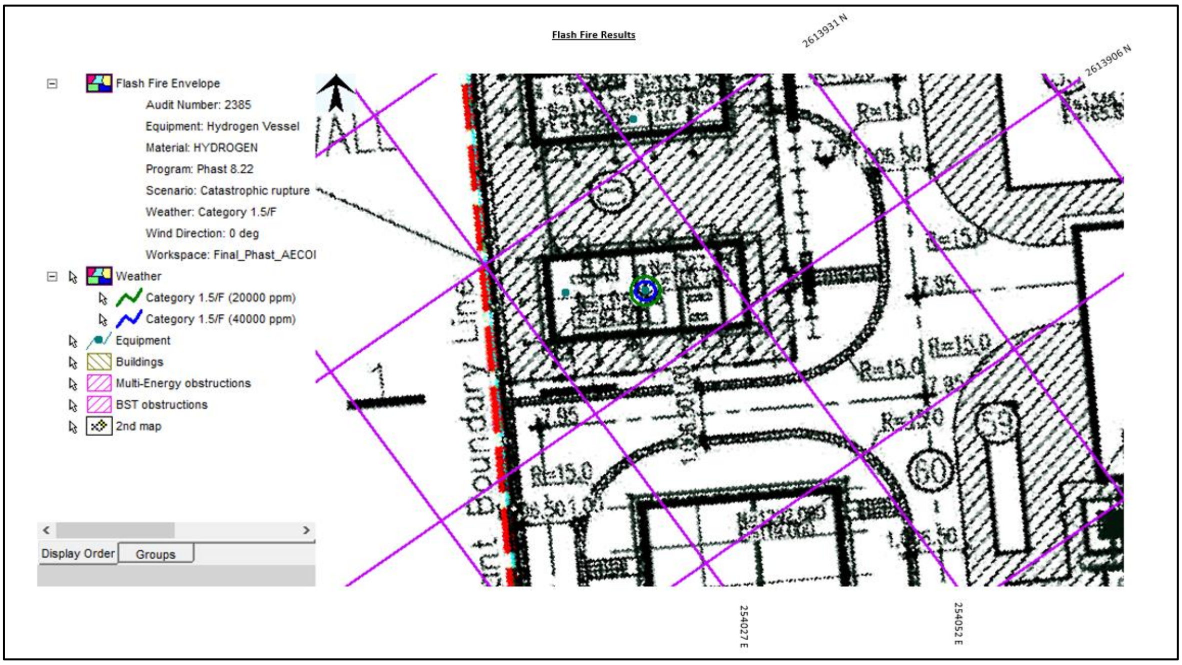


Figure 10.65: Flash fire scenario

IS-07- Diesel Tank, pump to Downstream System Valve

Weather Class: 5/D

Leak Size: 5mm

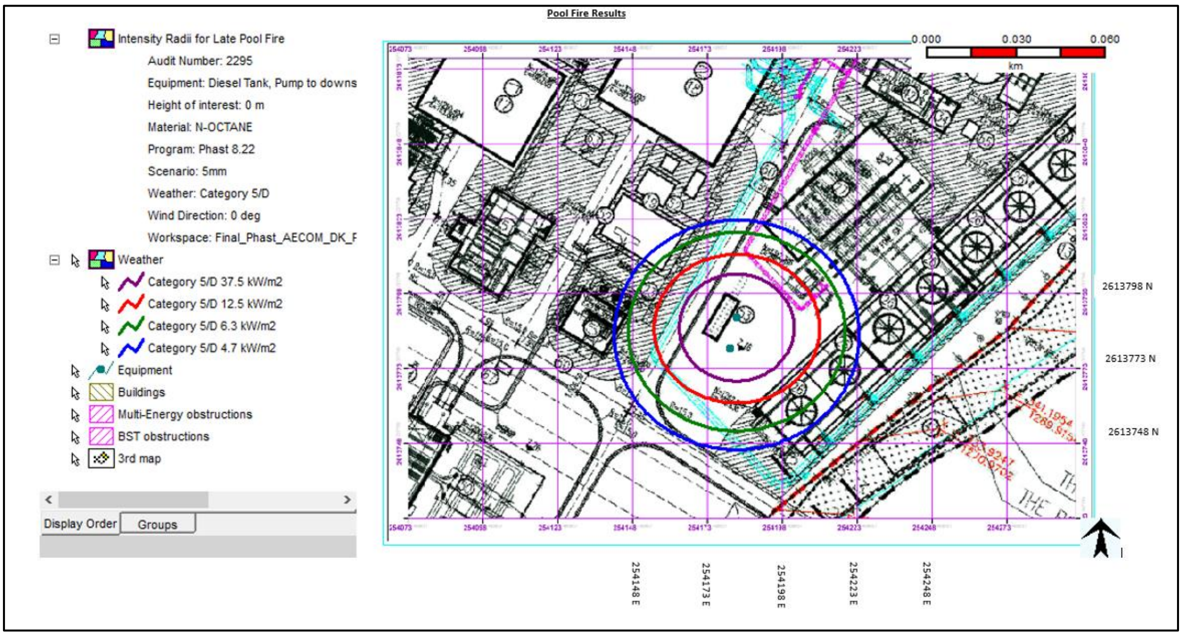


Figure 10.66: Pool fire scenario

Weather Class 1.5/F

Leak Size:5mm

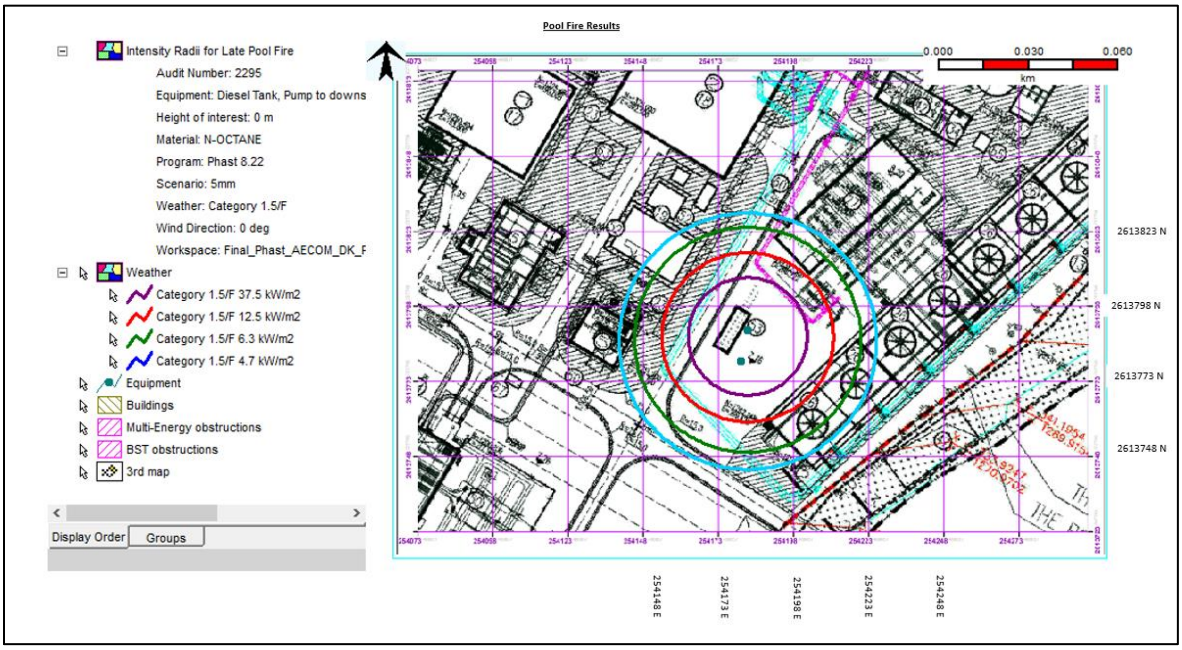


Figure 10.67: Pool fire scenario

Weather Class: 5/D

Leak Size: 15mm

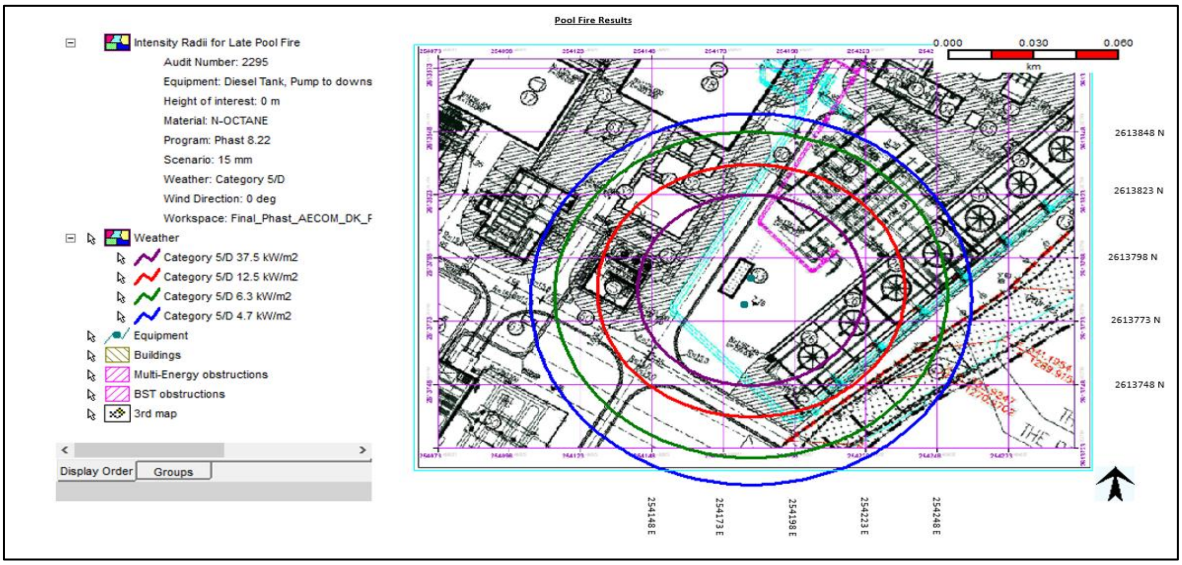


Figure 10.68: Pool fire scenario

Weather Class : 1.5/F

Leak Size: 15mm

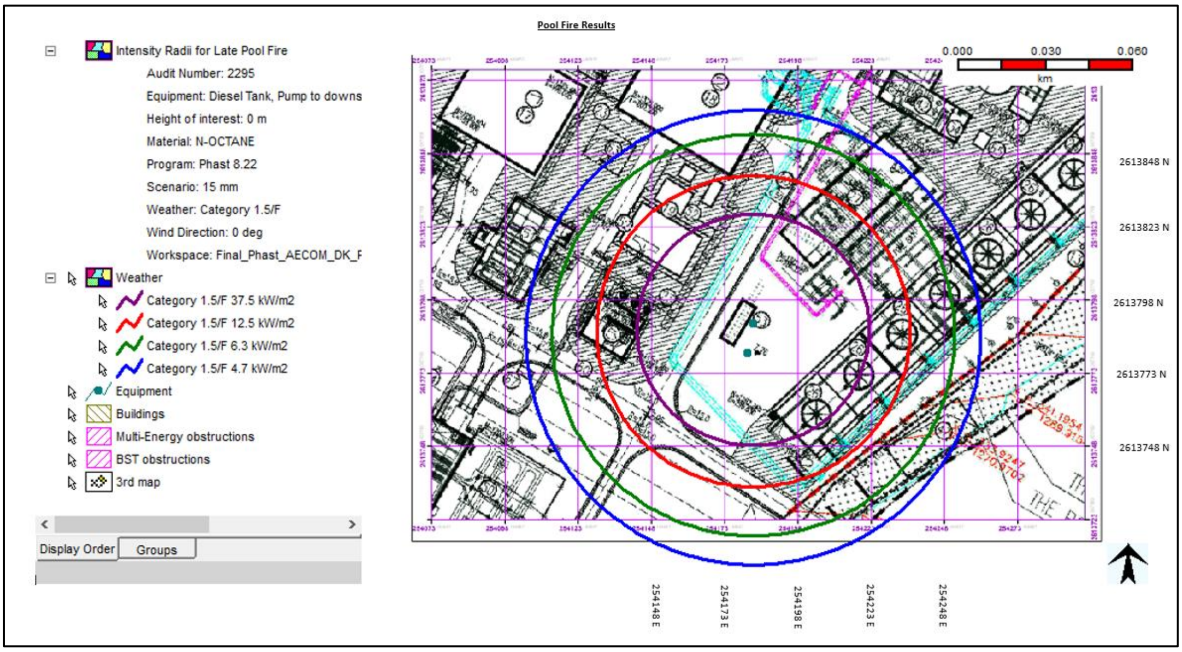


Figure 10.69: Pool fire scenario

Weather Class: 5/D
Leak Size: CR

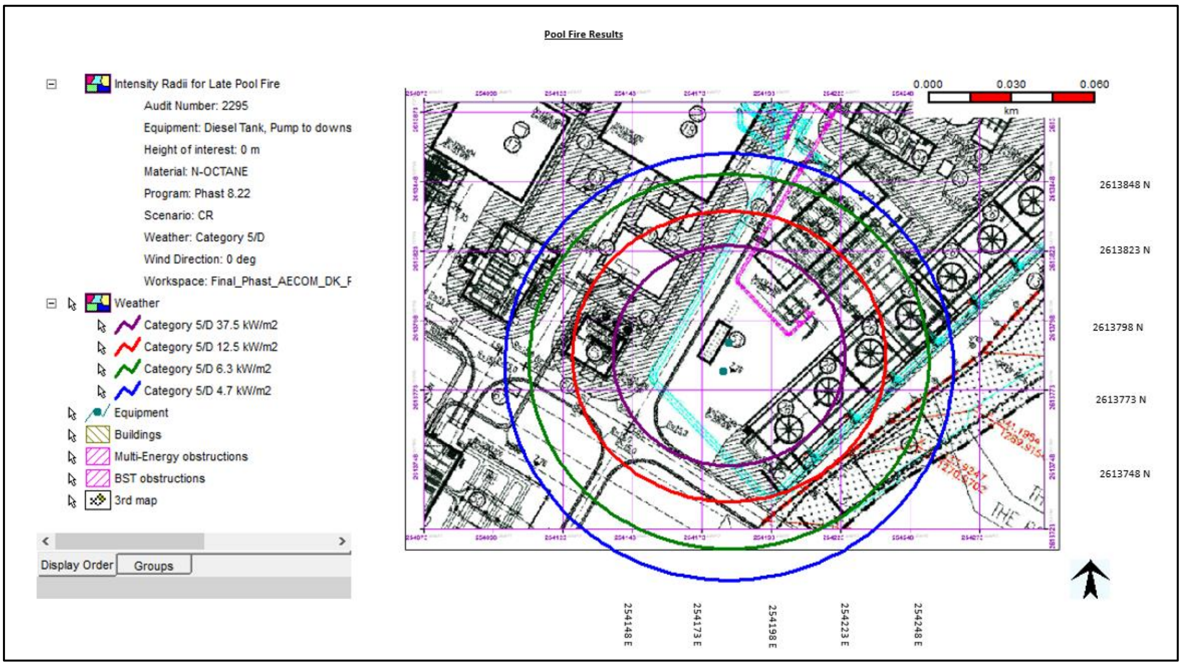


Figure 10.70: Pool fire scenario

Weather Class 1.5/F

Leak size: CR

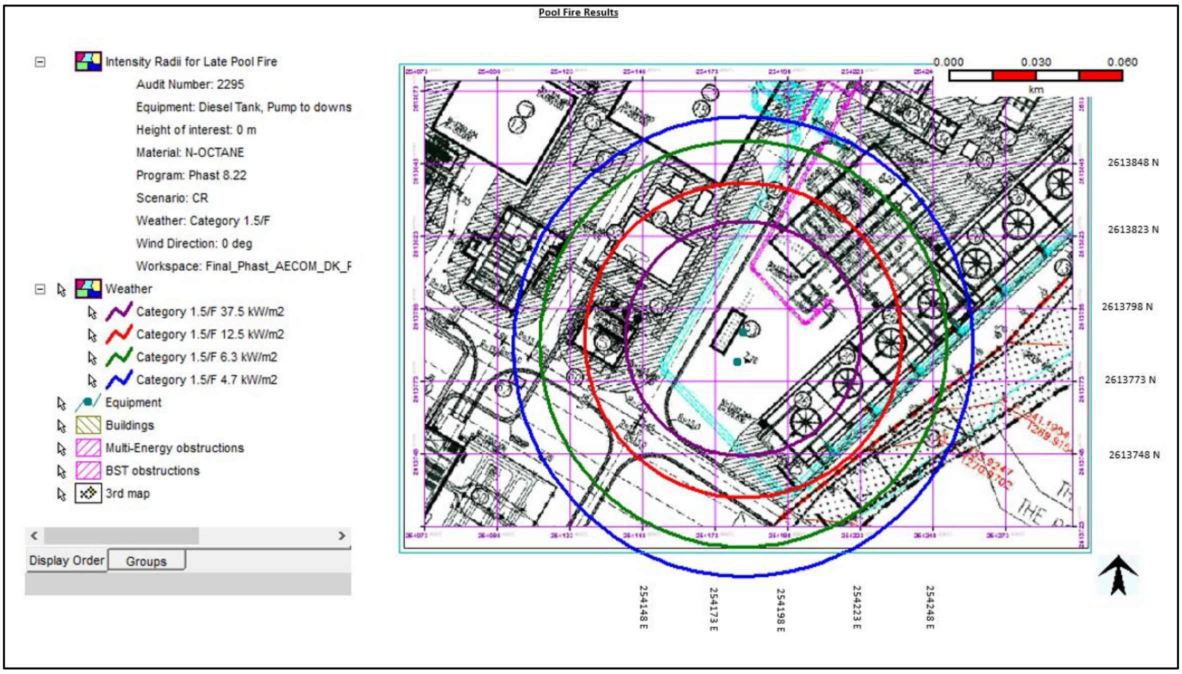


Figure 10.71: Pool fire scenario

IS-08- HCl Storage Vessel

Weather Class : 5/D

Leak size: Catastrophic Rupture

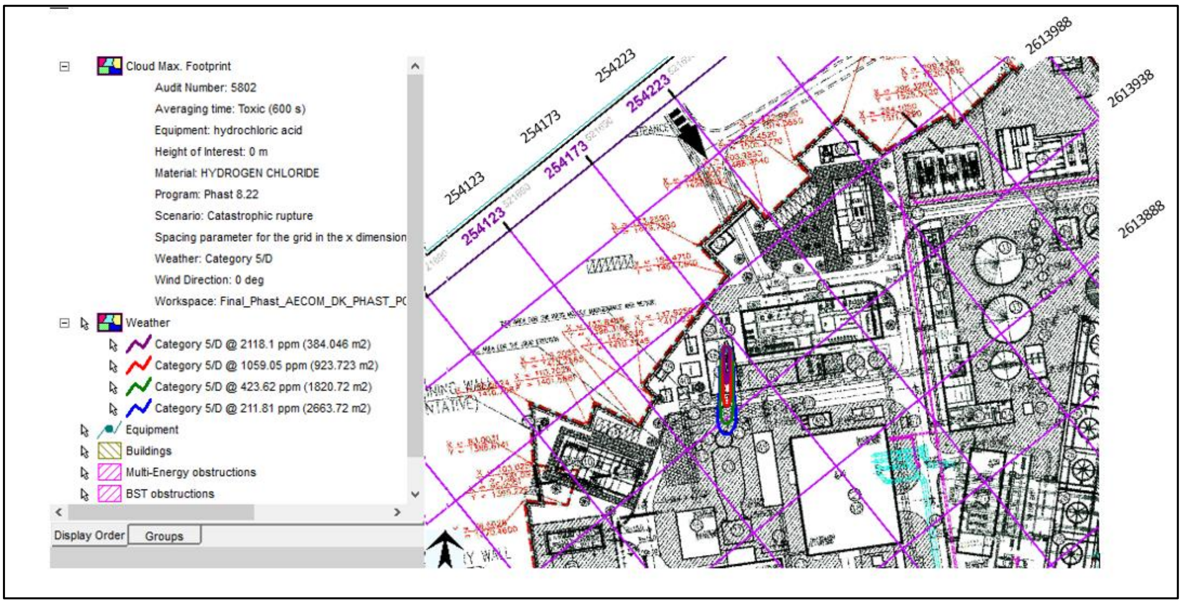


Figure 10.72: Toxic Footprint

Weather Class: 1.5/F

Leak size : Catastrophic Rupture

Figure 10.73:Toxic Footprint

IS-09- Sulfuric Acid Storage Vessel

Weather Class : 5/D

Leak size : Catastrophic Rupture

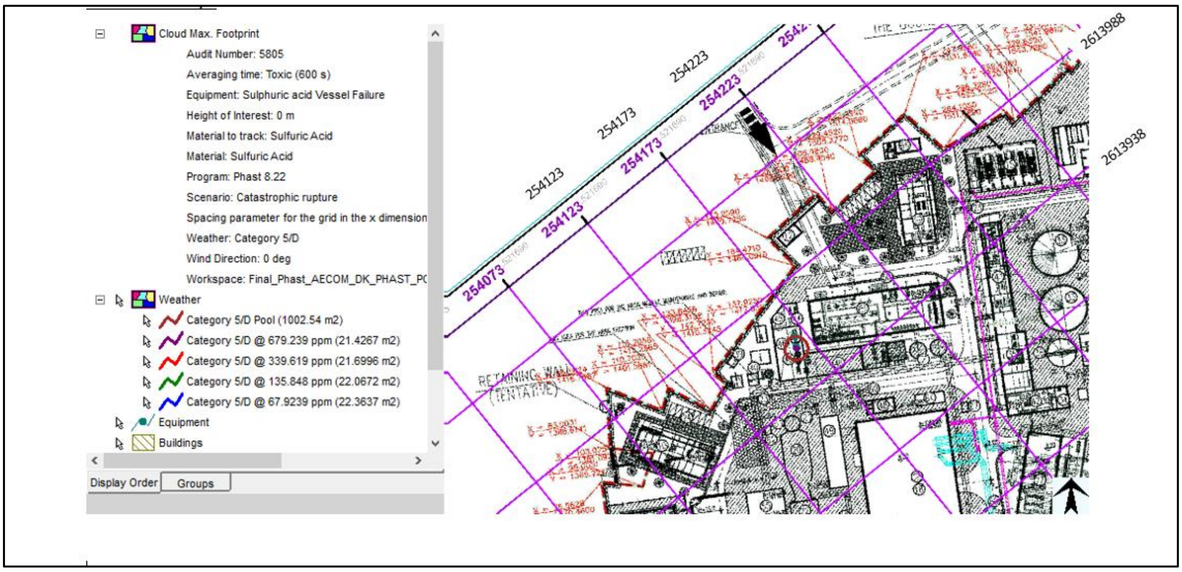


Figure 10.74: Toxic Footprint

Weather Class : 1.5/F

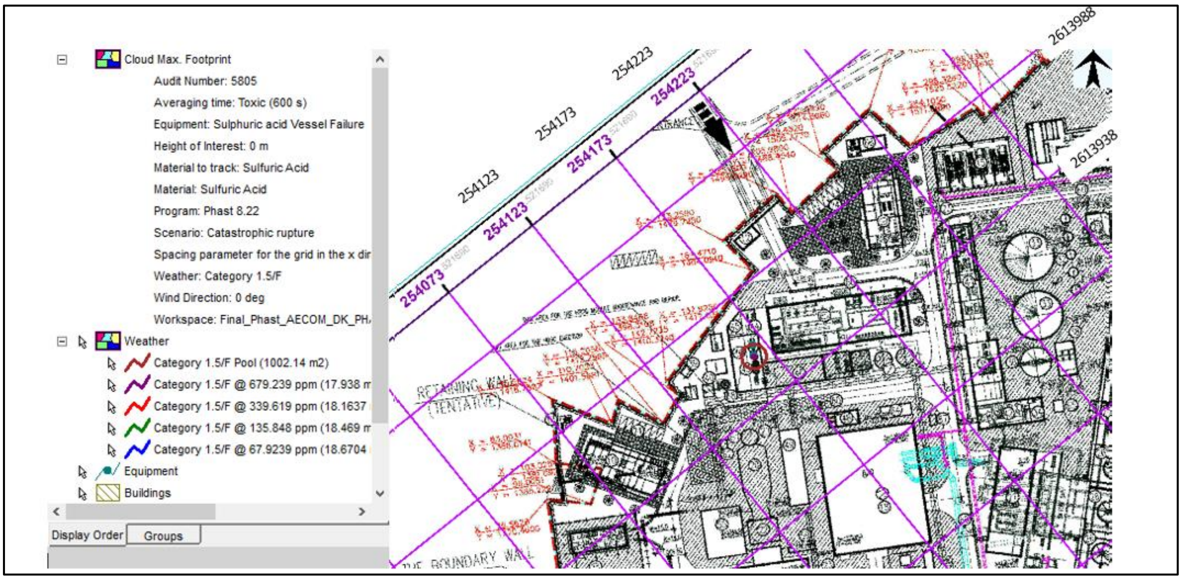


Figure 10.75: Toxic Footprint

IS-10- Ammonia Storage Vessel

Weather Class : 5/D

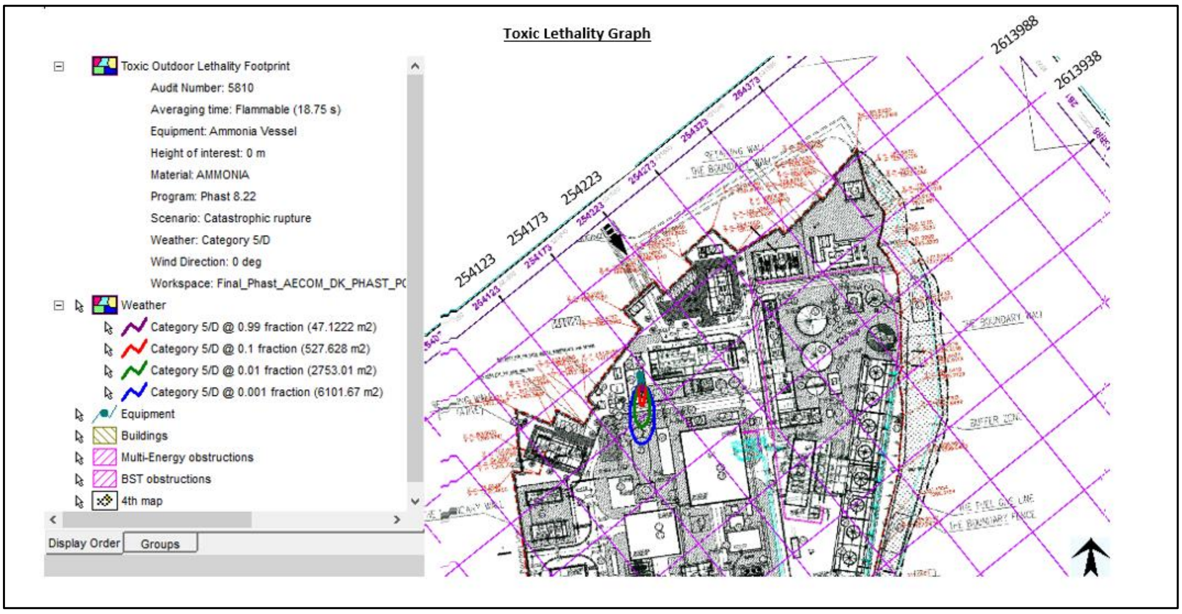


Figure 10.76: Toxic Lethality

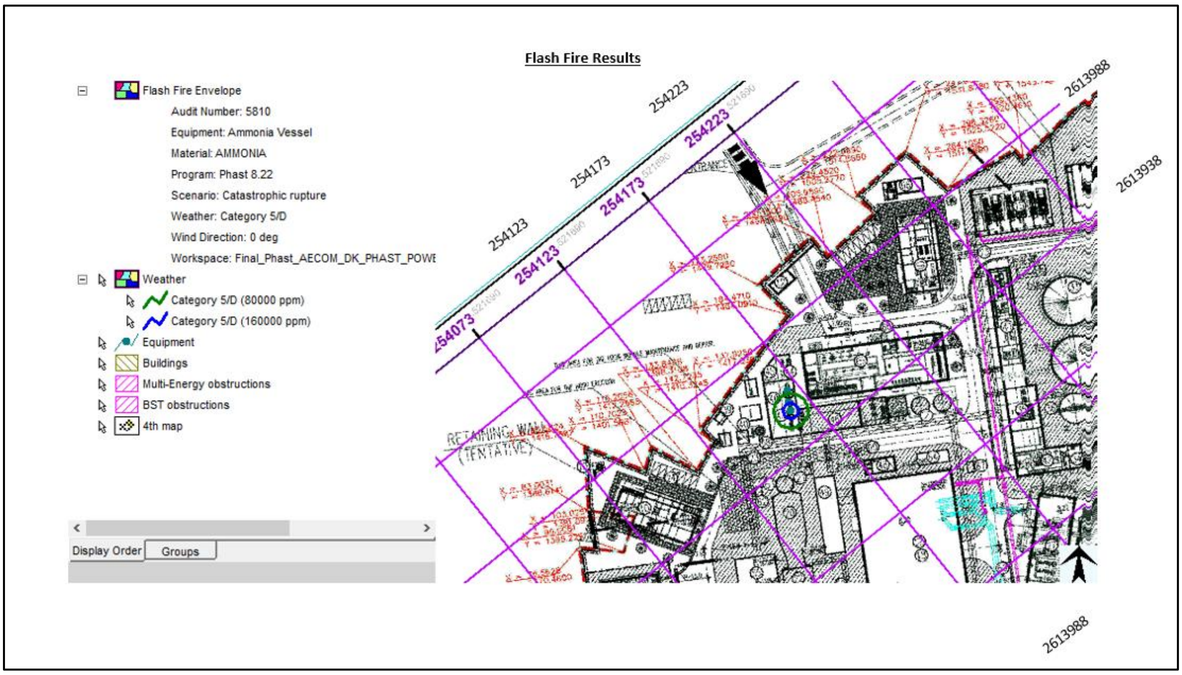


Figure 10.77: Flash Fire Scenario

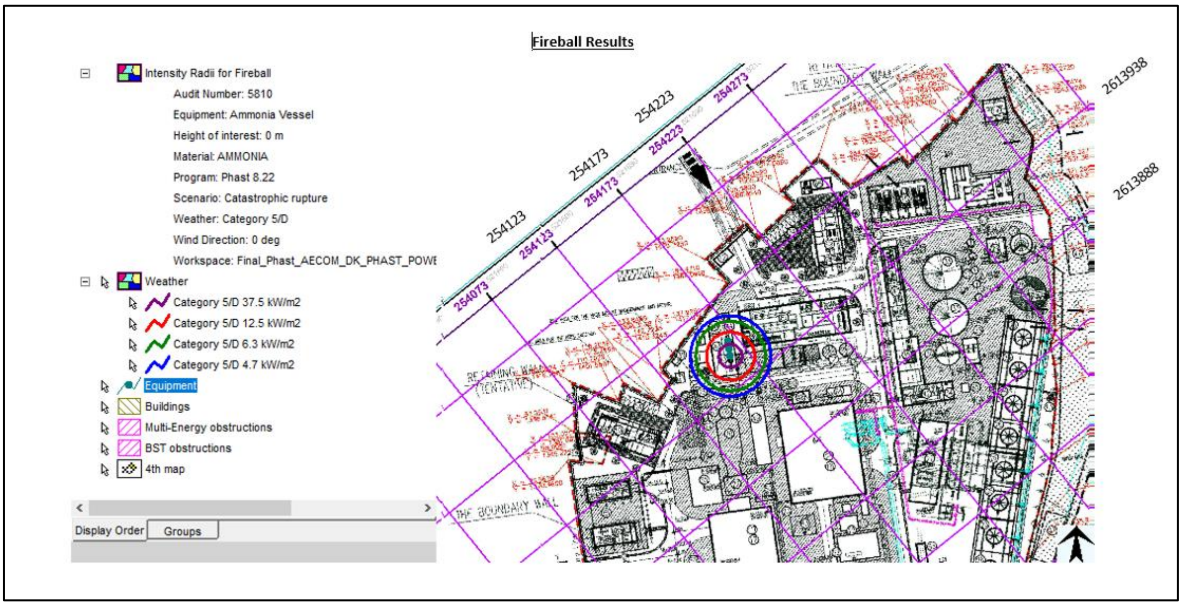


Figure 10.78: Fireball Scenario

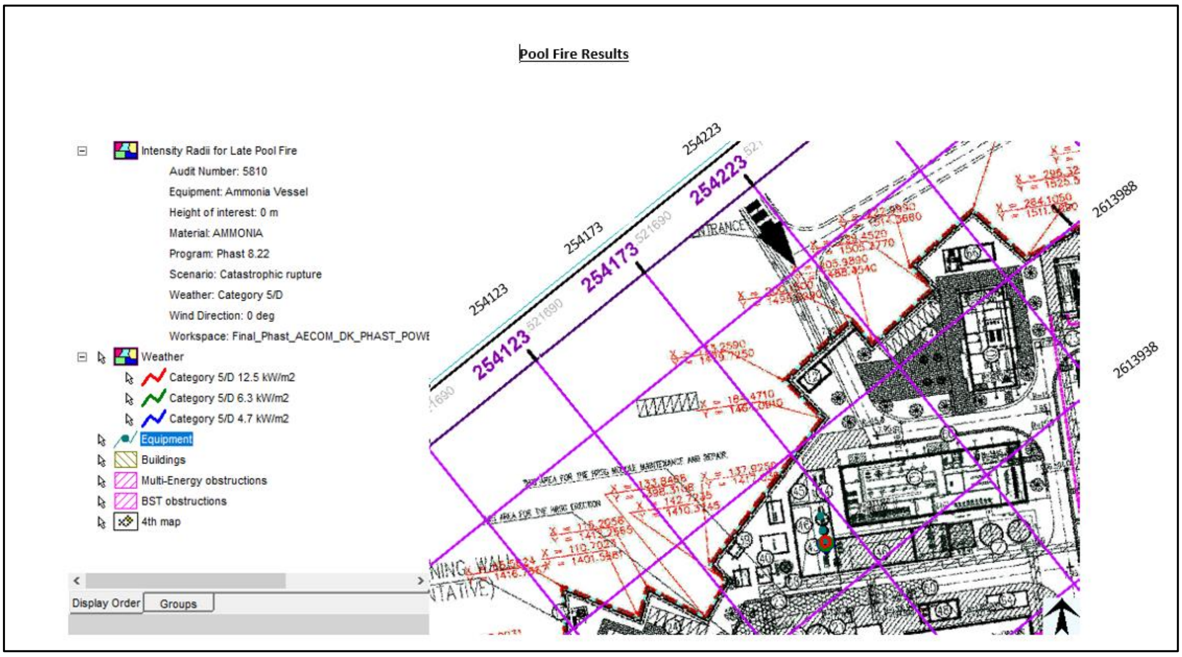


Figure 10.79: Pool fire Scenario

Weather Class : 1.5/F

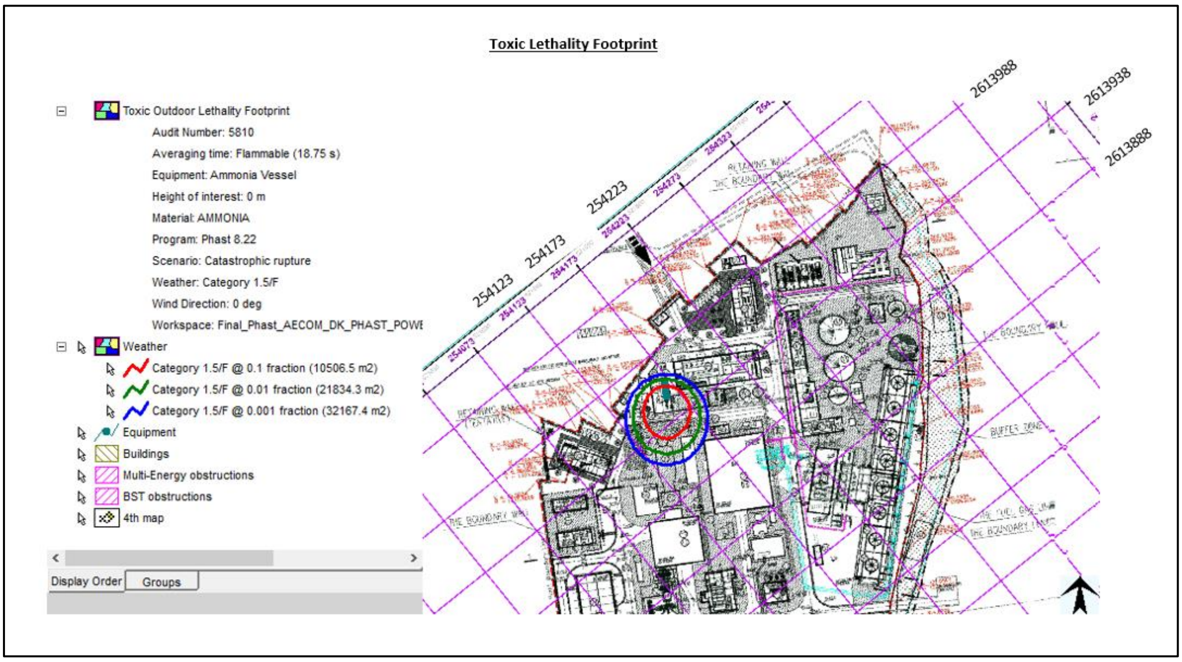


Figure 10.80: Toxic lethality foot print

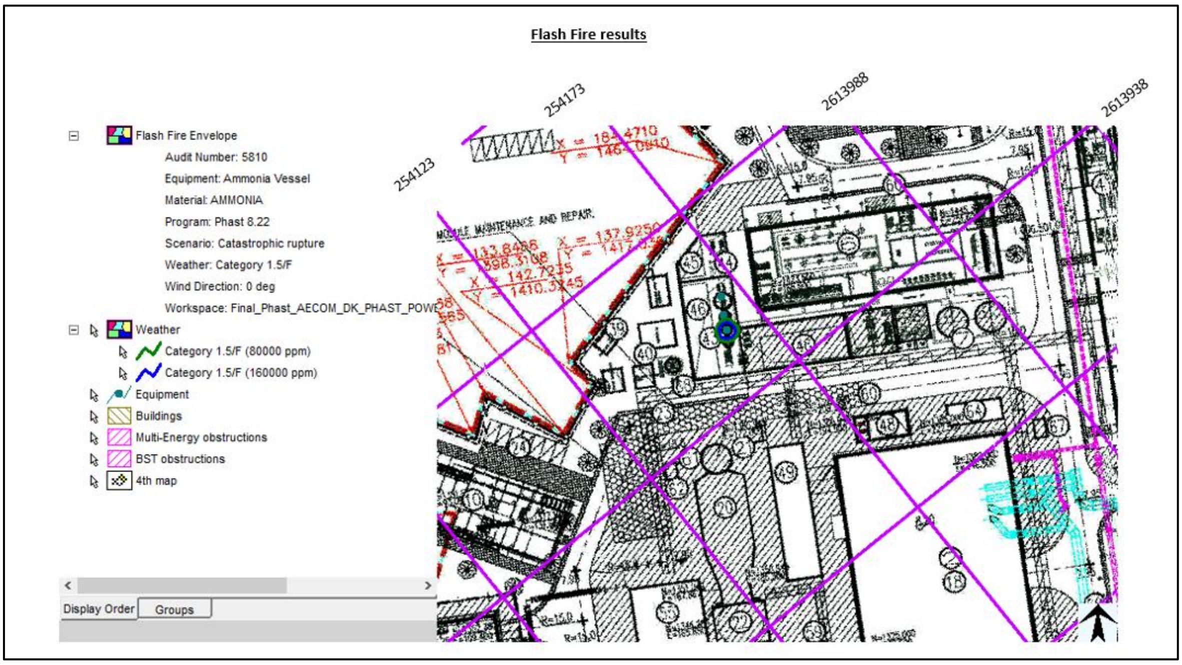


Figure 10.81: Flash fire Scenario

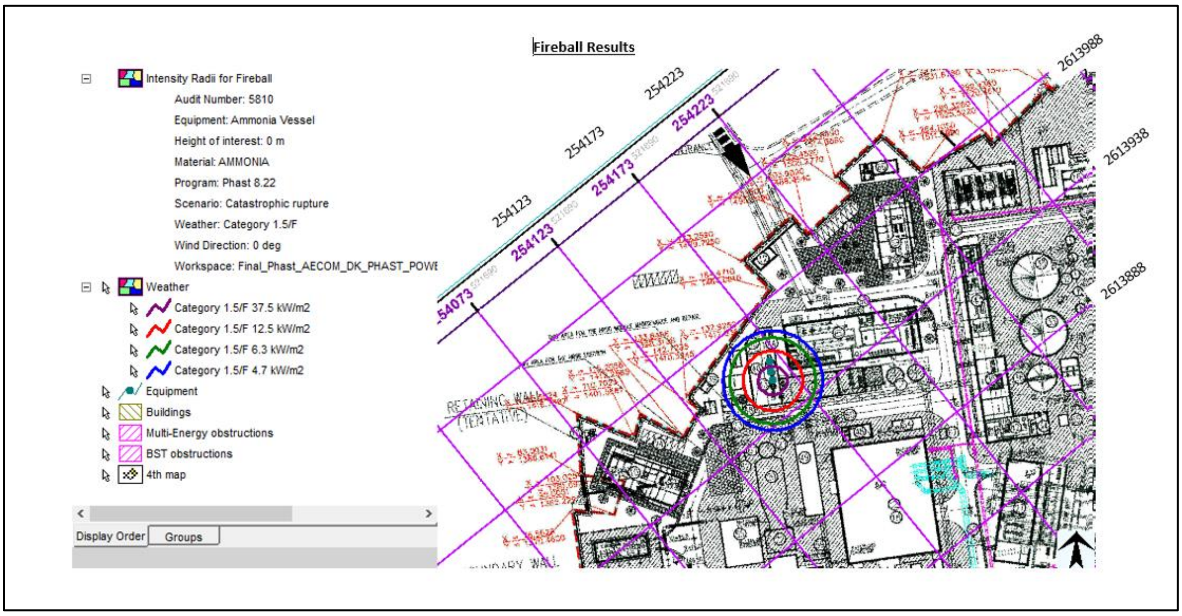


Figure 10.82: Fireball Scenario

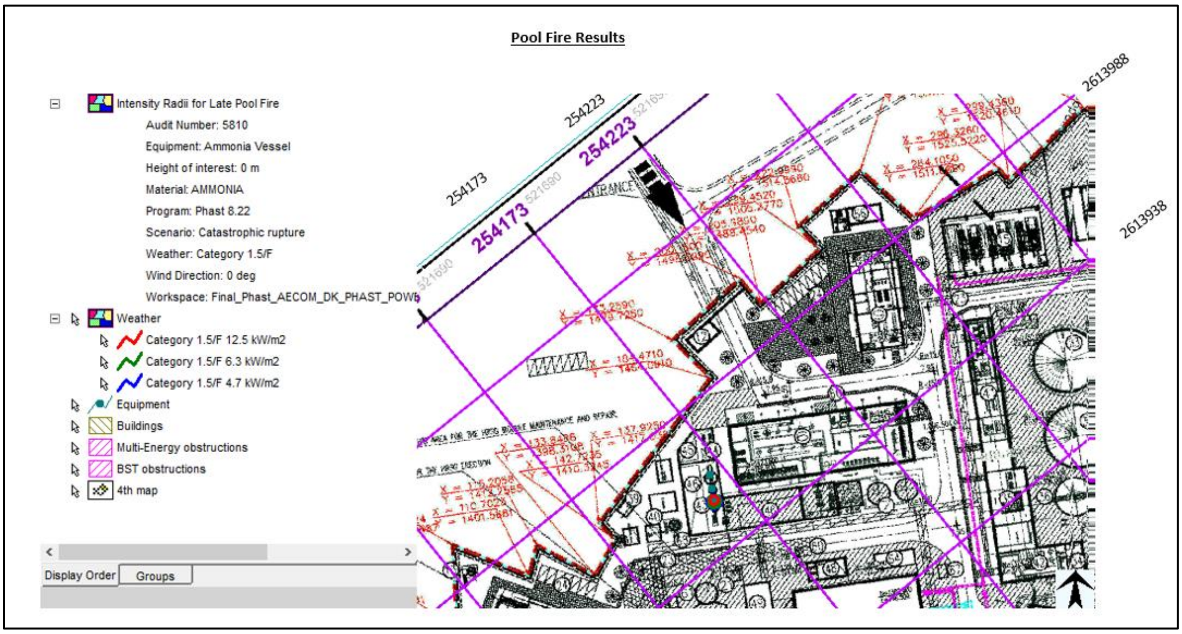


Figure 10.83: Pool fire Scenario

IS-11- Hydrazine Storage Vessel

Weather Class : 5/D

Leak size: Catastrophic Rupture

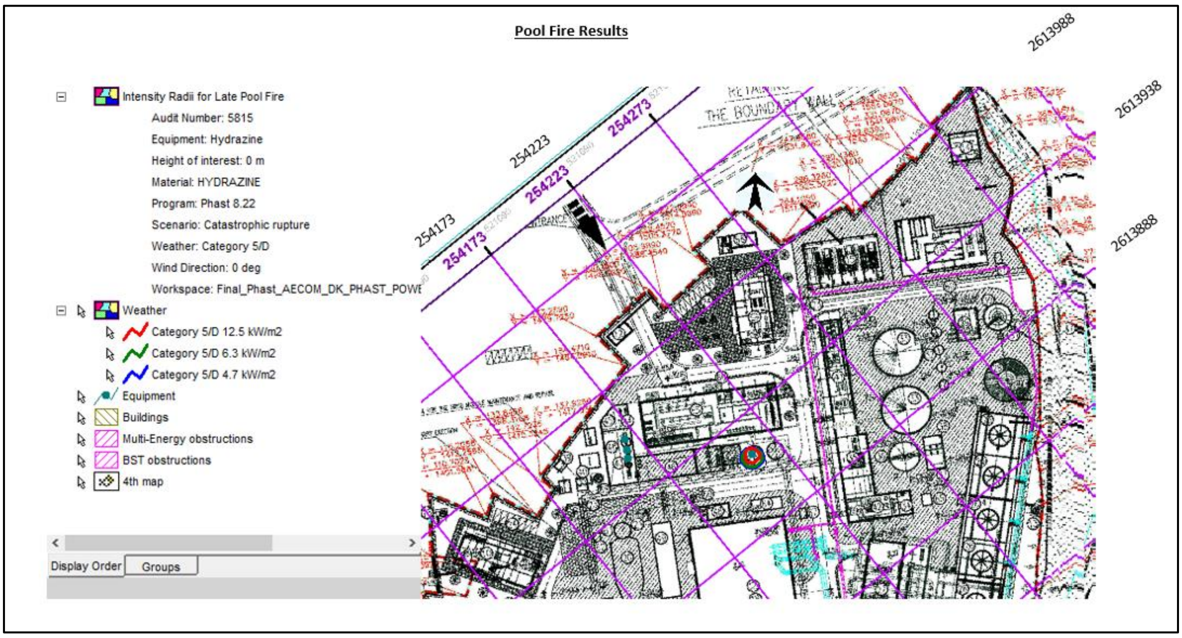


Figure 10.84: Pool fire Scenario

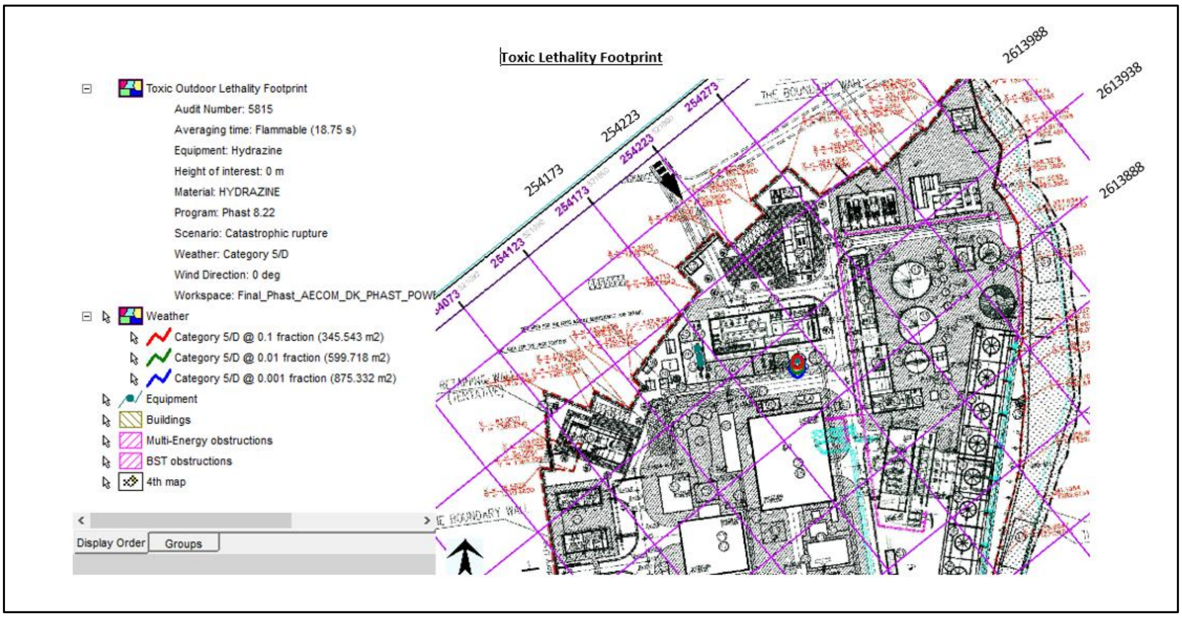


Figure 10.85: Toxic lethality footprint

Weather Class : 1.5/F

Figure 10.86: Pool fire scenario

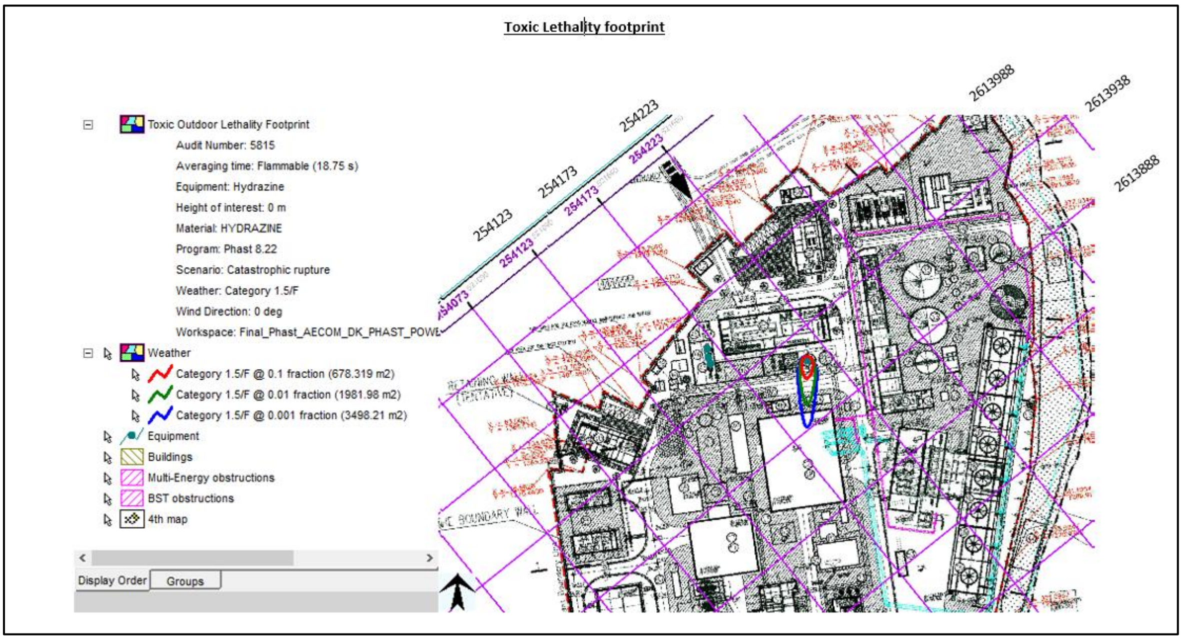


Figure 10.87: Toxic lethality foot print

IS-11- Chlorine Generation

Weather Class : 1.5/F

Leak size : Catastrophic Rupture

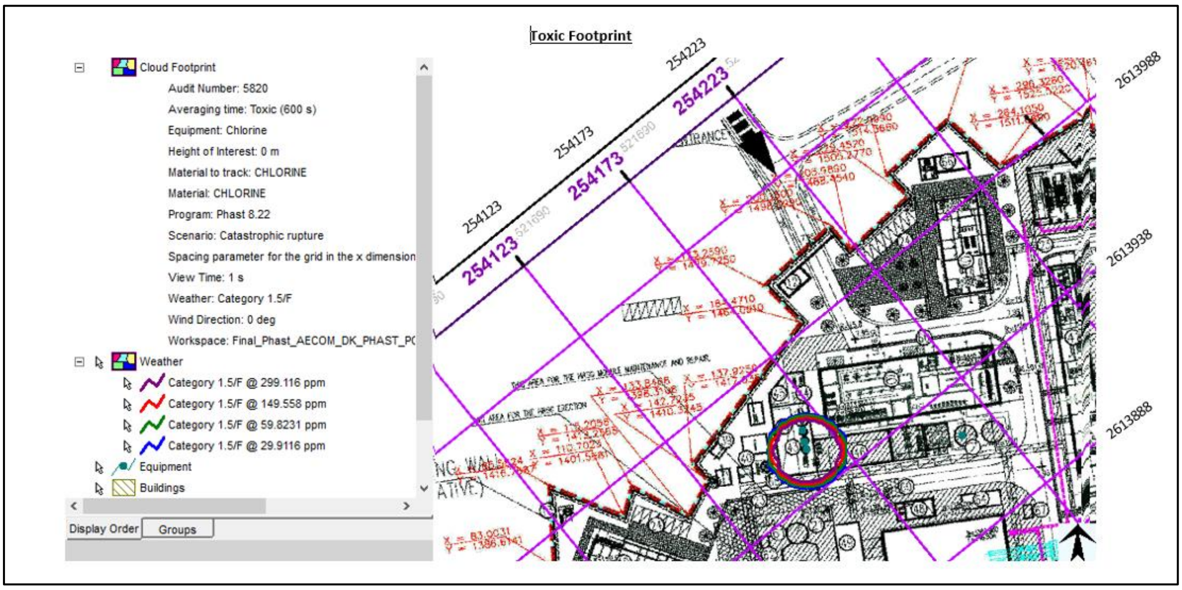


Figure 10.88: Toxic foot print

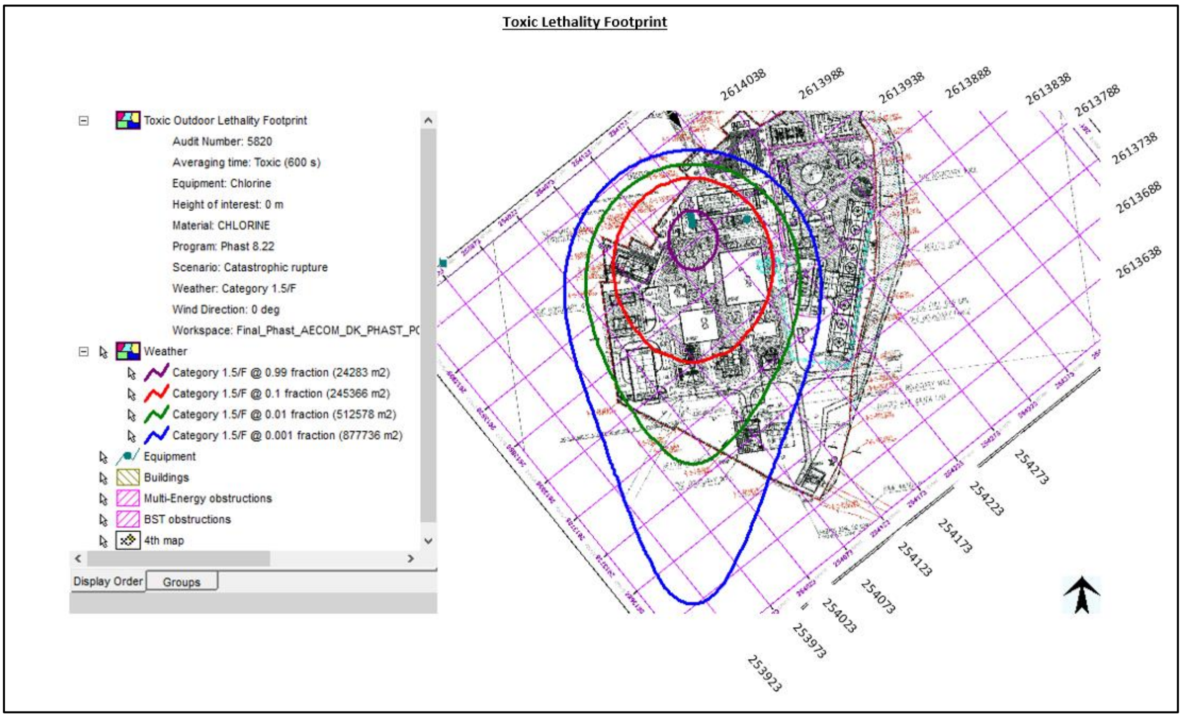


Figure 10.89: Toxic lethality foot print

Weather Class : 5/D

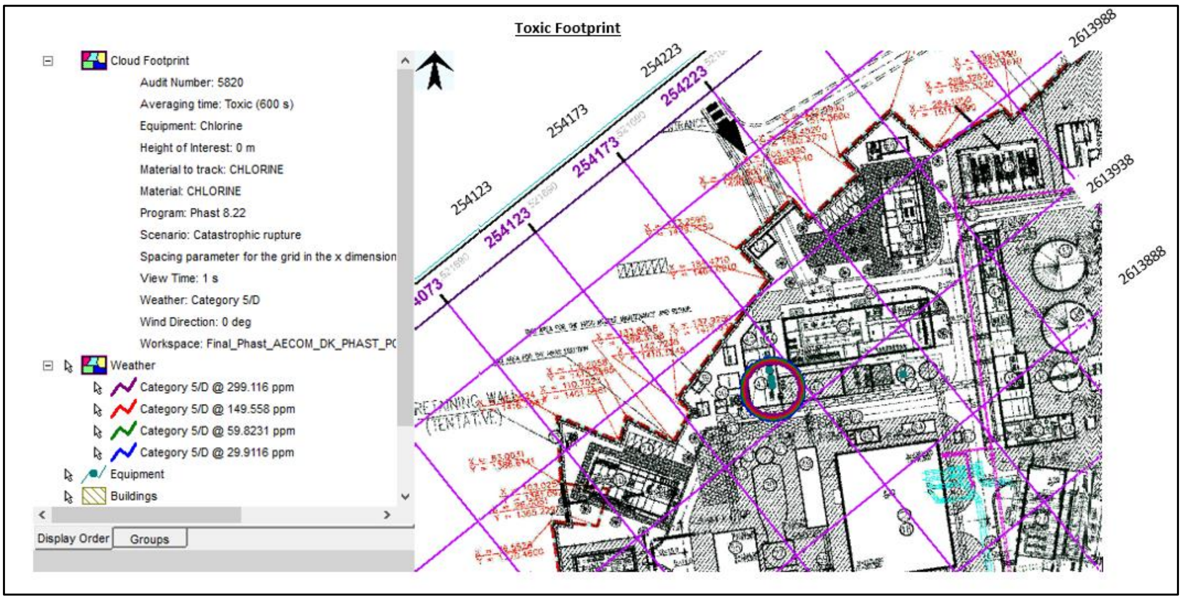


Figure 10.90: Toxic foot print

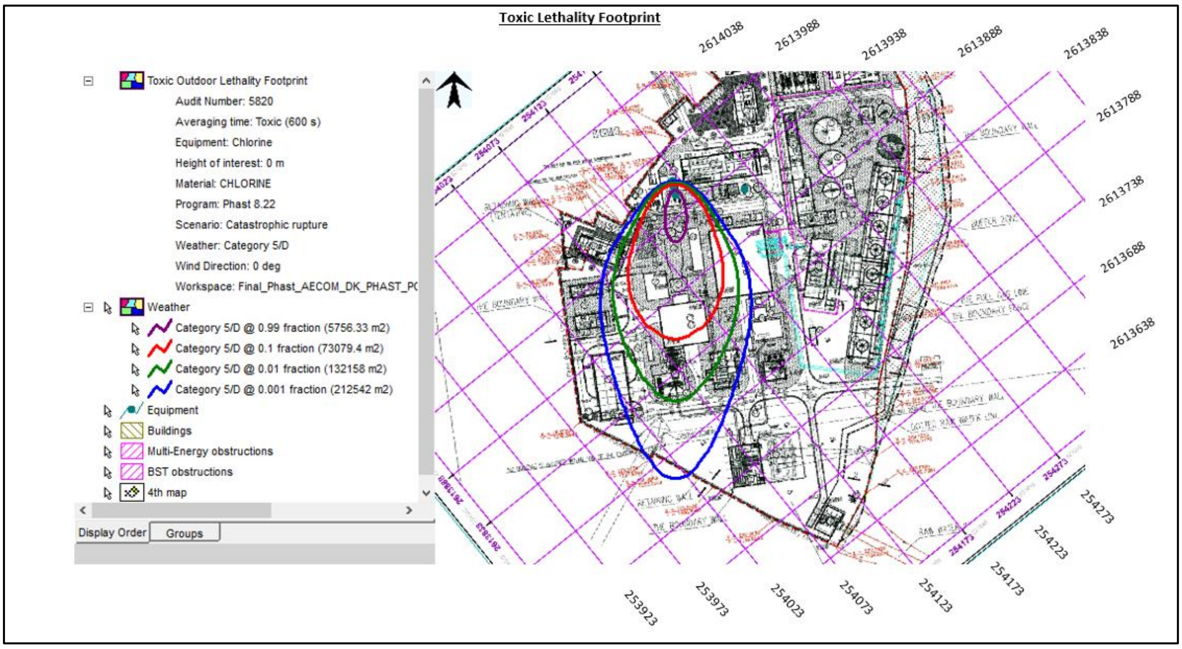


Figure 10.91: Toxic Lethality footprint

10.4 Risk Analysis and Risk Calculation

10.4.1 Failure Frequency Analysis

In this part of the study, the probability or frequency of occurrence of the incident is estimated. Any equipment has an inherent probability of failure, be it a pipe-work, flanges, or otherwise. This is possible despite the best design selection and fabrication to the highest quality. It is important to estimate these probabilities as risk combines probability with consequence distance.

The range of failure incidents in infinite ranging from a pinhole leak to a larger size leak and then to a catastrophic rupture. In QRA study, the procedure aims to categorize the various infinite failure possibilities into representative sets, which in total, cover the entire range of incidents anticipated and possible. Failure frequencies are derived from failure rate data bases. The generic failure rates data, upon which the study is based, are taken from the published databank source OGP Database September 2019. These databases reflect the worldwide experience of the oil & gas sector and are appropriate for the project in question.

10.4.2 Calculation of Location Specific Individual Risk, Individual Risk & Societal Risk

Societal Risk is representing the risk the project poses to society as a whole. The Societal Risk or Group risk (F-N) curves indicate the cumulative frequency (F) of (N) number of fatalities. Society is typically not willing to accept industrial installations that result in many fatalities, even with a low frequency rate!

Societal risk is used to describe multiple injury accidents/fatalities, or to describe risks to unnamed ‘Individuals’, which could include members of the public. Societal Risk is described through “F-N” Curves (Frequency vs. Fatalities listed in increasing order of magnitude where F denotes the Frequency of N or more fatalities per year; and N denotes the Number of fatalities). The derivation is given below:

Societal Risk = ∑ Frequency of hazard occurrence X Proportion of time person(s) are exposed X Number of people exposed X Vulnerability. The Combined F-N curves covering all scenarios for this project is provided in Figure 10.94.

The estimation of risks in the software is done through estimation of "risks" attributed to each failure case by determining the impact in terms of fatalities. In this step, the hazard or effect zone information, ignition source, population distribution, meteorological data and other relevant details are combined to determine risks.

In order to estimate risks (IR or SR), the number of fatalities for each incident outcome case is calculated and the frequencies of outcomes with equal fatalities summed up.

Location Specific Individual Risk (LSIR) is the risk for a hypothetical individual who is positioned at that location for 24 hours a day 365 day per year. Since in reality people do not remain continuously at one location, LSIR is a notional risk measure. The LSIR for the various locations are provided in Figure 10.95.

Individual Risk or IR represents the geographical distribution of risk to any individual - the time spent by any individual/Worker at a particular location.

10.4.3 Comparison to Risk Acceptance Criteria

Clearly almost all human endeavours entail some level of risk, so the acceptability of that risk must be balanced against the benefit derived. The most important factors which influence decisions on risk acceptability are:

- ***Economic benefit.*** Individuals or communities which receive direct economic benefit from a development through increased employment or income will be more tolerant of associated risk. Those who see no economic benefit are generally less tolerant of the development.
- ***Amenities.*** Individuals and communities are generally intolerant of developments that will be visually intrusive, noisy, smelly or pollution threats.
- ***Voluntary or Involuntary risk.*** Individuals who move into an area have generally made a decision to accept the existing risk, providing they can identify that the risk exists. Additional risk associated with new developments are usually considered involuntary risks that can only be avoided at great cost, such as by moving away from the area. Involuntary risk is much less acceptable than voluntary risk.
- ***Visible risk*** Where risk is concentrated in a local area. This can be contrasted with road accidents, or disease, where isolated individuals are affected and there is little concentration of risk on communities. Generally, society will expend greater efforts to reduce the visible risks despite the fact that more lives are lost by other causes.
- This penultimate step compares the estimated risk with respect to the Company's internal risk acceptability criteria or specific legislative or regulatory (as applicable in the country of operation) risk acceptability criteria. In this step, the risk "band" is determined- typically, the project risk band is determined to be negligible, acceptable, not acceptable are the risk assessment stage determines whether the risks are *"Broadly Acceptable", "Intolerable"* or "*Tolerable if ALARP"*.

10.4.4 Acceptability Criteria

Risk acceptability criteria are derived from interpretation of the risk acceptability criteria published by UK HSE-92 and is applied when assessing the tolerability of risk to persons for facilities, combined operations or activities. It broadly indicates as follows:

- Individual risk to any worker above 10^{-3} per annum would be considered intolerable for existing installation and above 10^{-4} for new installation and fundamental risk reduction improvements are required.
- Individual risk below 10^{-3} for but above 10^{-6} per annum for any worker would be considered tolerable if it can be demonstrated that the risks are As Low As Reasonably Practicable (ALARP).
- Individual risk below 10^{-6} per annum for any worker would be considered as broadly acceptable and no further improvements are considered necessary provided documented control measures are in place and maintained.
- Individual risk to any member of the general public as a result of Businesses activities would be considered as intolerable if greater than10^{-4} per annum, broadly acceptable if less than 10^{-6} per annum and would be reduced to As Low As Reasonably Practicable (ALARP) between these limits.
- For existing facilities, higher risk levels may be tolerated provided that they are As Low As Reasonably Practicable (ALARP) and meet the minimum standards given herein. The risk acceptability criteria are indicated in the following pages.

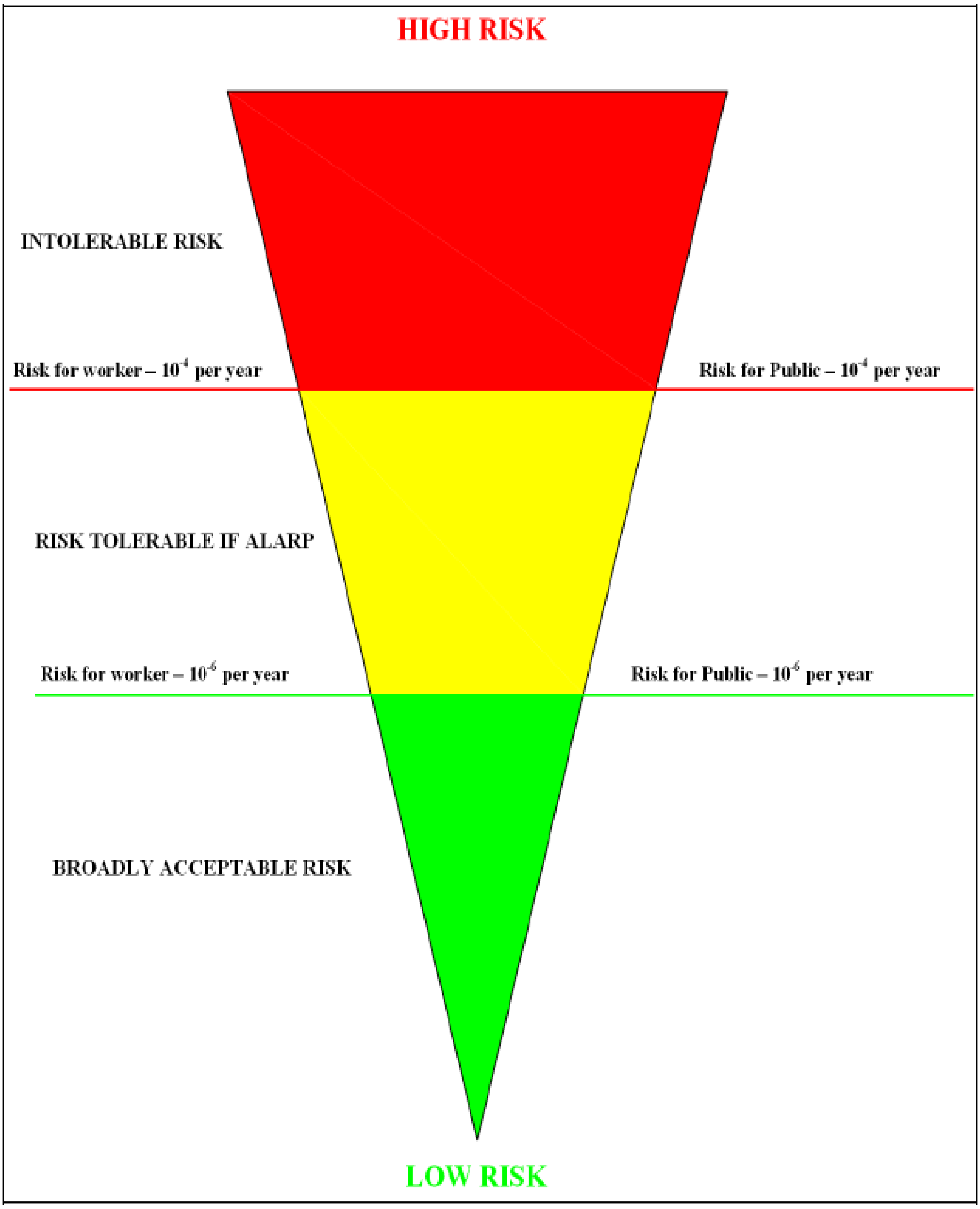


Figure 10.92 :UK HSE- Individual Risk Criteria

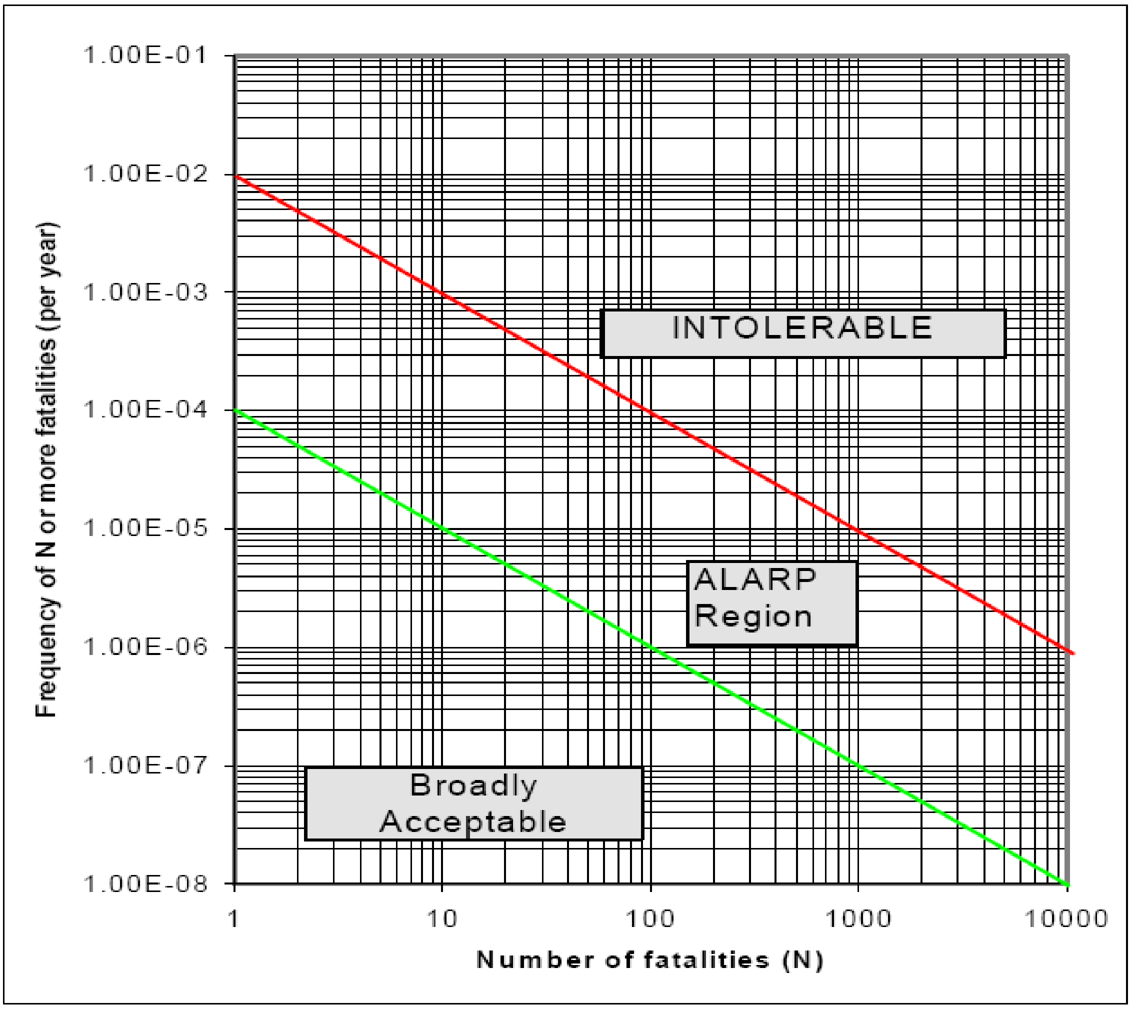


Figure 10.93: UK HSE Group Risk Criteria

The following values are acceptable in terms of the LSIR if meeting the following criteria:

- LSIR > 10^{-4} per year - No development
- 10^{-4}> LSIR > 10^{-5} per year - Process development
- 10^{-5}>LSIR > 10^{-6}per year - Control Room and Local Office development
- LSIR < 10^{-6}per year - Administration Building, Canteen, Accommodation etc. developments

(Source: QP-PHL-S-100)

In the land use planning document, the UK Health and Safety Executive suggest limits for exposure to a dangerous dose for the public. A more stringent acceptable risk criteria is suggested for more vulnerable populations, such as schools, homes for the elderly, caring institutions and long–stay hospitals. Some of these criteria are summarized as:

Upper limit: 10^{-5}/year Housing developments providing for more than about 25 people

Upper limit: 10^{-6}/year Housing developments providing for more than about 75 people

Lower limit: 10^{-6}/year Trivial for average populations if lower

Lower limit:3 x 10^{-7}/year Trivial for vulnerable populations if lower

These criteria are for those members of the public who are involuntarily subject to the risk. The UK-HSE has also suggested that the maximum tolerable level of risk to any member of the public from any large–scale industrial hazard should be 1 x 10^{-4}/year (one in 10,000 per annum).

10.4.5 ALARP Demonstration

Wherever risks are found to lie in the ALARP region, this suggests existing risk mitigating measures must be sustained and Best Industry Practices used. Any specific new risk reduction options may be evaluated through Cost Benefit Analysis (CBA) by the Company.

10.4.6 Risk Reduction Recommendations

This step analyses the risks estimated, their tolerability with respect to the risk acceptability criteria. The calculation of risk reduction includes ignition probabilities, along with ignition timing, number of population present within the plant, and also number of population present in the close proximity of the plant. All these are considered during preparation of F-N curve.

In case risks are found to fall in the "Unacceptable" region, risk reduction recommendations aimed at bringing risks to within the "Tolerable region if ALARP" are proposed. In such conditions, the Cost Benefit Analysis (CBA) is also carried out for specific risk reduction measures in order to "quantify" them or any other mitigative measures would be recommended.

In case risks have been found to be the ALARP or Broadly Acceptable region, recommendations may still be suggested for based on industry best practice. Such risk reduction recommendations are not "quantified" or mandatory but are proposed for safer operation of the facilities.

Ignition Probabilities

The ignition probabilities would be taken from the OGP Database (434-06).

Ignition timing

The time between the start of a hydrocarbon release and the time it ignites may be important for two reasons:

- Providing the release has been detected, the time until ignition influences the probability that workers can relocate to a safer area prior to ignition.
- The time has an influence on the size of a gas cloud or Pool Fire when it ignites and therefore the resulting consequences, particularly the explosion overpressure.

Ignition time for the modelling is considered 60 seconds. (Source: OGP Database 434-06)

The ignition probabilities selected for risk plot are provided in ***Table 10.14:***

Table 10.14: Ignition probabilities

S. No	Description	Ignition Probabilities
1	Rupture incidents – Process	0.05
2	Normal Flammable Gas incidents -Process	0.2
3	Adjacent Process Installations	0.5
4	High Voltage Electrical Supply	0.2
5	Motor Vehicle	0.4
6	Trains Near Railway Crossing	0.8
7	Office building	0.01

Weather class for the model run is considered as 5/D and 1.5/F, with average temperature of 27 degree centigrade. The manpower details in different facilities are provided in below ***Table 10.15:***

Table 10.15: Manpower details within the facility

S. No	Description	Manpower Details
1	Hydrogen Area	10
2	Control rooms	10
3	HSD tank area	5
4	Natural Gas area	5
5	Remaining Process/Plant Area	70

Any kind of hazard occurred in the plant could affect the nearby community, so during the model run the nearby communities has also been considered. The details of the nearby communities are resented in below Table 10.16:

Table 10.16: Man power details surrounding the facility

S. No	Name of Locations	Population
1	Kurbanpur	300
2	Dudhghata	400
3	Sardar para	450
4	Purbapara	600

10.4.7 Risk Analysis Results

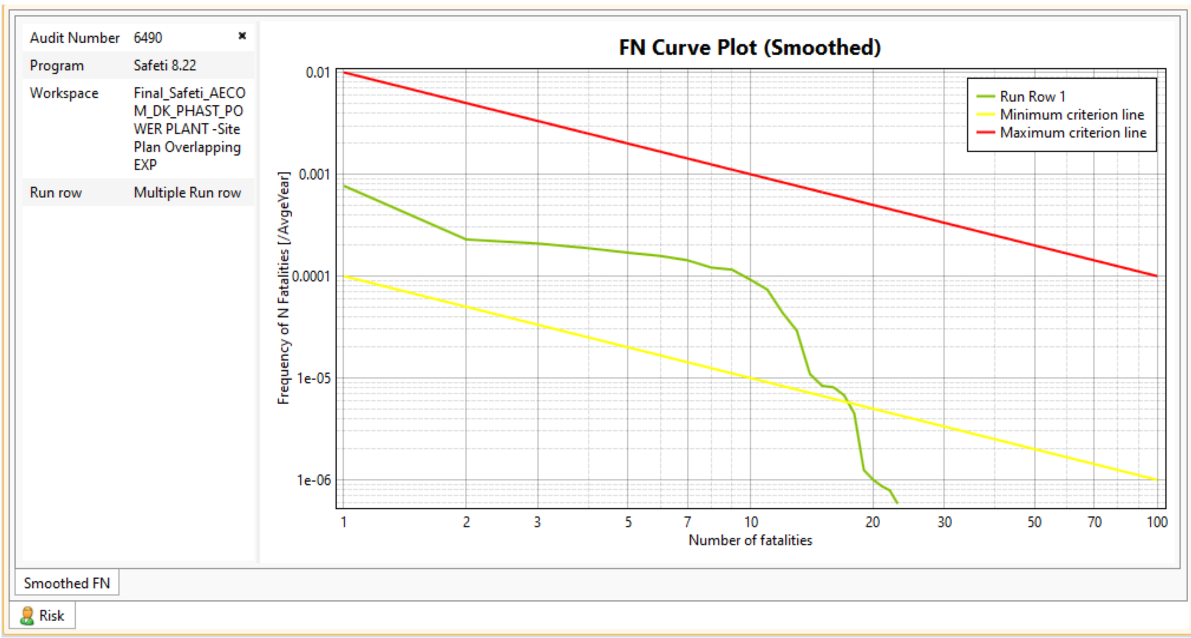


Figure 10.94: F-N Curve for the proposed project

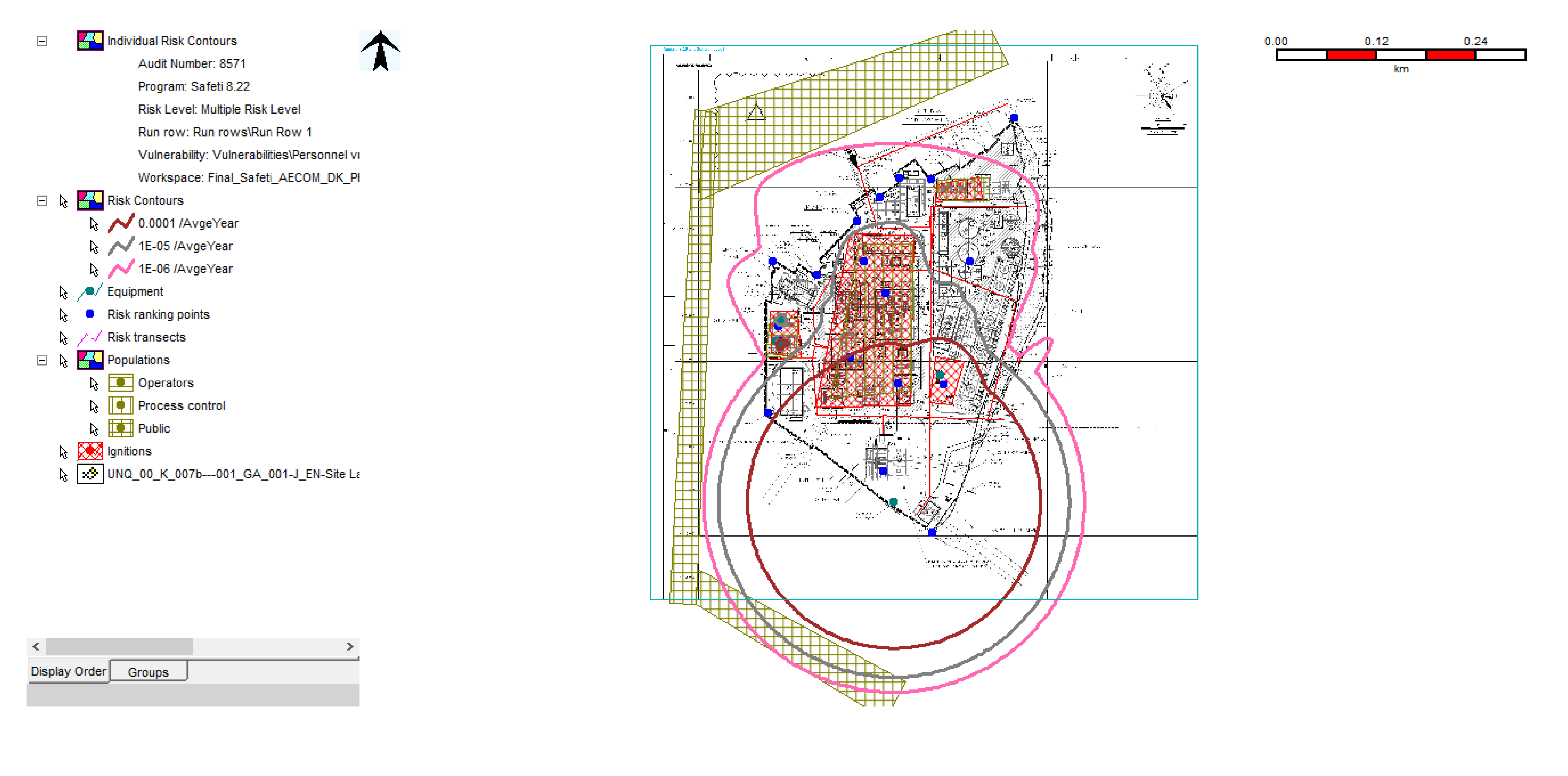


Figure 10.95 :Overall ISO-Risk Contour

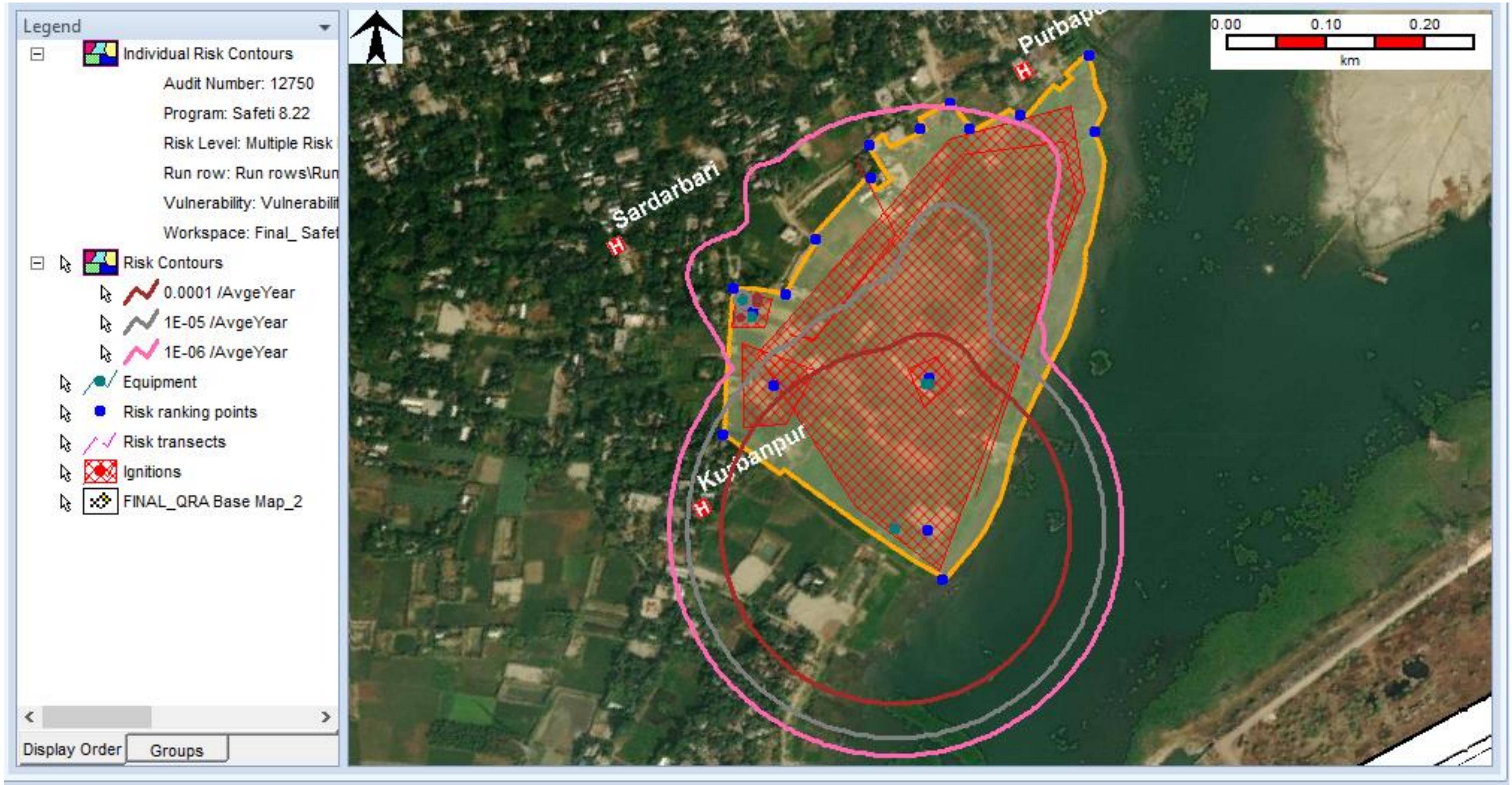


Figure 10.96. Overall risk contour on google map

The overall interpretation of the risk contour within the plant and the surrounding area, is presented in Table ***10.17***

Table 10.17: Risk categorization of the facility and the surrounding area

Plant area			Risk Frequency	Risk Ranking as per UK - HSE Criteria
S. No	Description	Manpower Details		
1	Hydrogen Area	10	1×10^{-6}	Tolerable risk
2	Control rooms	10	1×10^{-5}	Tolerable risk
3	HSD tank area	5	1×10^{-4}	Intolerable risk
4	Natural Gas area	5	1×10^{-4}	Intolerable risk
5	Remaining Process/Plant Area	70	1×10^{-6}	Tolerable risk
Locations outside the plant				
1	Kurbanpur (SW)	300	1×10^{-5} - 1×10^{-6}	Tolerable risk
2	Dudhghata (Close proximity)	400	1×10^{-4}	Intolerable risk
3	Sardar para (w)	450	Outside the risk zone	No risk
5	Purbapara (N)	600	Outside the risk zone	No Risk

10.4.8 Interpretation

Societal risk is defined as the relationship between frequency and the number of people suffering from a specified level of harm in a given population from the realisation of specified hazards [Jones, 1985]. Societal risk evaluation is concerned with estimation of the chances of more than one individual being harmed simultaneously by an incident. The likelihood of the primary event (an accident at a major hazard plant) is still a factor, but the consequences are assessed in terms of level of harm and the numbers affected (severity), to provide an idea of the scale of an accident in terms of numbers killed or harmed. Societal risk is dependent on the risks from the substances and processes located on a major hazard installation. A key factor in estimating societal risk is the population around the site, in particular its location and density. For example, the more (occupied) buildings in any particular area, the more people could be harmed by a toxic gas release passing through that area. For an installation with a population located in a specific compass direction, the chance of a toxic gas release would depend on the probability of drift in that direction. FN Curves relating the probability per year of causing N or more fatalities (F) to N. This is the complementary cumulative distribution function. Such curves may be used to express societal risk criteria and to describe the safety levels of particular facilities. F-N curves are constructed based on historical data (selected for various failure cases) in the form of number of landslides and related fatalities. They in fact represent current situation i.e. the situation we live now Higher slopes potentially mean that more stringent risk controls (requiring greater resources) may be applied to reduce risk in the region where the confidence in the risk estimate is likely the lowest; in other words, where the cumulative risk is dominated by single remote events rather than combinations of smaller events. From the above F-N Curve, it is observed that the integrated risks lie within the “ALARP” range. -this suggests existing risk mitigating measures must be sustained and Best Industry Practices ensured. Any additional major risk reduction options, in case being considered, may be evaluated through Cost Benefit Analysis (CBA).

It is observed that the maximum risk level lies in 1e-004 and the minimum risk lies 1e-006/Avg year. The project lies within the Location Specific Individual Risk (LSIR) acceptance criteria and may not pose an intolerable risk. In addition, land-use planning would be ensured in future expansion.

10.5 RECOMMENDATIONS

The following recommendations are suggested based on the Risk assessment:

- From the above F-N Curve, it is observed that the integrated risks lie within the "ALARP" range. -this suggests existing risk mitigating measures must be sustained and Best Industry Practices ensured. Any additional major risk reduction options, in case being considered, may be evaluated through Cost Benefit Analysis (CBA).
- It is observed that the maximum risk level lies in 1E-004 and the minimum risk lies 1e-006/Avg year for the project. In addition, land-use planning would be ensured in future expansion.
- The indicated damage distances for jet fire scenarios would be safeguarded against through proper fire protection means, including both extinguishments, cooling of adjacent/ impacted assets etc. for this purpose, proper firefighting training is essential. Preventing a small fire from escalating into an explosion through appropriate vessel/pipe/equipment cooling by water spray and isolation of leak source with PPE must be practiced and persons working in the area be made aware of.
- For Jet fire scenarios, small leaks may be safeguarded against through proper fire protection means (Fire and gas Detectors, Passive and Active firefighting systems, structural fire proofing, sprinklers, monitors, hydrants etc). Proper firefighting system design and implementation and fire drills, training etc. are essential and must be sustained through the project life cycle.
- The damage distance arises due to the Flash Fire mitigated by ensuring the that the area must be kept free of ignition sources to the extent possible and the same must be ensured even during maintenance activity. Non-sparking tools must be used and personnel entering the area must be "de-earthed" before entering. A hazardous area classification study is suggested for placement of electrical equipment in the classified area.
- The damage distance for pool fire arising due the pool fire for small leaks would be safeguarded against through proper fire protection means (Fire and gas Detectors, Passive and Active firefighting systems, structural fire proofing, sprinklers, monitors, hydrants etc. Proper firefighting system design and implementation and fire drills, training etc. are essential and must be sustained through the project life cycle.
- All maintenance work on electrical equipment should be undertaken under the control of a permit or an equivalent safety management system, with procedures that ensure electrical and mechanical isolations are effectively managed. The use of mechanical lock-off devices and safety tags is strongly recommended.
- The correct installation of Safety Critical Equipment (SCE) and their operational reliability are essential for the safety of the facility. In addition, initial and periodic testing of the SCE before installation and periodically is essential and the same must be ensured. Items covered as SCE could include firefighting pumps, hydrants, monitors, foam systems etc. These must be kept functional at ALL times through proper maintenance, spare parts management etc.
- Key non-routine activities must be preceded by a Job Safety Analysis and Job or Task Risk Assessment involving key personnel that would be working on the facility.
- Work Permit System must be implemented during the construction and operational phases of the project to safeguard against any accidents. It must subsequently also cover the operational phase.
- Trips and falls hazard, electrical hazards etc. must be minimized through periodic safety audits and site inspections using third party and Internal audit teams. Actions arising out of the audits must be implemented in a time bound manner and followed up for closure.
- It has been observed form the overall risk contour diagram, that the natural gas section falls in to the most vulnerable criteria of risk, for this extra precaution needs to be taken for this section. In case of fire the site should be equipped to shut down the main source of natural gas. The plant also needs to display precautionary boards along the route of the natural gas pipeline and at closer interval in the immediate neighbourhood at the southern part of the plant. The site also needs to ensure to provide proper firefighting training to the plant personnel and conduct awareness campaigns outside the plant in the vulnerable neighbourhood on the impacts due to an event and safety measures to be undertaken. It is imperative that release scenario is informed to the neighbourhood through hooters so that immediate safety actions may be adopted.
- UMPL must ensure suitable training to all personnel (Company as well as Contractor personnel) to help prevent incidents/ accidents- such training must be refreshed periodically, and a list of trained personnel must be maintained by UMPL,

- Unloading procedure must be available and subject to Hazard Identification/ Risk Assessment.
- Periodic maintenance of the GDs and FDs to be ensured and these must be fully functional at all times.
- Flame proof integrity of electrical fittings (lights, flame proof start/stop switches) must be ensured. Hazardous Area Classification must be conducted during engineering and only classified equipment used in specific hazardous zones.
- Population clusters is present nearby the facility and offsite populations likely to be affected by a major site incident. - the areas require special attention and drills, education campaigns and caution notices over and above engineering measures would be undertaken.
- Ensuring that the public in vicinity of the facility is made aware of the hazards associated with natural gas/ Hydrogen and also the hazards of unplanned and irregular third-party activities. This may be done through frequent safety awareness programmes, warning signage, explicit display of Do's and Don'ts etc.
- Emergency procedures should be well rehearsed, and state of readiness maintained. This should be done by ensuring that the Disaster Management Plan is in tune with the risk analysis and that regular Mock drills are held regularly with diversity of scenarios.
- Small leaks could occur frequently in routine operations and should be attended on priority.
- Routine patrolling would be ensured to ensure against any unlawful third-party activity and suitable action taken when any encroachment/ unlawful activity identified.
- Cathodic Protection robustness must be ensured through regular PSP monitoring and any defects taken up on priority. Proper records would be maintained as necessary.
- Any TCP (Temporary Cathodic Protection) would be monitored during the construction phase and replaced with PCP (Permanent Cathodic Protection) once the pipeline is operational. TCP would not be used beyond its design life; even in case pipeline construction delays take place.
- UMPL must ensure all the HAZID, and HAZOP recommendations are implemented.
- he Hydrogen generation and Storage facility is presently sited on edge of the boundary and scenarios may impact the vulnerability to the local community outside the plant. It may be relocated or suitable measures like installation of hydrogen gas analyser, construction of a proper bunding wall may be considered.
- Minimum distance between the two units would be maintained to prevent domino effect within the plant.
- Vulnerable points such as water body/ river crossings etc. must be closely monitored for exposure, scouring activity of sediments etc.- PSP across both sides, casing condition etc. must be closely monitored and trends identified.

11 Emergency Management Plan and Disaster Management Plan

Emergency response plan and disaster impact assessment has been formulated based on the outcome of the Environmental Impact Assessment based on detailed design. The Emergency Management Plan is a generic document based on which more tangible and detailed contents would be described on the final detailed project report/design.

11.1 Disaster Management

Disaster is an unexpected natural and man-made event that may occur due to sudden failure of the system, external threats, internal disturbances, and natural calamities like earthquakes, fire, and accidents during any phase of the project. The first step of Disaster Management is to identify the causes which develop/ pose an unexpected danger to the proposed project including Power Plant, natural gas pipeline, and jetty. The potential causes are natural or man-made events, failure, and malfunctioning of monitoring instruments, accidents, etc. It is to be noted that this Disaster Management Plan (DMP) provides only an overview of the disasters and methods of dealing with the disasters at a basic level of project configuration of UMPL. Every establishment (industrial, commercial or residential) that comes up in the Meghnaghat area would develop their emergency response plans or disaster management plans.

11.1.1 Preventive Action

Once the potential likelihood of a disaster is identified or suspected, actions need to be taken to prevent the detrimental consequences of such disaster. Personnel trained and specialized in taking preventive measures to minimize the impact of any failure or disaster would initiate actions to prevent failures and ensure the safety of laborers, machinery, and other important components of the project.

11.1.2 Reporting Procedure

It is very important to define the threshold beyond which an event or a failure can be termed as a disaster, and the threshold for this needs to be disseminated to all the employees/labours associated with the proposed project. At a scale that is considered a disaster, the surveillance requirements would be increased both in frequency and details.

The Deputy Manager EHS would notify all the workers of the following information:

- Exit points in the plant and work zones,
- Assembly areas at site
- Nearest medical facilities
- Nearest Fire station; and
- Nearest Police station

11.1.3 Communication System

Formulation of an early and efficient communication system is a key and integral part of any successful disaster management plan. Early communication of any disaster not only reduces unplanned actions (which may prove even more detrimental) but also help plan prudent actions specific to the event or failure. This has to be worked out in consultation with local authorities. More often, the entire communication system gets disrupted when a disaster occurs. It is essential to identify the areas which are likely to be affected due to any disaster events.

11.1.4 Disaster Management Committee

To ensure formulation and implementation of emergency action, a Disaster Management Committee would be constituted. The district civil administrator (District Magistrate or Deputy Commissioner) would be the Chairman of this Committee. The core committee may comprise:

- Police Officer-in-charge of the area,
- Nearest Fire Brigade Representative.
- Non-Governmental Organization of the area.
- Nearest Medical Facility Representative (Hospitals, Nursing home, etc)
- Representative of local media.
- UMPL Management Representative.

The Disaster Management Committee would be responsible for preparation and implementation of site-specific evacuation plans and procedures in the event of any based on existing local set-up and infrastructure available, which would likely include the following:

- Identification and demarcation of the areas which are more vulnerable to any emergency scenario and need to be evacuated with utmost priorities,
- Identification and demarcation of safe areas or shelters, where disaster-affected people can be routed for safety during an emergency. This also comprises ascertaining the adequacy of infrastructure and transport to accommodate disaster-affected people.
- Identification and demarcation of the best possible and safe evacuation route(s) for movement of people from disaster-affected areas to nearest safe shelter.
- Formation of a Disaster Management team and delineate functions and responsibilities of all the members of the Disaster Management team.
- Setting up an emergency control room to monitor the actions, their effectiveness, formulate alternate plans, and measure their effectiveness

All personnel involved in the Disaster Management Plan would be thoroughly familiar with all the elements of the plan and their responsibilities. They would be trained through drills for the Emergency Action as part of the Disaster Management Plan. The staff at the site would be trained for problem detection, evaluation, and emergency remedial measures.

Disaster Management Planning would also be done for the construction phase of the project. Disaster Management Planning during the construction stage would involve the following major steps:

- Identification of hazardous events is required to assess the potential emergency scenario that may arise during the construction phase. It would be followed by creating a disaster preparedness checklist to help in formulating the emergency response plan.
- An emergency response plan would identify personnel responsible for the specific task in emergency preparedness & disaster management during the construction stage. It would also involve evacuation procedure, emergency contact, and a flowchart showing the hierarchy of actions & flow of communication in case of an emergency. The flowchart depicting Do’s and Don’t’s would be displayed at strategic locations in the construction phase within the site.
- All employees, contractors, sub-contractors, and labourers would be briefed on the disaster preparedness plan, including evacuation procedures, emergency contacts, and the use of emergency equipment. Regular drills on disaster preparedness & emergency response must be arranged to educate employees about potential disasters and the protocols that should be followed when they occur to ensure the preparedness of all the employees on site. With regards to site infrastructure, it is proposed to have a central command post where all lines of communication and decision-making can be referred to in case of a disaster. The command post would be equipped with adequate communications equipment as well as reference materials that are essential in addressing the emergency. These include the emergency plan, site layouts and blueprints, a list of employees and their contact information, and backup power. It is proposed to assign onsite personnel of UMPL of EHS as the primary point of contact in the event of an emergency. He would be responsible for commencing the procedure of deployment of an Emergency plan in case of any emergency during the construction phase of the project

It is also essential to sensitize the public on the events which may be termed as Disaster and the importance of disaster mitigation plan and procedures in the event of an emergency. It is also essential to communicate by whom and how a declared emergency would be terminated. There would be proper notification to the public on de-alert signals regarding termination of the emergency. The notification would be clear so that the evacuees know precisely what to do when re-entering or approaching the affected areas.

The Emergency Control Centre (ECC) would be formulated in case of emergencies by the Disaster Management Committee. The ECC would be chaired by the head of UMPL and would have representatives from Police, Fire Department, Hospitals, Factory Inspectorate, and District Administration. The interaction matrix between ECC and other departments has been presented in ***Figure 11.1.***

The ECC would perform the following functions:

- Co-ordinate the acquisition, distribution, and scheduling of various modes of transport for transporting persons and/or supplies, as required.
- Determine if additional transport is required for evacuation or transport of persons and/or supplies;
- Discontinue utilities or services provided by public or private concerns without reference to any consumers in the region, or when the continuation of such utilities or services constitutes a hazard to public safety within an emergency area.
- Disperse people not directly connected with the operations who by their presence are considered to be in danger or whose presence hinders in any way the efficient functioning of emergency operations.
- Authorize the evacuation of those buildings or sections within an emergency area which are themselves considered to be dangerous or in which the occupants are considered to be in danger from some other source.
- Authorize casualty collection and evacuation in support of emergency health care authorities;
- Coordinate with other departments such as Police, Fire Department, etc.
- Arrange for services and equipment from local agencies;
- Arrange for accommodation and welfare, temporarily, of any residents who require assistance due to displacement as a result of the emergency.
- Arrange assistance from senior levels of Government as per requirements.

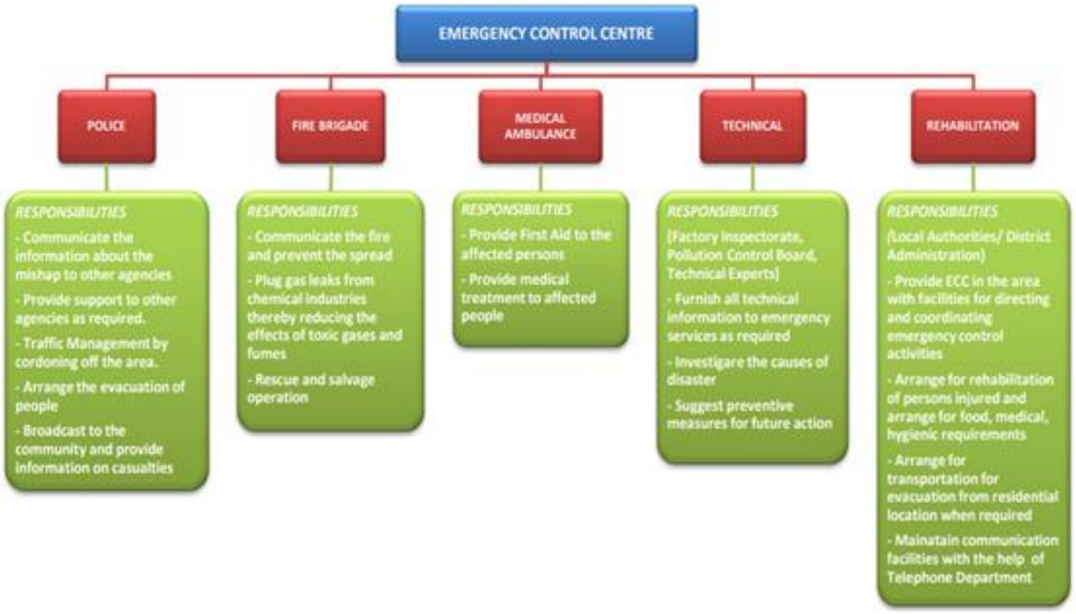


Figure 11.1: Emergency Control Centre

11.1.5 Disaster Tracking Unit

The key role of this unit would be to keep track of all foreseeable natural hazards such as floods, earthquakes, cyclones, etc. The unit would continuously coordinate with the Local/Regional Meteorological Department in Dhaka/Narayanganj, Bangladesh to identify any early disaster warnings and weather conditions in the region. On account of any extreme event predictions, the unit would communicate the same to the Disaster/Emergency Response Team which would issue warnings in the entire area.

11.2 Emergency Measures

The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape, ventilation shafts, etc. Emergency Action Plan aims to identify areas, population, and structures likely to be affected due to a catastrophic event of an accident. The action plan would also include preventive action, notification, warning procedures, and coordination among various relief authorities. These are discussed in the following sections.

11.2.1 Fire Protection

The project construction materials would be of appropriate fire resistance standard. Wood would not be used for any purpose, excluding artificial wood products, which are flame resistant. The materials which have zero surface burning characteristics need to be used. The electrical systems would be provided with automatic circuit breakers activated by the rise of current as well as activated by over current. The design of the project area would include provision for the following:

- Fire prevention measures,
- Fire control measures,
- Fire detection systems,
- Means of escape,
- Approach for fireman, and
- Means of firefighting.

A minimum of 30 minutes supply of water is to be assured in the case of fire. The pumps/overhead tanks would have the capacity to discharge the water at the rate of 1100 litres per minute at a head of 21 m at nozzle mouth. The storage capacity in an underground or overhead tank may be divided into two parts i.e. dead storage and running storage. Firefighting pumps would be provided with a diesel pump as a standby arrangement, in case of power failure. Fire of electrical origin, water cannot be used until the electric system has been made dead and earthen. For electrical fires, non-aqueous agents like ABC Power Choro Bromo Methane or CO_2 gas are utilized for firefighting. Fire extinguishers with these agents would be liberally provided at static installations and on the rolling stock. Generally, there are often more casualties from smoke inhalation than from burning. The smoke needs to be transported away from the site of the fire. Fire detection and alarm systems would be provided as per the prevailing state-of-the-art technology.

11.2.2 Fire Prevention and Safety Measures

Fire prevention measures would be designed and implemented to minimize the risk of an outbreak of fire by appropriate choice, location, and installation of various materials and equipment. In project area planning, potential sources of fire can be reduced by:

Fire Prevention

- Use of non-combustible or smoke retardant materials where possible,
- Rolling stock is provided with fire retarding materials, low smoke zero halogen type electric cable is also provided,
- Provision of layout which permits ease of maintenance for equipment and cleaning of the station premises,
- Prohibition of smoking in fire-prone areas,
- Provision of cigarette and litter bins, and
- Good housekeeping.

Safety

Following Provisions would be required from the fire safety point of view:

- Automatic sprinkler/detection system to be provided if floor area exceeds 750 sq. m.
- One wet riser-cum-down comer per 1000 sqm floor area with static underground storage tank, overhead tanks, and pumps of suitable capacity with hydrants, first-aid reel, etc.

- Portable fire non-aqueous extinguishers of Carbon di Oxide, chemical dry powder, etc. at suitable places.
- Automatic smoke venting facilities.
- Two separate means of exit would be provided if more than 10 persons are working and the area exceeds 1400 sq. m
- Fire resisting doors would be provided at appropriate places along the escape routes to prevent the spread of fire and smoke.
- The travel distance for fire escape would not exceed 20 m where escape is available in more than one direction; the distance could be up to 40 m.

11.2.3 Fire Alarm and Detection System

A complete fire detection system with equipment complying with the requirements of Bangladesh Fire service and Civil Defence would be provided to give a visual and audible indication of alarm conditions actuated by the operation of break glass contact or fire sensors e.g. detector heads, linear heat-detecting cables, etc. The system would be operated from 24 VDC Power sources. Alarm bells would be installed in each plant room complex and would be audible at all points in the room/area. A beam detector or heat detector would be installed at roof level, ceiling, and floor cavity. Smoke probe units would be installed in rooms/compartments. When an alarm point is operated, the fire pump would start to operate automatically. A fire station control and the indicating panel would be provided and installed in the project area controller's room, for the control indication and monitoring of the whole detection and firefighting systems. While designing the firefighting system, the zone of Bangladesh Fire Services and Civil Defence would be considered for linking with the same.

11.2.4 Ventilation Shafts

The Environmental Control system such as ventilation opening for closed rooms like a material storage room, office room, project operation room, etc., would be require ed. Depending upon the size of the room independent shafts are required for exhaust air, fresh air intake, and draft relief.

11.2.5 Emergency Door

Emergency doors in the office/building, work areas, and enclosed storage room would have provisions for emergency doors for evacuation of worker/labour in case of any emergency.

11.2.6 COVID Management Plan

UMPL has developed a "COVID- 19 Site Safety Plan" to protect the employees, partner, subcontractor, visitors and contract workers against risks to their health due to exposure to novel corona virus and further minimize the potential of transmitting the risk to other colleagues. This safety plan is likely to be utilized for site preparedness and implemented in conjunction with government and local regulatory guidelines.

General Precautionary Measures

- The general guidelines to reduce the general risk of transmission of acute respiratory infections include the following:
- Avoid close contact with people who are sick.
- Maintain good indoor ventilation.
- Avoid sharing of food, crockery, utensils, cups, cutlery, and other personal hygiene items.
- Frequent handwashing, especially after direct contact with ill people or their environment. When washing your hands, be sure to wash with soap and water for at least 20 seconds. If soap and water are not available, use an alcohol-based hand sanitizer.
- Avoid touching your eyes, nose, and mouth with unwashed hands.
- Avoid contact with Live animals including poultry and birds and consumption of raw and undercooked meats.
- Avoid crowded places and close contact with people who are unwell or showing symptoms of illness
- Sneezing and coughing would be done onto tissue paper which would be carefully disposed of in a rubbish/trash bin immediately.

- People with symptoms of acute respiratory infection would practice cough etiquette (maintain distance, cover coughs and sneezes with disposable tissues or clothing, and wash hands), wear a mask (N95 or surgical mask), leave the premise and seek appropriate medical advice and follow any government guidance/advisory.
- Wear N95 or surgical mask (as per Instructions from WHO)
- Cover all wounds or cuts on their hands with waterproof plasters.
- Practice good personal hygiene (e.g. after clean-up is carried out, after handling waste or other dirty items, and after visiting the toilet). Personal Hygiene would be reminded to all the staff during toolbox talk, shift meetings and other forums.
- Use disposable gloves, face masks, and rubber boots when carrying out cleaning work.
- Seek Medical Attention promptly if one is feeling unwell. Before you go to a doctor's office or emergency room, call ahead and tell them about your recent travel and your symptoms.
- Within healthcare facilities, enhance standard infection prevention and control practices in clinics & Quarantine Areas.
- Avoid handshakes when possible (Fest or elbow bump instead).
- When possible, measure your body temperature before leaving home, and if > 37.50C / 99.5F, stay home and seek medical advice.

Besides the general precautions issued by UMPL, they have also issued guidelines on the following:

- The right way of washing hands
- Washing hands for at least 30 seconds with soap and water
- Constant rubbing action helps soap break down the grease and dirt that carry germs and reducing germs count up to 99%.
- Precautionary measures towards Food Hygiene
- General Housekeeping/waste Management
- Pest Control Program

To ensure smooth deployment & execution of the COVID-19 Site Safety Plan, a task force has been formed. Site-entry screening protocol has also been developed which emphasizes Temperature checks as the key for establishing site preparedness. Two Tier approach monitor Temperature measurements.

- **Tier 1** – Screening before entering the premise – Site Medical Team, temperature measurement by Security Guards before entering the site.
- **Tier 2** - Daily monitoring of temperatures of all employees and contractors would be conducted at the site unless otherwise mandated by local government authorities.
  - Temperature screening would be conducted by trained personnel who can interpret the readings and would escalate the situation to the concerned medical team.
  - Face Masks, safety gloves, safety Glasses, Body Suits and hand sanitizers/soap would be used by the personnel taking temperature readings.
  - Usage of Non-contactable Infra-Red Thermometer recommended for measurement
  - If the temperature is >37.5° C / 99.5°F (or your local government's guidance), the person needs to be isolated and treated as a suspect case.
  - Contact tracing to be carried out for that personnel who are exposed to infected personnel but are not ill (Quarantine process)
  - Personal Hygiene to be strictly monitored as followed by all the staff during toolbox talk, shift meetings, and other forums.
  - Employees would report to their supervisor or see a doctor and stay away from colleagues if they are unwell during office hours.
  - All the employees/contractors/ visitors visiting the site would wear masks as a precautionary measure and in case the mask is not used, the same would be made available to distribute to all the

employees/contractors/ visitors visiting the site. The N95 mask is recommended and in the absence of N95, surgical masks can be utilized.

– Adequate quantity of hand sanitizer/handwash would be placed at multiple locations apart from restrooms, toilets, and cafeteria.

– Soap and Water are the preferred mode of cleaning and when not, practical hand sanitizer would be considered.

– Site Manager would ensure stock & track inventory of masks and disinfectant on a monthly basis.

12 Stakeholder Assessment and Disclosure

12.1 Stakeholder Assessment

Stakeholder consultations are important processes through which a two-way dialogue is created between the project proponents and the stakeholders. Stakeholders are persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively. They can comprise individuals, communities, social groups, organizations, etc.

By identifying and consulting all stakeholders, especially the poor and the vulnerable, it is essential to ensure that the project meets the need of all sections of the people. Stakeholder engagement is a continuous and inclusive process between a project proponent and those potentially impacted encompassing various activities and interactions over the entire life of the project.

12.1.1 Stakeholder Identification

The stakeholders in the project were identified based on their level of interest and influence over the project activities. The stakeholders were primarily divided into direct and indirect and further regrouped as internal and external. The types of stakeholders as per their level of interest and influence have been provided in ***Table 12.1*** below.

Table 12.1: Types of Stakeholders as per Their Interest Influence

Sr. No.	Types of Stakeholders	Stakeholders
1.	Direct Internal Stakeholders	• Unique Meghnaghat Power Limited (UMPL) • EPC Contractor • International Stakeholders such as Workers and Employee engaged directly and indirectly as part of EPC contract agreement
2.	Direct External Stakeholders	• Local Communities of Dudhghata Mouza including women group • Landowner including women • Land Dependent (Sharecropper, Agricultural Labour, Fisherman) • Hamdard Laboratories (Landowner of construction Camp Site) • Bangladesh Power Development Board, Govt. of Bangladesh • Pirojpur Union Parishad • Titas Gas Transmission and Distribution Company • Power Grid Corporation of Bangladesh (PGCB) • Department of Environment (DOE) • Bangladesh Inland Water Transport Authority • Multilateral Funding Agency
3.	Indirect External Stakeholders	• Opinion Leaders of Dudhghata Mouza • Department of Fisheries, Narayanganj • Sonargaon Upazila • District Authority, Narayanganj District • Bangladesh Industrial Development Authority (BIDA) • Local Government Engineering Department (LGED) • Local Media • Vendors • CBO and NGO • Other industry who are using the same resource e.g. Meghna River Water

The description of each stakeholder and their grouping into the various types have been provided below:

Direct Internal Stakeholders: Direct internal stakeholders comprise the project proponent, employees, and workers of the company including international workers, and EPC contractor who are involved in day-to-day activity. Direct internal stakeholders comprise of the following group/individual and entities:

- **Direct Employees:** At present, as the project is in the inception stage only a few employees are working on site. Once full-fledged construction of the project starts, it is envisaged that approximately 150 workers would be engaged in the project. During the operational period, approximately 100 skilled and semi-skilled would be engaged on site. The employees being direct stakeholders, their feedback is essential to foster and maintain the employee-management relationship.
- **EPC Contractor:** As the EPC contractor is engaged in the construction and commissioning of the plant on a turnkey basis, feedback of their employee and management is very important for the successful completion of the construction activity. This also include international workers and employee such as Chinese nationals engaged as part of the EPC for construction, operation and decommissioning of the project.

Direct External Stakeholders: Direct external stakeholders comprise the external bodies that have a direct stake in the project like landowner, land-dependent, Bangladesh Power Development Board, Titas Gas Transmission and Distribution Company, third-party contractors, and financial intermediary. These stakeholders directly affect the project activities and are not controlled by the project proponent.

- **Landowner:** The landowner of the Dudhgahta Mouza has been directly impacted by the project through land procurement.
- **Land Dependent:** Land dependent e.g. sharecropper, agricultural labour whose livelihoods are dependent on the tract of land proposed for plant construction, and land parcel proposed for construction camp are directly impacted by the project due to land procurement.
- **Fishermen:** As the project is located on the bank of the Meghna River Channel, the livelihood of the local fisherman community may be impacted due to approach restriction to the riverbank.
- **Local Community of Dudhghata Mouza:** The development of the project would add to the increase of vehicle movement and influx of workers from other areas which would, in turn, impact the local community to a considerable extent. Constant consultation and disclosure of information about the project activities need to be communicated to the local community so that transparency and support about the activities can be maintained with the local population.
- **Pirojpur Union Parishad:** The proposed site is located in Pirojpur Union Parishad. NOC from union Parishad has been obtained. Union Parishad may receive grievances from the local community and request for resolution of grievance raised by the community. Hence, they play a key role for avoiding any hindrances during the construction and operation of the plant.
- **Hamdard Laboratories:** Hamdard Laboratories is a company operated in Bangladesh whose land has been taken on temporary lease for three years for construction camp. Hence, they are considered as one of the key stakeholders for the project.
- **Bangladesh Power Development Board (BPDB):** Through the Power Purchase Agreement between UMPL and BPDB, UMPL would sell the power generated through the project to BPDB, hence, making it a key stakeholder.
- **Titas Gas Transmission and Distribution Company**: Through the Gas Supply Agreement between Titas and UPML. Titas would supply gas to UMPL during the project operation phase hence, Titas has a key role to play in the power plant operation.
- **Department of Environment (DOE):** Obtaining an environmental clearance certificate from the Department of Environment is in process and UMPL is bound to comply with the conditions as mentioned in the Environmental Clearance. The external reporting made to DOE (in case of any changes) and its observations would guide the implementation of the project activities.
- **Bangladesh Inland Water Transport Authority:** UMPL has received permission for water withdrawal, construction of water intake channel and jetties in Meghna Branch Channel. The permission has some conditions to be fulfilled by the UMPL.
- **Financial Intermediaries:** The financial intermediaries comprise financial institutions, in this case, AIIB, DEG IFC, and SCB who are undertaking the project financing. This stakeholder tends to be influential and has a set of guidelines, which UMPL would need to comply with. In addition to this, UMPL would have to comply with several undertakings made to the financial institution besides the set guidelines.

Indirect External Stakeholder: Indirect external stakeholders comprise those stakeholders whose interest even though are indirect they fall within the external group such as those involved in institutions or agencies concerned with managing the resource or those who depend at least partially on the business generated by the resource.

- **Local Opinion Leaders**: Opinion leaders like members of Pirojpur Union, Local Masjid Committee, religious leaders of the local Mosque(s), Dudhghata Primary School Teachers, and health officials fall within the category of opinion leaders. Being residents of the Dudhghata villages situated within the vicinity of the project site area, their opinions are valuable regarding the impacts and mitigation measures that would be applied to the different phases of the project.
- **Department of Fisheries, Narayanganj:** The withdrawal and discharge of water into the Meghna River is anticipated to have a no difference on the water temperature which would cause any potential significant impact. The department of fisheries in Narayanganj can play a significant role as an indirect external stakeholder. Being a monitoring agency actively working in the area because of the existing fishing activities, the department can be one of the first agencies to detect a change in the water temperature and its effect on the local fish population.
- **Local Government Engineering Department (LGED):** Village Road constructed and maintained by LGED would be used by UMPL as an approach road. LGED has a stake in the project and would be closely interacting with UMPL for proper utilization and maintenance of the road.
- **Sonargaon Upazila:** As the project is located in Sonargaon Upazila, they also have some indirect stake in the project in terms of land procurement, pollution, health, and safety, etc.
- **District Authority, Narayanganj District:** As the Narayanganj district authority has provided NOC to the project, they also have some stake in the project in terms of pollution, health and safety, etc.
- **Bangladesh Industrial Development Authority (BIDA):** As UMPL is registered in Bangladesh Industrial Development Authority, they also have a role in smooth and responsible operation on the plant.
- **Local Media:** Local media has a very important role to build a good face value of the project in front of the local people and other stakeholders which would help in plant construction and operation.
- **Other nearby Industries**: As Meghnaghat is an established industrial area, there are some resources like river water, waterways which would be shared between all the industry operating from this area. So good interrelationship between different industries is vital for the plant operation.
- **Vendors:** The vendors that would be engaged in the operational phase of the project would form a significant part of the project activities. The vendors would fall within the category of indirect external stakeholders as the crux of their function is to source raw material for the project.
- **Community-Based Organization or Non-Government Organization:** A total of 6 CBOs and NGOs are working in the vicinity of the UMPL power plant. These are
  - Kazirgao Faijuddin Ahmed Prodhan Pathagr
  - BRAC office (NGO)
  - Bureau Bangladesh (NGO)
  - Hossainpur Jonokollan Samiti (CBO)
  - Grameen Bank (NGO)
  - Asa (NGO)

However, as per discussion, their organization activity has limited interest in the project and project-related activity.

12.1.2 Stakeholder Analysis

Stakeholder analysis takes a more comprehensive view of the stakeholder’s group interests, how they would be affected and to what extent and influence they could have on the project. These aspects cumulatively provide the basis for constructing the stakeholder engagement strategy. Once different types of stakeholders have been identified and listed, matrices and other illustrative devices can be developed that map the nature of the stakeholder's interest in the project, the extent to which stakeholder interests converge or overlap, their importance in the different phases of the project activities and their influence over the project (as depicted in the power/interest grid).

The key stakeholders identified in the above section have been categorized into four major groups: Government Agencies, Positively Influenced Stakeholders, Critical to Engage, and Lenders. The categorization list of key stakeholders has been provided in the following ***Table 12.2.***

Table 12.2: Categorization of Stakeholders

Category	List of Stakeholders
Government Agency	• Bangladesh Power Development Board, Govt. of Bangladesh • Pirojpur Union Parishad • Titas Gas Transmission and Distribution Company • Power Grid Corporation of Bangladesh (PGCB) • Department of Environment (DOE) • Bangladesh Inland Water Transport Authority • Department of Fisheries, Narayanganj • Sonargaon Upazila • District Authority, Narayanganj District • Bangladesh Industrial Development Authority (BIDA) • Local Government Engineering Department (LGED)
Positively Influenced Stakeholders[58]	• Land Owner • Land Dependent • Local Community • Unique Meghnaghat Power Limited (UMPL) • EPC Contractor (Workers and Employee of foreign nationals) • Vendors
Critical to Engage[59]	• Political Leaders • Opinion Leaders • Local Media • Other Industry
Lenders	• AIIB, DEG, SCB

Having contemplated the stakeholders in terms of their interest matrix, the next step is to map the stakeholders as per their interest and influence as determined by the matrix. By using a power/interest grid, each stakeholder has been categorized in either of the four sections of meeting the requirement, important player, low significance and engage regularly. Below mentioned figure highlights the power/interest grid of the stakeholders identified.

As per the power/interest grid, the stakeholders who have a high interest in the project due to opportunities, benefits and risks involved have been categorized in the section of important players. The stakeholders which have a medium to high interest in the project have been categorized in the section of meeting the requirement while the stakeholder which has a low interest has been categorized in the low significance section. Those stakeholders wherein communication has to be regular have been categorized in the engage regularly section. Given ample amount of time during the different phases of the project cycle, the stakeholders who are in the meet the requirement section can be important players. Similarly, the stakeholder in the low significance can be shifted to the engage regularly section by the project proponent if a proper plan of stakeholder engagement and consultation is duly developed and implemented.

[58] *Positively Influenced Stakeholders - Stakeholders who were perceived to be directly or indirectly benefitted by the project*
[59] *Critical to Engage – Stakeholders whose views are important for the project; however engagement with them is difficult considering their availability and perceptions*

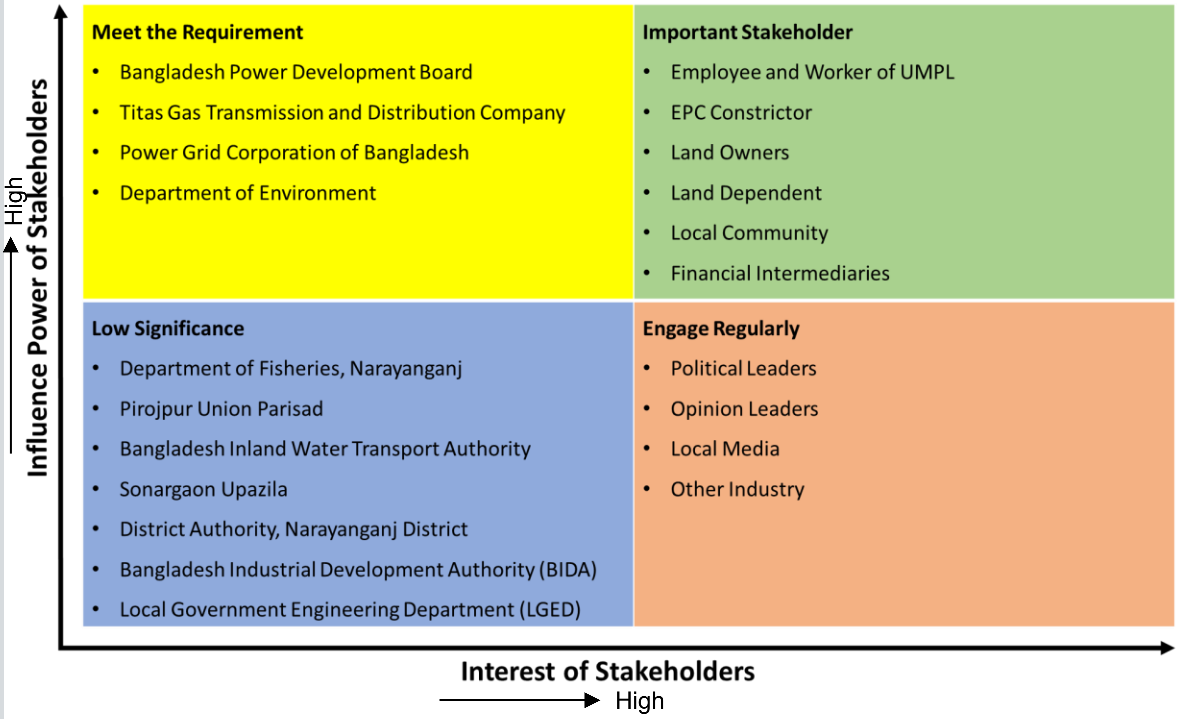


Figure 12.1. Power/Interest Matrix of Stakeholders Identified

To map the interest of the stakeholders in the project activities, a matrix showcasing the stakeholders and their interests has been developed. This step is to assess the interest/influence into high, medium, and low as well as to assess the power relationship, impact, support, and attitude of the various identified stakeholders. The interest matrix has been provided in ***Table 12.3*** below.

Table 12.3. Categorization of Stakeholders

Category	List of Stakeholders	Influence: Power to facilitate or impede project	Importance: Degree of priority needs and interests	Interest Level
Government Agency	Bangladesh Power Development Board, Govt. of Bangladesh	High	High	High
	Power Grid Corporation of Bangladesh (PGCB)	High	High	High
	Pirojpur Union Parishad	High	Medium	Medium
	Titas Gas Transmission and Distribution Company	High	High	High
	Department of Environment (DOE)	High	High	High
	Bangladesh Inland Water Transport Authority	High	Low	Low
	Department of Fisheries, Narayanganj	Low	Low	Low
	Sonargaon Upazila	Low	Low	Low
	District Authority, Narayanganj District	Low	Low	Low
	Bangladesh Industrial Development Authority (BIDA)	Low	Low	Low
	Local Government Engineering Department (LGED)	Low	Low	Low
Positively Influenced Stakeholders	Landowner	High	High	High
	Land Dependent	High	High	High
	Local Community	High	High	High
	Unique Meghnaghat Power Limited (UMPL)	High	High	High
	EPC Contractor	Low	Low	Low

Category	List of Stakeholders	Influence: Power to facilitate or impede project	Importance: Degree of priority needs and interests	Interest Level
	International Stakeholders such as Workers and Employee engaged directly and indirectly as part of EPC contract agreement	High	High	Medium
	Vendors	Low	Low	Low
Critical to Engage	Political Leaders	Medium	Medium	Medium
	Opinion Leaders	Medium	Medium	Medium
	Local Media	Medium	Medium	Medium
	Other Industry	Low	Low	Low
Lenders	AIIB, DEG, SCB	High	High	High

12.1.3 Stakeholders Consultation

Preliminary consultations were held with various stakeholders during the site visit by the AECOM Experts. The stakeholders comprised of a representative of landowners, local community, committee of local Mosque, opinion leaders. The details of the consultations held with various stakeholders have been provided in the following and transcript of the consultation indicating the date and location has been provided in **Appendix M**:

Consultation with Chairman of Pirojpur Union

Consolation was held with the Chairman of Pirojpur union during the site visit. He is very positive about the project and assured that he would extend his support to UMPL in the successful completion and operation of the project.

Consultation with Purbapara Jame Masjid Committee

Consultation was organised with Dudhghata Purbapara Jame Masjid. This masjid is located just outside the north-eastern boundary of the project. They are positive about the project and are expecting some CSR contribution from UMPL for the development of their Masjid. However, they are apprehensive of impacts like generation of dust, noise during construction and operation especially during prayers hours.

Consultation with Madhyapara Jame Masjid Committee

Consultation was carried out with Dudhghata Madhyapara Jame Masjid Committee during the site visit. This masjid is located 135 meters away from the main entrance gate of the proposed plant. As per consultation, this is the main old mosque of the Dudhghata Mouja. The current condition of the Mosque is poor considering its age-old structure. This mosque does not have a proper approach road. The Masjid committee are expecting support from the UMPL in the renovation work of the Mosque.

Consultation with Sub Register of Sonargaon Sub Register Land Office

The meeting was organized with the Sub Register of Sonargaon Sub Register office. He is a Govt official responsible for the registration of land which has been procured by UMPL. He confirmed that he had spoken to every landowner about the fair transaction of the land and the full final payment of the land price before land registration. He had also provided govt land price of Dudhghata Mouza and no land can be procured less than the government land rate. He also confirmed all the land procured by UMPL has been a fair transaction and no grievance has been recorded to date.

Consultation with Deed Writer Union of Sonargaon Sub Register Land office.

A consultation was carried out with the deed writer union on the actual land value of the Dudhghata Mouja. Since they are involved in the writing of the land deed of Sonargaon Sub Register Land office, hence they have a reasonable idea about the actual land price of the Dudhghata mouza. They confirmed the actual market price of the land is higher than the govt. stipulated rate.

Consultation with Land Aggregator and Landowner

Consultation was held with Mr. Rasid during the site visit. He is a land aggregator and he have land at the proposed site. He informed that as he is involved in land transaction business (buying and selling) in Dudhghata and other surrounding mouza. UMPL has contacted him during February 2019 to find out suitable land for their power plant on bank of Meghna river. He had identified the land parcel (currently identified as project site) and assisted UMPL in land negotiation with the landowners. He also confirmed that UMPL has provided land value as per the negotiated land price which is higher than the govt land price and equivalent or higher than the present market price of land.

Consultation with Dudhghata Primary School

The consultation was also carried out in the Dudhghata Primary School to understand the perception of the school community about the project and their expectations from UMPL. The school community is very positive about the project as they believe the project can improve the socio-economic condition of the village. Simultaneously, they are also warrying about pollution aspects mainly emission and noise generated by the project which may deteriorate the living condition of the village and safety of their children due to movement of heavy vehicle. As observed during the site visit, the primary school is a government school having all the requirements & provisions. However, the condition of the approach road of the School is very poor. The school committee also expressed their need for a school library.

Focus Group Discussion and Community Consultation

Focus group discussion was also carried out with landowners, Purbapara Jame Masjid Committee, Madhya Para Jame Masjid Committee, Dudhghata Primary School, land-dependent, farmer groups, river water users, women's group, fishermen group, youth group to understand the socio-economic condition of the study area. Photograph for FGD and Community Consultation is presented below. The transcript and attendance sheet of the FGD is attached in Appendix M.

Figure 12.2: FGD With Fisherman Group

Figure 12.3: FGD with Land Dependent and Farmer

Figure 12.4: FGD with Landowner and Masjid Committee

Figure 12.5: FGD with Female and River Water User

Figure 12.6: FGD with Youth Group

Major Outcome of Focus group Discussion

Village community

The community as a whole were positive about the project however they expressed concerns with regards to dust generated, noise pollution and drainage problem. They have requested UMPL to take necessary preventive measures regards their concerns. The local community also expressed interest in getting employment opportunities as created by UMPL during operations. This is viewed by the local youth and community would help the locals from migrating to other places for work especially provide an opportunity for those who are currently working overseas a chance to get employed in their village and hometown.

Landowner

Landowners, in general, are happy with the land price received for the land take. They are very much supportive of the project as the project would create employment opportunities for the local resident. They informed that several rounds of meetings were organized by UMPL before land procurement takes place. They also confirmed to have sold their land willingly, no compulsion or coercion activity has been done by UMPL during land procurement. Full and final payment of land price was paid by UMPL before the land registry.

Mosque Committee

There are two mosques Purbapara Jame Masjid and Madhyapara Jame Masjid adjacent to the proposed project area. The Purbapara Jame Masjid is located just outside the boundary wall of the project site whereas Madhyapara Jame Masjid is 500 meters away from the project site. In general, the committee members are positive about the project, however, both the Mosque committees are worried about the noise that would be generated from the plant especially during prayer time. Other issues -Purbapara Jame Masjid has water logging issues and is expecting a good periphery drain which would solve their existing water logging problem.

Madhyapara Jame Masjid committee demanded a 250 ft connecting road for the entrance of the mosque which is an emergency need.

Agriculture Land Dependent

Land dependents informed that they have been using this land for many years for agriculture purposes. Major crops grown in the region are Wheat, Potato, Tomato, Green chilis, and Paddy. Apart from agriculture, cattle rearing, fishing, and agricultural labour are the other secondary sources of livelihood. The agriculture-dependent community is positive about the project and is expecting local employment opportunities from the project.

Farmers Group

Agricultural production is the main occupation of the farmers group. The majority of the landowners carry out cultivation in their own land. Bargadari is also practiced in the area and reportedly some of the farmers have given the land to sharecroppers for cultivation. The sharecroppers share the crops with the landowners on the basis of a predetermined contract. Apart from agriculture, they are also engaged in seasonal fishing. Farmer also expects some job opportunity and village development work from the project.

River water User

Most of the community peoples use river water for daily uses as bathing and washing clothes. Though every household has tube well water for drinking & cooking purposes, for other domestic uses, they are dependent on river water. Prior to the project, people could easily access the riverfront, however, at present, there is no direct access to the river. They are expecting renovation of the existing ghat for easy access to the riverfront. They are also apprehending the pollution of river water due to the discharge of chemicals that would be generated from the project and other industrial discharges from the existing industries near the Meghnaghat area.

Women Group

Women in Dudhghata area are mostly engaged in household chores such as collecting firewood for domestic uses. Daily activities of women start between 6.00 AM to 7.00 AM, involve cooking and cleaning, collection of firewood, taking care of children, feeding the cattle and other livestock, etc. Besides household work, some of the women reported they assisted men in agriculture. Women mostly do not go out for work outside their village. About 70-80% of the female have completed primary level of education. Girls drop out in the area is very common. The major reason for girl’s dropout is majorly poor family economic condition and high cost of education. Girls drop out mostly after completing secondary education, post which they got married. The most common age of marriage for girls is between 19 to 20 yrs. As per consultation, there are no cases of domestic violence and rape reported in the project area. Women in the area are not involved in community-level decision-making activity. Most of the participants opined that gender-wise employment opportunities for males and family members would benefit the local community from jobs created by the project. The women also expressed interest in receiving vocational training like tailoring, boutique, animal husbandry, etc. The women groups also requested UMPL to renovate the existing river ghat for bathing.

Fisherman

The fisherman would travel up to 2 to 3 km downstream in the main Meghna river for fishing. “Faisha Jal” is reported to be the most commonly used nets. The most common fish species found are Ruhit, Chingri, Shing, Baim, Aair, Lida, Gojar. Reportedly, the most common catch by fishermen in the area is shrimp. In peak season the daily average catch is 2 to 2.5 KG whereas during the off-season is 1 to 1.5kg daily. The average income during a good catch is 2000-2500 BDT per day. The average income from fishing was reported to be very low during the offseason. About 250 boats (two members in one trawler) are used for fishing in the entire Dudhghata Mouja. About 70% boat is a motorized boat and 30% non-motorized. Of the 250 boats, 20 boats anchored in Purbapara ghat. As reported during the consultation, fisherman complains of water pollution through wastewater discharge from nearby industries. Apart from fishing activities, cattle farming, small-scale business can be potential alternative livelihood source for the local community. Details of stakeholder consultation is presented in Land Procurement Audit Report.

Consultation with Fishing Authority

Consultation was carried out with two Ichthyologist Dr. Mohammad Ashraful Alam, Chief Scientific Officer, Bangladesh Fisheries Research Institution, Riverine Station, Chandpur and Upazila Fishery Officer, Senior Upojilla Fishery Department, Sonargaon, Narayanganj, Bangladesh. The consultation was carried out between September-

October 2019 for ESIA and for CHA study October-November 2021. The main purpose of the discussion was to ascertain the distribution status of critically endangered, endangered, and vulnerable fish species reported from the Meghnaghat region. In addition, information regarding fishing activity, fishing methodology, types of fish gears, type of fish catch etc. Furthermore, AECOM team ascertain their view regarding presence of critical habitat, if any, for the reported fish species from Meghnaghat region. As per consultation, it has been confirmed that the Meghnaghat region does not harbour any significant number of critically endangered, endangered and vulnerable fish species for which critical habitat would be triggered.

Consultation with Bird Expert

Consultation was undertaken with Ornithologist, Mr. Sayam U. Chowdhury: Assistant Coordinator in Spoon-billed Sandpiper Task Force and Team leader in Bangladesh Raptor Research & Conservation Initiative; Former Consultant of IUCN Bangladesh. The main purpose of the consultation was to understand the presence of any migratory birds in and around the project site (1 km, 5km, 10 km), presence of any big birds like flamingo, crane, pelican, ibis and stork in and around site (1km, 5km, 10km). Information was also collected regarding presence of any migratory bird's congregation sites and its distance from project area. As per the consultation it was informed that there are no migratory birds congregation site present within 10 km from the project area.

12.1.4 Disclosure Requirement

In-accordance with the lender's guidelines, to maintain clarity and transparency in all project activities consultations and disclosures of project activities and plan documents at regular intervals become essential. The communication process needs to be done in the following manner –

- Disclosure of the ESIA content & mitigation measures to the PAPs in vernacular language, for their suggestions & query clarifications through public meeting organized by UMPL at Union level. Invitations to all the relevant stakeholders including PAPs would be circulated through newspaper publications, public address system present in local mosques and distribution of printed pamphlets & publishing notices of disclosure meeting at conspicuous locations
- ESIA is to be sent to Union Chairman and member for comments
- Final discussion with UMPL on the ESIA and incorporation of their suggestions & advises.
- Presentation of the final version of ESIA to the PAPs & local administration.
- Circulation of the Final ESIA to the lenders for comments and approval.

12.1.5 Public Disclosure for UMPL Project

The public disclosure process of UMPL in relation to ESIA and LRP was completed during the period March-May 2022 to explain key social and environmental risks, anticipated impacts & their mitigation measures for various stakeholders including Project Affected Households, fishermen and other community people. During the process, UMPL also received the concerns and feedbacks from the stakeholders. The key steps of the disclosure process followed by UMPL are given below.

1. AECOM submitted final version of ESIA and LRP on 26/03/2022.
2. ESIA Report uploaded in website on 27/03/2022 (https://umplbd.com/esia-lrp/) for disclosure followed by AIIB's web disclosure on 26/03/2022. Bengali translation of ESIA and LRP Executive Summary were subsequently uploaded on 28/04/2022.
3. Total 10 copies of ESIA, 500 copies of translated LRP Executive Summary and 500 copies of ESIA Executive Summary were printed for public distribution and copies of the documents were made available in UMPL Social Office at community, Union Parishad Office, Ward Members Office and UMPL site office. Also, UMPL placed notice banners in several public places regarding the availability of the documents along with contact address.
4. Public distribution started from 29/04/2022 and around 400 people received the documents, which include project landowners, land dependents, local community and fishermen group.
5. Focus Group Discussions (FGD) with the affected groups commenced from May 10, 2022 and ended on May 29 2022, where participants were briefed on key environmental & social findings of the ESIA Report. The feedbacks were received & responded. Total 14 FGDs were organized and AIIB E&S Consultants, UMPL Team participated in the FGDs. Minutes of the FGDs, photographs etc. were properly documented maintaining all the COVID-19 protocols.

12.1.5.1 Post Disclosure Consultation

Post disclosure consultations were organized as a continuous process for different stakeholders to understand their issues and concerns with respect to the project as well as the feedback on the safeguard documents submitted, including ESIA.

A total of 14 Focused Group Discussion were organized with different stakeholder groups, the details of which are given below:

Table 12.4. Demography of Stakeholder Consultations

Sl No	Type of Stakeholder	Number of Consultation
1	Male Landowners	5
2	Female Landowners	1
3	Fishermen Group	2
4	Displaced population	1
5	General community members (Male)	2
6	General community members (Female)	2
7	Sharecroppers	1

The major issues which emerged from the discussions can be summarized as follows:

- People did not have any clarity regarding their alternate livelihood options
- Many people were not aware of the Grievance Redressal Mechanism developed for the Project
- Improvement of infrastructure such as roads near the Plant area
- Issues related to waterlogging in the area adjacent to the plant
- Pollution of river water from the plants
- Issues related to increased traffic and over speeding of plant vehicles in settlement areas
- Concerns related to long term increase in noise level in the vicinity of the plant
- People wanted better understanding of the CSR and other development activities organized by UMPL

12.1.5.2 Details of Outcome of Consultation

The issues that emerged from the stakeholder consultation along with the response and actions taken by UMPL is provided in the matrix below. The minutes of the FGDs are presented in **Appendix W.**

Table 12.5. Details of Disclosure Consultations

Date	Group Type	No. of Participants	Location	Photographs	Major Issue discussed in FGD	UMPL's Response to Community	Status in ESIA
10/05/22	Male Landowner	14	UMPL Social Office, Dudhghata		**Translated ESIA & LRP** • Distributed the translated ESIA & LRP to participant and informed about web version. • Participants were unable to understand content of reports properly.	**Translated ESIA & LRP** • UMPL assured to explain the findings ESIA Report to interested parties in social office located near plant. • UMPL also encouraged landowners to discuss with local educated people & understand about reports findings .	
10/05/22	Female Landowner	14	UMPL Social Office, Dudhghata		**Livelihood Restoration** • PAFs were confused to select livelihood skill training • Few women participated in UMPL's sewing training program and looking for future support	**Livelihood Restoration** • UMPL replied that they will engage NGO to conduct vocational training based on Need assessment and LRP implementation. • UMPL will provide support to them based on their needs	**Livelihood Restoration** All the livelihood options identified from need assessment have been provided in the Livelihood Restoration Plan.
11/05/22	Male Landowner	16	UMPL Social Office, Dudhghata		**GRM** • All the community members were not aware about project GRM processes. • Locals requested to assist improvement of access road connection to residentials and village road.	**GRM** • Key personnel of UMPL briefed about entire GRM process to all the participants including communication process. • UMPL suggested to submit application on this matter to local authority.	**GRM** A full mechanism of the GRM along with the process of GRM disclosure has been provided in the ESIA Report
11/05/22	Female Community Member	14	UMPL Social Office, Dudhghata		**CSR** • Community was not aware about UMPL's CSR plan and implementation process. • Few people showed their interest to be under UMPL's monthly vulnerable group pension and asked for eligibility. • Participants requested to provide sand for Madhyapara Mosque Road. • Villagers asked for Gas connection from Titas gas connection as they will provide Gas to plant. • Fishing equipment including boat were stolen from the Ghat and fishermen requested for security at the Ghat.	**CSR** • UMPL will construct a Ghat on Meghna Branch Channel for use by the local community. UMPL will also facilitate community health services, tree plantation, education, drainage and supply of drinking water during project life cycle. • Already 52 Nos vulnerable family is under the pension scheme and will add more eligible candidates under the Monthly Vulnerable Group Pension. • UMPL ensured to provide sand under UMPL's CSR program. • UMPL informed that they are not authorized to provide Gas connection. But they will work for some alternative if possible. • UMPL recorded the incident and stated that they will look into the matter.	**CSR** All CSR activities identified along with budget as per the need assessment have been provided in the ESIA Report
12/05/22	Fishermen	20	UMPL Social Office, Dudhghata				
12/05/22	Male Community Member	14	UMPL Social Office, Dudhghata				
13/05/22	Community Member of Dudhghata Village	12	UMPL Social Office, Dudhghata		**Noise Generation** • Issues raised by villagers about higher level noise generation due to pilling work & plant construction activity. • Community groups is also concerned about noise generation during operational phase.	**Noise Generation** • UMPL replied that this is due to construction activity, and they will ensure that adequate measures would be taken to control the noise. • UMPL's assure that they have considered to use latest technology to control the noise during operational phase.	**Noise Generation** Noise level impact prediction and mitigation measures have been provided in the ESIA Report.
14/05/22	Male Landowner	15	UMPL Social Office, Dudhghata		**Air Pollution** • Participants intended to know about the Air pollution due to plant during operational period.	**Air Pollution** • UMPL has informed the community about less chances of air pollution during operational phase as latest design and technology have been	**Air and Dust Pollution** All mitigation measures for fugitive and gaseous emissions

Date	Group Type	No. of Participants	Location	Photographs	Major Issue discussed in FGD	UMPL's Response to Community	Status in ESIA
14/05/22	Land dependent/ sharecroppers	16	UMPL Social Office, Dudhghata		• Community informed that dust generation is increased in the locality due to vehicle movements and construction work.	used and along with that UMPL would maintain compliance with environmental laws & standards to prevent any pollution. Water spraying activity has already been undertaken by UMPL. UMPL requested community to contact with social officer of UMPL if they feel concerned.	have been addressed in the ESIA Report
15/05/22	Member from Resettled Household	9	Resettlement houses at Mongoler Gaon, Dudhghata and Korbanpur		**Water Logging** • Water logging is a major issue raised by local community and has requested to mitigate these issues.	**Water Logging** • There will be no water logging issues nearby plant area once construction is completed. UMPL's plant design has considered peripheral drainage network for diverting surface run-off from surroundings area to the river.	
16/05/22	Male Landowner	12	UMPL Social Office, Dudhghata		**Water Pollution** • Issue has been raised about migration of fish population in river due to discharge of polluted water from plants	**Water Pollution** • UMPL informed that they will treat the water before discharging it into river and they would also conduct adequate studies on aquatic resource and would adopt steps to protect aquatic resources.	
23/05/22	Male Landowner	16	UMPL Social Office, Dudhghata		**Traffic Management** • It has been noticed by community that Over speeding of vehicle on village road can create issues like accident, fugitive dust generation, etc in the locality.	**Traffic Management** • It has been informed to community that restrictions have been imposed on the drivers regarding speed limit and it is continuously under monitoring and also restricted night-time movement of vehicle.	
23/05/22	Fishermen	17	UMPL Social Office, Dudhghata		**Other Concerns** • Reported that, sand flows from the laydown area to adjoining agriculture land.	**Other Concerns** • UMPL is ready to scrape sands from that area after internal discussion	
29/05/22	Female group	13	UMPL Social Office, Dudhghata				

13 Grievance Redressal Mechanism

Grievance Redressal Mechanism (GRM) is an important criterion for development projects wherein ongoing risks and impacts of projects are probable. The GRM provides a way to reduce risks for projects, offer communities and workers an effective avenue for expressing concerns and achieving remedies and promote a mutually constructive relationship. It is an important tool through which the affected communities and workers' concerns, and complaints are registered and addressed. This mechanism is a significant pillar of the stakeholder engagement process as it creates opportunities for the project proponent and communities to identify problems and determine solutions together. The mechanism tends to meet the requirements of stakeholder engagement process, prevent and address community and workers concerns, reduce risk, and assist the processes that create positive social change. A well-functioning grievance mechanism contains the following elements:

- Provides a predictable, transparent, and credible process to all stakeholders, resulting in outcomes that are seen as fair, effective, and lasting.
- Builds trust as an integral component of broader community relations activities and between employees.
- Enables more systematic identification of emerging issues and trends, facilitating corrective action and community engagement.

The GRM prepared by AECOM has been developed with an intention of it being an effective tool for early identification, assessment, and resolution of complaints during project implementation. It is a means through which acceptance, assessment, and resolution of community and workers' complaints concerning the performance or behaviour of the project proponent, its contractors, and employees are ascertained and addressed. The GRM prepared would be implemented to the entire life cycle of the project prior to the construction phase.

13.1 Grievance Mechanism Principal

Grievance Mechanisms would respond to the project needs if they are developed early in the project cycle as a measure to anticipate rather than respond to the rise of apprehension with surrounding communities. As per WBG's Good Practice Note on Addressing Grievances from Project-Affected Communities, September 2009, five principles have been recommended to ensure that the mechanism becomes acceptable to the communities. The five principles relate to:

- **Proportionality:** Scaled to risk and adverse impact on affected communities
- **Cultural Appropriateness**: Designed taking into account culturally appropriate ways of handling community concerns
- **Approachability:** Clear and understandable mechanism that is approachable to all segments of the affected communities at no cost
- **Transparency and Accountability:** To all stakeholders
- **Appropriate Protection:** A mechanism that prevents retribution and does not impede approaches to other remedies
- **Inclusive & Non-discrimination**: design not to marginalise any stakeholders because of ethnic, religion, gender, socio-economic and to handle all grievance with the same principle and notion.

13.2 Approach to Grievance Redressal

Grievance Redressal has three interlinked steps. The steps are provided in the following:

- A risk-based assessment of potential grievances, disputes, or conflicts that may arise during project preparation and implementation
- Identification of the UMPL's existing capacity for grievance redress
- An Action Plan that identifies priority areas for strengthening grievance capacity, or if necessary, establishing new mechanisms at the project level.

13.3 Potential Grounds for Grievance

Grievance may arise from environment related issues on one hand and social and security issues such as compensation and restoration etc. The GRM is design to handle grievance related to offences such as non-discrimination, fraudulent and gender-based violence and sexual harassment. The list of potential grievance aspects are as follows: -

Environment

- Dust Generation
- Traffic Congestion
- Non-compliance with procedure as laid down in ESMP
- Noise pollution
- Waste accumulation and dumping of liquid and solid waste
- Risk of pollution of water and environment
- Dangerous situations which can lead to accidents (non-compliance with speed limitation around populated area, non-secured working areas)

Social

- Work site accident or incident occurring during construction phase
- Discrimination in access to compensation and restoration support
- Lack of information
- Degradation in agricultural land due to indiscriminate sand filling
- Access Restriction
- Decrease in overall income due to restriction/declining fish stock
- Conflicts related to engagement of local youth for employment in the project
- Disagreement between contractor workers and employee of UMPL
- Non-payment of wages and working hours
- Conflicts related to exploitation of ground water

Gender Based Violence & Offences

- Non-discrimination and exploitation
- Sexual Harassment in the workplace

13.4 Process involved in an Effective Grievance Management

Effective grievance management encompasses a step-by-step process that is necessary along with competent personnel for proper completion of grievances handled. WBG's Good Practice Note on 'Addressing Grievances from Project Affected Communities' highlights five steps that would be considered in implementing an effective grievance mechanism. In the case of EPC contractor, the GRM can be managed through contractor management plans, which cascade investor requirements, such as GBVH-related policies, codes of conduct and training, to contractors and third parties, making it easier to manage risks.

The five process steps have been detailed in the following,

- **Publicizing Grievance Management Procedures:** An effective grievance mechanism can be determined by how popular and approachable it is to the stakeholders. By publicizing the grievance mechanism in line with the cultural characteristics and approachability factor, the success of its acceptability can be determined among the stakeholders. UMPL would have channels through which they can report GBVH, including options to report anonymously. **Receiving and Keeping Track of Grievances:** Once publicizing the grievance mechanism is undertaken the project proponent would have the capacity of collecting grievances, recording, registering, and tracking them throughout the processing cycle to reflect their status and important details.
- **Reviewing and Investigating Grievances:** A successful grievance mechanism reflects the transparency and speed by which it records, registers, and addresses the grievances.
- **Developing Resolution Options and Preparing a Response:** Once acknowledgment and understanding of the grievances is done, resolution options to commensurate with the nature of grievances by considering community preferences, project policy, past experiences, current issues, and potential outcomes are to be developed.
- **Monitoring, Reporting, and Evaluating a Grievance Mechanism:** The tools of monitoring and reporting are important components for measuring the effectiveness of the grievance mechanism. Monitoring helps identify common or recurrent claims that may require structural solutions or a policy change, and it enables the project proponent to capture any lessons learned in the resolution of grievances

13.5 Steps for Developing a Grievance Mechanism

UMPL while developing the Grievance Mechanism is required to adhere to the following steps:

Steps 1: Development of Procedures: UMPL would ensure that procedures for lodging and registering of grievances are in place before the plan is implemented at the site level. The procedures of Grievance Mechanism would comprise of identifying the personnel (Chief Grievance Officer at Corporate level and Grievance Officer at Site level) who would be responsible for receiving and addressing the grievances at the site level and handle the cases at the escalation level. The procedures to be developed would include assessment procedures, procedures to determine the appropriate resolution process, procedures for making decisions on proposed settlements, appropriate time frames for each step in the grievance resolution process, and notification procedure to the complainant about eligibility, assessment results, proposed settlements and the like.

The GRM procedure would also provide scope for raising gender-based violence and harassment. The procedure would work in tandem with the sexual harassment procedure and non-discrimination policy. The procedure would include assign key personnel female employee of UMPL to be part of the member of the grievance mechanism at the project site in case a report of GBVH is received. It is important this lead person be trained on how to respond to reports of GBVH and has the skills and confidence to take a survivor-centred approach.

Step 2: Develop Resolution Options and Response: Once UMPL has developed procedures, formal and informal resolution options would be developed along with the preparation of formulating a response. General approaches to grievance resolution include proposing a solution, reaching a resolution through discussion or negotiation, using the third party to either informally or formally resolve the matter through mediation and traditional and customary practices.

Step 3: Publicise the Grievance Mechanism: Once the procedures for Grievance Mechanism has been developed by UMPL, it has to be publicized through various stakeholder engagement activities as detailed out in the Stakeholder Engagement Plan. UMPL would inform the local community in the first instance and then remind them of this mechanism regularly during the project construction and operation phases. In addition, information on the GRM would also be disseminated to the direct and indirect workers and community on a regular basis in vernacular language. Communicative methods can be adopted in disseminating the information would includeprinted materials, displays, face-to-face meetings, and website updation. The community members and UMPL worker including foreign national would be made aware on what GBVH is and ways to report and how such incidents will be managed for redressal. **Step 4: Training/ Workshops on Grievance Redressal Mechanism:** A separate training/ workshop would be undertaken by UMPL at the community and worker's level to discuss the process of how a grievance gets registered, the local contact person's/grievance officer details of receiving grievances, the significance of grievance boxes, the timelines for addressing the grievances and the personnel involved in the redressal process. These trainings would be held every half-yearly and feedback/suggestions from the community and workers would be acknowledged and changes to the GRM would accordingly be undertaken to make it more user-friendly. Foreign nationals' employee & workers are required to receive code-of-conduct training and information on the grievance mechanism including GBVH.

Step 5: Recording of Grievances: Once the stakeholders are aware of the mechanism and process for raising a grievance, UMPL is required to acknowledge the same and keep the complainant's identity anonymous. Consequently, UMPL is required to collect grievances by checking the grievance boxes once daily, record and register the grievances that have come in as per the identified formats and track them throughout the redressal process to reflect on their status and important details. In the case of GBVH grievance, UMPL would provide private spaces where support options and potential safety measures can be discussed with complainants for maintaining confidentiality.

A Grievance Log or database emphasizing the records and status of the grievance is to be maintained by the identified Grievance Officer at the site level. The Grievance Log can be used to analyse information about grievance and conflict trends, community issues, GBVH issuesand project operations to anticipate the kinds of conflicts that the project proponents might expect in the future both to ensure that the grievance mechanism is set up to handle such issues and to propose organizational or operational changes.[60]

Step 6: Appeal: If the grievance redressal solution is not acceptable or agreed upon by the project proponent and either party, the complainant would be offered an appeal process. Circumstance revolving around when an appeal can be made would be set by UMPL so that accountability and transparency are promoted by them in every step. National Court or convening of a senior and independent panel of individuals to seek appropriate resolution of the

[60] *A Guide to Designing and Implementing Grievance Mechanisms for Development Projects by The Office of the Compliance Advisor/ Ombudsman for IFC and MIGA, 2008.*

case with representation from both government and civil society is often encouraged. This panel may also play the role of providing strategic oversight and assurance of the mechanism through review monitoring and tracking data.

Step 7: Resolve and Follow Up: Once the corrective action has been agreed upon, a good practice is to collect proof of those actions in terms of taking photographs, documentary evidence, getting confirmation from the complainant, and filing the same within the case documentation. In addition, monitoring and follow-up on the resolution agreed upon would be conducted once to close the case accordingly. UMPL is required to provide regular (quarterly) reports to the public and workers that track the number of complaints received, resolved, not resolved, and referred to a third party. In addition, the funding agencies also need to be constantly apprised of the quarterly reports in order to support UMPL in the early identification of developing risks.

Building HR capacity to support leadership efforts
HR departments or functions play an important role in making sure that measures to prevent GBVH are integrated into company processes and management structures. However, they are sometimes seen as working for management, so may not be trusted by workers. An HR function can help support company leadership to tackle GBVH by:

- addressing the risks of GBVH during the recruitment process, including checking that appropriate processes are followed in terms of job applications, interviews, vetting and background checks, contracting and inductions
- developing and/or commissioning training and awareness-raising activities on GBVH policies and procedures
- supporting workers who experience GBVH by directing them to relevant services and ensuring they

13.6 Proposed Grievance Redressal Mechanism for UMPL

UMPL, in order to implement the Grievance Redressal Mechanism, is required to identify the contact person/ grievance officer involved at the site level for registering the grievances, the process of registering and action taken thereon for the resolution of the grievance, the timeline required in each step and criteria in the escalation of the case to the higher level. For this atwo-level approach is proposed to be developed for all cases of grievances. As per the severity of each case, resolution of the grievances can be undertaken at each level. The steps of grievance redressal for UMPL have been provided below:

Receive and Register a Complaint

- Compliant can be registered in writing, through verbal communication and digital means like SMS, WhatsApp, etc. Local communities can submit their grievances through a number of methods, but not limited to the following
  - In Person: To Grievance Officer designated by UMPL: Manager Social Development
  - Over telephone using the following number 01713205310
  - In writing: through email ID: feedback@umplbd.com Facebook page https://www.facebook.com/UMPL777, LinkedIn page https://www.linkedin.com/company/unique-meghnaghat-power-limited/ and Grievance boxes, currently located outside the entrance of the plant and in Social development Office located outside the plant.
- Any worker/ stakeholder with concerns pertaining to onsite work such as occupational health and safety, terms of employment, wages paid, issues with community or among co-workers, management, etc. may register their complaint in writing to the nominated person/grievance officer at site (Level-I);
- Secured grievance boxes would be placed at a various strategic location within the site area, site office, labour camp, and community level.
- If the complainant wishes to remain anonymous, he/she can write down the grievances and drop them in the available complaint boxes.
- Complaint box would be checked daily
- Once a complaint has been received it would be recorded in the grievance log register or data system and an acknowledgment slip is provided to the complainant.

- Reports of GBVH may either come through formal grievance mechanisms, however, complaints may also be likely to come through informal channels such as through direct approaches by survivors on site visits, through media reports or through third parties.

Assessment and Addressal of Complaint

The identified Grievance Officer at Level I would open the complaint boxes daily and forward the grievances to the Plant Manager for further action. In addition, in turn of the physical receipt of compliant, the same would be forwarded to the Plant Manager.

The grievance would be assessed to determine if the issues raised by the complaint fall within the mandate of the grievance mechanism or not.

- During the assessment of complaints, the team at ***Level I*** am comprising the Grievance Redressal Committee (in cases concerning Contract Workers then Contractor Site Supervisor would also be involved) would gather information about the key issues and concerns and helps determine whether and how the complaint might be resolved. The GRC would comprise of the Chairman of Pirojpur Union Parishad, Project Manager- UMPL, Plant Manager – UMPL, Plant Manager – UMPL, Electrical Engineer – UMPL, and EHS Officer – UMPL, Female Employee of UMPL and women representative of Dudhghata village. The local female representative would take part only in case of grievances associated with local community.
- If the grievance is failed to be addressed at Level-I within stipulated time period or to the satisfaction of the complainant, the grievance would be referred to the Chief Grievance Officer (Level – II) to take the final decision pertaining to the complaint.
- the issue would be forwarded to the Chief Grievance Officer based at the Corporate Office (Level II) to screen and assess the grievance. If the complaint seems to require intervention, then it would be considered for further action, otherwise, it would be invalid and the same would be communicated to the concerned complainant by the Grievance Officer based at the site level within 2 working days
- The grievances would be addressed at Level-I by the GRC and Contractor Supervisor (in cases involving contract workers) within 15 working days.
- At level-II, the Chief Grievance Officer (identified by the Company) would discuss the issue with the Director (Human Resource & Administration) and Director (Operation) and try to address the grievance. The Chief Grievance Officer would provide support in terms of decision-making. If necessary, meetings would be conducted with the complainant and evidence would be examined. The grievance would be closed within 10 working days of referral;
- The worker/ complainant would have the opportunity to be present at the committee meetings and discuss the grievance at both levels.
- If the grievance is not resolved at GRC Level II or the complainant is not satisfied with the solution provided by GRC, the complainant will have the option to approach Court of Law.

The project affected people's mechanism has been established by AIIB to provide an opportunity for an independent and impartial review of submission from PAPs who believe they have been or are likely to be adversely affected by AIIB's failure to implement its E&S policy in situations when their concerns cannot be addressed satisfactorily through Project-level Grievance Redress Mechanisms or AIIB Management's processes.

Information on AIIB's PPM is available at: https://www.aiib.org/en/policies-strategies/operational-policies/policy-on-the-project-affected-mechanism.html

The Grievance Mechanism proposed for UMPL to consider, and implement has been provided in **Figure 13.1** below.

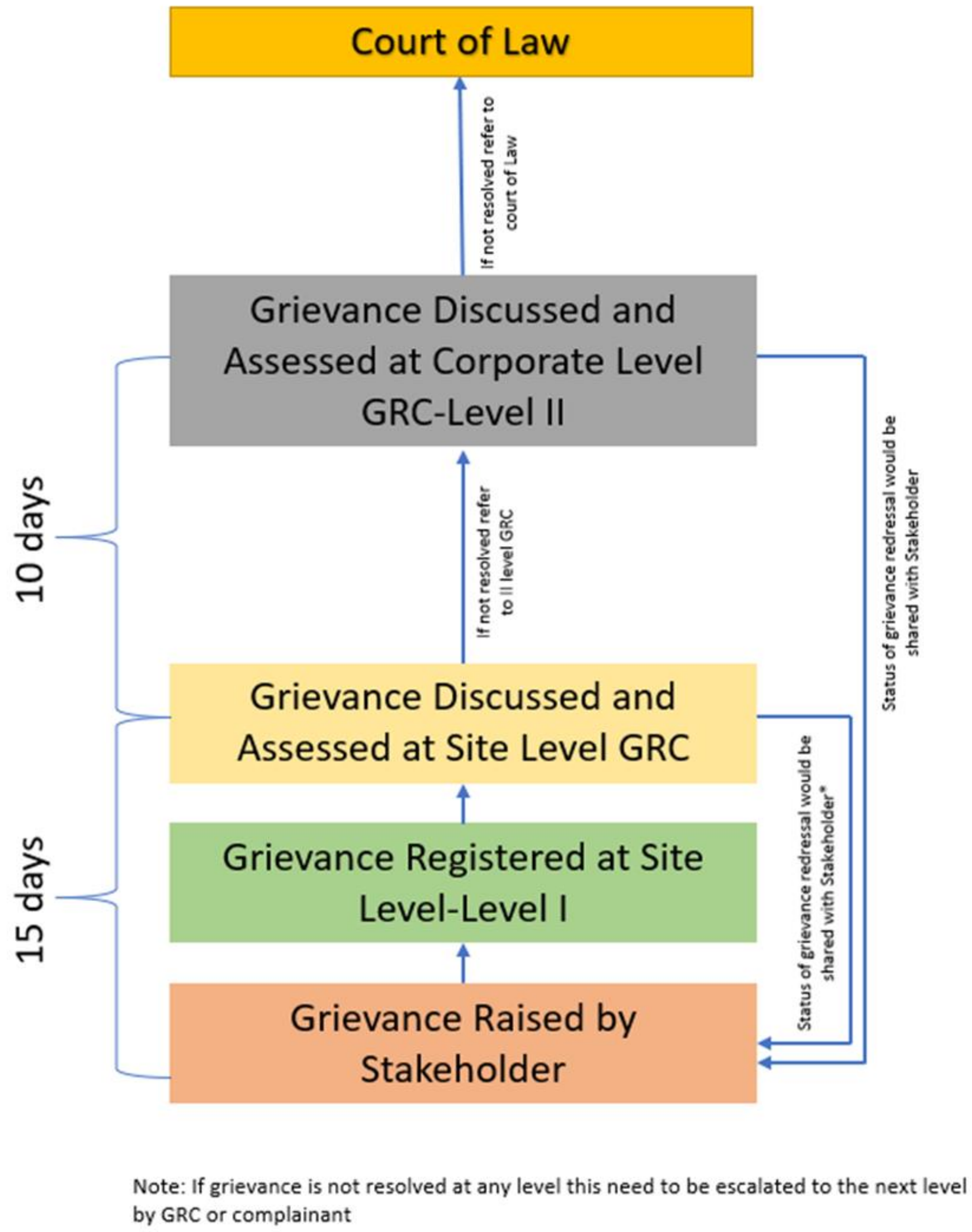


Figure 13.1. Proposed Grievance Mechanism Structure for UMPL

13.7 Resource Required for Grievance Mechanism Implementation

A Grievance Mechanism becomes successful if adequate resources are assigned in its implementation. Adequate resources here refer to people, systems and processes, and associated financial resources. In order to incorporate the responsibility of designing, implementing, and monitoring the grievance mechanism, the senior management at the corporate level of UMPL would be involved in executing the various tasks.

Responsibility

For a grievance mechanism to function effectively, it is important to establish a governance structure and assign responsibilities for the mechanism's implementation. The following roles and responsibilities have been identified for grievance mechanism implementation:

Chief Grievance Officer (Corporate Level/ Level II): A Chief Grievance Officer is to be nominated at the corporate level. The incumbent has more than 13-15 years of experience working including possessing prior knowledge of Grievance Redressal Mechanism and its Management. He is to report directly to the Executive Director of UMPL and work in tandem with Site/ Plant Manager & Sr. Manager Technical.

Grievance Officer (Site Level/ Level I): Gen Manager-Site would be the site-level grievance officer. He is to report directly to the Chief Grievance Officer based at the Corporate Level as well as the Site/Plant Manager at the Site Level. The Grievance Officer is to work in tandem with the Deputy Manager-Social & Community Development, Deputy Manager-EHS. It is recommended that a female employee of UMPL is nominated as the key person for registering grievance with regards to GBV and Harassment The female representative at site level would ensure that GBVH report is appropriately and securely lodged as per the GRM process and that confidential records are kept properly. She has to also ensure that ongoing monitoring and communication with the complainants redressal status on a regular basis.

A Grievance Redressal Committee has been formed at the Site Level. It is imperative to mention here that to maintain ultimate transparency and accountability for the grievance mechanism process third parties which are neutral and independent have also been included within the structure. To realize these criteria, one member from the local administration (Chairman Pirojpur Union), Pirojpur Union Member of Dudhghata Village, Female member of Dudhghata Village identified by UMPL to be a part of the GRC. Inclusion of female members of the local community in site-level GRC would make GRC suitable for females and help them to approach the GRC easily. In cases of grievances from contract workers, the Contractor Supervisor would also join the Grievance Committee and take part in the discussion and resolution of grievances. This would no doubt, help build the trust of the community members, contractor and the effectiveness of the project proponent's grievance mechanism would be strengthened.

The list of members to be included within the GRC has been provided in **Table 13.1** below.

Table 13.1. List of Members of Grievance Redressal Committee

Sr. No.	Member	Role	Contact Number
Permanent Committee			
1.	General Manager Site	Chairperson & Head of the Grievance Redressal Committee	01787690851
3.	Deputy Manager Site	Chief Grievance Officer of UMPL	01713205320
4.	Deputy Manager Admin	Member	01713205315
5.	Deputy Manager-EHS	Member	01713205295
6.	Deputy Manager- Social Development	Member	01713205310
7	Female Employee-UMPL	Member	017150106441
Additional Member for Community Grievance			
1	Chairman Pirojpur union	Community Representative	01682806020
2	Pirojpur Union Member of Dudhghata Village	Community Representative	01836853006
3	Female Member of Dudhghata Village	Community Representative	01814074010
Additional Member for contractor or contract Employee			
1	Contractor Supervisor	Contractor Representative	

13.8 Disclosure of the Grievance Redressal Mechanism

The following aspect would be considered in the disclosure of GRM.

- GRM would be disclosed, and the procedures mentioned therein would be properly disseminated to all the stakeholders identified in ESIA report or identified in the latter stage.
- Name and contact of the Chief Grievance officer at the site level would be mentioned in the GRM discloser document
- GRM would be included in the induction training program of UMPL employees and contractual employees.

13.9 Grievance Reporting Procedure

UMPL would ensure any person /group can file grievances without any intimidation. Grievances would be submitted either in writing or may be submitted verbally to the GRC. The decision made by GRC would be communicated to the concerned person or group in writing.

GRC would maintain records of any grievance received at their end in written or verbal or through digital platform like SMS, WhatsApp etc, custodian of which would be the Deputy Manager (Social & Community Development) as referred in Table 11. 2.. This record would include the details of the complainant, the subject of the grievance, the appropriate department, and the status of the grievance. A sample recording format is provided in ***Table 13.2*** below.

Table 13.2: Sample Grievance Recording Format

Sr. No.	Date	Department/ Village	Name of the Complainant	Details of Grievance	Concerned Department	Status	Status As of	Remarks

13.10Monitoring and Reporting

Monitoring and reporting are requisite tools for measuring the effectiveness of the grievance mechanism, the efficient use of resources, determining broad trends, and acknowledging recurring problems so that they can be resolved before they reach a higher level of contention. They also create a base level of information that can be used by the project proponent to report back to the stakeholders.[61]

Monitoring: Depending on the extent of project impacts and the volume of grievances, monitoring measures like internal and external audits every six-monthly based on the complexity of the nature of grievances can be adopted by UMPL. Grievance records maintained would provide the background information for these regular monitoring exercises. Through the review of each grievance and analysis of its effectiveness and efficiency, UMPL can draw on the complaints to evaluate systematic deficiencies. In addition, monitoring of the grievance mechanism helps to ensure that the design and implementation of the mechanism are adequately responding to stakeholder's comments in a cost-effective manner.

Reporting: All grievances registered have to be recorded and regularly updated. The site management or Grievance Officer is responsible for discharging this responsibility and he would be able to produce this document whenever any audits take place. In addition, a monthly reporting system would be introduced wherein the Grievance Officer is required to submit a Grievance Report to the Chief Grievance Officer even if 'nil' grievances are recorded at the site level. The report should be shared during the safety committee meetings. All minutes of meetings with stakeholders, complainants, and Grievance Redressal Committee are to be recorded and documented regularly for reference purposes. In addition, through the process of monitoring and the reports produced thereafter, assurance of continual improvement of the company's operations is guaranteed. The company can also use these monitoring reports to report back to the community on its implementation of the mechanism and the modification/ changes proposed to make it more user-friendly.

13.11Budget

The UMPL administration would ensure adequate budgeting and resource allocation for implementing the grievance redress mechanism.

[61] *IFC's Good Practice Note on Addressing Grievances from Project-Affected Communities*

14 Conclusion and Recommendations

14.1 Conclusion

Environmental and Social Risk and Impact Assessment study involving identification and assessment of impact of the proposed 600MW CCPP project activities on the environmental (i.e. physical, ecological etc) and socioeconomic components during both construction and operation phases suggests that most of the adverse impacts ushered by the project related activities on the physical and biological environment are moderate to minor in nature and can be minimized further to acceptable limit with adequate implementation of the mitigation measures formulated in the Environmental Management Plan (ESMP) and their measure their effectiveness through implementation of Environmental Monitoring Plans.

The major environmental components likely to be impacted during the project's construction phase are air quality, noise quality, surface and groundwater quality through vehicular emissions, dust, construction equipment and machineries and the corresponding noise generated during the activities during the construction phase, discharge of untreated wastewater and dust laden stormwater into the surface water; and spillage of fuel/chemicals into the soil and leaching into the groundwater aquifer. However, these impacts can be off-set or minimized through adequate mitigation measures. Also, there are no ecologically sensitive or critical areas within the study area, hence no major impacts are anticipated during construction phase.

From socio-economic point of view, no resettlement is required, and majority of the socio-economic and occupational health and safety related impacts were found to be in the range of moderate to minor and can be controlled through suggested mitigation measures.

The potential sources of pollution during operation phases are likely to be air emissions from power plant stacks, noise from major rotating equipment or mechanical items, wastewater discharge and groundwater pollution. However, with natural gas a s fuel and use of low NOx burner (technology), the impact on air pollution is minimised at the design stage which has been substantiated by the air dispersion modelling also. With appropriate engineering control mechanism (e.g. acoustic enclosure, noise absorbent padding & barriers wherever feasible, sewage and effluent treatment plant, spill management kit etc), the impact on noise, soil, surface and groundwater during operational lifecycle can be significantly controlled and minimized.

The project is also likely to generate new employment opportunities and other livelihood opportunities (e.g. shops, local product supply etc), which would improve the socio-economic conditions of the area. The overall study suggests, that the CCPP can be installed with appropriate mitigation measures in place and implemented and monitored adequately to prevent and/or minimize adverse impact on physico-chemical environment, ecological environment and socio-economic aspects of the site surrounding region.

14.2 Recommendations

The environmental impact assessment studies carried out for the proposed Unique Meghnaghat 600MW CCPP suggests that majority of the environmental and social impacts ranges from moderate to low scale of adverse impacts, which can be reduced to acceptable level through implementation of the recommended mitigation measures as specified in the Environmental Management Plan and carrying out monitoring for ESMP as per the Environmental Monitoring Plan to establish the effectiveness of the ESMP. The risks associated with air emissions, noise generation, water consumption and wastewater generation, solid and hazardous wastes generation during the construction and operation phases can be mitigated through appropriate implementation of mitigation measures.

It may be concluded that the proposed Natural Gas based Combined Cycle Power Plant would have minimal impacts if the suggested mitigation measures are properly implemented throughout the project life cycle. It is also recommended that the ESMP be effectively monitored in order to identify any alterations in the predicted impacts and take appropriate actions to mitigate any unexpected adverse residual impacts to the extent possible during the operational lifecycle of the plant. Also, in the event of any emergency, major accidents and natural and man-made disasters, effective deployment of Emergency Response Plan (ERP) in a very short period of time in a pre-determined sequence would be able to prevent loss of lives and property.

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